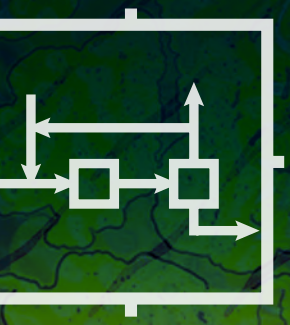
UNIVERSITY OF DELAWARE

CHEMICAL & BIOMOLECULAR ENGINEERING

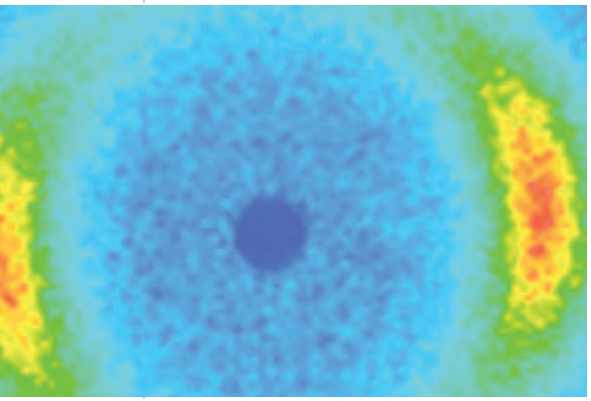
FALL 2018
cbe.udel.edu

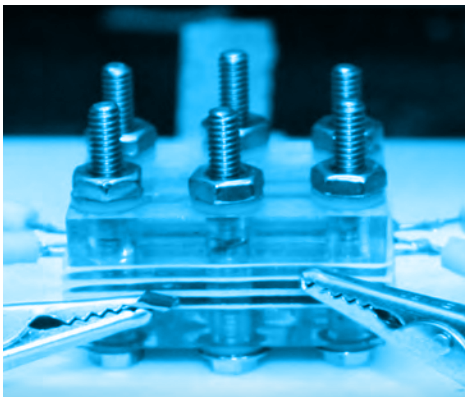


RESEARCH & INNOVATION | FACULTY HIGHLIGHTS
STUDENT SUCCESS | ALUMNI

UNIVERSITY OF DELAWARE
ENGINEERING

TABLE OF CONTENTS





CBE.UDEL.EDU

FALL 2018

CHEMICAL AND BIOMOLECULAR ENGINEERING NEWS

Chemical & Biomolecular Engineering News is published for the alumni, friends and peers of the Department.

University of Delaware
Department of Chemical
& Biomolecular Engineering
Allan P. Colburn Laboratory
150 Academy Street
Newark, DE 19716

DEPARTMENT CHAIR
Eric Furst

Please submit address changes to cbe-info@udel.edu or call (302) 831-2543.

Subscribe or send comments to cbe-info@udel.edu

ERIC M. FURST

Department Chair & Professor

I am pleased to present the 2018-19 issue of Chemical and Biomolecular Engineering News.

Delaware Chemical and Biomolecular Engineering is growing — leading new areas of research, scholarship, teaching, and invention. Our centers and research partnerships are transforming UD's STAR campus from a 20th-century automotive plant to a 21st-century innovation hub for advances in manufacturing of biopharmaceuticals, chemicals, and advanced materials.

On the pages that follow, learn how we engineer materials for energy production and storage, turn biomass into valuable products, push the frontier of molecular simulations and more. Read about PhD student Himaghna Bhattacharjee, the 2018 Laird Fellowship recipient, who represents the passion and broad interests of our students. Delaware remains a beacon, attracting talent across the country and world, and our department welcomed 39 PhD students this fall. Our undergraduate enrollment is at a historic high, and undergraduates take advantage of exchange programs with the National University of Singapore, study abroad at the University of Melbourne, and a joint master's program with the University of Leuven, Belgium.

Turn to the alumni news to see where Blue Hens have left their mark in engineering or taken leadership roles that draw from their training. Rakesh Jain '74M, '76PhD and Arup Chakraborty '88PhD are pioneering solutions for cancer and HIV. Dr. Kara Odom Walker's (BChE '99) recent Jack A. Gerster Memorial Lecture showed how chemical engineering skills can be applied to grand challenges in public health and social services. Dr. Walker, the Secretary of the State of Delaware's Health and Human Services, recently joined our advisory council.

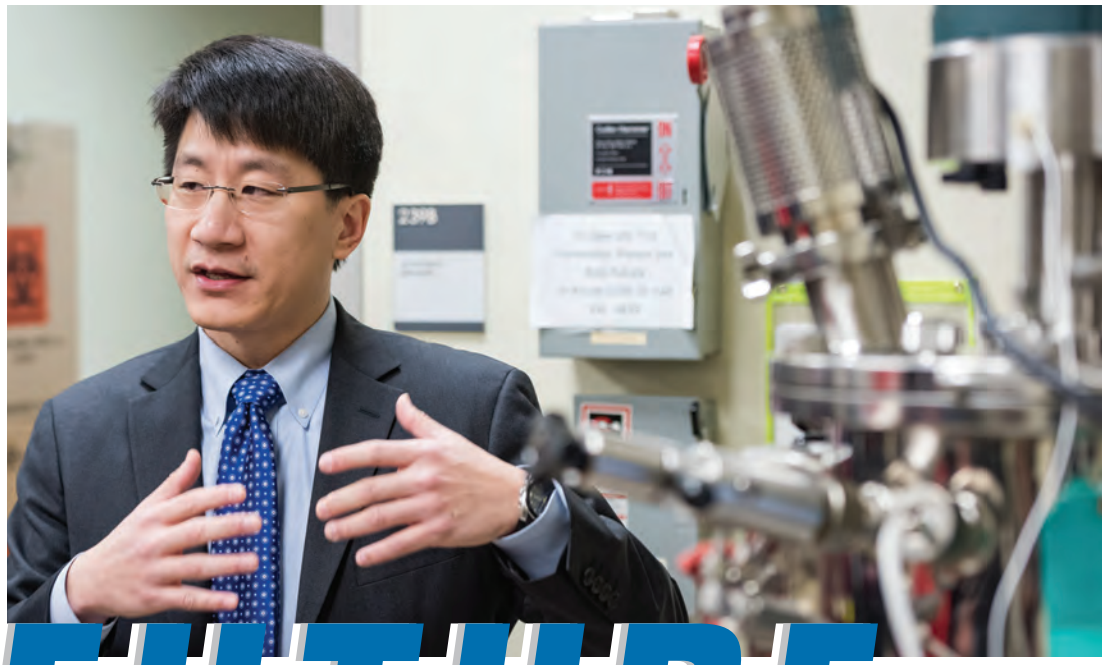
We are also proud to introduce our new colleagues in Colburn Laboratory. Prof. Levi Thompson joined us as the Elizabeth Inez Kelly Professor of Chemical Engineering and Dean of the College of Engineering. LaShanda Korley, who studies bio-inspired materials, joined as Distinguished Associate Professor. New assistant professors Marat Orazov and Aditya Kunjapur will expand our scholarship in catalytic science and biomolecular engineering. We also welcomed back Prof. Babatunde Ogunnaike after seven years as Dean.

Awards and promotions abound. A highlight was Terry Papoutsakis' induction into the National Academy of Engineering, where he joined Professors Ogunnaike, Wagner, and Sandler and emeritus faculty Russell and Barteau. We celebrated Prof. Millicent Sullivan's promotion to Professor, Prof. April Kloxin's promotion to Associate Professor with Tenure, and Prof. Josh Enszer's promotion to Associate Professor. Our student AIChE chapter was selected as an "Outstanding Student Chapter" again under the advisement of Prof. Enszer and our undergraduate Academic Advisor, Megan Argoe.

Delaware Chemical and Biomolecular Engineering boasts more than 600 students, faculty, and staff working together to learn, teach, develop groundbreaking scholarship, and reach for our goals. Our superb staff keeps the teaching and research machines oiled and running, and our exceptional team of associated and adjunct faculty enriches our base of expertise with their decades of experience in industry and engineering practice. They lead our Masters of Engineering in Particle Technology and contribute to our senior design class and electives in intellectual property law, entrepreneurship, green chemistry, and other critical topics for tomorrow's chemical engineering leaders.

What is on the horizon? Recently, we designed new laboratories for Junior and Senior Labs. Now, we seek to build collaboration spaces to enrich our academic programs and provide the latest teaching and research facilities so that we continue to recruit and retain the best talent to UD.

Sometimes I think of my service as Chair as a countdown clock. The appointment is for five years — a good time frame to plan on, not too long to get in a rut. But it's only 10 semesters to achieve our goals, and the clock now stands at "8". It's time to hustle. In the meantime, I welcome visits from our alumni, their families, and our many friends, and I look forward to your continued involvement with the department.



BUILDING THE FUTURE WITH BIOPHARMACEUTICALS

Groundbreaking shows commitment to NIIMBL partnership, research

It seemed like a pipe dream to Kelvin Lee, Gore Professor of Chemical and Biomolecular Engineering - this idea that the University of Delaware might find room for a place where innovation in biopharmaceuticals could happen. He wished for 60,000 square feet of space. But how could that work?

UD President Dennis Assanis had even bigger ideas.

"Why settle for 60,000 square feet," Lee recalled Assanis saying, "when the University could build 200,000 square feet at the STAR Campus?"

In October 2017, the dream Lee once thought too expensive and too ambitious was taking shape in striking fashion, as 14 symbolic shovels plunged into a symbolic mound of dirt on UD's Science Technology and Advanced Research (STAR) Campus, the ceremonial start of construction on a six-story, $156 million Biopharmaceutical Innovation Building.

It will be a gateway, University officials hope, to a major role for Delaware in the emerging biopharmaceutical sector, where scientists and innovators will tackle some of the world's most

vexing diseases - Alzheimer's, Parkinson's, diabetes, cancer, to name a few - and help to train a world-class workforce.

There, Lee will direct the extensive national initiative known as NIIMBL - the National Institute for Innovation in Manufacturing Biopharmaceuticals, with $70 million in federal funding from the National Institute for Standards and Technology (NIST) and millions more in support from UD and about 150 other partners in government, industry and academic sectors.

The Delaware Biotechnology Institute will relocate faculty, staff and three facilities to the new building - bio-imaging, bio-informatics and sequencing - and related UD-led life science research and technology programs will be housed there, too. Opening day is projected for January 2020.

It is another beginning on a 272-acre site that once was a gloomy symbol of economic despair in Delaware, where bulldozers razed the shuttered Chrysler automobile plant in 2009, ending more than 50 years of manufacturing. Combined with UD's recent partnership with the DuPont Company and the state in launching Delaware Innovation Space Inc. at DuPont's Experimental Station, it brings fresh hope to a state where 1,700 scientists were laid off last year.

NIIMBL's mission, as announced in December 2016 by the U.S. Department of Commerce and NIST, is to accelerate innovation in biopharmaceutical manufacturing, support the development of standards that enable more efficient and rapid manufacturing capabilities, and educate and train the nation's workforce, making the U.S. the world leader in the industry.

Biopharmaceuticals have shown great promise in medicine - relying on living cells instead of chemistry to treat disease. NIIMBL is meant to generate the innovative advances that will allow more rapid and flexible production with the precision needed to effectively meet healthcare needs and respond quickly to pandemics or other biological threats.

Phillip Singerman, associate director of NIST, praised the proposal submitted by Lee and his outstanding team of faculty collaborators.

"NIIMBL had the most outstanding proposal among the two dozen we received," Singerman said, "and the extraordinary leadership of Professor Kelvin Lee was responsible for that success."

It costs more than $1 billion to bring a new drug to market, but NIIMBL wants to reduce this cost.

"In the case of antibodies, which are used to treat cancer and autoimmune disorders, NIIMBL is focused on approaches that accelerate the time to market for these medicines or that can reduce the cost of goods for manufacturing these medicines," said Lee. "In the case of gene and cell therapies, which are the newest types of treatments approved by the FDA, NIIMBL is focused on developing approaches that reduce the manufacturing time and ensure that as many patients as possible can access those life-saving treatments."

Workforce development is also a priority for NIIMBL.

"There is a need for a skilled workforce that can manufacture these medicines once they are approved by the health authorities," said Lee. "Workers in this industry are among the highest paid for any industry and yet, we consistently hear from the industry about the challenges of finding a manufacturing workforce and filling those jobs."

Lee envisions a variety of training opportunities, from on-site and online classes to hands-on training using new and innovative approaches.

"We see opportunities for virtual reality training opportunities to prepare individuals to work in a manufacturing environment as well as augmented reality opportunities to assist the manufacturing process itself," he said. "In all of these, we can envision an opportunity to impact students going through credit-bearing courses such as at universities and community colleges, but also training opportunities that are non-credit bearing and focused on providing skills and training needed to be successful in this industry."

"NIIMBL HAD THE MOST OUTSTANDING PROPOSAL AMONG THE TWO DOZEN WE RECEIVED, AND THE EXTRAORDINARY LEADERSHIP OF PROFESSOR KELVIN LEE WAS RESPONSIBLE FOR THAT SUCCESS."

PHILLIP SINGERMAN, ASSOCIATE DIRECTOR OF NIST

NEW PROCESS TURNS WOOD SCRAPS INTO TAPE

UD engineers convert commonly discarded material into high-performance adhesive

Whether you're wrapping a gift or bandaging a wound, you rely on an adhesive to get the job done.

These sticky substances often are made from petroleum-derived materials, but what if there was a more sustainable way to make them? A team of engineers has developed a novel process to make tape out of a component of trees and plants called lignin—a substance that paper manufacturers typically throw away. What's more, their invention performs just as well as at least two commercially available products.

The researchers described their results in ACS Central Science, and they are working on more ways to upcycle scrap wood and plants into "designer materials" for consumer use.

Sticky science

Lignin is a renewable resource from trees, but you do not have to cut down trees to get it, because there's plenty lying around. When pulp and paper manufacturers process wood, the lignin is left behind and usually discarded in landfills or burned for heat. An inexpensive, plentiful and sustainable material, lignin presents a prime opportunity for some scientifically advanced upcycling.

Lignin is a natural polymer and shares some structural and materials property similarities with petroleum-derived polymers, such as polystyrene and polymethyl methacrylate, which are commonly used in adhesives and other consumer products.

"One of the thoughts that we have always had is: Can we take lignin and make useful products, and in this case, useful polymers out of it?" said Thomas H. Epps, III, the Thomas and Kipp Gutshall Professor of Chemical and Biomolecular Engineering, Professor of Materials Science and Engineering

University of Delaware

at UD, and the corresponding author of the new paper. Epps suspected that lignin could be used to make adhesives with similar strength, toughness, and scratch resistance to the petroleum-based versions.

Before the lignin could be transformed into a product, it was broken down by researchers at the Catalysis Center for Energy Innovation (CCEI), a multi-institutional research center at UD established by a grant from the U.S. Department of Energy.

Dionisios Vlachos, director of CCEI and the Delaware Energy Institute, is an international expert in catalysis, and for nearly a decade, Vlachos and his team have perfected methods to break down some wood components, cellulose and hemicellulose, into useful products. They aim to make renewable products that are better for the environment, with unmatched performance. However, compared to other wood components, lignin presents a tougher challenge.

"Lignin is very hard, a solid part of the biomass that is the hardest to break down," said Vlachos. "Developing a catalyst and a process to actually crack these molecules is difficult."

Vlachos and his colleagues developed a mild, low-temperature process that busts the lignin into small, molecular fragments.

Then, Epps used those materials to synthesize new materials, adjusting their properties for use in pressure-sensitive adhesives. "We start with a biopolymer, and we end up with another polymer," said Vlachos.

"We can use the same separation, purification, polymerization, and characterization methods to make these materials as one can use to make the current commercial, and petroleum-based, analogues," said Epps. "But we can get better properties, and we can use a much greener source."

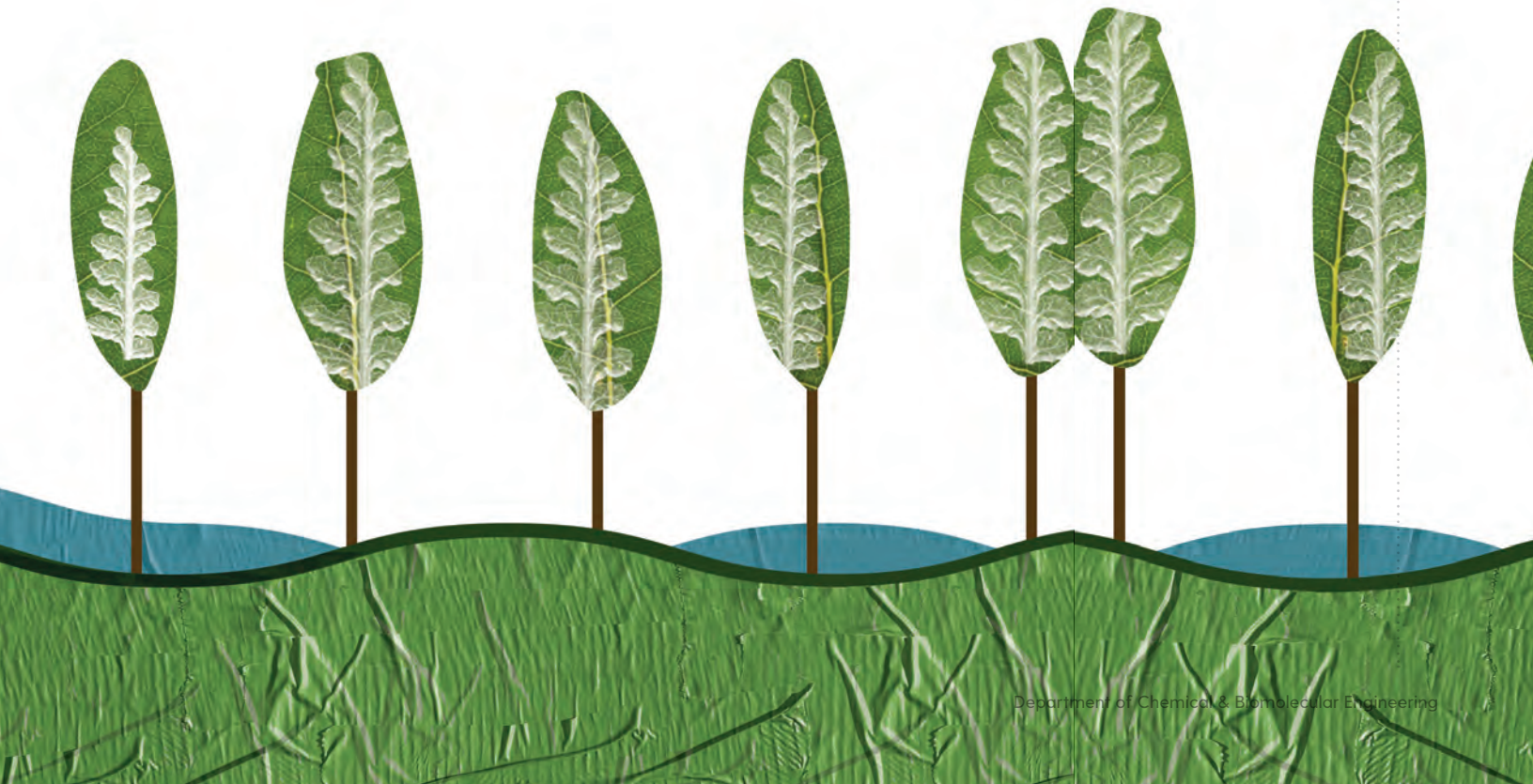
Mechanical tests of adhesion and tackiness revealed that the tape performed on par with Fisherbrand labeling tape and Scotch Magic Tape.

"We were expecting it to be competitive because we knew that if we could form well-defined polymers, we could engineer them to have similar performance," said Epps. "The thing that we found a bit surprising and interesting is that our materials gave similar performance to Scotch tape and Fisherbrand tape without any additional formulation or other additives that are typically used in commercial materials to improve their performance."

Many tapes have added tackifiers, which increase adhesion but can also decrease the lifetime of materials.

The research team utilized lignin sourced from poplar wood, but they plan to explore the potential of other woods and other plants with high lignin content, such as switchgrass.

The paper's authors also include Shu Wang, a former postdoctoral associate at UD who is now a materials scientist at Bridgestone Americas; Li Shuai, a former postdoctoral associate at UD who is now an assistant professor in the Department of Sustainable Biomaterials at Virginia Tech University; and Basudeb Saha, associate director of CCEI.



A "SMART" SPORTS BRA

Reebok uses UD research in new activewear

Norm Wagner, Unidel Robert L. Pigford Chair in Chemical and Biomolecular Engineering and faculty member in the Biomechanics and Movement Science graduate program at the University of Delaware, was intrigued when the problem came to him. Reebok, the global athletic footwear and apparel company, wanted to build a better sports bra, one that actually worked, providing the kind of support that active females want.

Reebok's designers had heard about Shear Thickening Fluid (STF) — the technology Wagner invented with the Army Research Laboratory's Eric Wetzel, an alumnus of UD Mechanical Engineering — and wondered if its unique properties might meet the challenge.

When integrated in a textile, Shear Thickening Fluid makes the fabrics tougher and stronger as pressures on the fabric increase. Its potential applications are extensive. UD spin off company STF Technologies LLC, co-founded with Richard Dombrowski (CBE grad) more than five years ago is commercializing a number of products based on STF. For example, NASA is testing novel STF-armor™ for use on next-generation spacesuits to protect astronauts from projectiles and other potential perils in space and on the surfaces of the moon and Mars.

Reebok wondered if it might also provide better support and performance for female runners and others in high-action endeavors. So they contacted Wagner and Dombrowski. Working with Reebok designers and materials experts, marketing and customer insight experts, an R&D program was developed.

First, they needed data. Wagner called on the biomechanics expertise of Jim Richards, distinguished professor in the Department of Kinesiology and Applied Physiology in UD's College of Health Sciences. Richards and department colleague, assistant professor Elisa Arch, developed a biomechanics assessment, recruited females to wear the necessary data-gathering gear and soon delivered the information the product development team needed — precise calculations on where, when and how the fabrics in these runners' bras were moving, stressing and stretching.

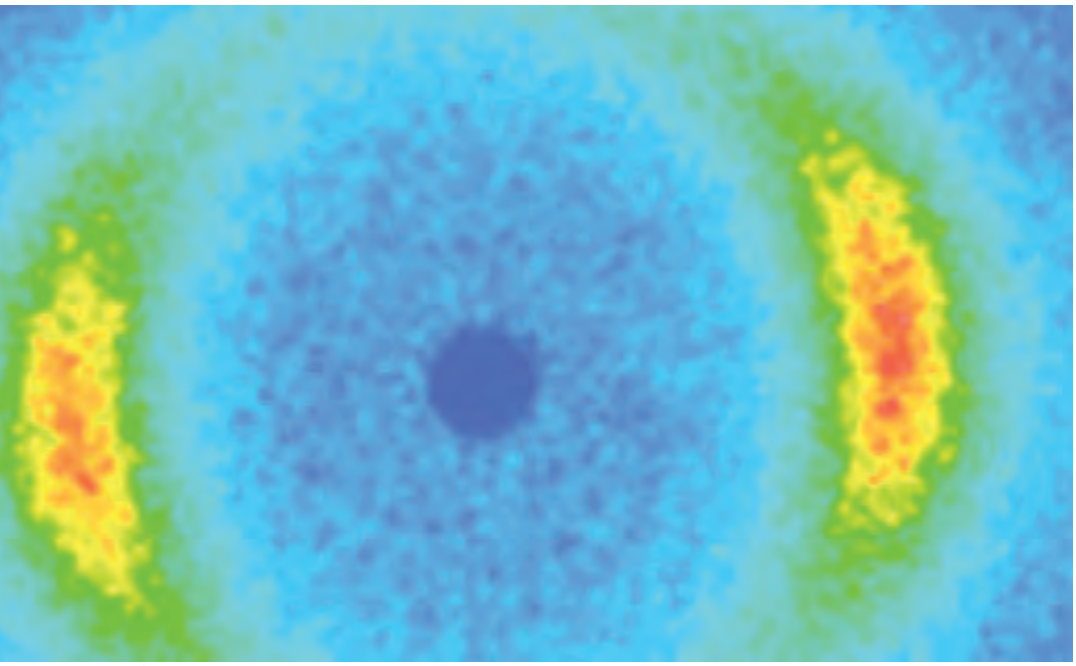
The engineers at STF Technologies then developed a solution to create a fundamentally new, exceptional "movement reactive fabric" that provided the necessary support.

"Norm thinks about molecules in his head," Richards said, "visualizing molecular structures — just like that."

That took things to a whole 'nother level for Reebok. They now had a "smart" sports bra, the $60 PureMove, which went on the market earlier this year. On its website, Reebok describes it as "an innovation that simply adapts to your movement, like an external skeleton." The company also made a video documenting the technology.

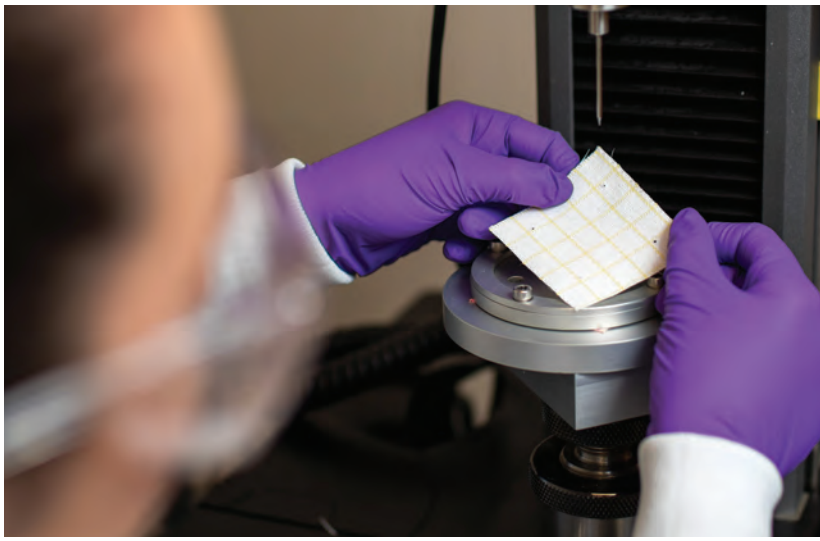
Innovation backed by UD science.

"They were interested in doing the engineering science," Wagner said, "and that is the culture in that company. They distinguish themselves by product engineering based on solid biomechanics data and state-of-the-art engineered materials to address a critical problem in women's exercise health."



THE CENTER FOR NEUTRON SCIENCE

UD's Center for Neutron Science, which was founded in 2007 and is directed by Norm Wagner, recently entered into another cooperative agreement with the National Institute of Standards and Technology (NIST) Center for Neutron Research (NCNR). Under this new agreement, the Center for Neutron Science will advance the field of neutron scattering by developing new techniques, applying these techniques to new applications, and training the next generation of neutron scientists. Under the new cooperative agreement, Wagner and his collaborators will use techniques such as small-angle neutron scattering, very small angle neutron scattering, neutron reflectometry and neutron spin echo. They will also develop new methods, including a new interfacial rheology-neutron reflectometry sample environment. The agreement began on Sept. 1, 2017, with $1.7 million of funding and a projected funding total of more than $8.7 million through Aug. 31, 2022.



SAFER, TOUGHER SPACESUITS

When astronauts go out for a walk in space, they need a lot of protection from sharp, dusty, fast-moving debris. NASA sees great promise the shear thickening fluid technology being co-developed at the University of Delaware by Wagner. After proving its mettle with support from a NASA Small Business Innovation Research Phase 1 contract, STF Technologies won a $750,000 Small Business Technology Transfer Research Phase II grant to produce a prototype that will shield astronauts whether they are in low-earth orbit - as they are at the International Space Station - on the moon or stepping onto Mars. In fall 2017, STF's materials went to the International Space Station for exposure testing.

BETTER MATERIAL FOR FUEL CELLS

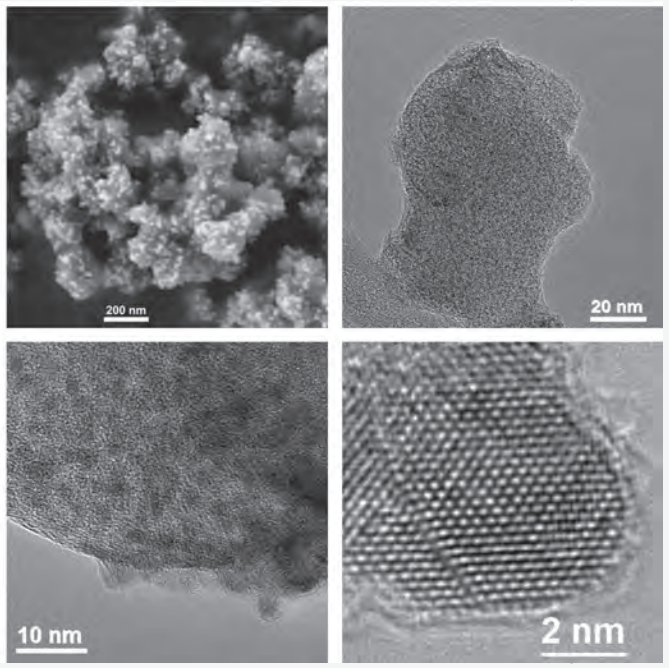
Research team aims to make fuel cells more durable, less expensive

Authors include Weiqing Zheng, a research associate at the Catalysis Center for Energy Innovation; Liang Wang, an associate scientist in the Department of Mechanical Engineering; Fei Deng, a research associate in materials science and engineering; Stephen A. Giles, a graduate student in chemical and biomolecular engineering; Ajay K. Prasad, Engineering Alumni Distinguished Professor and chair of the Department of Mechanical Engineering; Suresh G. Advani, George W. Laird Professor in the Department of Mechanical Engineering; Yushan Yan, Distinguished Engineering Professor in the Department of Chemical and Biomolecular Engineering and the Associate Dean for Research and Entrepreneurship for the College of Engineering; and Dionisios Vlachos, Allan and Myra Ferguson Professor of Chemical and Biomolecular Engineering and director of the Catalysis Center for Energy Innovation.

Take a ride on the University of Delaware's Fuel Cell bus, and you see that fuel cells can power vehicles in an eco-friendly way. If their power sources could last longer and cost less, fuel cell vehicles could go mainstream even faster. Now, a team of UD engineers has developed a technology that could make fuel cells cheaper and more durable, which they described in the journal Nature Communications.

Cleaner energy, lower cost

Hydrogen-powered fuel cells are a green alternative to internal combustion engines because they produce power through electrochemical reactions, leaving no pollution behind. Catalysts spur these electrochemical reactions, and platinum is the most common catalyst used in fuel cells for vehicles. However, platinum is expensive. — around $30,000 per kilogram. Instead, the UD team made a catalyst of tungsten carbide nanoparticles, which goes for around $150 per kilogram. They produced tungsten carbide nanoparticles in a novel way, much smaller and more scalable than previous methods, using a series of steps including hydrothermal treatment, separation, reduction, carburization and more.



"The material is typically made at very high temperatures, about 1,500 Celsius, and at these temperatures, it grows big and has little surface area for chemistry to take place on," Vlachos said. "Our approach is one of the first to make nanoscale material of high surface area that can be commercially relevant for catalysis."

Next, the researchers incorporated the tungsten carbide nanoparticles into a proton exchange membrane fuel cell (PEMFC), which contain a polymeric membrane. This membrane separates the cathode from the anode, which splits hydrogen (H2) into ions (protons) and delivers them to the cathode, which puts out current.

The membrane wears down over time, especially if it undergoes too many wet/dry cycles, which can happen easily as water and heat are produced during the electrochemical reactions in fuel cells. However, when tungsten carbide is incorporated into the fuel cell membrane, it humidifies the membrane at a level that optimizes performance. The team also found that tungsten carbide captures damaging free radicals before they can degrade the fuel cell membrane. As a result, membranes with tungsten carbide nanoparticles last longer than traditional ones.

ENGINEERING ON A BLUE STREAK

A pair of engineers at the University of Delaware has developed a process to form interwoven polymer networks more easily, quickly and sustainably than traditional methods allow. Their secret ingredient? Blue light.

Abhishek Shete, graduate research assistant in materials science and engineering, and Christopher Kloxin, assistant professor in chemical and biomolecular engineering and materials science and engineering, described their method in a paper featured on the cover of the 24th issue of Polymer Chemistry in 2017.

Kloxin groupcreates interwoven polymers with blue light

Two or more types of polymer chains with different individual properties can be linked together to form interpenetrating polymeric networks, materials that often combine favorable mechanical properties from each polymer such as high strength and toughness.

"These chemistries independently are used in a broad range of applications," from dental composites, automobile bumpers to drug delivery materials, Shete said.

However, the process of linking polymers requires two chemical reactions, which are typically initiated through either a lengthy two-step process or a one-step process induced at elevated temperatures and longer time spans. The method Kloxin and Shete developed is one step and works rapidly at room temperature and ambient conditions.

They use 470-nanometer blue light, which triggers reactions with a photosensitizer, camphorquinone, and an activator, amine. These materials are commonly utilized in polymeric dental composites for filling cavities.

The light irradiates the materials to photostimulate the two chemical reactions, but not simultaneously. First up is a reaction called the copper-catalyzed azide-alkyne cycloaddition (CuAAC) click polymerization. This reaction is facilitated by copper, and polymerization occurs in steps. Next is methacrylate polymerization, which forms a plastic-like material in a manner similar to adding links to a growing chain. "This is unique in the way the blue light induces sequential reactions," says Kloxin.

The end result is a material that Kloxin and Shete describe as a "glassy film," less brittle than pure methacrylate and stronger than pure CuAAC at higher temperature. The films made from this IPN material also exhibit shape memory—when deformed, it can be returned to its original size and shape with 15 minutes of heating at 80 degrees Celsius.

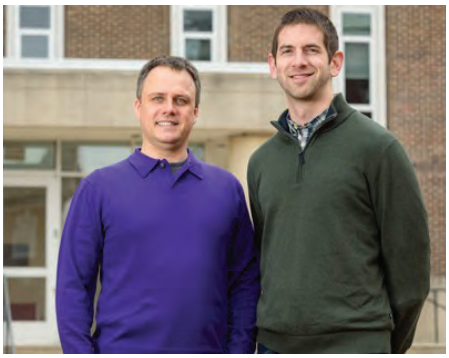
This blue-light approach to form interpenetrating polymer networks saves time and energy, but those are not its only advantages. This approach allows Kloxin and Shete to control the pair of chemical reactions with increased precision, allowing them to fashion the polymer networks into complex shapes. This rapid method also keeps the ingredients from separating in a way that could otherwise interfere with the formation of an interpenetrating polymer network.

In addition, the new process requires none of the solvents or additives commonly used in plastics manufacturing, often added to prevent brittle fracture. The materials reported by Kloxin and Shete exhibit enhanced toughness that overcomes this brittleness without any solvents or additives, also making it a greener synthetic approach.

The team has filed a provisional patent for the method. "These chemistries could be attached to other molecules," Kloxin said, and the team will test their applications to form hydrogels, dental materials and other polymer networks.

NEW DISCOVERIES USING METABOLIC FLUX ANALYSIS

Antoniewicz lab uncovers fundamental insights about bacterial, cancer cells



A team from the University of Delaware and University of California, San Diego has uncovered insights about how E. coli bacteria mutate in response to a life-threatening challenge. Their results were published in Proceedings of the National Academy of Sciences (PNAS).

Co-author Maciek R. Antoniewicz, Centennial Professor of Chemical and Biomolecular Engineering at UD, and students used whole-genome sequencing and metabolic flux analysis. "One of the novelties of this paper is that we used two complementary approaches to elucidate how these cells evolved," Antoniewicz said. "This is one of the first times both approaches were combined to see a link between genotype and phenotype."

Collaborators at UC-San Diego modified and evolved ten strains of E. coli bacteria, robbing them of a key metabolic enzyme. However, these E. coli cells eventually recovered 46 to 71 percent of their growth rate. The UD cohort used genomic analysis and flux analysis to identify three key mutations responsible for the recovery.

Antoniewicz is also using flux analysis to study cancer cells. In a paper published in Nature Communications, he and collaborators at the University of Illinois at Chicago described a method to kill liver cancer cells and inhibit tumor growth. First, they silence a key cellular enzyme, and then they add a powerful drug.

The Illinois cohort grew liver cancer cells, manipulated their expression of the enzyme hexokinase-2, and treated them with metformin, a diabetes drug. The UD cohort used mass spectrometry to analyze the cancer cells and determine intracellular metabolic fluxes for cells with and without hexokinase-2. They found that targeting hexokinase-2 alone had only a marginal impact on stopping cancer cell growth. Metformin was needed to complete the job.

"The importance of our paper is that we show that targeting hexokinase-2 can indeed be a successful strategy for cancer therapy, when you also target a second compensatory mechanism with the drug metformin," said Antoniewicz.

MODELING NEW MATERIALS

Jayaraman uncovers molecular mysteries

Before you develop a brand new material, you can use computer simulations to see how the molecules will behave under changing conditions. As researchers around the world invent increasingly innovative and complex materials, they need models and simulations that run for longer time scales, and offer resolutions at multiple length scales, than what is available.

Arthi Jayaraman, an associate professor in the Department of Chemical and Biomolecular Engineering and Department of Materials Science and Engineering at the University of Delaware, is building better models. With collaborators Ryan Hayward of University of Massachusetts Amherst and Paul Butler of National Institutes of Standards and Technology, she was recently awarded a $726,000 grant from the U.S. Department of Energy Office of Basic Energy Sciences for this work.

Advancing polymers through simulation

Jayaraman is developing computational methods to study polymer nanocomposites. These types of materials are ubiquitous in nature--DNA is just one example.

"That's the beauty of this project," said Jayaraman. "The models we will develop in this work will be widely applicable, for studying materials well beyond just polymer nanocomposites."

Scientists who design such materials want to understand how these polymers behave at the molecular level, especially in response to temperature. When these substances are heated to a certain point, the "stickiness" of their hydrogen bonds is lost, leaving behind polymer segments or "chains" that are now free to move around and rearrange. The pace and path of their movement is not random—it's like a choreographed dance.

With modeling, Jayaraman can see what temperature changes or other factors would be required to make molecules rearrange the way we want them to. This predictive capability of models allows researchers to tailor materials with specific, desired properties.

Jayaraman and her research team utilize high-performance computing resources at UD to simulate the materials with their new computational models. Then she shares these simulation results with her collaborators, who do the analogous experiments to verify the models. "The only way to know if the models work is to test them against results from experiments," said Jayaraman.

Once the models are verified, they will be important tools for use before experiments. "Computations then guide the experimentalists on what to try next," said Jayaraman.

The union of modeling and experimentation drives innovation forward.

"We think that understanding, and ultimately controlling, how nanoparticle fillers interact with polymers through hydrogen bonds will open the door to polymer nanocomposites with precisely tuned structures and properties. We are very excited for the opportunity to work together with Arthi on the project, and to pair the theory and simulation methods that she has been at the forefront of developing closely with experimental characterization of these materials," said Ryan Hayward, professor in the Department of Polymer Science & Engineering at the University of Massachusetts-Amherst.

FOCUSING ENERGY RESEARCH

UD scientists develop new theory to help improve catalysis research

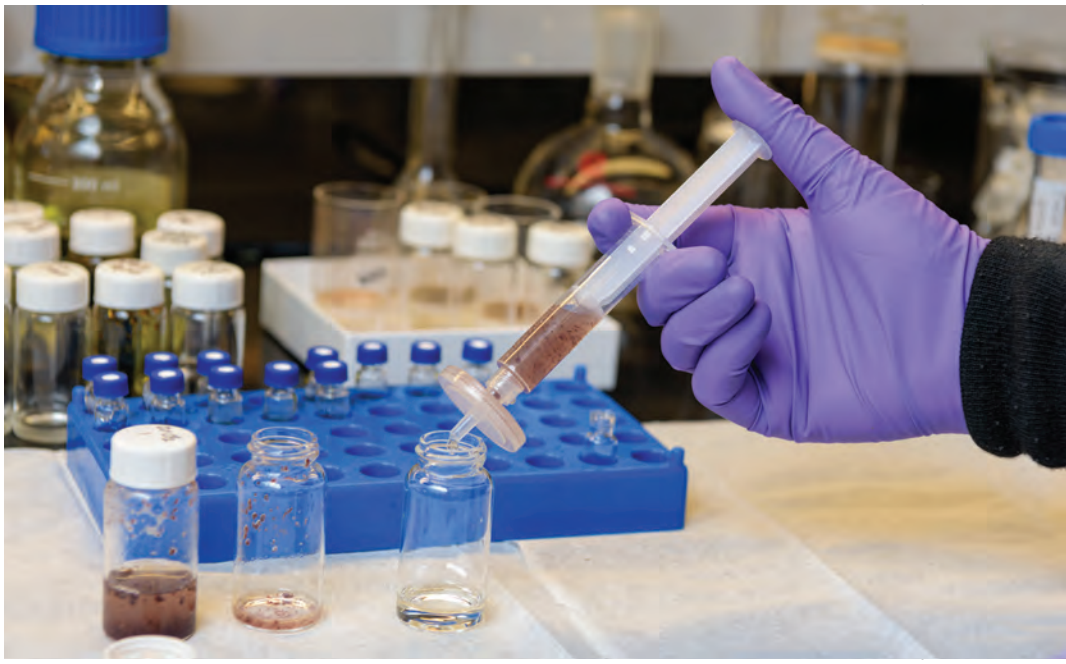
A new theory by researchers at the University of Delaware-led Catalysis Center for Energy Innovation (CCEI) will help bring greater accuracy and focus to molecular science research, with the potential for far-reaching impact across multiple industries.

The findings— reported by UD graduate student researchers Joshua Lansford and Alexander Mironenko with support from CCEI director Dionisios Vlachos— establish predictive capability for the behavior of molecules called adsorbates.

Adsorption is essential to important scientific processes like catalysis, and lends itself to multiple industrial applications, including water filtration, the production of non-stick coatings and silica gel, and even extending the shelf life of prescription medication.

CCEI's theory, published in Nature Communications, will help increase the rapidity and accuracy of thermochemistry predictions used in adsorption research.

"Our theory identifies important parameters that can be used in machine learning models to predict frequencies for larger molecules or more complex surfaces," says Lansford. "Not only do these findings provide new insight into the interaction of molecules and surfaces, they will also guide and focus efforts in the future." Scientists have often used the classic arcade game Tetris, where blocks of varying shapes or sizes are assembled onto a flat surface, as a simplified illustration of how adsorbate molecules are "fused" to an adsorbent surface.



Adsorption is an essential first step in heterogeneous catalysis, including transforming non-food-based biomass materials into renewable fuels and chemicals. The scaling and modeling calculations proposed by CCEI can accelerate testing of new materials used in catalyst discovery.

"This is an exciting theoretical development that fills in a long-standing scientific gap," adds Vlachos, who is also the Allan and Myra Ferguson Professor of Chemical and Biomolecular Engineering at UD. "It could allow one to identify species on surfaces, unravel structures of nanocatalysts, develop predictive models, and ultimately make better materials for production and storage of renewable energy, fuels and chemicals."

PROGRAMMING DNA TO DELIVER CANCER DRUGS

Chen lab controls cellular proteins with biological computing

A UD research team has developed technology to program strands of DNA into switches that turn proteins on and off. Described in Nature Chemistry, this technology could lead to the development of new cancer therapies and other drugs.

This project taps into an emerging field: DNA computing. Data we often send and receive, such as text messages and photos, utilize binary code. DNA is essentially a code with four components, the nucleotides guanine, adenine, cytosine, and thymine. Here, the team has repurposed the DNA code to design logic-gated DNA circuits.

"Once we had designed the system, we had to first go into the lab and attach these DNA strands to various proteins we wanted to be able to control," said study author Rebecca P. Chen, a doctoral student in chemical and biomolecular engineering (no relation to Wilfred Chen). The custom sequence designed DNA strands were ordered from a manufacturer while the proteins were made and purified in the lab. Next, the protein was attached to the DNA to make protein-DNA conjugates.

The group then tested the DNA circuits on E. coli bacteria and human cells. The target proteins organized, assembled, and disassembled in accordance with their design.

"Previous work has shown how powerful DNA nanotechnology might possibly be, and we know how powerful proteins are within cells," said Rebecca P. Chen. "We managed to link those two together."

The team also demonstrated that their DNA-logic devices could activate a non-toxic cancer prodrug, 5-fluorocytosine, into its toxic chemotherapeutic form, 5-fluorouracil. Cancer prodrugs are inactive until they are metabolized into their therapeutic form. In this case, the scientists designed DNA circuits that controlled the activity of a protein that was responsible for conversion of the prodrug into its active form. The DNA circuit and protein activity was turned "on" by specific RNA/DNA sequence inputs, while in the absence of said inputs the system stayed "off."

The scientists based their sequence inputs on microRNA, small RNA molecules that regulate cellular gene expression. MicroRNA in cancer cells contains anomalies that would not be found in healthy cells. The group calculated how nucleotides should be arranged to activate the cancer prodrug in the presence of cancer microRNA, but stay inactive and non-toxic in a non-cancerous environment where the microRNA are missing. When the cancer microRNAs were present and able to turn the DNA circuit on, cells were unable to grow. When the circuit was turned off, cells grew normally.

This technology could have applications to other diseases and also beyond the biomedical field. The team demonstrated that their technology could be applied to the production of biofuels, by utilizing their technology to guide an enzymatic cascade to break down a plant fiber.

JIAO SPEAKS AT SENATE COMMITTEE HEARING

He shares carbon utilization expertise with environment and public works committee

Associate professor Feng Jiao, director of UD's Center for Catalytic Science & Technology, spoke at a hearing of the U.S. Senate Committee on Environment and Public Works on April 11, 2018.

The subject of the hearing was S. 2602, the Utilizing Significant Emissions with Innovative Technologies Act, or USE IT Act. This bill was introduced on March 22, 2018 to "support carbon dioxide utilization and direct air capture research, to facilitate the permitting and development of carbon capture, utilization, and sequestration projects and carbon dioxide pipelines, and for other purposes."

Jiao was invited to the hearing by Delaware Sen. Thomas R. Carper, ranking member of the Environment and Public Works Committee.

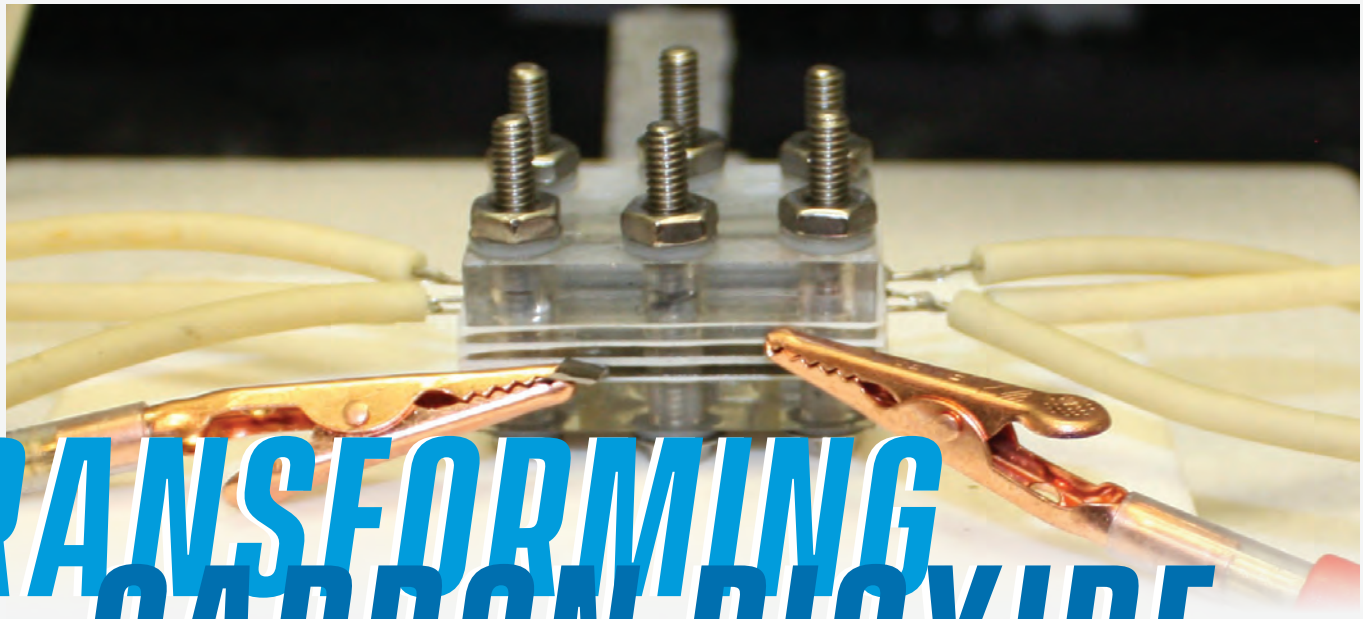
Jiao has 15 years of experience in research and development of electrochemical technologies for energy storage and conversion. His research group at UD has received funding from federal agencies including the National Aeronautics and Space Administration, Department of Energy, and National Science Foundation. He is developing processes to electrochemically convert carbon dioxide to high-value chemicals, including alcohols such as propanol.

In written testimony submitted to the Environment and Public Works Committee, Jiao described how carbon utilization can help to mitigate the problem of rising atmospheric carbon dioxide levels—which has climate impacts. He also offered a condensed version of his comments as oral testimony.

"More R&D [research and development] efforts are urgently needed in the U.S. to further this technology as well as other CO2 [carbon dioxide] utilization technologies so that we can be the global leading technology providers," he told the committee. With a $500,000 NSF grant starting August 1, 2018, Jiao and assistant professor Bingjun Xu, an assistant professor of chemical and biomolecular engineering, are studying solar-driven carbon dioxide utilization for environmental sustainability.

"If successful, this technology could provide the community a green, sustainable way to produce chemicals and fuels without using any fossil source," said Jiao. "This technology also aims to address the challenges associated with renewable energy utilization and storage."

In collaboration with researchers at Tianjin University in China, Jiao and Xu are designing a system that could reduce greenhouse gas emissions by using carbon-neutral solar electricity. Their system will utilize electrolysis, with help from a copper catalyst, to convert carbon dioxide and water to liquid carbon-based fuels such as ethane and propane. Then, the research team will develop a prototype reactor and perform technical and economic analysis to determine the potential to commercialize this technology. Finally, the team will determine the environmental impacts of their device.



TRANSFORMING CARBON DIOXIDE

A research team at UD's Center for Catalytic Science and Technology (CCST) has discovered a novel two-step process to increase the efficiency of carbon dioxide (CO_2) electrolysis, which could aid in the production of valuable chemicals and fuels. The results of the team's study were published in Nature Catalysis.

The team, consisting of Feng Jiao, associate professor of chemical and biomolecular engineering, and graduate students Matthew Jouny and Wesley Luc, obtained their results by constructing a specialized three-chambered device called an electrolyser, which uses electricity to reduce CO_2 into smaller molecules.

Compared to fossil fuels, electricity is a much more affordable and environmentally-friendly method for driving chemical processes to produce commercial chemicals and fuels. These can include ethylene, which is used in the production of plastics, and ethanol, a valuable fuel additive.

"This novel electrolysis technology provides a new route to achieve higher selectivities at incredible reaction rates, which is a major step towards commercial applications," said Jiao, who also serves as associate director of CCST.

Whereas direct CO_2 electrolysis is the standard method for reducing carbon dioxide, Jiao's team broke the electrolysis process into two steps, reducing CO_2 into carbon monoxide (CO) and then reducing the CO further into multi-carbon (C_{2+}) products. This two-part approach, said Jiao, presents multiple advantages over the standard method.

"By breaking the process into two steps, we've obtained a much higher selectivity towards multi-carbon products than in direct electrolysis," Jiao said. "The sequential reaction strategy could open up new ways to design more efficient processes for CO_2 utilization." Electrolysis is also driving Jiao's research with Bingjun Xu, assistant professor of chemical and biomolecular engineering. In collaboration with researchers at Tianjin University in China, Jiao and Xu are designing a system that could reduce greenhouse gas emissions by using carbon-neutral solar electricity.

This work was supported with a grant from the U.S. Department of Energy's Office of Fossil Energy and an award from the National Science Foundation Faculty Early Career Development Program.

Established in 1978, the CCST has pioneered multidisciplinary research in the scientific and engineering principles of catalysis. CCST has forged a strong tie to industrial practice, supported through grant and contract research, collaborative projects with industrial scientists and engineers, and industrial sabbaticals and exchanges of research personnel. Additionally, the Center's laboratories and wide range of research instrumentation represent one of the foremost facilities for catalysis research in academia.

PAPOUTSAKIS ELECTED TO NAE

He joins top ranks in the National Academy of Engineering

Eleftherios (Terry) Papoutsakis, Unidel Eugene du Pont Chair of Chemical and Biomolecular Engineering, has been elected to the National Academy of Engineering (NAE).

He was selected "for contributions to metabolic engineering, especially the industrial biotechnology of Clostridia, and to biomanufacturing of therapeutic proteins." Clostridia are industrial organisms that Papoutsakis' lab has worked on for many years to develop their industrial applications.

Membership in NAE is among the highest professional honors an engineer can receive. Papoutsakis is one of 83 new members and 16 foreign members selected in 2018. There are now 2,293 U.S. members and

continued on next page

continued orom previous page

262 foreign members of NAE. Papoutsakis and other members of the newly elected class were formally inducted during a ceremony at the NAE's annual meeting in Washington, D.C., on Sept. 30.

"The impact for which one gets this kind of recognition comes from the collective effort of so many," said Papoutsakis. "It reflects largely the creativity, good work, sleepless nights, long days and work weekends of a large number of past and current lab members, some 60-plus doctoral students, 30-plus postdocs and many, many master's degree students and undergraduate students, and the road we traveled together, the risks we took and our failures, which showed us the way to success. But it also reflects on our teachers, our mentors and our collaborators, and our families that supported and support this wonderful voyage of exploration in science and engineering to do good, teach and bring out the best of human nature."

Papoutsakis joins four other chemical and biomolecular engineering faculty members and emeritus faculty as members of the NAE: Norm Wagner, Unidel Robert L. Pigford Chair in Chemical Engineering (2015); Babatunde Ogunnaike, dean of the College of Engineering (2012); Stanley Sandler, H.B. du Pont Chair of Chemical Engineering (1996); and T.W. Fraser Russell, Allan P. Colburn Professor Emeritus of Chemical Engineering (1990).

"The University of Delaware is incredibly fortunate to have an excellent teacher and prolific scholar like Terry, an exemplary UD citizen who contributes so generously to his academic field as well as to our entire academic community," Assanis said. "Election to the NAE is one of the highest distinctions in the engineering profession, so congratulations to Terry on this much-deserved honor."

"Terry is a pioneer in the field of metabolic and cell-culture engineering whose discoveries have touched countless lives," said Ogunnaike. "His work to understand cellular processes has had significant impact on medicine, biomanufacturing, biofuels, and countless other fields. He is more than deserving of this long-overdue recognition from the National Academy of Engineering."

Groundbreaking work in metabolic and cell-culture engineering

Papoutsakis has had a profound influence on the field of biotechnology. He has published more than 275 refereed publications that have garnered 17,864 citations, according to Google Scholar. He has also co-edited two books that have had a significant impact on the field: Foundations of Biochemical Engineering: Kinetics and Thermodynamics in Biological Systems (ACS Symposium Series No. 207, 1983) and Metabolic Engineering (Marcel Dekker, 1999).

His work has also found commercial success. He has filed 20 patents and started two successful companies. Tissue Therapeutics, which developed bioreactors for research and development and therapeutics, was sold to Resodyn Corp in 2001, and Elcriton, which developed microbial-based technologies, was sold to White Dog Labs in 2014. Papoutsakis also contributes to the broader scientific community. He has served on many review boards, journal editorial boards, advisory panels and professional societies in the biochemical and biomolecular engineering communities. Currently, he is an editor at mBio, the top-tier journal of the American Society of Microbiology.

NAE is far from the only organization to honor Papoutsakis. He has received the ACS Murphree Award from American Chemical Society (2016), DIC Wang Award for Excellence in Biochemical Engineering (2013), the James E. Bailey Award for Biological Engineering (2012) and the International Metabolic Engineering Award and the Elmer Gaden Award (2010). He is also a fellow of the American Institute of Chemical Engineers, the American Chemical Society, the American Academy of Microbiology, American Association for the Advancement of Science and the American Institute of Medical and Biological Engineers.

Papoutsakis earned his doctoral degree in chemical engineering at Purdue University. He was a faculty member at Rice University and then at Northwestern University before joining UD in 2007.

THE FUEL CELL AUTHORITY

Yan recognized for advances in energy technology

Yushan Yan received the Electrochemical Society (ECS) Energy Technology Division Research Award for 2018. Yan is a Distinguished Engineering Professor and Associate Dean for Research and Entrepreneurship in the University of Delaware's College of Engineering.

The Electrochemical Society advances electrochemical and solid state science and technology. Its Energy Technology Division focuses on energy conversion through technologies such as fuel cells, electrolyzers, flow batteries, and more. The ECS Energy Technology Division Research Award recognizes researchers whose achievements will likely impact future research and development in the field.

Yan leads and contributes to multiple projects funded by the Department of Energy. In 2017 alone, his research group secured more than $5 million in research funding.

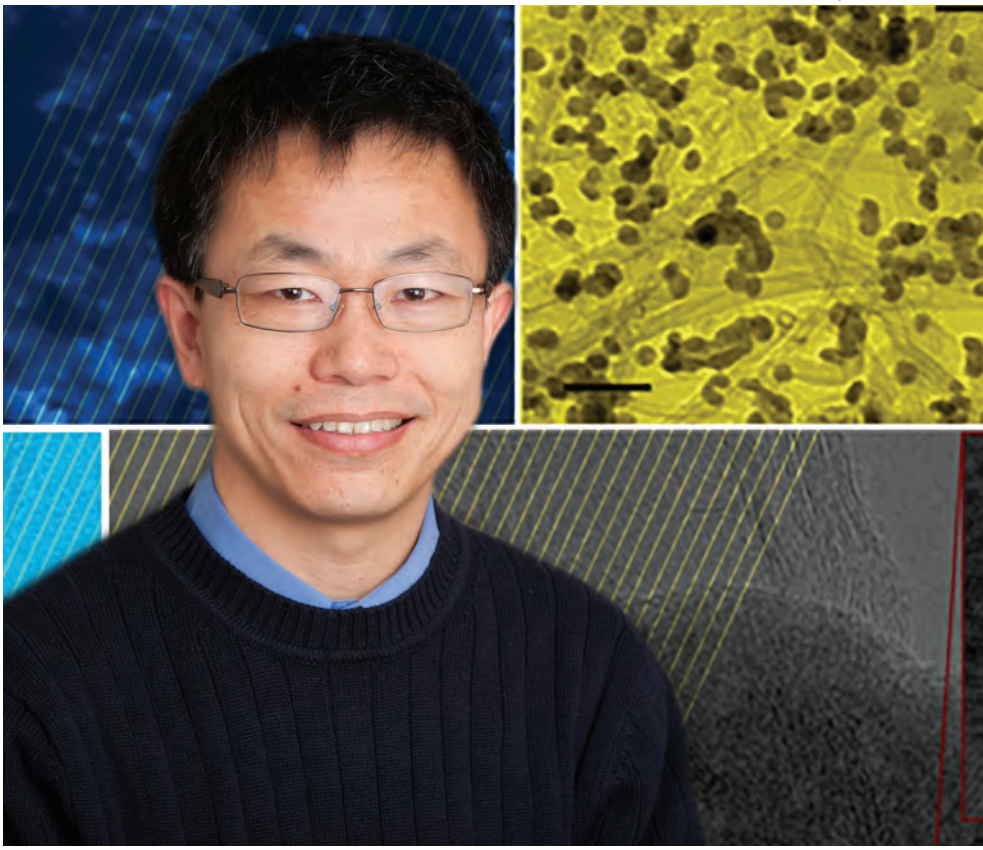
Much of Yan's research focuses on fuel cell for use in vehicles, and he is tackling a challenge that has slowed the widespread development and adoption of fuel cell vehicles: the relatively high cost of fuel cells.

As part of this effort, Yan is zeroing in on fuel cell membranes and catalysts. The membranes, currently made of polymeric Nafion, need the assistance of an expensive catalyst to spur power-generating electrochemical reactions. Often this catalyst is platinum, which can stand up to the acidic environment inside fuel cells.

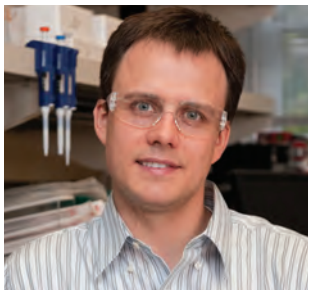
Yan is developing membranes made with a Nafion substitute that shifts the environment within fuel cells from acidic to alkaline. Termed by him as hydroxide exchange membranes, these can employ less expensive metals, such as nickel, as catalysts instead of platinum. "This hydroxide exchange membrane is becoming a very important foundation for new fuel cells, electrolyzers, even low flow batteries," Yan said. "We're developing this foundational technology and testing it for several applications in clean transportation."

Yan also aims to make fuel cells more eco-friendly and sustainable. He is looking for greener ways to obtain hydrogen—the gas that fuel cells convert into electricity. Now, hydrogen is usually obtained from natural gas.

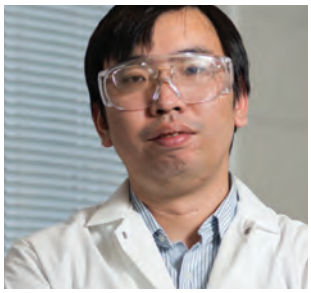
"To completely move away from fossil fuels, we need hydrogen from a clean source," said Yan. "The best is to split water to produce hydrogen using wind and solar electricity." Under a new project through the Department of Energy's Energy Efficiency and Renewable Energy, Yan and collaborators from Northeastern University and Advent Energy are developing methods to do that.



FACULTY HIGHLIGHTS

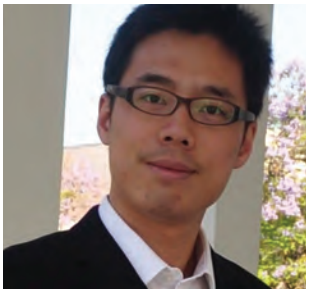


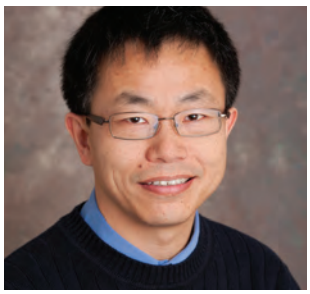












Maciek Antoniewicz, Centennial Professor in the Department of Chemical and Biomolecular Engineering, was inducted into the College of Fellows of the American Institute for Medical and Biological Engineering (AIMBE) in 2018. Antoniewicz was selected for pioneering contributions in advancing stable-isotope tracing and quantitative metabolic flux analysis approaches in biomedical and biological engineering.

Wilfred Chen received the 2018 AIChE Food, Pharmaceutical and Bioengineering Division Award in Chemical Engineering.

Joshua Enszer was promoted to associate professor of chemical and biomolecular engineering, effective September 1, 2018.

Thomas H. Epps, III, the Thomas & Kipp Gutshall Professor in the Department of Chemical and Biomolecular Engineering, was named a Fellow of the American Physical Society (APS) in 2017. "Prof. Epps' accomplishments in the research and engineering of block-copolymers and his service and leadership in the American Physical Society forum make him exceptionally qualified for this honor," said Eric Furst, chair of the department of chemical and biomolecular engineering. "He is an extraordinary researcher and educator whose work has had a major impact on macromolecular and soft matter science and engineering." In 2018, Epps was named to the Royal Society of Chemistry.

Richard Grenville, an adjunct professor in chemical and biomolecular engineering, won the 2017 NAMF Forum Award from the North American Mixing Forum. This award is given for excellence and sustained contributions to mixing research and practice. Grenville is director of mixing technology at Philadelphia Mixing Solutions.

Feng Jiao, assistant professor, was named to the ACS Industrial & Engineering Chemistry Research inaugural call of Influential Researchers.

April Kloxin was named the American Chemical Society Division of Polymer Chemistry Researcher of the Month for May 2018. She has also been promoted to associate professor of chemical and biomolecular engineering, effective September 1, 2018.

Kelvin Lee, Gore Professor of Chemical and Biomolecular Engineering, and director of the National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL), was named one of "36 Intriguing Delawareans" by Delaware Today magazine.

Babatunde Ogunnaike
AIChE Warren K. Lewis Award for Chemical Engineering Education.

Millicent Sullivan was promoted to professor of chemical and biomolecular engineering, effective September 1, 2018.

Norman Wagner, the Unidel Robert L. Pigford Chair in Chemical Engineering, has received the 2018 Sustained Research Prize from the Neutron Scattering Society of America (NSSA). The NSAA selected Wagner "for his seminal and sustained contributions to our understanding of soft condensed matter physics using neutron scattering." He was also elected President of the Society of Rheology, effective January 2018.

Bingjun Xu, assistant professor received support from the University of Delaware Research Foundation for early-stage research to ways to capture and use thermal energy that now goes wasted. In collaboration with Raul Lobo, Claire D. LeClaire Professor of Chemical and Biomolecular Engineering, Xu will work to use that harvested energy to produce valuable chemicals, including hydrogen and syngas.

Yushan Yan
2018 Energy Technology Division Research Award,
The Electrochemical Society

FORMER FACULTY NEWS

The late Richard Wool, a member of the UD faculty from 1994 until his death in 2015, was honored with a symposium at the 44th annual North American Thermal Analysis Society (NATAS) conference. Wool was a professor of chemical and biomolecular engineering and director of the Affordable Composites from Renewable Sources (ACRES) laboratory. In 2013, he won the Presidential Green Chemistry Challenge Award for his work with bio-based materials. The following year, he won the World Green Design Award for his invention of eco-leather, a leather substitute made with materials such as flax and cotton combined with plant oils.

Mark Barteau, who was a chemical engineering professor at UD from 1982 to 2012, was named vice president of research at Texas A&M University, starting on February 15, 2018.

Henry C. "Hank" Foley, who was a chemical engineering professor at UD from 1986 to 1996, was officially installed as the president of New York Institute of Technology on April 12, 2018.

WELCOME, NEW FACULTY!

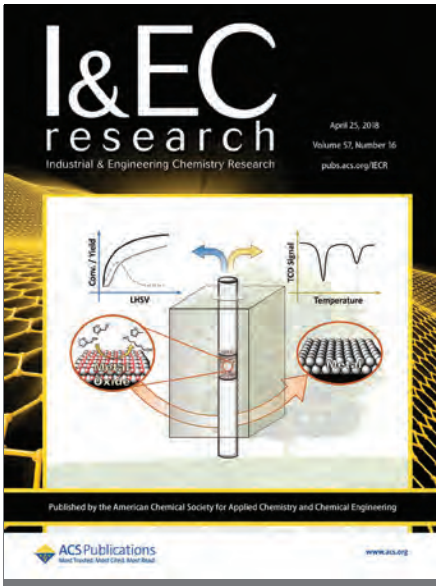
LaShanda Korley joined UD in January 2018 as a Distinguished Associate Professor of chemical and biomolecular engineering and materials science and engineering after 10 years on the faculty at Case Western Reserve University. Korley earned her doctoral degree from the Massachusetts Institute of Technology in chemical engineering and the interdisciplinary program for polymer science and technology. She studies bio-inspired materials, including composites such as fiber-reinforced hydrogels and actuating polymer-peptide hybrids. She also brings expertise in fiber and film manufacturing. Korley is also passionate about mentoring students, especially through undergraduate research opportunities.

Marat Orazov joined the department as an assistant professor in 2018. He received his doctoral degree in chemical engineering from the California Institute of Technology, followed by two years as a postdoctoral scholar at Stanford University, where he developed catalytic routes from syngas to higher alcohols. At UD, his research program aims to understand chemocatalytic routes for functionally complex molecules by engineering individual catalysts and coupled catalytic systems.

Aditya Kunjapur will join the department as an assistant professor in 2019. He received his doctoral degree in chemical engineering from the Massachusetts Institute of Technology, followed by a postdoctoral position in genetics at Harvard Medical School. The goal of his lab is to use synthetic biology approaches to investigate how microbes can use non-standard chemistry and unusual building blocks to generate products that exhibit enhanced functionality. Products of interest include fuels, chemicals, materials, and therapeutics.

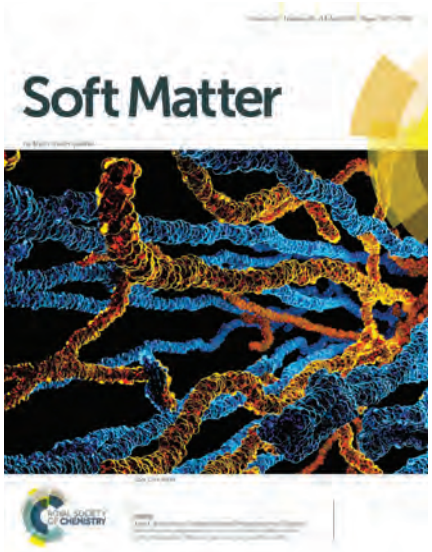
"Nanoporous Cu–Al–Co Alloys for Selective Furfural Hydrodeoxygenation to 2-Methylfuran"
By: Gregory S. Hutchings, Wesley Luc, Qi Lu,
Yang Zhou, Dionisios G. Vlachos, and Feng Jiao*

*Named to the I&EC Research inaugural Class of Influential Researchers



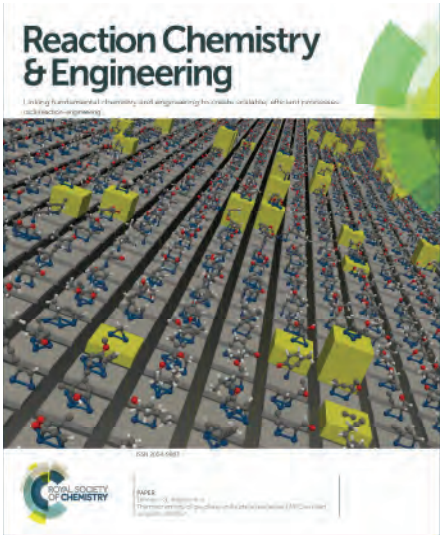
"Characterization of Oxidation States in Metal/Metal Oxide Catalysts in Liquid-Phase Hydrodeoxygenation Reactions with a Trickle Bed Reactor"
By: Matthew J. Gilkey, Casper Brady,
Dionisios G. Vlachos, and Bingjun Xu

"Selective hydrodeoxygenation of tartaric acid to succinic acid"
By: Jiayi Fu, Efterpi S. Vasiliadou, Konstantinos A. Goulas
Basudeb Saha, and Dionisios G. Vlachos



"Branching and alignment in reverse worm-like micelles studied with simultaneous dielectric spectroscopy and RheoSANS"
By: John K. Riley, Jeffrey J. Richards,
Norman J. Wagner and Paul D. Butler

"From Tree to Tape: Direct Synthesis of Pressure Sensitive Adhesives from Depolymerized Raw Lignocellulosic Biomass"
By: Shu Wang, Li Shaui, Basudeb Saha,
Dionisios G. Vlachos, and Thomas H. Epps, III



"Thermochemistry of gas-phase and surface species *via* LASSO-assisted subgraph selection"
By: Geun Ho Gu, Petr Plechac and Dionisios G. Vlachos

BALANCING ACT

Chemical engineering student recognized for interests outside the classroom and laboratory

Graduate students don't have a lot of free time, but when Himaghna Bhattacharjee has a spare moment, he makes the most of it.

The doctoral student in chemical and biomolecular engineering has more than a few hobbies. He's a photographer with a darkroom in his basement. He reads two novels a week. He has played bass guitar for a dozen years. He joins his labmates for pickup soccer games. He watches science fiction movies. He constructs social commentaries out of Legos. He already speaks seven languages, but he is trying to pick up another one—Spanish.

For the committee behind the University of Delaware's Laird Fellowship—an annual award that helps one first-year engineering graduate student pursue interests beyond his or her field of study—Himaghna's broad and deep pool of interests, especially his talent in photography, made him the clear choice for 2018.

"The selection committee looks for someone with a balanced portfolio: academic excellence, perseverance, creativity, humor, and more," said Ajit Thyagarajan, president of the Laird Fellowship and founder and chief technology officer of Atomic Mole, a cybersecurity company. "Himaghna fit those requirements. What stood out for us was his ability to travel the world with a camera and tell a story with his pictures, capturing touching moments and articulating the meaning behind what he was seeing."

From India to France to UD

Himaghna grew up in India and went to college there. He studied chemical engineering and joined a photography group during his undergraduate years. In the final year of his graduation, he bought his first camera and started packing it on his adventures. For two weeks, he lived with a fisherman in southern India, taking pictures of fishermen in boats and scenes on the shore. During a stint working for Michelin in France, he would spend his vacation time traveling around Europe and taking photographs of fjords, forests, the Danube, and more. He has visited 32 countries in total.

After two years, Himaghna grew restless. A futurist at heart, he longed to develop and understand emerging energy technologies.

"If there is one area where you can make the biggest impact on the future, it is energy," he said.

That's why Himaghna came to the University of Delaware.

"I knew I wanted to work in catalysis, and UD is one of the best places in the world for catalysis," he said. He specifically hoped to work with two professors that both advise and mentor him: Dionisios Vlachos, the Allan and Myra Ferguson Professor of Chemical and Biomolecular Engineering and director of the Catalysis Center for Energy Innovation and director of the Delaware Energy Institute, and Yushan Yan, associate dean for research and entrepreneurship in the College of Engineering.

"Himaghna has a very diverse set of skills and interests. He is remarkably mature and driven for the stage of his career," said Vlachos. "He has made great progress on studying on the computer the mechanism by which renewable derivatives of biomass are converted into dienes, the molecules we use to produce tires for bicycles and cars. His work can enable the commercialization of renewable tires manufactured from waste, leaves, and trees."

Himaghna aims to use computational tools to understand how the surface environments of catalysts, substances that speed up chemical reactions, encourage or discourage these reactions.

ABOUT THE LAIRD FELLOWSHIP

The George W. Laird Merit Fellowship is given to honor the memory of George W. Laird. He earned an A.B. degree at Hamilton College in 1964. He then attended the University of Delaware, where he was awarded a B.M.E. degree with highest honors in 1968 and an M.M.A.E. degree in 1971. On Sept. 6, 1977, at the age of 35, George W. Laird was killed in a tragic accident.

Determined that something positive should come from this seemingly senseless loss, his family and friends established a fund to support a major fellowship, based on merit, that will provide a source of strong motivation to students working toward graduate degrees in the College of Engineering. The generous support of more than 300 donors has made this award possible.

Yan, an expert in catalysis, nominated Himaghna for the Laird Fellowship.

"I have been impressed by Himaghna since before he even came to UD," said Yan. "At UD, he has shown great enthusiasm for catalysis, and he excelled in my Electrochemical Energy Engineering course. More importantly for the Laird Fellowship, his wide interests and experiences beyond the traditional academic excellence made him the ideal candidate for the selection committee."
Himaghna has many aspirations for how he will utilize his expertise in catalysis. For one, he aspires to start a technology company someday.

"It's been a long dream of mine to work on something that addresses the energy crisis," he said.

He has not yet decided how he will spend the prize money from the Laird Fellowship, but he might put it toward his photography habit. As he optimizes his free time, Bhattacharjee has his eyes firmly focused on what's next.

"I am very excited about the future," he said.

FULBRIGHT WINNER

Senior honors student and master's student in particle technology will study in Poland

Nine University of Delaware students and alumni were selected to receive U.S. Student Fulbright Awards in 2018, marking the largest number of Fulbright award winners in University of Delaware history.

Among them is Richard Egan. A senior honors chemical engineering and 4+1 master's student in particle technology, Richard Egan recently departed not just for his Fulbright research award in Poland, but first to complete a Critical Language Scholarship in Japan.

In Poland, Egan is partnering with faculty at the University of Warsaw to better understand some of the many elements that contribute to smog.

"While scientists do know the general ingredients in smog, they do not know how it actually forms– and the specific reactions, mechanisms and organic chemistry that result in the compounds that produce smog and air pollution," he said. Egan will contribute to the conversation by measuring a number of very specific factors that feed into larger equations to predict how smog forms in Poland.

RESEARCH TEAMS HAVE STRONG PULL FOR UNDERGRADS

UD marks 30+ years in national undergrad research program

Science made some important contributions to life on this planet in 1987.

It was the first time a heart-lung transplant was accomplished, the first year DNA samples were used in a criminal conviction, and it was the birth year of the Perl computing language, now known as the "duct tape of the Internet."

It was also the first year the National Science Foundation offered grants for Research Experience for Undergraduates summer programs.

UD's Department of Chemical and Biomolecular Engineering had REU teams in operation in 2017 and 2018. The program is open only to students from outside of Delaware, as required by NSF. Students from universities around the nation came to UD to work on research, explore future study options, learn protocols and skills.

In 2017, Professors Eric Furst and Thomas Epps, III directed a 10-student REU team in chemical and biomolecular engineering, called the Interfacing Sustainable Energy and Materials REU. Students studied such things as solar energy, lubricants from biodiesel, catalysts, nanoscale engineering, peptide synthesis and polymers from renewable sources.

"The program offers not only a deep research experience, but also professional development opportunities like workshops on time management, graduate school and visits to industrial and government R&D laboratories," Furst said. "It also introduces students to the cutting-edge research being done at the University. We hope to recruit some of these students to our Ph.D. program."

Among this team's activities was a visit to the National Institute for Standards and Technology's Center for Neutron Research in Gaithersburg, Md., where they saw the new vSANS (very small angle neutron scattering) facility.

Research ethics also was a focus of study for this team, which had support from NSF and the Department of Defense Air Force Office of Scientific Research.

WINNERS AT AICHE ANNUAL MEETING

Three students earned awards at the 2017 event

University of Delaware students, faculty and alumni won awards at the 2017 American Institute of Chemical Engineers (AIChE) annual meeting, which ran from Oct. 29 to Nov. 3, 2017 in Minneapolis.

Thomas Gartner, a doctoral student in the Department of Chemical and Biomolecular Engineering, won first place in the Materials Engineering and Sciences Division (MESD) Graduate Poster Awards. His winning poster was titled: "Influence of Molecular Design on the Self-Assembly of Single-Stranded DNA Amphiphiles." Gartner is part of associate professor Arthi Jayaraman's research group.

Three UD students won awards in AIChE's Undergraduate Student Poster Competition.

Victoria Muir, a senior majoring in chemical engineering, won first place in MESD division for her poster titled: "Efficient tuning of siRNA dose response by combining mixed polymer nanocarriers with simple kinetic modeling." She does joint research in the labs of Thomas H. Epps, III, Thomas & Kipp Gutshall Professor of Chemical and Biomolecular Engineering and Professor of Materials Science and Engineering, and Millie Sullivan, Centennial Junior Professor of Chemical and Biomolecular Engineering.

Trent Simonetti, a senior majoring in chemical engineering, won first place in the Catalysis and Reaction Engineering division for his poster titled: "Catalytic Hydrodeoxygenation of Renewable Oils to Diesel-range Hydrocarbons Using Ir-ReOX/SiO2 Catalyst." His mentor is Sibao Liu, a postdoctoral researcher in the Catalysis Center for Energy Innovation.

Rob Cipolla, a senior majoring in chemical engineering, won second place in the Food, Pharmaceuticals, and Biotechnology division for his poster titled: "Elucidating the Metabolism of Sulfolobus solfataricus using 13C Metabolic Flux Analysis." He does research with Maciek Antoniewicz, Centennial Professor of Chemical and Biomolecular Engineering.

STUDENT HIGHLIGHTS

Christopher Long won the University of Delaware's 2018 Theodore Wolf Prize in Physical and Life Sciences for his doctoral dissertation, Interrogating Bacterial Metabolism via the Mapping of Fluxomic Responses to Gene Knockouts and Adaptive Evolution.

Yifan Wang, a doctoral student, was one of four doctoral students to receive the University of Delaware's Excellence in Graduate Student Teaching Award in 2018.

Doctoral student Tamas Prileszky won the first place Langmuir Poster Award at the 91st ACS Colloid & Surface Science Symposium at City College of New York for his poster titled "Non-spherical aerosol droplets with internal structure".

Cesar Calero-Rubio won first prize in the poster competition at the 2017 Colorado Protein Stability Conference. This is the first time anyone from UD has won this prestigious competition in biopharmaceutical sciences.

Doctoral students Ka-Hei Siu and Julia Rohlhill won first and second place, respectively, in the Biochemical and Molecular Engineering XX poster competition in 2017.

Doctoral student Ru Chen Xie was selected for the "Excellence in Graduate Polymer Research" Symposium.

Tyler Roberts, who graduated with a bachelor's degree in 2018, was selected as a winner of the Donald F. & Mildred Topp Othmer Scholarship Award from AIChE. There are only 15 students selected annually to receive this award, based on outstanding academic achievement and involvement in AIChE.

Jason Anderchak, a 2017 UD graduate who is now a doctoral student at the University of Pennsylvania, won a NSF Graduate Research Fellowship.

Margot Wagner received a NSF Graduate Research Fellowship.

Dakota Thomas and Jennifer Mills received honorable mention from the NSF Graduate Research Fellowship.

Our AIChE student chapter was recently featured in the AIChE newsletter, ChEnected, for their interactions with their sister chapter at the Universidad Nacional de Colombia, sede Bogota.

UNDERGRADUATE RESEARCH SPOTLIGHT

ERIN HOGAN

Chemical engineering sophomore Erin Hogan is helping to develop the next generation of NASA spacesuits fit for a mission to Mars. Hogan is working with Dr. Norman Wagner, the Unidel Robert L. Pigford Chair in Chemical & Biomolecular Engineering, to develop and optimize material composites that can enhance astronaut protection from micrometeoroids, abrasions, low-pressure environments, atomic oxygen exposure, UV exposure, extreme temperatures, and dust (which will be crucial for Mars), she says. The secret ingredient is a specially formulated space-worthy shear thickening fluid, which is used to treat the spacesuit fabrics. Over the summer of 2018, Hogan worked on three samples to send up to the International Space Station as a part of the tenth Materials International Space Station Experiment (MISSE-10).

CONGRATULATIONS CLASS OF 2018

Undergraduates

Minori Akiba
Hassan Al Bulushi
Abdullah Al-Alawi
Michael Ashworth Jr.
Kees Baas
Harrison Ball
Carly Battistoni
Matthew Beauchamp
Ciaran Bowen
Brady Bowman
Jacob Brennan
Daniel Brownell
Peter Burtone
Justin Caccavale
Jia Chen
Nathaniel Cohen
Thomas Comiskey
Matthew Criscuolo
Jingyun Dai
Sean Daniels
Lia Dawson
Nicole Devitt
Hasani Eason
Richard Egan
Byron Fan
Zirui Fan
Daniel Ferraro
Erica Fisher
Dillon Gashi
Albert Green
Logan Greer
Sarah Gross
Samuel Haas
Ana Haddad
Kierstyn Harris
Daniel Harry
Ian Heffner
Erin Hitchner
Michael Hogan Jr.
Colin Jenkins
Alani Johnson
Matthew Jones
Alison Jones
Christopher Knieste
Sumeet Kothare
Sara Kubik
Krysta La Bruna
Hannah Lawrence
Jacob Lawton
Kyle Lennon
Jason Lombino
John Longordo
Jose Lopez
Graham Lovell
John Malone
Evan Martz
Michael Maxey
Tobias Mazal
David McAndrews IV
Julia McLaverty
Ryan McNulty
Monique Michalec
Victoria Muir
Christopher Mundy
Rachel Muzzelo
Andrew Nardone
Amy Nicolas
Michael Paisner
Gabrielle Parker
Christine Parrish
Tyler Paul
Olivia Platt
Tyler Roberts
Abbegail Rufinus
Collin Sager
Samuel Schmidt
Tyler Seidel
Gretchen Simms
Jesse Spinelli
Maura Swift
Michael Thomas
Dipan Vaidya
Andrew Venanzi
Robert Vinson
Margot Wagner
Tyler Walters
Jessica Weber
Clare Wunder
Yan Yang
Linggang Zou

WHERE DID THEY GO?

Graduate School

University of Pennsylvania
Purdue University
University of Michigan
Penn State
Massachusetts Institute of Technology
University of California Santa Barbara
University of California San Diego
Sidney Kimmel Medical College
University of Warsaw Fulbright Scholar

Industry

Air Liquide
Applied Control Engineering
Arkema
Axens North America
Buchi Corporation
Capital One
CB&I
Chemours
Compact Membrane Systems
Deloitte
Epic Systems
Eurofins Lancaster Lab
ExxonMobil
ILC Dover
Johnson Matthey
Kellogg Brown & Root
Merck
Navair
Newark Wire Cloth Co.
Occidental Petroleum
TA Instrumentation
W.L. Gore & Associates
Xergy inc.

PhD graduates

Robert Bennett
Stefanie Berges
Michelle Calabrese
Cesar Calero Rubio
Ellinor Carlson
Qi Chen
Alan Fast
Nikodimos Gebreselassie
Matthew Gilkey
Jacqueline Gonzalez
Chad Greco
Geun Ho Gu
Maura Koehle
Christopher Long
Stephen Ma
Jennifer Mantle
Erik Munsell
Ryan Murphy
Paul Mwasame
Marcel Nunez
Christopher O'Brien
Ryan Patet
Edward Schreiner
Cameron Shelton
Huibo Sheng
Andrew Tibbits
Morgan Urello
Ru Xie

M.Ch.E

Paul Braswell
Joshua Condon
Andrew Craft
Kimberly Dennis
Lucas Dunshee
Nicholas Evenepoel
Michaela Gallucci
Samhita Kattekola

MEPT

Sora Lee
Dustin Britton
Ravinderdeep Gill
Alda Kapllani
Michael Horvath
I-Hsun Lee
Brian Levy-Polis
Minghan Xian
Gretchen Simms

Chemical engineering doctoral students and faculty who participated in the Doctoral Hooding Ceremony as part of Commencement events at UD.

ALUMNI & FRIENDS RECEPTION

MONDAY, OCTOBER 29, 2018
7:15 - 9:30 PM

DAVID L. LAWRENCE CONVENTION CENTER
ROOM 309 | PITTSBURGH, PA

FACULTY AWARDS & HIGHLIGHTS

Welcome to Levi Thompson
Elizabeth Inez Kelley Professor of Chemical Engineering and Dean of the College of Engineering, Fall 2018

Babatunde Ogunnaike
AIChE Warren K. Lewis Award for Chemical Engineering Education

E. Terry Papoutsakis
Elected to National Academy of Engineering

Maciek Antoniewicz
Inducted into the College of Fellows at the American Institute for Medical and Biological Engineering (AIMBE)

Antony Beris
Named Fellow of the Society of Rheology

Joshua Enszer
Promotion to Associate Professor

Thomas H. Epps, III
Named American Physical Society Fellow

Feng Jiao
Named to the ACS Industrial & Engineering Chemistry Research inaugural call of Influential Researchers

April Kloxin
Promotion to Associate Professor; Named the American Chemical Society Division of Polymer Chemistry Researcher of the Month and 2018 ACS PMSE Arthur K. Doolittle Award

Kelvin Lee
Biotechnology and Bioengineering Elmer Gaden Award for Outstanding Publication, 2018

Millicent Sullivan
Promotion to Full Professor

Norman Wagner
Received the 2018 Sustained Research Prize from the Neutron Scattering Society of America

Yushan Yan
2018 Energy Technology Division Research Award, The Electrochemical Society

Welcome to Aditya Kunjapur
Assistant Professor, Winter 2019

Welcome to Marat Orazov
Assistant Professor, Fall 2018

UD Awarded Outstanding AIChE Student Chapter, 2017–18

INTERSECTING PATHS, UNPRECEDENTED JOURNEYS

These highly decorated scientists earned their doctoral degrees at UD

Photo by Bryce Vickmark

As a research facility at one of America's top hospitals buzzes with activity, two men chat in a narrow, unassuming office. One is jaunty, with a smile as his default facial expression and a melodic lilt to his voice. The other is more reserved and speaks with a softer, deeper tone.

They haven't seen each other in about a year and a half, but once they've shaken hands, their conversation turns to science. When your work has the potential to save lives, that's what you do.

Rakesh K. Jain, 74M, 76PhD, has spent decades working on some of the world's most pressing health problems, and has come to be regarded as one of America's most accomplished scientists. Arup K. Chakraborty, 88PhD, is tackling one of the world's most elusive challenges: creating a vaccine for the human immunodeficiency virus (HIV), the causative agent of AIDS. Both are where they are today partly thanks to the school that helped set their scholarly paths: the University of Delaware.

Jain, the Andrew Werk Cook Professor of Tumor Biology at Harvard Medical School, is responsible for a game-changing paradigm in cancer treatment: By normalizing the function of blood vessels in tumors, he discovered, one can treat the tumors more effectively. In 2014, this principle led to the approval of the first medical treatment for patients who lose their hearing from a benign tumor, known as schwannoma-UK. This principle has the potential to improve treatment of more than 70 diseases that afflict half a billion people around the world.

As director of the Massachusetts Institute of Technology's Institute for Medical Engineering and Science, Chakraborty is the Robert T. Haslam Professor of Chemical Engineering, Physics and Chemistry. He spends his days targeting another deadly disease: HIV. He is

attempting to manipulate adaptive immunity—part of the immune system that targets and destroys harmful germs in a pathogen-specific way—to create a vaccine that prevents infection from HIV. Their work has garnered acclaim. In 2017, Chakraborty joined Jain as one of just 21 people in America who have been elected to the National Academy of Science, National Academy of Engineering and National Academy of Medicine—three academies that bring together the nation's foremost experts in a brain trust. Jain was also elected to the National Academy of Inventors, making him one of only 14 people in America to belong to all four organizations. He is also a recipient of the National Medal of Science.

These men have more than success in common. Their paths have also been studded with a few of the same milestones. Both earned their undergraduate degrees at the Indian Institute of Technology Kanpur. Both earned their doctoral degrees in chemical engineering at UD, where they completed thesis projects that defied the norms of their eras. Both teach and conduct biomedical research in Boston, at two of the world's finest universities.

Both also set the stage for their success at UD.

TO HARVARD, VIA DELAWARE

As an undergraduate chemical engineering student at the Indian Institute of Technology Kanpur, Jain read three textbooks by Mort Denn, then a chemical engineering professor at UD. He was so intrigued that he came to Newark in 1972.

"I had great teachers at Delaware," he says. "Stan Sandler was a model for how to teach thermodynamics. Mike Greenberg was the most incredible math teacher. Eli Ruckenstein infected us with a passion for science. Art Metzner was an inspiring department head." As planned, Jain did research with Denn, building models of pollution control in the Delaware River. Denn encouraged Jain to travel to New York City and see the Museum of Modern Art and Guggenheim, fostering his enduring love of art. James Wei introduced Jain to the opera, inspiring a lifelong love of music.

Jain would finish his master's degree in two years, and could have earned his doctoral degree with just another year or two of work on Denn's project. But then, Jain got an opportunity that would change his course—and the future of medicine.

In 1974, Jain and Wei visited the late Pietro M. Gullino, then a top researcher at the National Cancer Institute. Gullino showed Jain a model of a cancerous tumor that he had developed to study its biology. While tumors usually have many blood vessels, Gullino had created a tumor with a single artery and a single vein. "One input, one output," Jain explains of the model. "That's what engineers do, input/output analysis. Now all the concepts available to engineers and to physiologists could be applied to cancer."

Jain had a question: Had anyone used this model to study how cancer drugs infiltrate a tumor—or don't? To be effective, the medicine needs to stay in the tumor long enough to kill it. No one had addressed this, so Jain did. "I was being allowed to do a Ph.D. in something you would never have imagined being conducted in a chemical engineering department anywhere in the country," he says. "That really was the beginning of a whole field of applying engineering principles to cancer research."

SYMBOLS OF THEIR ALMA MATER

Both Jain and Chakraborty returned to UD to give the Colburn lecture in chemical engineering. They each received an engraved paperweight to commemorate their speech—and both still display them in their office to this day.

When Jain took on the project, he didn't know anything about cancer research. He locked himself in a room for a week and read a human physiology textbook cover to cover. It paid off. In his doctoral thesis, he described how drugs flow into and out of solid tumors. "If you are too comfortable, that means you are not pushing the boundaries," he says.
After graduation, Jain was a faculty member at Columbia University and then at Carnegie Mellon University. In 1983, he visited UD to give the Allan P. Colburn Memorial Lecture, a talk by a distinguished early-career chemical engineer. (Chakraborty, then a first-year graduate student, attended, but their formal introduction would come later.) Jain later left Carnegie Mellon for Harvard Medical School and Massachusetts General Hospital (MGH), where he has conducted research since 1991. He hears stories from surgeons who've felt rock-hard tumors soften to spongy masses thanks to one of his pioneering therapies. He attributes his success to hundreds of collaborators all over the world, and to more than 200 graduate students and post-docs.

> "PASSION FOR WHAT YOU DO AFFORDS A CERTAIN FREEDOM IN LIFE. I REALLY BELIEVE WE ONLY EXCEL IN THE THINGS WE CARE ABOUT."
>
> ***– Arup K. Chakraborty, 88PhD***

TO MIT, VIA DELAWARE

Like Jain, Chakraborty learned about UD as an undergraduate student at the Indian Institute of Technology Kanpur. He was inspired by the late Ken Bischoff, a leader in chemical reaction engineering.

"I had read many of his papers and thought it was really brilliant stuff," Chakraborty says. "I went to UD to work with him." Chakraborty did indeed work with Bischoff, who co-advised him with the late Gianni Astarita. Like Jain, Chakraborty forged a new path. His research represented a new interface of disciplines, bringing quantum mechanical theory to chemical engineering problems.

"One of my thesis advisers told me that he encouraged it, but he didn't know whether I would succeed and whether I would get a degree or not," says Chakraborty, who then consulted longtime professor Robert Pigford for advice before proceeding. By this time, Pigford was "the senior statesman on the faculty."

Pigford gave Chakraborty a copy of a rule-defying book he had published in 1947, The Application of Differential Equations to Chemical Engineering Problems, as a graduation gift. The volume, now with a weathered cover, sits in Chakraborty's office at MIT. "When he was doing this, this is not what chemical engineers were doing, differential equations in chemical engineering," says Chakraborty. "The field was much more macroscopic then. This was a revolutionary thing on its own."

Chakraborty forged ahead. He worked hard but had fun, too. A tennis player in his youth, Chakraborty picked up racquetball. When he visited UD in 1993 to give the Colburn lecture (the seminar Jain gave 10 years before), he challenged the undefeated Prof. Michael Paulaitis and won. "UD was not just the place where I was educated as an engineer and scientist," he says. "It was where I learned about America, and decided that I wanted to spend my life here."

After graduating, Chakraborty joined the faculty at the University of California-Berkeley, where his mentor was Mort Denn, the man who had inspired Jain to attend UD nearly two decades earlier. When Jain visited UC-Berkeley for a seminar, Denn and his wife invited Jain and Chakraborty to dinner. It was the first time the two would meet.

Some years later, Chakraborty read a paper on the immune system that intrigued him. He decided to explore the concepts further—a pivot from his earlier research. "Most people thought that this was a very risky move, a bad move, but that's what I wanted to do," he says, adding, "You might strike out if you swing for the fences, but you could also hit a home run."

Chakraborty left Berkeley in 2005 and joined MIT. Since 2009, he and his colleagues have been working on rational design of vaccines against highly mutable pathogens, especially HIV. Chakraborty thinks of his path to immunological research as one of the most significant, satisfying things he has done—a success he attributes to his curiosity.

"Passion for what you do affords a certain freedom in life, says Chakraborty. "I really believe we only excel in the things we care about."

NSF GRADUATE RESEARCH FELLOWSHIPS

Two honors graduates in chemical engineering are selected

Eleven UD students and alumni won National Science Foundation Graduate Student Research Fellowship Program (GRFP) awards for 2018.

This highly competitive fellowship, the oldest of its kind in the nation, supports outstanding graduate students pursuing research-based master's or doctoral degrees in science, technology, engineering and mathematics (STEM) and STEM education at accredited U.S. institutions.

Kaitlyn Engler, an honors graduate in chemical engineering, will continue her graduate research at the University of California-Berkeley through the fellowship.

Nikifar Lazouski, an honors graduate in chemical engineering, will continue his graduate research at the Massachusetts Institute of Technology through the fellowship.

Hopen Yang and Jennifer Mills, doctoral students in chemical engineering at UD, earned honorable mentions.

Dakota Hanemann-Rawlings, an alumnus of chemical engineering and now a graduate student at the University of California-Berkeley, also received an honorable mention.

ALUMNI HONORS

Radhakrishnan Mahadevan, '02D, won the 2017 Biochemical Engineering Journal Young Investigator Award. He is a professor in the Departments of Chemical Engineering & Applied Chemistry and Institute of Biomaterials and Biomedical Engineering at the University of Toronto.

Ron Forsythe, Jr., '89, was named one of Savoy Magazine's 2017 Most Influential Black Corporate Directors. Forsythe is the CEO of Qlarant.

Linda J. Broadbelt, '94D, won the 2018 E.V. Murphree Award in Industrial and Engineering Chemistry from ACS. At Northwestern University, she is the Sarah Rebecca Roland Professor of Chemical and Biological Engineering and Associate Dean for Research.

Jeffrey D. Rimer, '07D, is the recipient of the 2018 Norman Hackerman Award in Chemical Research. He is the Ernest J. and Barbara M. Henley Associate Professor of Chemical and Biomolecular Engineering at the University of Houston.

Modupeola Fadugba, '08, had her first solo art exhibition in Nigeria. Her paintings were curated and organized by SMO Arts in Lagos.

Robert D. Tilton, '86, was installed as the Chevron Professor of Chemical Engineering at Carnegie Mellon University in 2018.

Rakesh Agrawal, '77M, won the 2017 Alpha Chi Sigma Award for Chemical Engineering Research. This award recognizes an individual with outstanding accomplishments in fundamental or applied chemical engineering research carried out in the past 10 years. Agrawal is the Winthrop E. Stone Distinguished Professor of Chemical Engineering at Purdue University.

Xuankuo Xu, D'08, received the 2017 Bristol-Myers Squibb Product Development Engineering and Technology Leadership Award (ETLA).

COSTEL DENSON

He made history at UD and beyond

Costel D. Denson, a former professor, interim dean of the College of Engineering and later vice provost for research at the University of Delaware, passed away Monday, April 23, 2018, at the age of 83.

"Cos Denson was a pioneer, a scholar, a leader, a mentor and a friend to many during the nearly three decades that he worked at UD," said Babatunde Ogunnaike, dean of UD's College of Engineering. "The College of Engineering benefited greatly from his willingness to step up and serve as interim dean, and those of us who were privileged to know him are sad to hear of his passing."

Dr. Denson was born June 14, 1934, in Aliquippa, Pennsylvania, to Costel and Virginia Denson.

He was the first African American student to be admitted to Lehigh University, graduating in 1956 with a degree in chemical engineering.

In 1956, Dr. Denson joined the U.S. Army Reserves, rose to the rank of captain and proudly served until 1968, when he was honorably discharge.

Following his graduation from Lehigh, Dr. Denson worked as a chemical engineer for General Electric in Schenectady, New York, for several years, before he obtained his master's degree in chemical engineering from the Rensselaer Polytechnic Institute in 1960. In 1965, he received his doctoral degree in chemical engineering from the University of Utah. Dr. Denson then resumed his career with General Electric. In 1968, he was invited to return to Lehigh as a visiting professor for a year. The following year, upon returning to General Electric, he was promoted to manager of GE's Polymer Research division at Appliance Park in Louisville, Kentucky.

In September 1977, Dr. Denson, renowned for his expertise in polymer engineering and fluid mechanics, joined UD's faculty in chemical engineering. He was recruited to UD from industry by Arthur Metzner, then the chair of the chemical engineering department. Dr. Denson was the first African American faculty member in UD's chemical engineering department.

In 1982, Metzner recruited Prasad Dhurjati, professor of chemical and biomolecular engineering, mathematical sciences and biological sciences, who became Dr. Denson's friend.

"We had a small department of a dozen or so closely-knit faculty at that time," said Dhurjati. "My faculty office was near that of Cos Denson, and I got to develop a very good friendship with him over a couple of decades. He loved Indian food and even after his retirement, we used to meet once a month for lunch at an Indian restaurant."

At UD, Dr. Denson met his future wife, Carol, who had also recently joined the faculty in consumer studies. They married in 1982.

Dr. Denson served as interim

dean of engineering at UD from 1991 to 1992 after R. Byron Pipes, previous dean of engineering, became UD's provost and vice president for academic affairs.

In announcing Dr. Denson's appointment, a 1991 article in UD's Messenger publication noted: "Since joining the faculty of the College of Engineering, Denson has been responsible for establishing and supervising graduate research programs in polymer processing and developing and teaching courses at both the undergraduate and graduate levels." As interim dean, Dr. Denson was instrumental in the formulation of a strategic plan to offer students more opportunities to study energy, the environment, and manufacturing — focus areas that the College of Engineering is known for today. Dr. Denson later worked as UD's vice provost for research from 1994 to 2000, and then he returned to his faculty position until his retirement from the University in 2005.

After making history as Lehigh University's first African American undergraduate student, Dr. Denson "broke down barriers at UD and created more 'firsts' as vice provost for research and as interim dean of the College of Engineering," said Dhurjati.

"At Delaware, he continued to fight for the rights of the underprivileged," said Dhurjati. "I treasure the fact that he always reached out to me as someone who understood and empathized with the causes that he was fighting for. I was privileged to have the opportunity to understand the civil rights movement and the history of the early struggles in America through the eyes of a person who had actually lived through these challenging times. I remember him for his positive and forgiving attitude and for his sense of humor and humanity."

Michael Vaughan, associate dean for academic affairs in the College of Engineering, said Dr. Denson was one of his first and lasting mentors at UD. Dr. Denson hired Vaughan in 1992 after a national search.

"In many ways, Cos is the major reason that I decided to join UD," said Vaughan. "I can remember our hiring negotiations vividly where he provided many compelling reasons why I should join the UD engineering team. First among these was that I would have an opportunity to make a real difference and contribute at a high level to the college's success. His encouragement, faith in my abilities and willingness to serve as a mentor gave me the resolve and confidence to take on this new role and move my young family from North Carolina. I have developed many good relationships at UD since my arrival but none more notable and important to me as the friendship that Cos and I built over the years." Vaughan added: "I was shaken noticeably when I heard of Cos' passing but I found great comfort in the fact that Cos lived a long, rich, blessed and consequential life ... full of love with his dear wife, Carol, family and friends! Who could ask for more than this? I will miss my friend but a wonderful part of him will remain with me, always."

Dr. Denson was an active member of a number of professional societies, including the American Institute of Chemical Engineers, the Society of Rheology and the Society of Plastics Engineers. The Extrusion Division of the Society of Plastics Engineers gave him a Lifetime Achievement Award in 1995. In 2005, he launched Costech Technologies, LLC, which advised on environmental research programs. In 2009, Dr. Denson was appointed as a scientific adviser to the U.S. Department of Defense and the U.S. Environmental Protection Agency.

Dr. Denson is survived by his wife, Carol; brother, Fred, of Rochester, New York; son, Eric of Seattle, and daughter, Deidra of Vienna, Virginia, from his first marriage; and stepsons Carl Reiter and Andrew Smith from his second marriage.

ROBERT (BOB) GRASSELLI

passed away on January 11, 2018 in Munich. He was an adjunct professor in our department for many years. He spent most of his career as the head of the catalysis group at SOHIO, and later was a program director at ONR for a few years before joining Mobil-Paulsboro just prior to his retirement.

UD GIVING

GIFTS IN MEMORY OF FORMER FACULTY MEMBERS OR ALUMNI MAY BE MADE ONLINE AT UDEL.EDU/GIVING

ALUMNI NOTES

'60s

BILL HOULE '68 retired in 2006 as a Distinguished Engineering Associate at ExxonMobil after spending 36 years with Esso, Exxon, and then ExxonMobil with assignments in the USA, Canada and Europe. He initially worked in process design and process engineering, where one of his favorite assignments was as a member of the team that designed, oversaw construction, and started up the initial phase of the Syncrude Canada Tar Sands Project in Alberta, Canada in the 1970s. The latter part of his career was in project management with emphasis on project planning and front-end engineering, and in fact his last major assignment was also in Alberta, managing the front-end engineering for the Ultra-Low Sulfur Diesel Project at Esso Canada's four refineries.

Before his Esso career Bill had followed his ROTC role at UD by serving for two years in the US Army Munitions Command, where he was part of a team managing the Army's explosive and ordinance plants and modernizing TNT plants. Since retirement Bill and his wife, Ginny, have moved back to New Jersey to be close to family, including two children and four grandkids. They travel extensively, including a love for hiking, particularly in the Canadian Rockies. They volunteer for a number of activities in their church and community and Bill is an avid photographer, gourmet cook and computer geek.

CLARK MCCOLLOUGH '68 went to work for Esso (now ExxonMobil) at the Bayway, NJ, refinery and retired 34 years later after 16 job assignments and a fulfilling career. He filled us in on a lot that happened in between and since, along with some valuable lessons for new graduates. During the first 15 years with Exxon, Clark worked in refining, including assignments in plant engineering, process simulation, linear programming, facilities planning, project management, operations technical support, and refinery maintenance management. He subsequently moved into roles aligned with his passion – computing technology and its application. The range included justifying and installing 4 IBM PCs (!) in Exxon Shipping, saving $1.8M within 3 months, to taking an $18M Cray supercomputer request to the Corporate Board on behalf of Exploration and Production. This experience led to Clark's becoming the ExxonMobil Global Services - Computing Technology & Security Manager for ExxonMobil in 1999, and when he retired at age 55 in 2002, he was responsible for all of ExxonMobil's global computing technology selection and standards as well as computing and network security.

Clark writes: "The discipline and problem-solving skills honed as an undergraduate led me to a successful career in technical disciplines I could never have imagined as an undergraduate. In college, my state of the art computer was a 40-inch folded slide rule. We openly debated whether analogue or digital computing would eventually dominate. Three years after graduation, the first Intel microprocessor was introduced."

In retirement, Clark's passion is his church and its many missions, especially helping the poorest of the poor in Lima, Peru. This year, he and his wife, Carol Toop '67, celebrate their 50th wedding anniversary with their 3 children and 4 grandsons. Clark and Carol met at Gilbert D&E dorms at UD in 1965. She was social chairman of the experimental "new" co-ed dorm, and he was its first president. Those dorms are gone, but not the enduring friendships which continue to this day.

SHELDON KAVESH D'68 also recounts his career decisions, specifically one regarding graduate study. "In the spring of 1965, I was 32 years old, an army veteran, married with two children, ages 6 and 3, and the proud possessor of a house and mortgage in northern New Castle County. I had Bachelors' and Master's degrees in Chemical Engineering from MIT and Brooklyn Poly. I had been working in industrial R&D for the past eight years. I had been doing good work, had two patents, two publications and an industrial award, but felt that my future in R&D would be limited without a Ph.D. I had been taking courses at night at U of Del., but that was clearly never going to converge to a Ph.D.

"After discussion with my family, and a slightly skewed vision of the time required, I decided to give it a full-time effort. I presented myself to the Acting Chairman of Chemical Engineering, and told him that since I already knew how to do research, I could complete a Ph.D. program in a year. He was kind enough not to laugh. He presented me with a challenge. The Ph.D. requirements at that time included passing qualifying exams in two languages. Pass one exam by fall, and I would be admitted as a provisional student in the fall semester.

"I did pass a French language qualifier and did enroll full time in the fall of 1965. My wife went back to teaching part time. My children were in elementary and nursery school, I had support from the Korean GI Bill. After the first year, I also received support from the Department. Fast forwarding to 1968, with three qualifying exams, another language qualifier, an original proposition, a math minor and a dissertation behind me, I did receive the Ph.D. in Chemical Engineering." Sheldon subsequently spent 30 years at Allied Chemical, as it was then known, receiving 59 US patents (62 today), being an author of 15 publications, and receiving several honors. Since

retiring from Allied (now Honeywell International) in 1999, Sheldon passed the so-called patent bar and became a Registered Patent Agent, preparing 60 issued US patents for others. His daughter became a lawyer (Harvard Law School) and his son an MD electrophysiologist, but he says that he'll leave the bragging on the grandkids to his children.

Sheldon concludes, "My time at the University of Delaware made that all possible."

170s

R. CRAIG MATTHIESSEN '73 was happy to write, given that it was for fun rather than to earn a grade, and he filled us in both on pre- and post-graduation events. After graduation he worked for the DuPont Company for about 8 years, before joining the Environmental Protection Agency (EPA) in Washington, DC, from which he recently retired after more than 35 years of service. The latter part of his EPA career was focused on chemical and oil spill prevention, preparedness and emergency response. The most rewarding part professionally was leading EPA's efforts on chemical process safety management and chemical accident prevention. Craig earned a PE license and was elected a Fellow of the AIChE. His wife of almost 44 years is also a UD alumna and recently they were able to use social media to reconnect with a few classmates and their spouses and to reminisce about campus and fellow classmates. Craig and his wife have three terrific children and two grandchildren.

Craig has many wonderful memories of his days at Delaware and says that "without question the UD ChE curriculum definitely prepared me for my future both at DuPont and EPA"; he provides a good example of the EPA-related preparation: "My senior thesis at UD involved studying clarification of aerated versus oxygenated activated sewage sludge for a project under Dr. T. W. F. Russell's leadership. I borrowed an old University pickup truck and filled two, five-gallon cans of sewage at the Wilmington waste treatment plant. Unfortunately, one of the cans was empty by the time I returned to campus! Further, two large vats of sewage were kept aerating in a fume hood in Colburn Lab during the project. One night there was a power outage and the next morning the Lab smelled absolutely awful until I was able to get the fume hood running again!"

ROGER REINICKER M'73 writes that he knew nothing about Delaware before coming from Carnegie Mellon to UD for his masters degree, but that has changed after some 34 years in the state. After graduation he was at the Hercules Research Center for a few years but was then transferred to an aging pigment plant in upstate NY as a process engineer. Hercules sold the plant to Ciba-Geigy in 1979, but Ciba closed it in '89 and Roger returned to Delaware, to the CIBA pigment plant in Newport, where he worked in technical support until retirement in 2014, the last 5 years with BASF. His expertise in pigments for plastics and synthetic fibers resulted in his election as a Fellow in the Society of Plastic Engineers in 2015.

As a very young chemical engineer Roger was told that, as a group, we are very family oriented, and indeed, Roger and his wife have a son and two daughters, all of whom graduated from UD. Their son, AARON REINICKER '10, is a chemical engineer who migrated in the opposite direction to Roger by earning a PhD from Carnegie Mellon. Roger can recall several humorous events from his UD days, but feels that they are best left unreported.

J. GARY MCDANIEL '78 has spent his career working in emerging ventures, Fortune 500 corporations, and multinational enterprises undergoing various stages of start-up, turnaround, and rapid growth. His roles have often been at the crossroads of science and business – he added an MBA to his chemical engineering qualifications and has had positions in sales and marketing, finance and accounting, manufacturing, research and development, and supply and distribution, culminating in several challenging senior executive roles. After rising through the ranks, Gary became a "serial CEO" and has led 6 start-up / early-stage companies, including several to successful exit. These efforts included writing business plans, sales and marketing plans, and memoranda that have raised over $50 million in capital from investors ranging from angel investors and venture capitalists to banks and governments. He has built and led sales, marketing, and technical teams that then delivered appreciable growth. A tennis player, scuba diver, and (mediocre, he claims) golfer, Gary now lives in Bel Air, MD, with his wife of 36 years, Barbara (UD '79). From there he advises and mentors other budding entrepreneurs, including as a VMS Mentor at UD's Horn Entrepreneurship program. He is also an Entrepreneur-in-Residence at bwtech@UMBC, a Mentor at the University of Baltimore's Center for Entrepreneurship and Innovation, and a C-Level Advisor at the Emerging Technology Center in Baltimore.

180s

ROBERT SASSA '83 has just celebrated 35 years with W L Gore & Associates, home to many of our alumni, and feels fortunate to work for such a stable company that values individuals, innovation and technology. His entire career focus has been new product and new business development, with his current commitment being in biopharmaceutical market development of bioprocessing components. His 3 children are Blue Hens as well, and he actively supports the UD Horn Entrepreneurship Hen Hatch program and enjoys attending the ChE annual reunions, where we also enjoyed seeing him in June.

ROB KWORTNIK '88 was commissioned as a Second Lieutenant in the US Army upon graduation, through UD Army ROTC. He served on active duty in the US Army Chemical Corps and Quartermaster Corps in various field

leadership assignments for 6 years, enjoying the opportunity to travel across the US and abroad. He completed graduate degrees including a MBA at Purdue University and an MS in Materials Science and Engineering at the University of Dayton. Following active military service, Rob worked in the automotive industry for six years in various engineering and operations plant management roles. Since 2001 he has worked at Merck & Co., primarily in the vaccines business. In his current role as director of supplier performance improvement, he works directly with Merck's material suppliers. He continued his military service part-time in the Pennsylvania National Guard, retiring as a lieutenant colonel with 28 years of service in 2016. Rob lives in southeastern Pennsylvania with his wife Lea, son Noah, and daughter Natalie. In his spare time, he enjoys fishing, hiking and the great outdoors.

Rob writes: "Beyond my direct education in chemical engineering, I often credit the University of Delaware, Chemical Engineering program for equipping me with essential problem solving skills and developing me as a critical thinker. I will always fondly remember junior year project report outs, long, yet fun hours of team preparation and the confirmation of 'deep understanding' by the faculty panel, including my resolute advisor, Jon Olson."

90s

CHAD HUTCHINSON '93 has had an impressively varied career, having worked in the minerals, online B2B, publishing, health care, entertainment, and power industries, albeit none of that actually as a chemical engineer. However, his UD degree got him started, landing him his first full-time job in a laboratory, formulating and optimizing paper coatings. Chad writes that "when the internet exploded in 1995, I focused my energies on web design and never looked back". He is currently a senior user experience strategist at PJM Interconnection in Audubon, PA. PJM manages the power grid and several energy markets that cover all or part of 13 states, plus Washington, DC. In parallel with his employment, in 1999 Chad also co-founded a progressive rock music festival called the North East Art Rock Festival (NEARfest), which had a very successful run through 2012. The music festival "hobby" has now been replaced by a love of birding. Chad has been married over 16 years to his wife, Cheryl, who is a kindergarten teacher. They have two boys, Liam (13) and Cameron (10), an Australian cattle dog named Echo, and live in Malvern, PA.

BILL MILLER '93 moved to San Francisco with Robyn Waxman (BS Visual Communication at UD) three days after graduation. Bill started graduate school a year later and earned his Ph.D. in chemical engineering from UC Davis. Bill and Robyn got married in June 1999, and that fall Bill started teaching in the Chemistry Department at Sacramento City College. Bill teaches General Chemistry but has also taught experimental courses, including Nanoscience and Materials Chemistry and, intriguingly, Design of Coffee. He also participates in the department's fledgling undergraduate research program and serves as a Councilor for the Sacramento Section of ACS, as Secretary/Treasurer of the faculty union, and on the Board of the California Science Teachers Association. Robyn also teaches at SCC and they live in Davis, CA. Their daughter, Sophia, was born in 2002 and their household is a busy one that includes 2 donkeys, 12 chickens, a dog and a cat.

DAVID RICE D'93 has had a busy and successful career at leading companies worldwide and also picked up an MBA from Harvard Business School along the way. He had productive career stops with McKinsey & Company and Procter & Gamble's Oral Care R&D, where he invented, holds patents for and launched products in the United States, Europe and China. He then spent twelve years with SABMiller, a fast-growing consolidator in the brewing industry before it was acquired for $109 billion in late 2015. At SABMiller, Dave held various commercial strategy and operating roles in the US, South Africa and Latin America. He also played a role in the formation of the largest Coca-Cola bottler in Africa (CCBA) through various mergers. He is now at PepsiCo, where he is currently Vice-President of Global R&D Strategy for PepsiCo's $30 billion snacks business with responsibility for long-term technical capability and portfolio investments plans.

David currently lives in Dallas, TX, with his wife, Phairat, and two children. The 25 years that have passed seem to have healed a painful experience he remembers as being less funny at the time. A thesis completion disagreement with his advisor led to an unfortunate energetic interaction between David's hand and the cinderblock in Colburn Lab that resulted in his having bones realigned and showing up in a cast for his meeting the next day. This sight prompted a change of heart by his advisor and a more expeditious completion of his thesis, so (almost) all was well that ends well.

JAMES JARIWALA '98 has spent the full 20 years since graduation at the same company, Applied Control Engineering, home to many other graduates of the department (including four from the class of 2018). James notes that most of what he does professionally today, he learned on the job, but that UD taught him to attack every project with energy and a thirst to learn. He remembers the long nights in the computer lab; the endless number of engineering pads filled with equations and notes; the Wall of Fame & Wall of Shame; falling asleep in some classes. He also fondly remembers all the clubs, groups and activities he enjoyed around campus, as well as the variety of people he met during his four years, recognizing that a lot of engineering requires working with others.

2000s

The class of 2003 seems to have been a fertile environment for students interested in biomedical careers. The path of DANA

(UNGERBUEHLER) HERRIGEL '03 is a good example. Dana started off at Merck after graduation but then succumbed to the lure of medical school a few years later and graduated from Robert Wood Johnson Medical School in 2009. Two years ago she accepted a position with the Mayo Clinic in Florida as an assistant professor in the department of medicine, practicing hospital internal medicine. She is also involved with the Mayo Clinic School of Medicine, as a course director and member of the admissions committee. She loves all things related to medical education, simulation, and ultrasound. Dana writes, "While my career path diverged from chemical engineering, I use the skills and tools that my chemE education provided every day, and I will always be grateful for my experiences and mentors who believed in me at UD." She also developed close friendships through chemE, and it will surprise no one who knew the class of 2003 that Dana is still very close to JENNIFER ZAK GREY (see below), including getting their families together on vacation and seeing their kids growing up together. Speaking of kids, Dana's family expanded on June 1, as little brother Kaleb joined his big sisters Lyla (7) and Adeline (4), as well as father Jay Herrigel (UD 2002).

JENNIFER ZAK GREY '03 is not quite part of the medical brigade but is close, having spent her career at Merck since graduating in 2003. She has filled various roles, primarily supporting the vaccines business, initially on the R&D side, then in the manufacturing division and roles in tech ops, procurement, and supply chain. About two years ago, she shook things up even further by moving to the commercial side, where she is now an associate director of global vaccines strategy, responsible for global strategic planning and realization projects for Merck's vaccines portfolio. Along the way, Jen did a second tour at UD, graduating with her MBA in marketing in 2008, where she felt that the classes/exams were a walk in the park compared to "the thermodynamics exams with those pages-long preambles and near impossible questions (thank goodness for the curve!)! All these years later, I still have a visceral reaction to green engineering paper..." Jen has been happily married for 12 years to a fellow Blue Hen, Andrew, and they have an almost-8-year-old daughter, Maddie, and a 4-year-old son, Jake (note that the ages line up nicely with those of Dana's children...).

ERIC PRIDGEN '03 adds evidence that Merck had a banner year in UD recruiting in 2003. Eric joined Merck as a bioprocess engineer, also in vaccines, where he worked on the human papillomavirus vaccine. He went on to research nanoparticle drug delivery in Robert Langer's lab at MIT and received his PhD in chemical engineering in 2013. However, the siren song of medical school entered the picture again, and Eric then attended Stanford Medical School, receiving his MD in 2017, and is now a resident in the Department of Orthopaedic Surgery at the Hospital of the University of Pennsylvania. Eric and his wife, Wenny Lin (Biochemistry 2003), currently live in Philadelphia and recently welcomed their first child, a boy named Ryan, who has great taste in clothing (see attached photo).

Last but certainly not least, BEN TANG '03 ventured into biomedical engineering with a PhD at Johns Hopkins and a postdoc at MIT, focused on developing new drug delivery platforms. About 3 years ago he moved to the Bay area to work in pharmacokinetics and drug metabolism at Amgen. He is now at UCSF as a faculty member in a drug discovery program in the Institute for Neurodegenerative Diseases. Ben claims – not entirely convincingly – that his math skills have continually diminished since Delaware, and says that he leans heavily on Excel these days. Outside of work, he finds San Francisco quite enjoyable in spite of the large sunshine tax, and he runs and cycles nearly every day.

JOSH SELEKMAN '08 finds it difficult to believe that 10 years have passed since graduation, and more specifically since the senior banquet at which he and MATT REICHERT roasted the faculty (all in good fun, of course) at Deerfield. Josh is back east after completing his PhD at Wisconsin. After a ~ 4 year stint in pharmaceutical development at BMS (New Brunswick), he is now at their Princeton location as a manager in strategic options and assessment in a newly-formed Business Insights and Analytics organization. The group is half chemical engineers who have transitioned from technical roles to applying their training to optimizing value within the R&D portfolio.

Josh and Rebekah have 2 sons, Sam (6) and Jonah (3), and love to travel with (or without) the kids - including an occasional trip to Newark to visit their favorite restaurants on Main St. and walk around the campus. Josh notes, "I truly only look back on my experience at UD, specifically the CHEG dept, in a positive light and could not have asked more from the experience. The education helped shape who I am and the camaraderie across our class and the professors was unmatched."

TOM KELLY D'13 has found the five years since he left UD "challenging, exhilarating, and rewarding". He spent three years at Air Products & Chemicals in northeastern Pennsylvania, where he learned the ropes of industrial R&D and corporate structure and enjoyed interactions with fellow UD alumni including FRANK PETROCELLI D'85, JOHN BEDENBAUGH M'09 D'12, MAEVA TUREAU D'11, and others. In 2017 he moved to Chemours, where he is in the fluorochemicals R&D division at the DuPont Experimental Station. Tom is developing processes for producing hydrofluoroolefins (HFOs), the next generation of refrigerant molecules, which involves an enjoyable mixture of piloting processes, responding to plant problems, and intellectual property defense. In a happy coincidence, Chemours R&D divisions are moving to the UD Science, Technology, and Advanced Research (STAR) campus (site of the old Chrysler assembly plant in Newark) next summer. Tom looks forward to being just down the street from UD and Main Street, and will do so with important company: while at Air Products he met Theresa Meder, and their wedding was set for the summer of 2018.

GIVING BACK

We extend our sincere appreciation to the following alumni and friends of the Department of Chemical and Biomolecular engineering who made gifts between July 1, 2017, and June 30, 2018.

Contributions from these generous individuals help us to provide the vital resources that allow our students, our faculty and our campus to thrive.

Abbott Laboratories*
Kevin J. Abraham '15
Benjamin F. Adams Jr. '51M
David C. '88 and Mary N. Adams*
Air Products and Chemicals, Inc.*
The Air Products Foundation*
Minori Akiba '18
Abdullah A. Al-Alawi '18*
Gregory C. '85PhD and Patrice S. Alexander
Lori Purvis Althouse '83
Robert T. Alzamora '86 '98M and
Lori Petrovich Alzamora '86 '97M
Joseph C. Ambrosi '15
American Endowment Foundation*
Moris Amon '82PhD and Terry Perahya Amon '82
Erik J. Anderson '13
John E. Anderson '62M '64PhD and
Fay LaGrange Anderson '60*
John L. Anderson '67 and Patricia Siemen Anderson '67*
Robert J. '67M '68PhD and Nancy B. Anderson*
Jason C. Andrechak '17
Tanner Andrews '82*
John P. '71 '72 and Sally M. Anerousis*
Apple Inc.*
Paul J. '70M and Susan Paula Arruda '71M
Ashland, Inc.*
Michael D. Ashworth Jr. '17
Rajai H. Atalla '58M '61PhD and
Dorothy Voshell Atalla '62 '66M*
Randall C. Atkinson '70
Magdy W. and Caroline Attia*
Robert L. Auger '92
Kees T. Baas '18
Byron D. Babcock '52*
Kushalkumar M. Baid '73PhD*
Harrison M. Ball '18*
William R. '78 and Ann P. Banick
Christopher E. '94 and Janet Banschbach*
Ulises Barcena and Viviana Sanchez*
Udit Batra '91 and Indira Malik Batra
Carly M. Battistoni '18
Harold E. Bauer Jr. '51 and Joanne Bronson Bauer
Doris Lerner Baumgarten '56M*
Kathlyn Card Beckles '97 and Kevin A. Beckles
Thomas W. Beggs '69*
Corinne A. Behen*
Kenneth J. Bell '53M '55PhD*
Barry J. '78 and M. Therese Verdugo Bentley
Alan B. Bernath and Minhtrang T. Doan*
Ira S. '65 and Jo Ann R. Bernstein*
Michael J. '88PhD and Teresa M. Betenbaugh*
Anjana N. Bhat '05PhD and Ashish B. Mhadeshwar '05PhD
John T. Bianculli '81*
Kevin J. Bichoupan '16
Estate of Ruth L. Bickling**
Marsha Stalker Bischel '87 '97PhD and Wesley T. Bischel
Ricardo C. Blackett '99 and LaWhan Yancy Blackett '98
Adrienne K. Blevins '15
Ricardo J. Bogaert-Alvarez '79M '86PhD*
Robert E. '60M '63PhD and Mary P. Bollinger*
Peter Bouloucon '62M '64PhD and
Carolyn Gibe Bouloucon '64
Stephen T. '74 and Veronica L. Boyd*
Joye L. Bramble '84
Bristol-Myers Squibb Foundation, Inc.*
Dennis H. Broderick '80PhD*
Douglas F. Brown '76
George A. Brown '50M '56PhD*
Lawrence A. Brown '71 '72 '77M*
Lee F. '55M '63PhD and Monica W. Brown*
Nicole F. Brown '93PhD*
Eugene H. and Lorin D. Buck*
John H. '68 and Danele Buehler
Christopher L. Burket '02 and Heather Katen Burket '04
John S. '52 and Mary C. Burpulis*
William G. Burroughs Jr. '59 and
Elizabeth Ewing Burroughs '59
Allen W. Burton Jr. '00PhD*
Brian W. '64M '66PhD and Virginia P. Bussey*
James M. Byrnes Jr. '84M and Catherine Eckert Byrnes '85M
Dennis R. Cacciola '72*
Robert F. Cairncross '85*
Darin M. Campbell '98PhD*
Matthew and Carmen Carlisle*
Charles E. '66 and Lou Ann Carroll*
Robert W. '64 and Jane W. Carroll*
Joseph R. '83 and Mary C. Castagna*
Arup K. Chakraborty '89PhD
David R. '73PhD and Helen Chang*
Pao C. Chau '76
Chevron Corporation*
Minshon J. '79PhD and Yuwen C. Chiou*
Carly Fleagle Chisholm '09
T. John Claggett '65 and Alice Hammond Claggett '65*
Tiffany N. Claggett '01
Douglas M. Clarke Jr. '85*
Cynthia McDevitt Clarkson '89
Nathaniel R. Cohen '18
Edward F. Colburn '63*
Stephen H. Cole '64*
Morton '58 '15H and Donna K. Collins
Charles T. Collins-Chase '04
Thomas F. Comiskey '18*
Dennis A. Conlan '63
Patrick T. Connor '82M
Alvin O. '58M '61PhD and Merry E. Converse*
Cawas A. Cooper '79PhD*
Danielle Mauz Cooper '06
Jessica M. Cowan '17
Douglas A. '66 and Antoinette M. Cox
James K. Craig '15
Teresa Young Crane '09PhD
Kathryn Kreemer Culver '56
Thomas E. Currier '64M
Nicole Neal Custis '92 '94M
Sheldon J. Cytron '67PhD*
Dady B. Dadyburjor '72M '76PhD and
Lou Crago Dadyburjor '72*
Sara J. Davidson '12
G. James Davis '58
Heather Hollowell Davis '97
Ruth Van Leer Davis '80M and Gary Davis*
Lia L. Dawson '18
Matthew J. '06 '15M and Niki Decker*
Phillip E. '85 and Elyse DeDominicis*
Thomas F. Jr. '77PhD and Anne R. Degnan*
Edward M. Delate '80*
Alexander A. Delluva '15
Deloitte Foundation*
Edward C. Deming '12 and Cara Gavin Deming '12
Matthew A. DeSieno '06 and Katherine Miklosz DeSieno '06*
Jennifer E. Devaney '11

** Indicates gift was designated directly to the Department of Chemical & Biomolecular Engineering.*

*** Indicates donor is deceased.*

Nicole M. Devitt '18
R. Bertrum Jr. '80M '99PhD and Elizabeth E. Diemer*
Bernard J. '56M and Vivian S. Dillon
Anthony E. and Elisa R. Dimarco*
J. J. DiNorscia '72
Vincent A. D'Ippolito Jr. '91*
Kerry M. Dooley '83PhD*
Martin M. Doordan '83 and
Christine Courtney Doordan '88
Andrew M. Dorfman '17
Dow Chemical Company*
William L. Dreshfield '73*
David W. '87M and Catherine R. Drew
Kyle M. Ducharme '17
Arthur E. Jr. '65 and Diane R. Dungan*
James B. Dunson Jr. '61M and Jean Parker Dunson '77
Stephen R. Dziennik '92 '02PhD
John R. Eagle '56**
Hasani Eason '18
Carl D. Eben '63M '68PhD and Judith Danek Eben '64*
Lisa A. Edwards '95
Carl W. Eilo '83*
Richard E. Emmert '52M '54PhD and
Marilyn Marner Emmert '75*
William D. '78 and Melissa L. Epstein
Erie Community Foundation*
Neil C. Evans '94
Leslie F. Excellent '93
ExxonMobil Corporation*
ExxonMobil Foundation*
James G. Faller '62M '67PhD and
Catherine Eliades Faller '58
Byron Fan '18
A. Robert Faulkner '85 and Sheryl Beda Faulkner '92
Ryan A. Fauth '00 and Abigail Davis Fauth '99
Peter S. Jr. '74 and Sharon M. Fedkiw*
James E. Feig '66M and Judith Adams Feig '61M
John R. Felten '64
Hailey Cramer Felts '15
Myra Campbell Ferguson '66*
Hunter H. Ficke '73 and Dorothy E. Bellhouse*
Fidelity Charitable Gift Fund*
Erin J. Finehout '00
Diane Goldey First '81M*
George L. '61M and Patricia J. Fish*
A. Gerald Fishbeck '74*
Erica N. Fisher '18
Marianna L. Fleischman '15
John M. Fletcher Jr. '63 and Anne Tavani Fletcher '64*
John V. Flynn Jr. '64 and Mary Lou Lobaccaro Flynn '64*
Samuel P. Foster '48M and Dorothy Bukowski Foster
Suzanne Fostinis*
Steven W. Francisco '13
Christine Frazier-Hollins '99
Thomas A. Frederick '78 and Diane Mery Frederick '79
John H. Frey '87PhD and Beth Cooper Frey '84M*
Andrew P. Full '94PhD*
Eric M. Furst and Teresa W. Chang
Edward A. Gadsby '52 and Charlotte Hutson Gadsby '53
Jonathan H. Galarraga '16*
Shekhar S. '97PhD and Shilpa Garde*
Raymond G. Jr. '86 and Jane D. Gardner*
Martha E. Garske '84*
Edward P. Gatzke '00PhD*
Frank M. and Marina Giannattasio*
Robert J. Giraud*
Steven I. '72M and Susan Gleich
Lloyd A. '67PhD and Grace T. Goettler*
Bryan R. Goldman '15
Arthur L. '59M and Vida F. Goldstein*
Liezhong Gong '99PhD*
Donald A. '56 and Nancy S. Goodridge
Robert W. '59 '10H and Jane Gore
Rajeev L. Gorowara '01PhD and
Christine Carrino Gorowara '00PhD
Robert D. II '65 and Kaaren Gotwals
Catherine Smith Gow '86*
Brian K. Grafton '00 and Heather Hartline-Grafton '99*
Ronald A. '72 and Joyce F. Greenberg
Douglas A. Greenfield '52**
John E. Greer Jr. '68 and Elizabeth Michener Greer '67
Albert W. Griffin '82M*
Claire A. Griffiths '16
Susan M. Grill '85M*
Edward G. Grochowski '59
Sarah M. Gross '18
Marc D. Grossman '82
Joseph and Louise A. Guastella*
Joanne Stallmann Guempel '77 and Herbert G. Guempel
Jason G. Gulbinski '16
Franklin J. Gulian '83
Wayne A. Gulian '83*
Henry H. '61 '72M and Elizabeth D. Gunther
Rakesh K. Gupta '80PhD*
Thomas L. '60 and Kipp T. Gutshall*
Charles R. Hahn '73 and Valerie Shockley Hahn '75 '80
Richard C. '57 and Janet M. Haines
Jeanne C. Haley '92*
Jeffrey S. Hanft '08
Benjamin D. Hankins '04
Michael and Joyce Hanlon*
William T. Harper '60M*
Douglas G. Harrell '80 and Michelle Talmo Harrell '84*
John H. Harrington Jr. '67M*
Laura Krumwiede Hartwell '85 and James A. Hartwell*
Syed and Hena Hasan*
Ned C. Haubein Jr. '97 and Lisa N. Siebenson '97
Richard L. Hawthorne '67 and
Shirley Hitchner Hawthorne '67*
Malcolm L. Hayes '82M
Colin A. Heberling '10*
Roland H. '75PhD and Donna L. Heck
Nathan J. Heckroth '16*
Sarah Heether '16
Ian C. Heffner '18
David M. '81 and Linda S. Heitzer
Frederick A. Heller '05 '12M and Melissa Pittman Heller '05
Ernest J. '50 and Barbara M. Henley*
Pantaleon Henriquez III '74 and
Virginia Balling Henriquez '75
John R. Hepola '69M and Susan Leach Hepola '67
D. Charles Herak '85 '94M*
Nicholas Hernjak '04PhD*
Nathan D. Hess '13
Spencer S. Hirata '84 and Cecilia Mucha Hirata '81
David S. Hirshfeld '59M
Erin N. Hitchner '18
Mark Kai Leung Ho '16*
Teh C. Ho '77PhD and Wei Wei Hsu Ho '76M*
Teh C. Ho '77PhD and Wei Wei Hsu Ho '76M
Norman N. & Gale R. Hochgraf Charitable Foundation*
Norman N. Hochgraf '54M '56PhD*
Martin F. Hoenigmann '79*
Bradley Q. Hoffmann '12 '12M
Michael J. Hogan Jr. '18
Allen L. Holzman '54M*
John W. Hooper '56*
Jack R. '64M and Marilyn S. Hopper*
Craig A. Horak '00 and Jessica Bryson Horak '01
James P. Horgan '81 and Anne M. Gaffney '82PhD
Scott R. Horton '16PhD*
Steven D. Horton '73 and
Susan Jingeleski Horton '74
Estate of Richard J. Horvath '68**
Thomas F. Houghton '81 and Sarah E. Scott '81*
William E. Jr. '68 and Virginia A. Houle*
Paul W. Huang '96
Christopher S. Hudson '11 and Evelyn Hayman Hudson '11
Joseph J. Huggins Jr. '67 '74M and
Lois Reynolds Huggins '67
Richard F. '61 and Laura H. Humphreys*
Gilbert L. Huppert '87*
Stephen J. '82 '14M and Amy J. Hurff*
Neil W. Huskey '12
Bryan L. Hutton '95
Matthew J. Ingham '17
G. Brinton '62 and Lynne D. Ingram
Shawnta Lorthridge Jackson '02 '09M
Cynthia Jackson-Elmoore '88 and Ambrose P. Elmoore
Victor F. Janas '87PhD and Bernadette Garchinsky Janas '84
J. James Jariwala '98
Janine I. Jelks-Seale '04
Rodman Jenkins '47M
Douglas C. '76 and Anna B. Jennings
Richard H. Jensen '72M and Lorraine S. Grimes '81
Manuel R. Jimenez Diaz '10
Johnson & Johnson Family of Cos.*
Douglas W. Johnson '68 and Joyce Carlton Johnson '68
Dale A. Jolly '74
Alison D. Jones '18*
John F. Jones '56M
Michael L. Jones '69M*
Stuart L. Jones '58M
Terri E. Jones '99
Prasanna V. '98PhD and Sonali J. Joshi
Donald E. '58 and Ivy S. Jost
Alexander D. Jung '98
S. Tobias Junker '04PhD
Theresa M. and Robert Kalesse Sr.*
Marcus E. Kantz '73M and Charlotte Berry Kantz '75M*
Michael Karavolias '16
James C. Kauer '87*
John P. Kearns '95 '00M
Chelsea Y. Keefe '17
Terrence P. '84 and Heidi Kelly*
James R. Kennedy '17
Janet Kennedy*
Hal '61 and Molly Kenton '60
Steven M. '71 and Sandra K. Kessler*
Kevin J. Keyser '88*
Rishi L. Khan '00 '07PhD and Eileen Paschik Khan '02
Sharon Bickle King '89
Merritt C. Jr. '60 '66M and Alberta B. Kirk
Jeffery B. Klauda '03PhD*
Lothar W. '72M and Donna H. Kleiner*
Gerard F. Klinzing '77M and
Kathryn Baldwin Klinzing '75 '78M
Kent S. '78M '80PhD and Pamela K. Knaebel*

John W. Koch '51 '60M**
Donald A. and Elisabeth J. Korinda*
Austin J. Kotch '14
John T. Kramer '82 and Brenda Pasapane Kramer '83*
William A. Krebs Jr. '57 and Laurie Bliss Krebs '59
Benjamin G. Kremkow '16PhD*
Stewart M. Krug '75M
Christopher L. Kulp '95 and Kristen Sipics Kulp '95*
Thomas J. and Lori A. Kuntz*
Robert J. Kwortnik Jr. '88
Krysta G. La Bruna '18*
William L. Jr. '59M and Linda L. Lafferty*
C. Steven Lai '79*
Lam Research Foundation*
Stephen M. Lambert '89*
Bruce P. LaPorte '75 and Maureen Golder LaPorte '73 '77M*
Mauri J. Lappinen '69*
Allan Larsen '64*
Felicia Ryder Lee '87 '91M
Ilsoon Lee '98M '00PhD and Jue Lu '04PhD*
Robert A. Lee '83 '98M and Diane Negrepont Lee '87
Sidney D. Lehr '79 and Pamela Adams Lehr '80
Dean E. '61M and Dean W. Leib*
Robert J. Leipold '92PhD*
Abraham M. and Roleen T. Lenhoff*
Kyle R. Lennon '18*
Brian S. Levy '09 and Shannon L. Deibel '11
Cristian Libanati '92PhD and Laura Weinert Libanati '87
Lembit U. Lilleleht '53
Shiang-Tai Lin '01PhD
Zhexi Lin '15
Lloyd Lobo '10M*
Michele Dickman Lobo '06PhD and Raul F. Lobo*
William P. Long Jr. '66
Kenneth E. Loprete '14 and Amy Hallahan Loprete '13
Graham H. Lovell '18
Kyle W. Lusignea '16
Kyle T. Macasevich '10 '11M*
Alice Beckley MacDonald '66 and William A. MacDonald*
Sean G. Mack '14 and Hannah Mueller Mack '14
Michael E. Mackay '79
Patricia D. Mackenzie '79
Gregory S. Maliken '76 and Phyllis Kirkwood Maliken '76*
Mallinckrodt Pharmaceuticals*
John S. Malone '18
Francis G. '73 '81M and Linda F. Maloney
Stephen D. '90PhD and Leslie A. Maloney*
Milton D. Marder '50M*
Frank A. Maresca '82
Jacob A. Markiewitz '12
Andrew L. Marshall '05 '11M
Carl J. '77 and Jane L. Martin*
George R. '77M and Jennifer K. Martin*
Evan M. Martz '18
Robert J. Mattson '55*
Michael G. Mauk '81 '84M '86PhD
Irenee d. May**
Katharine E. May*
Ernest Jr. '69PhD and Irene S. Mayer*
Tobias Mazal '18
David H. McAndrews IV '18*
Christopher W. '03 and Cecily McChalicher*
Clark A. McCollough '68 and Carol Toop McCollough '67
Ryan J. McDonough '16
Michael R. McGurk '83
Kati L. McLaughlin '16
Julia E. McLaverty '18
John B. McVaugh Jr. '71 '75M and Brigid Hawk McVaugh '74
Eric P. Meehan '07
Samantha M. Meehan '15
Merck & Company, Inc.*
Merck Company Foundation*
Martin R. Mersky '71
Jack L. Messman '62*
Carol R. Millar*
Daniel S. Miller '09 and Elizabeth Byrd Miller '08
Robert W. '58M and Janet B. Miller
C. Douglas Mills '75
Helen R. Mills*
Norman T. Mills '61M**
Daniel K. Mitchell '11
Mark R. '92 and Christie J. Mitchell
Roxana E. Mitrut '17
MKS Consulting LLC*
Darrell B. Mobley '96 and Dore Gaston Mobley '94
Joseph S. and Danette Modica*
John T. Mongan '82 and Carol McKenna Mongan '81
Paul W. Montigney '74 and Deborah Bunting Montigney '73
Ramon Morales and Maria Garcia*
Stacy Evans Moritz '05
Pamela Leung Morrison '94 and David W. Morrison*
Wilbert Moultrie III '92
Ryan C. Mowers '13
Victoria G. Muir '18
Patrick J. '77M and M. Mulvihill
Robert E. Murch '70PhD and Jane Stronge Murch '66*
Luis E. Murillo '08PhD and Yamaira I. Gonzalez '05PhD*
Duane B. Myers '93*
Gary R. Myers '65*
Heather E. Myers '99*
Steven R. Myrick '77 and Linda Justice Myrick '77
Michael D. '86 and Barbara M. Nagle
William S. Neifert '05
Frank H. Nickel Jr. '55*
Thomas R. and Linda J. Oeffinger*
Lee C. '91 and Leigh A. Oesterling*
Charles J. Orella '82M and Annette Murray Orella '83*
James E. Orr Jr. '49
Peter S. O'Sullivan '84 and Karen A. Fletcher '81 '82M*
Randolph A. '03 '09M and Crystal Oswald
Robert E. Oves '71 and Mary de Young Oves '72
Justin M. Paloni '16
Christine Pan '09
Eleftherios T. and Maria C. Papoutsakis*
Robert S. Parker '99PhD and Stacy Nabers Parker '00M
Elliot S. '66 and Karen W. Parkin*
Christine M. Parrish '18
David J. Paul '56*
James S. Pawloski '84 and Barbara Weaver Pawloski '84
William L. Jr. '60 and Mary O. Payne
Rudolph L. Pedrotti*
Jessica A. Penetar '05
Angela M. Pereda '16
Francis P. '85PhD and Lisa A. Petrocelli*
James M. and Kendra C. Pfeifer*
Robert E. Phelps '66*
A. James Pirigyi Jr. '89
Timothy A. Poludniak '93 and Julie Toms Poludniak '92
Tracy Powell '11
Donna M. Praiss '86
Frank J. Precopio '82*
Carl D. Price '65
Eric M. Pridgen '03 and Wenny Lin '03
James M. Prober '68 '72M '74PhD and Cheryl O'Neill Prober '70
William D. Provine '92PhD and Annette Woolard Provine '84M '93PhD*
Narahari S. Pujar '96PhD
Robert K. Pyle '70
Amy L. Quach '14
Tyler J. Rabe '09 '13M
Sangeeta Raje*
Michael R. Rasch '06
Charles T. '71 and Dariece M. Rau*
James F. and Jana L. Rayfield*
Xiaofeng W. '95M '95PhD and Dennis Rears*
John C. Reed '54M*
Matthew S. Rehmann '16PhD
Christina Picarro Reich '03 '05M
Carlonda Russell Reilly '92M '96PhD and Michael P. Reilly*
Roger A. '73M and Sandra W. Reinicker*
L. Philip Reiss '58*
Renaissance Char. Foundation, Inc.*
Terence A. Rensi '79M and Jane Phillips Rensi '73
Joseph A. Reynolds '14
John R. '94PhD and Jean M. Richards*
Joseph M. '89PhD '91M and Janice Ritter*
Christopher J. Roberts '94*
E. Jeffrey Roberts '75M and Betty J. Hughes
Richard S. Roberts Jr. '98 and Sandra Arbogast Roberts '00
Tyler M. Roberts '18
Robert W. Robey '92
Donald G. Robinson '59PhD*
Douglas A. Robinson '68
Jerome D. '66M '68PhD and Sheila K. Robinson*
Richard C. '56M '58PhD and Margaret V. Romano
Charles M. '94PhD and Lorie Roth*
Charles F. Rudolph Jr. '57
John D. Rudolph '70 and Carolyn Roblou Rudolph '69*
Mary Jo Kennel Russell '84 and William R. Russell III
T. W. Fraser Russell '64PhD '10H
Johndavid Sabedra '13
Collin E. Sager '18
Seidatu A. '13M and Binyamin Salis Sr.*
Gaurab Samanta '09PhD
Cory E. Sanderson '07 and Jaime Unruh Sanderson '07*
Stanley I. Sandler*
Ajit V. '80PhD and Madhuri A. Sapre*
Robert L. Sr. '83 and Carmela M. Sassa*
Lisa A. Sawicki '17PhD
B. Karl Saydlowski Jr. '88*
Duane S. Scarborough '73*
David G. '77 and Gail R. Schechter
Joshua B. Schein '09
Ralph C. Jr. '53M and Margaret H. Schilly
Paul H. '73 and Denise B. Schipper*
Samuel E. Schmidt '18
Jennifer Colombo Schmitt '96 and John J. Schmitt III*
Schwab Charitable Fund*
Steven A. and Sallyann M. Scott*
Aaron M. Scurto '97*
Tyler J. Seidel '18
Joshua A. Selekman '08 and Rebekah Kaplan Selekman '08
William H. Severns Jr. '50PhD*
Andrew B. Shah '13*
Thomas M. Sharp '16
Shell Oil Company Foundation*

Laetitia Bonnaillie Shelton '04M '07PhD and Keith M. Shelton
Joel T. and Susan K. Shertok*
Earl L. Jr. '71 and Terry M. Shiflett
Chelsea T. Shockey '15
Kenneth L. '73 and Nancy J. Shugart
Allyn M. Shultis '05 and Megan McGrath Shultis '06*
John Siczka '54 and Christine Sundt Siczka '59
Jeffrey J. and Sharon A. Siirola*
Linda E. Silowka*
Charles G. and Cynthia A. Simms*
Robert H. Simon '48*
Kelsi M. Skeens '14
William H. Jr. '64M '67PhD and Judith K. Slack*
Benjamin A. Smith '16
John K. Smith Jr. '74 '86PhD and Kimberly Carrell-Smith '81M '89PhD
Lewis S. Smith Jr. '85*
Shelley A. Smith*
Carrie Loehr Smolinski '97*
E. Bryan Snell '78
Charles R. Snyder '68
Ryan C. Snyder '01*
Lori A. Sobel '82*
Martha J. Sorgen*
Raymond M. Sowiak '80
James A. Spearot '70M '72PhD and Rebecca Moore Spearot '71M*
Dwight S. Springer '65*
Jared S. Sproul '62M
Thomas W. Staley '89
Robert L. Stevenson Jr. '86 and Donna Nugent Stevenson '86
Cynthia B. Stouffer**
E. Marvin Stouffer '64*
Donald C. '68M '70PhD and Joan H. Sundberg*
Susan G. Komen for the Cure*
Chris Horley Susman '86
Ronald W. Swanson '60M '66PhD*
Benjamin C. Tang '03
John M. Tarbell '72M '75PhD*
James and Antonette Taylor*
John W. Terres '58 and Ruth Ann Follett Terres '62
The Pfizer Foundation, Inc.*
Arthur M. Thomas Jr. '56M
George E. Thomas Jr. '81 and Vivian Bonfanti Thomas '70*
Levi T. Jr. '81 and Maria A. Thompson*
Carolyn Thompson Thoroughgood '65*
Jason E. '96 and Tonya N. Tiffany*
Walter C. Timm '57*
Michael M. '73 and Carla A. Todd*
J. Gregory '78 and Andrene H. Townsend
Lynn Kelsey Tracey '92PhD and Edward F. Tracey Jr.
Peter M. Train '87PhD and Leigh Spayd Train '84*
John G. Trexler '78 and Maryanne Chippie Trexler '78
Joseph A. Trotta '14
Jane Tsai '77M
Janna W. Tuthill*
Richard A. Tybout '43
E. Alan '64M '66PhD and Marsh W. Uebler*
James S. Ultman '67M '70PhD and Deena Shur Ultman '67
Unidel Foundation, Inc.*
Lauren Rallo Vahle '09
Lawrence R. Valencourt '70*
Karel E. Valentine '00
Robert T. Van Ness '50
Kyle S. Van Riper '99 '04M*
Leland M. Vane '87 and Carolyn M. Acheson '87
Vincent J. Verruto '03 and Samantha Kwan Verruto '03
T. Bruce Vickroy '79 and Karen Krippahne Vickroy '79*
Andrew J. Vitelli '14
Chester A. Vogel '70M*
Norman J. and Sabine B. Wagner*
Michael A. '71 and Patricia D. Walsh*
Anna V. Walter '14*
Philip E. Walter '68*
John H. '57 and Rita A. Warren*
Scott H. '88 and Elisa J. Wasserman*
Katherine Raimondi Wassil '88 '98M and Paul Wassil III
Sharon L. Watkins '86 '93M
Linda H. Weaver*
Jessica M. Weber '18*
Matthew P. Weber '17
Robert W. Weeden '51
John A. Wehner '82 and Ann Marshall Wehner '83
Charles E. Weil '67*
Peter B. Wells '09
Donald R. Wheatcraft Jr. '63 and Jane Weaver Wheatcraft '62*
Robert W. Whetzel '81 and Michele Davison Whetzel '84
Michael L. White '13
Robin J. Whitlock '73
Jake M. Wiley '17
Jay J. Williams '71*
W. Randall '61 and Susan S. Williamson
Thomas B. Willing '72*
Robert S. Windeler '90
Eric W. Wiscount '16*
John M. Witheford '51*
Mark H. Witterholt '81
Robert S. Wojewodzki '70 and Catherine Willis Wojewodzki '70 '97M
Carl H. Wolf '53
Albert S. Wong '64M
Ronald T. Wood Jr. '65 '75M and Phylis Stone Wood '65*
Jeffrey W. Wright '94 and Linda Hopkins Wright '82 '86M
Clare M. Wunder '18*
James C. '70M and Theresa S. Wykowski*
E. Scott Yawger '83 '92M and Ellen M. Yurek '84
Albert C. Young '88PhD*
Wen-Shiue Young '12PhD*
John B. Yourtee '68 and Rosemary Quittence Yourtee '68*
Seif M. Yusuf '12M
Herbert H. '51 and Nancy Zachow*
James L. Zawicki '59
Jacob S. Zerby '16
Wenjuan Zheng '14PhD '16M
Erik M. Zimmerman '15
Jaclyn R. Zimmermann '17
Roger J. Zipfel '69M and Joyce Kenyon Zipfel '69
Kenneth S. Zrebiec '94 '98M and Barbara Glodek Zrebiec '94 '04M
Robert E. Zumwalt '60M '66PhD and Doris Wild Zumwalt '59 '63M

Department of Chemical
and Biomolecular Engineering

Allan P. Colburn Lab
150 Academy Street
Newark, DE 19716

FOLLOW US ON TWITTER @UDChBE

**DEPARTMENT OF CHEMICAL
& BIOMOLECULAR ENGINEERING**

ALUMNI & FRIENDS RECEPTION

MONDAY, OCTOBER 29, 2018
7:15 - 9:30 PM

**DAVID L. LAWRENCE CONVENTION CENTER
ROOM 309**

PITTSBURGH, PA