Chemical and Biomolecular

UNIVERSITY OF DELAWARE
FALL 2017

ENGINEERING NEWS

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NIIMBL & RAPID

TWO NEW INSTITUTES NOW AT UD

FACULTY, STUDENT & ALUMNI NEWS

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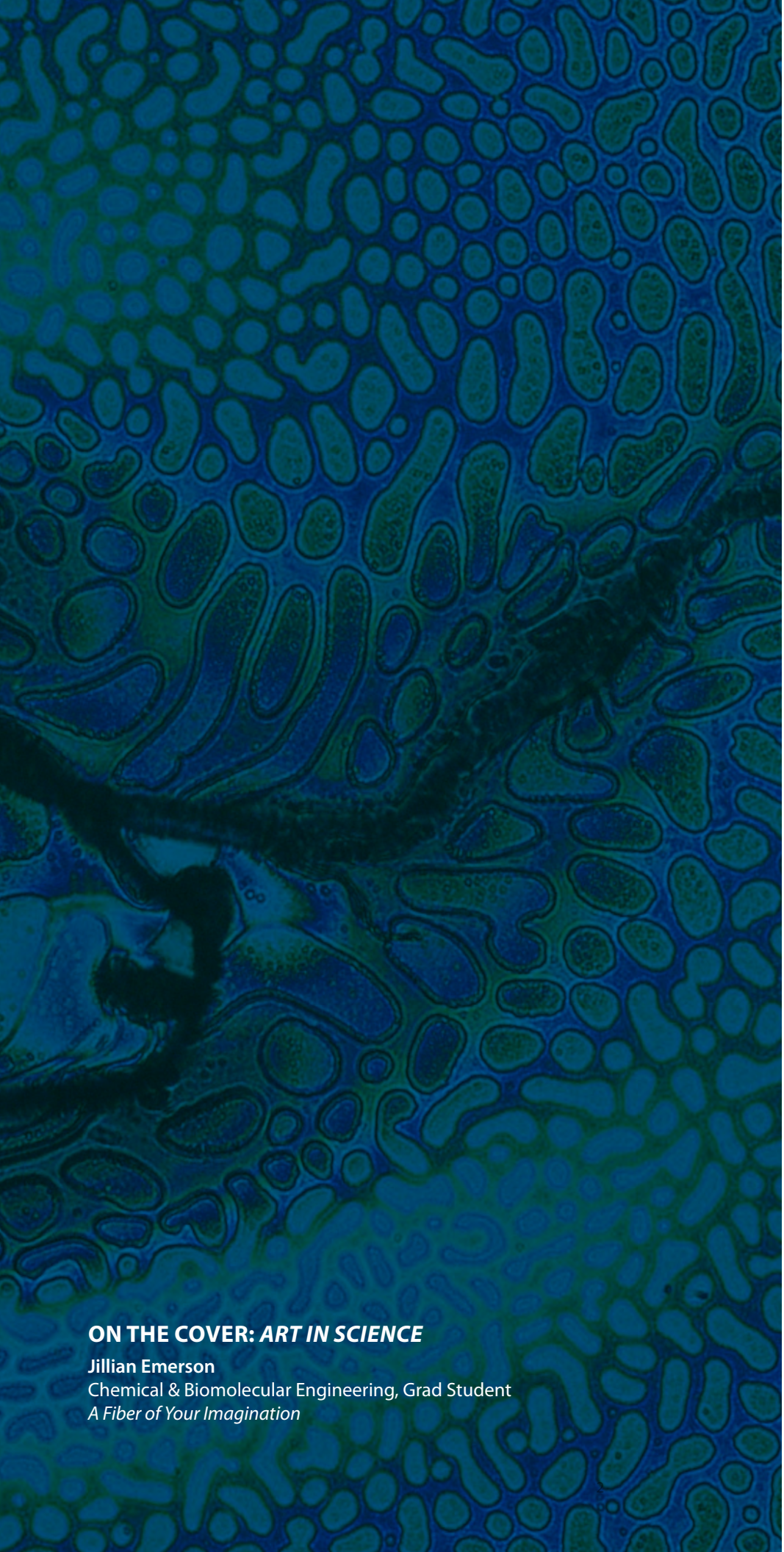

ON THE COVER: *ART IN SCIENCE*

Jillian Emerson
Chemical & Biomolecular Engineering, Grad Student
A Fiber of Your Imagination

Fall 2017

Chemical and Biomolecular Engineering News

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

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OUTGOING CHAIR ABRAHAM M. LENHOFF

ALLAN P. COLBURN PROFESSOR AND CHAIR

After five years as chair of the Department of Chemical and Biomolecular Engineering, it is my pleasure to pass the torch to my colleague, Professor Eric Furst.

I am grateful for his willingness to assume this responsibility. I chaired our department's faculty search committee when Eric was hired, and over the last 16 years I have seen his career blossom in all its facets. He is much beloved for his teaching, even in such challenging courses as thermodynamics and process control, in the latter of which I had the pleasure of team-teaching with him in recent years. He is also widely recognized as a leader in the colloid science and rheology communities, and a landmark in his scholarship is his completion this year of *Microrheology*, a book published by Oxford University Press. Eric is unfailingly loyal to our department and an articulate advocate for its excellence. I am confident that he will be an excellent leader as we move forward.

The chair position provides a unique vantage point over our department and the exceptional accomplishments of our students, staff and faculty. Eric's message on the facing page, and the articles on the pages that follow, describe the numerous landmarks attained in the past year. Each represents a point of pride for the whole department and a large part of the privilege of being chair. I am grateful to all in the department for their contributions and would especially like to thank our staff, led by the indefatigable Patti Hall, for all that they do for us.

I would also like to note two activities that were highlights of my experience as department chair. One is the opportunity to work with our student leaders, in their roles as the Colburn Club executive for graduate students and the AIChE Student Chapter for undergraduates. Their commitment to their fellow students and to the department as a whole creates new realities from which we all benefit. The second highlight of the position is especially lasting for me, namely the opportunity to interact with so many of our alumni and friends. The range of career paths and breadth of impact of our alumni is astounding and gratifying, and those sentiments are amplified by the continued interest in and engagement with the department that so many continue to display.

More than three decades ago I served as our department's seminar coordinator in what was, and remains, a valuable rite of passage for new assistant professors. One of our visiting speakers was Professor Donald Paul of the University of Texas, and in introducing him I mentioned that he had just stepped down as chair of the UT Department of Chemical Engineering. He corrected me: "No, I've just stepped *up*." I can now understand his view that a regular faculty position represents the pinnacle of job satisfaction in the academic structure. It is a privilege for us as faculty to play a part in educating the outstanding students who populate our classes and labs, and I look forward to the opportunity to spend more time on this. The privilege extends also to interacting with them after they become alumni, as it does to being in touch with all of you. I thank you all for the past and future opportunities, and for your continued engagement, interest and support.

Bramie Lenhoff

INCOMING CHAIR ERIC M. FURST

DEPARTMENT CHAIR

The fall semester is in full swing here at the University of Delaware.

Since beginning my term as Chair of the Department of Chemical and Biomolecular Engineering in July, I have marveled at the breadth and depth of our endeavor. The department is over 600 strong in students, faculty, and staff working together to learn, teach, and develop groundbreaking scholarship. This year, the department welcomed 130 freshmen, 36 first-year doctoral students, and 10 students in the Masters of Engineering in Particle Technology Program. The energy, enthusiasm, and spirit of these students are palpable. Of course, it's the people that make us a top-10 department in chemical engineering. From the beginning, our focus on attracting, mentoring, and developing talented faculty, students, and staff has defined our course and sustained its excellence. We work with a peer group that supports us and pushes us, in an environment that provides the resources to define the highest levels of education and research. I think of this special esprit de corps of Delaware often.

This year we are excited to welcome two new faculty members, Catherine Fromen and LaShanda Korley. Professor Fromen is establishing a multidisciplinary program using fundamental discoveries in science to drive translational innovations in pulmonary drug delivery. Her research is at the intersection of materials science, chemistry, transport phenomena, pharmaceutics, and immunology. Professor Korley joins us from Case Western Reserve University with a joint appointment in Materials Science and Engineering. Her research into polymeric materials synthesis and processing draws inspiration from biological structures to design and realize new nanocomposites and tough elastomers.

The University of Delaware today is a force of discovery and innovation. In the past year, the announcement of two USA Manufacturing centers has demonstrated the tremendous leadership our faculty brings to bear across the wide range of chemical engineering practice -- from biomolecular engineering to energy and chemicals. NIIMBL, led by Professor Kelvin Lee, will advance the production of some of the most important emerging pharmaceuticals, and RAPID, which focuses on process intensification, has a major node at Delaware led by Professor Dion Vlachos. Right behind our senior leaders, a strong group of early career faculty is rapidly rising in distinctions, including Professors Feng Jiao, April Kloxin, and Bingjun Xu. You can read about their accomplishments, as well as the awards and initiatives of many other colleagues and students, in the pages that follow.

Advances in scholarship, research, and entrepreneurship flourish because of our sustained commitment to delivering a world-class chemical engineering education here at the University of Delaware. The mutual engagement of a community of learners, teachers, and scholars results in far more than the accumulation of credit hours, quality points, and research papers on the way to a degree. "Colburn Lab, [is] the place where I learned how to learn," were the words of Dr. Udit Batra, who delivered the Gerster Memorial Lecture earlier this year. His sentiments are echoed by many alumni who come back to visit and share their own challenges and accomplishments.

As I begin my term as Chair, I recognize the work of my predecessors who have built a strong and lasting foundation for our department's future. To outgoing Chair, Professor Abraham Lenhoff, I offer special gratitude. Bramie: Thank you. For the past sixteen years you have been a mentor, and for the past five you have been an indefatigable advocate of the department, a careful listener and an equitable mediator. You are a man of many hats or, more appropriately, many sweaters.

Eric M. Furst

Half-Century of Service

Stan Sandler reaches 50-year mark as UD faculty member

"ONE OF MY TEXTS IS NOW IN ITS FIFTH EDITION. IT NOT ONLY CHANGED WHAT WE DO HERE BUT ALSO HAS HAD AN IMPACT ON INSTRUCTION AROUND THE WORLD."

Stan Sandler usually takes the steps to get to his second-floor office in Colburn Lab. But today he's taking the elevator because he's hauling two black bags filled with heavy books — books that will be added to a growing pile destined to be shipped to developing countries including Nigeria and Ethiopia. It's easy to accumulate a lot of books over the course of an academic career, especially one that spans half a century, and, even with 150 or 200 books already boxed up, the shelves in Sandler's office are far from empty.

The walls are crowded too — with framed certificates of the dozens of awards he's won over the past 50 years.

While Sandler is proud of those awards — which include membership in the National Academy of Engineering and being named one of the top 30 chemical engineering authors by the American Institute of Chemical Engineers — there are other things for which he would like to be remembered.

The first, he says, is the many books he has authored, including two new ones in just the past two years.

"One of my texts is now in its fifth edition," he says. "It not only changed what we do here but also has had an impact on instruction around the world."

He's also proud of the accomplishments of his students, his efforts to promote the use of computers in chemical engineering instruction, and his initiation of a conference series in thermodynamics that was supposed to be a one-time event but so far has had a 40-year run. The most recent meeting was last year in Porto, Portugal.

Now the Henry Belin du Pont Chair of Chemical Engineering, Sandler has served as department chair and as interim dean of the College of Engineering, but his heart lies with research and teaching, not with administration.

This accomplished academician didn't plan to be a college professor, but the encouragement of one of his professors at City College of New York, Robert Pfeffer, set him on this path.

"In my senior year, he encouraged me go to graduate school — a possibility that had never occurred to me," Sandler says. "I had no idea what one studied in graduate school or that an assistantship would make such a choice financially viable."

"Ever since then," he adds, "I've considered mentorship of students to be very important because I wouldn't be where I am today without him."

After earning his doctorate at the University of Minnesota, Sandler still had no thoughts of academia.

"But I had done my Ph.D. thesis in kind of a weird area, so I was only getting weird job offers from industry, including one from Bell Labs focused on determining the potential effects of a nuclear attack," he says. So, with an offer in hand from UD, Sandler and his late wife, Judith, moved to Delaware.

Having grown up in Manhattan, he was unprepared for small-town life, and he promised Judith that they would stay just three years.

That was in 1967. Three children and several job offers later, they were permanently settled in Newark's Oaklands neighborhood.

Sandler was also apprehensive about how he would fare as a faculty member at a top-ranked chemical engineering program, but his fears were unfounded. He was promoted to associate professor with tenure before his 30th birthday and to full professor by the age of 32. Sandler's early years at UD saw some Vietnam-era unrest, with protests on campus leading to the dismissal of a number of students and faculty. He quickly became an activist and was instrumental in establishment of the AAUP Collective Bargaining Agreement at UD.

In addition to his teaching and research, Sandler has consulted on a number of projects, including the destruction of armed chemical weapons and the encasement of radioactive wastes left over from the production of plutonium for nuclear weapons during World War II and the Cold War. He has also served as an expert witness in patent litigation.

"Projects like these are far removed, to say the least, from 138th Street and Convent Avenue, where I arrived as a bewildered freshman," he says. And the young man whose parents never owned a car — believing that any place that couldn't be reached by subway wasn't worth going to — has since traveled the world. Between professional trips and personal vacations, Sandler has visited all 50 U.S. states and 110 countries.

Judith Sandler lost her life to cancer in 2014, and in 2017, he married Ellen Pifer, professor emeritus in UD's Department of English.

"I was married for 51 years, and she was married for 49, so between us we have 100 years," Sandler says. "And together, we've authored or edited 16 books."

At this point, Sandler shows no signs of slowing down—two of his books were published within the past two years.

WILFRED CHEN
Gore Professor of Chemical
and Biomolecular Engineering

TERRY PAPOUTSAKIS
Unidel Eugene du Pont Chair
of Chemical and
Biomolecular Engineering

KELVIN LEE
Gore Professor of Chemical
and Biomolecular Engineering

Major Awards

Three receive accolades at ACS national meeting

Three of our faculty were recognized with major awards at the American Chemical Society (ACS) National Meeting held in April in San Francisco.

Wilfred Chen, Gore Professor of Chemical and Biomolecular Engineering, received the Marvin J. Johnson Award in Microbial and Biochemical Technology from the ACS Division of Biochemical Technology. Chen delivered an address on his research, "Building Complex Protein Functions at the Intersection of Nanofabrication and Synthetic Biology." The lecture highlighted work in his lab focused on the creation of smart protein complexes that can sense and adapt to constantly changing cellular environments. Applications include functional nano-devices for synthetic biology applications in bio-catalysis, bio-sensing, and therapeutics.

"Wilfred joins a list of distinguished prior awardees that includes virtually all major figures of the last 50-60 years in biochemical engineering and biotechnology, nationally and internationally," says Eleftherios (Terry) Papoutsakis, Unidel Eugene du Pont Chair of Chemical & Biomolecular Engineering.

In nominating Chen for the award, Papoutsakis wrote, "Over the past 22 years, Prof. Chen has developed a strong and widely recognized research program in the area of biomolecular and protein engineering. Distinctive features of his approach include his breadth of knowledge of the biological sciences, his creativity in exploiting biological systems for a wide range of applications, and the exceptional diversity of those applications."

Papoutsakis specifically cited Chen's achievements in five research areas: detection of pathogens and drug discovery; creation of synthetic scaffolds for energy production and cancer diagnostics; bio-detoxification and detection of organophosphate nerve agents; bio-sorbents for heavy metal removal using cell and protein engineering; and tunable biopolymers for bioremediation, bio-separation, and bio-sensing.

Other UD recipients of the Marvin Johnson Award, which was established in 1978, include Papoutsakis (1998) and Abraham (Bramie) Lenhoff, the Allan P. Colburn Professor of Chemical Engineering (2011).

Papoutsakis also won an award himself: the E.V. Murphree Award in Industrial and Engineering Chemistry. The award is sponsored by ExxonMobil Research and Engineering Company and its purpose is to stimulate fundamental research in industrial and engineering chemistry, the development of chemical engineering principles, and their application to industrial processes.

Papoutsakis has made significant contributions in the areas of cell culture engineering, metabolic engineering, genetics and genomics, and stem-cell and T-cell bioengineering.

"Terry started his academic career 35 year ago with problems that would be clearly identified now as core issues in modern, molecular-based biological engineering," says Chen, who nominated Papoutsakis for the award.

"He was one of the pioneers who recognized the importance of molecularly based interdisciplinary research for the advancement of metabolic and biochemical engineering."

Papoutsakis is also credited with starting two companies. The first, Tissue Therapeutics, was launched 15 years ago and later sold to

Resodyn Corp. More recently, he started Elcriton, which develops microbial-based technologies and was sold to White Dog Labs in 2014.

Papoutsakis has served on many review boards, journal editorial boards, advisory panels and professional societies in the biochemical and biomolecular engineering communities, including serving as editor-in-chief of Biotechnology and Bioengineering from 1990 to 1996 and currently serving as editor for Biotechnology Advances.

He is 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 has 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).

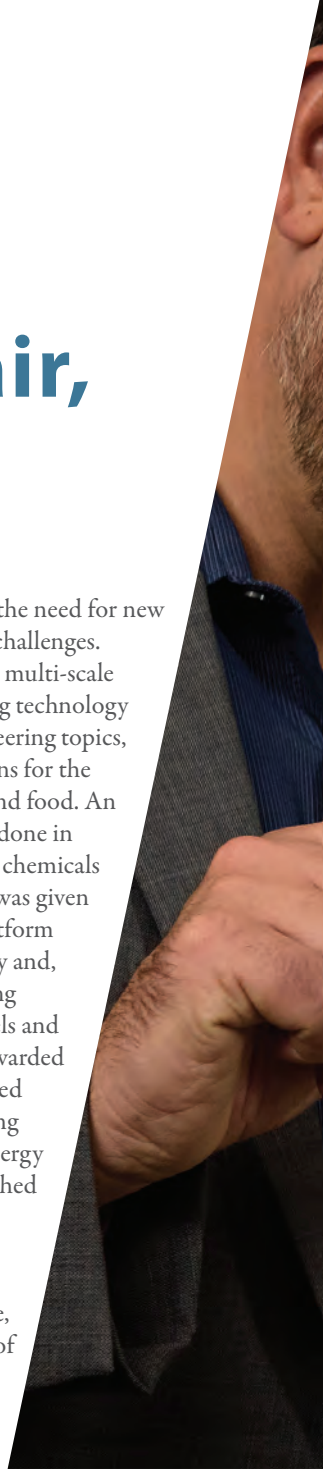
Kelvin Lee, Gore Professor of Chemical and Biomolecular Engineering, received the Gaden Award, named in honor of Elmer L. Gaden, Jr., the founding editor of Biotechnology & Bioengineering. This honor is given in recognition of a truly outstanding paper published in the journal during the last year.

Lee was selected to receive the award for his paper: "Expression of difficult - to - remove host cell protein impurities during extended Chinese hamster ovary cell culture and their impact on continuous bioprocessing." The work, published in June 2015, included co-authors Kristin N. Valente, who graduated in 2014 with a Ph.D. in chemical and biomolecular engineering, and Abraham Lenhoff, Allan P. Colburn Professor of Chemical Engineering.

Wilfred joins a list of distinguished prior awardees that includes virtually all major figures of the last 50-60 years in biochemical engineering and biotechnology, nationally and internationally

Terry was one of the pioneers who recognized the importance of molecularly based interdisciplinary research for the advancement of metabolic and biochemical engineering.

Vlachos named Ferguson Chair, Director of UDEI



"KNOWING ALLAN FERGUSON FOR YEARS THROUGH HIS CLOSE TIES WITH THE DEPARTMENT MAKES THIS TREMENDOUS HONOR EVEN MORE SPECIAL."

Dion Vlachos has been named the first Allan and Myra Ferguson Chair of Chemical and Biomolecular Engineering and appointed director of the UD Energy Institute. Vlachos is also director of the UD node of Rapid Advancement in Process Intensification Deployment (RAPID), a manufacturing institute of the Manufacturing USA initiative focusing on chemicals, and the Catalysis Center for Energy Innovation (CCEI), an Energy Frontier Research Center.

The new professorship was established in 2015 with a gift from UD alumni Allan and Myra Ferguson. Allan Ferguson had a 20-year career as a chemical engineer at Johnson and Johnson, then senior operating positions at two biotech companies, followed by 20-plus years in international venture capital investing in early-stage biotech and medical device companies. Sadly, Allan Ferguson passed away recently (see obituary in In Memoriam, page 48).

"Knowing Allan Ferguson for years through his close ties with the department makes this tremendous honor even more special," Vlachos said. "Allan's strategy — to focus on simplifying real-world problems, breaking down complexities into simple parts — aligns so well with my research. Simplicity in solving a problem is elegant and reminds me of the giant Albert Einstein who said, 'Make things as simple as possible, but not simpler.'"

Vlachos delivered an inaugural lecture on April 17 titled "Meeting Future Global Energy, Water, and Food Needs." He addressed the grand challenges in meeting the global energy, water, and food needs that have emerged from population growth, urbanization and increasing emissions. He outlined potential science and technology solutions and discussed the need for new materials to meet these challenges. Vlachos also introduced multi-scale simulation as an enabling technology to address diverse engineering topics, leading to better solutions for the nexus of energy, water and food. An overview of work being done in the CCEI on renewable chemicals and fuels from biomass was given as one technological platform toward increasing energy and, in particular, to providing green transportation fuels and chemicals. The newly awarded RAPID was also discussed as an effective engineering approach to reducing energy use in numerous established and emerging processes.

As the new director of the UD Energy Institute, Vlachos takes the helm of a university-wide entity that has more than 250 affiliated researchers working on energy policy, catalysts, vehicle-to-grid technology, hydrogen fuel cells, solar technology, wind power and next-generation magnets. "I'm looking forward to building on this strong foundation," Vlachos said. "With rapid changes in the business and energy sectors — such as increased opportunities for solar penetration and low oil prices, along with increased population and urbanization in certain regions of the world — there are opportunities to engage our campus in new energy challenges."

Prior to his new appointments, Vlachos was the Elizabeth Inez Kelley Professor of

Chemical Engineering, and he holds a joint appointment as professor of physics and astronomy in the College of Arts and Sciences.

Vlachos earned his doctoral and master's degrees in chemical engineering and materials science from the University of Minnesota and his undergraduate degree from National Technical University of Athens. He was on the faculty of the University of Massachusetts for seven years prior to joining the UD faculty in 2000.

A prolific researcher, Vlachos has published more than 340 peer-reviewed scientific papers, which collectively have had over 10,000 citations. He is the executive editor of Chemical Engineering Science, a member of the editorial advisory board of ACS Catalysis, and a member of several international scientific committees and boards.

Vlachos has received numerous awards and honors, among them the 2016 Philadelphia Catalysis Club Award, the 2011 R.H. Wilhelm Award in Chemical Reaction Engineering from the American Institute of Chemical Engineers, election as a fellow of the American Association for the Advancement of Science in 2009, the National Science Foundation Career Award in 1997, and the Office of Naval Research Young Investigator Award in 1997.

Vlachos also holds a U.S. patent for developing the highest-ever thermal efficiency technology for converting chemical energy to electricity for portable power generation.

EARLY-CAREER AWARDS

Bingjun Xu wins NSF Career Award and AFOSR Young Investigator Grant

Assistant professor Bingjun Xu has received two major early-career grants.

In February, Xu received a National Science Foundation Faculty Early Career Development Award to address electrochemical reduction of the greenhouse gas carbon dioxide.

The five-year, $523,000 grant, "Elucidating Molecular Level Interplay Between Catalysts and Electrolytes in Electrochemical Reduction of CO_2", was awarded through NSF's Division of Chemical, Bioengineering, Environmental, and Transport Systems. "Climate change, largely caused by anthropogenic CO_2 emissions, has sparked a great deal of interest in harvesting the sun and wind to produce renewable electricity, but a major disadvantage of these renewable energy sources is that they are intermittent," says Xu. "Matching peak production to peak demand generally involves storing the harvested energy in some way and then delivering it when it's needed. An alternative is to use the energy as it's produced for another application. Using it to remove CO_2 from the environment could solve two problems at the same time."

Xu's research will focus on using the excess energy produced by renewables to convert existing atmospheric CO_2 to fuels and commodity chemicals through an electrochemical process — a development that he says is hampered by a lack of understanding of the interaction among species at the electrochemical interface, such as the reactant, the electrolyte and the electrode.

To shed light on this interaction, Xu and his team will investigate the molecular-level interplay among cations, anions and surface-mediated reactions using a variety of advanced spectroscopic tools. The next step will be to establish guiding principles for process and device development. "The level of atmospheric CO_2 recently exceeded 400 parts per million, which is described as 'the point of no return,'" Xu says. "So even if all CO_2 emissions were stopped now, which is obviously not feasible, we would still endure the effects of this greenhouse gas for years to come. The only solution is to start removing it from the atmosphere, and we believe that our proposed approach is an economical, environmentally friendly way to do that."

In October, Xu was one of 58 scientists and engineers across the U.S. to receive a three-year research grant from the Air Force Office of Scientific Research (AFOSR) Young Investigator Program (YIP). The awards last year totaled $20.8 million. The YIP is open to scientists and engineers at research institutions who received Ph.D. or equivalent degrees in the past five years and who show exceptional ability and promise for conducting basic research.

Xu's research will focus on using the excess energy produced by renewables to convert existing atmospheric CO_2 to fuels and commodity chemicals through an electrochemical process

The objective of the program is to foster creative basic research in science and engineering, enhance early career development of outstanding young investigators, and increase opportunities for the young investigators to recognize the Air Force mission and the related challenges in science and engineering. Xu's research will focus on catalyst development to enable flameless combustion of hydrogen in

unmanned aerial vehicles (UAVs). More commonly known as drones, UAVs have limited range because they are primarily battery powered. Xu will investigate the replacement of batteries with hydrogen-powered fuel cells as the energy source to extend the operating range of UAVs.

"Hydrogen has the highest specific energy of all known fuels," says Xu. "Hydrogen-powered fuels cells have been used in commercial vehicles such as the Toyota Mirai, but this application has required the use of expensive platinum-based catalysts."

Xu plans to develop nonprecious metal-based catalysts to reduce the cost of hydrogen fuel cells by manipulating the composition and structure of materials on the molecular level under alkaline, rather than acidic, operating conditions. The work leverages research being conducted under a recent ARPA-E award to a team that includes Xu and is led by Yushan Yan.

Xu earned his doctorate in physical chemistry at Harvard University in 2011 and then spent two years at the California Institute of Technology as a postdoctoral researcher. He joined the UD faculty in 2013. He has published almost 40 papers in refereed journals and is a co-inventor on five patents.

Yan wins AIChE Nanoscale Science and Engineering Forum Award

Yushan Yan, Distinguished Engineering Professor, received the 2016 Nanoscale Science and Engineering Forum Award from the American Institute of Chemical Engineers (AIChE). He was selected for "breakthrough contributions to the development of nanoporous thin films and nanocatalysts for fuel cells."

The award recognizes outstanding contributions to the advancement of nanoscale science and engineering in the field of chemical engineering through scholarship, education or service.

Yan is internationally recognized for solving many of the most critical renewable energy problems. His work has led to more than 170 invited lectures, 60-plus trained scientists and engineers, some 200 journal publications, 25 patents, seven startup companies, and one commercialized technology. Yan's renewable energy effort focuses on affordable electrochemical energy devices, including fuel cells, electrolyzers, and redox flow batteries.

He received the award at the 2016 AIChE Annual Meeting in San Francisco, where he delivered his award lecture, "Toward a Distributed Renewable Electrochemical Energy and Mobility System (DREEMS): Electrocatalysis for Automotive Fuel Cells."

The lecture highlighted a recent breakthrough by Yan and colleagues that promises to bring down the cost of hydroxide exchange membrane fuel cells (HEMFCs) by replacing expensive platinum catalysts with cheaper ones made from metals like nickel. The researchers achieved the breakthrough, discussed further in the Research section of this newsletter, by switching the fuel cell operating environment from acidic to basic. Yan also pioneered the catalyst concept of platinum nanotubes and thin layers on metal nanowires for proton exchange membrane fuel cells (PEMFCs), which are attractive for powering cars because of their high efficiency, high power density, and zero emission.

FACULTY NEWS


ANTONIEWICZ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SANDLER


SULLIVAN

FORMER FACULTY

Francis J. Doyle III, *Dean of the Harvard John A. Paulson School of Engineering and Applied Sciences, was elected to the National Academy of Medicine in October. He was a faculty member in our department from 1997 to 2002.*

Henry C. Foley *is the newest president at the New York Institute of Technology, effective June 1. He was on our faculty from 1986 to 2000.*

FACULTY HIGHLIGHTS

Maciek Antoniewicz has been appointed a Centennial Junior Professor in recognition of his accomplishments and contributions to UD's scholarship and educational programs. He is also promoted to professor starting in the 2017-8 academic year,

Joshua Enszer, assistant professor of instruction, won this year's College of Engineering Excellence in Teaching Award, given to a faculty member who demonstrates true excellence in teaching, is highly knowledgeable about his or her subject matter, challenges students intellectually, shows a deep committed to teaching, is skilled at communicating with students and promoting learning, and has a positive and long-lasting impact on students.

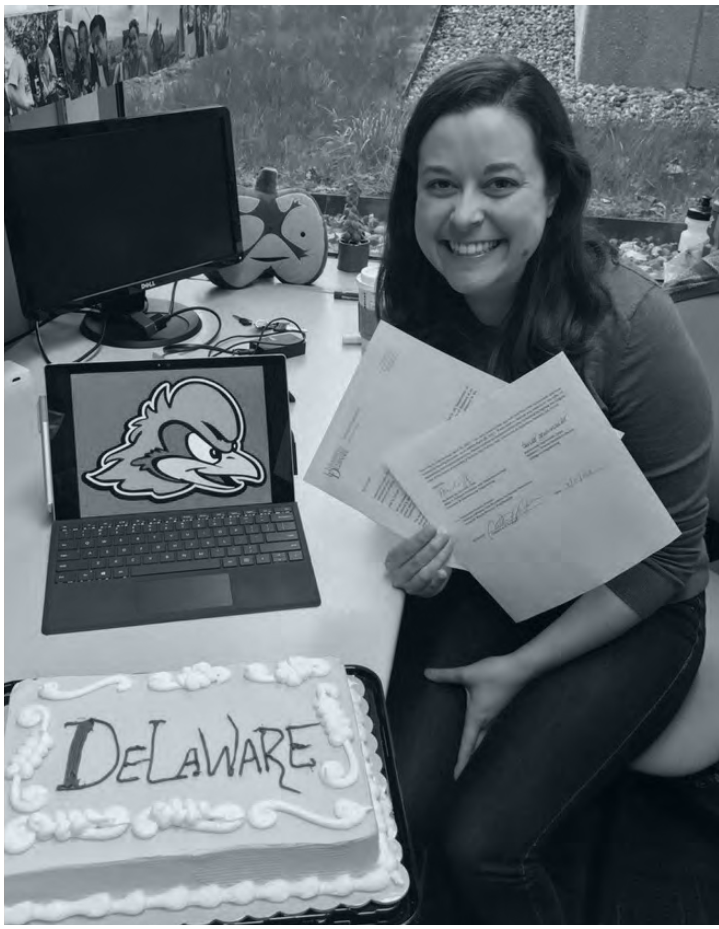
Thomas H. Epps, III, was selected to present the 2016 Thiele Lecture at the University of Notre Dame, named in honor of Ernest W. Thiele, a prolific 20th century chemical engineer.. This lectureship recognizes outstanding research contributions by a younger member of the chemical engineering profession.

Feng Jiao is promoted to associate professor starting in the 2017-8 academic year.

Babatunde Ogunnaike, dean of the College of Engineering, was awarded a fellowship from the Carnegie African Diaspora Fellowship Program. This enabled him to spend 15 days at the University of Lagos, where he worked with Prof. Adetokunbo Denloye to review and strengthen the master's program in chemical engineering.

Stanley Sandler was honored by the alumni association of the City College of New York as a 2017 Townsend Harris Medalist. This award was established in 1933 for outstanding postgraduate achievements in their chosen fields.

Millie Sullivan has been appointed a Centennial Junior Professor in recognition of her accomplishments and contributions to UD's scholarship and educational programs. She was also elected to the College of Fellows at the American Institute for Medical and Biological Engineering (AIMBE) for her outstanding contributions to the development of new materials for gene and drug delivery.



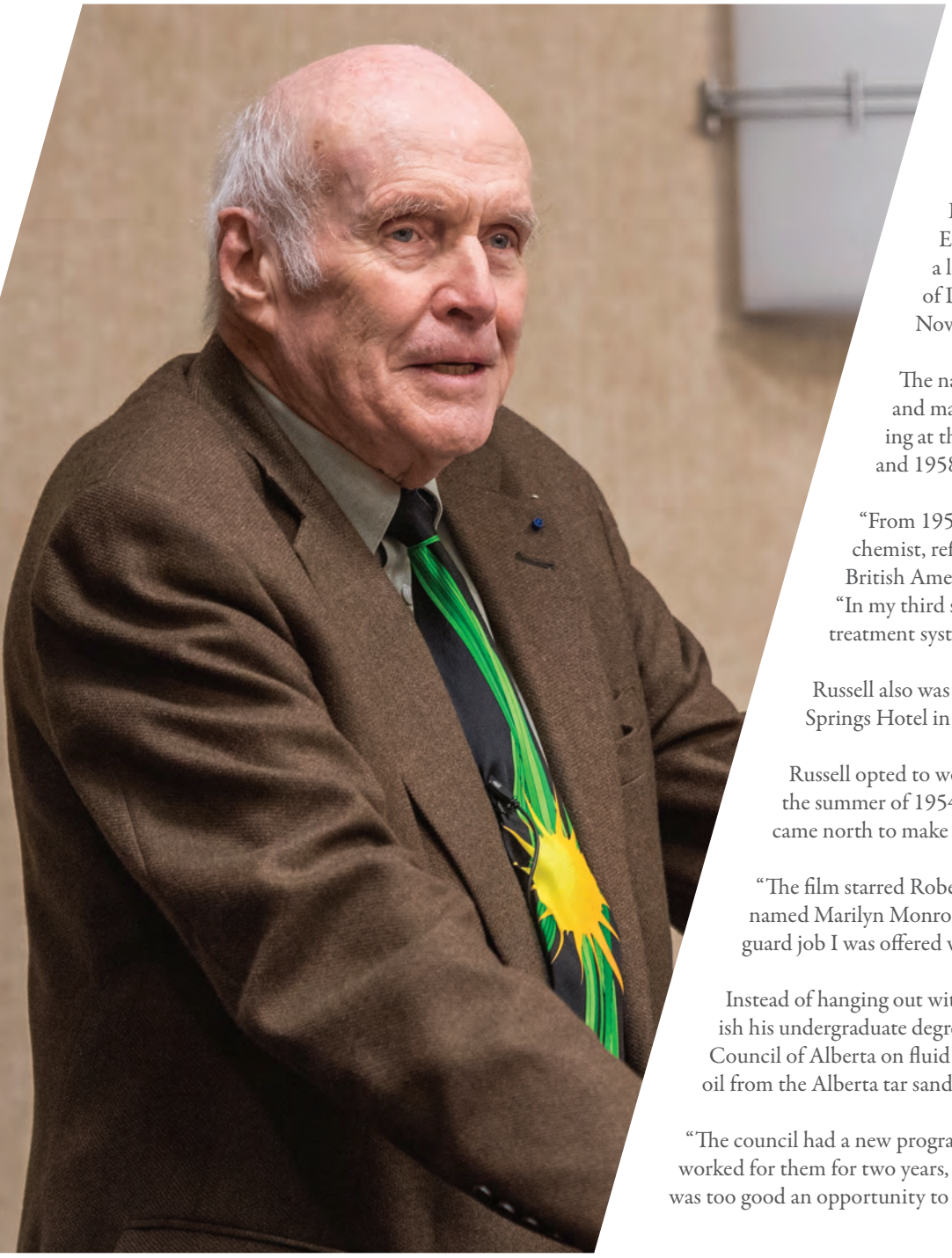
Cathy Fromen joins the department in Fall 2017

Cathy Fromen, who completed her Ph.D. in chemical engineering at North Carolina State University in 2014, is joining the department as an assistant professor this fall. She was previously a UM President's Postdoctoral Fellow at the University of Michigan. Fromen is passionate about advancing treatment of respiratory diseases and uses engineering tools in this pursuit. At UD, she plans to employ 3-D printing to optimize pulmonary drug delivery testing and use engineered nanoparticles to probe lung function and target immune cells involved in allergies, cancers, and other lung diseases. She celebrated her signing her acceptance letter with YouDee, the UD mascot, present in virtual form, and a cake, which was real!

A LIFE IN REVIEW

Fraser Russell reflects on career as teacher, researcher, administrator

During a summer as an undergraduate student, T.W. Fraser Russell chose to work in an oil refinery rather than take a lifeguard job at a world famous Canadian hostelry.



Working in the field in which he would become a respected teacher, researcher and author, Russell did, however, miss the opportunity to spend time with an iconic Hollywood star of the 1950s.

Russell, the Allan P. Colburn Professor Emeritus of Chemical and Biomolecular Engineering, shared his experiences during a lecture given to members of the University of Delaware Association of Retired Faculty in November.

The native of Canada earned his bachelor's degree and master of science degree in chemical engineering at the University of Alberta, Canada, in 1956 and 1958, respectively.

"From 1953 to 1955, I worked summers as a shift chemist, refinery operator and design engineer at the British American Oil Co. in Edmonton," Russell said. "In my third summer, I was asked to help design a waste treatment system for the refinery."

Russell also was offered a job as a lifeguard at the Banff Springs Hotel in Alberta, one of the world's premier hotels.

Russell opted to work on the water treatment project during the summer of 1954, the same year that people from Hollywood came north to make a movie called The River of No Return.

"The film starred Robert Mitchum and a little-known young actress named Marilyn Monroe," Russell said. "The man who took the lifeguard job I was offered was hired to teach the actress how to swim."

Instead of hanging out with the legendary star, Russell went on to finish his undergraduate degree and accepted a position with the Research Council of Alberta on fluid mechanics associated with the production of oil from the Alberta tar sands.

"The council had a new program where they offered a master's degree if you worked for them for two years, Russell recalled. "We also were paid, so it was too good an opportunity to turn down."

With undergraduate and master's degrees in hand, Fraser and his wife Shirley and two-year-old son Bruce made the trek from Edmonton to Montreal, where he had accepted a position as a design engineer with Union Carbide, Canada.

"They had just bought a plant there and wanted to do a major expansion," Russell said. "I had complete responsibility for the economic evaluation, process design, drafting, field construction and start-up for their ethylene glycol unit and the multi-purpose glycol ethers and ethanolamines unit."

In the fall of 1961, the Russell family, which now included sons Brian and Carey, arrived at UD, where Fraser would continue until his retirement in 2009.

"The presence of Arthur Metzner and Robert Pigford, chemical engineers with both an exceptional academic and professional reputation, who understood people and how to effectively interact with them, made coming to UD seem like a good idea," Russell said.

Russell received his doctoral degree in 1964, with the completion of his experimental doctoral thesis on "The Flow Mechanism of Two Phase Annular Flow," supervised by David Lamb, and officially joined the UD faculty.

After receiving his doctorate, Russell partnered with colleague Morton Denn to redesign the traditional freshman chemical engineering class.

"For six years we taught the class in two sessions," Russell said. "Mort and I would get together to compare notes on the classroom effectiveness of the course material being developed."

This collaboration also produced Introduction to Chemical Engineering Analysis, published by John Wiley and Sons in 1972.

Promoted to associate professor in 1967 and full professor in 1970, Russell also held administrative positions, including associate and acting dean of the College of Engineering.

Russell also recalled being tapped to direct UD's Institute for Energy Conversion (IEC) in 1979.

"Federal funding for photovoltaic research was being reduced from $150 million to $40 million annually," Russell said. "Between 1979 and 1996, we were able to receive over $20 million in federal funding, $3 million from industry and over $600,000 from the state, and this set up the institute on a healthy basis."

In addition, the Institute for Energy Conversion was recognized by the U.S. Department of Energy as a center of excellence for photovoltaic research.

This achievement, Russell noted, was due in large part to having an excellent staff through the years that included Sheri Barwick, Margaret Stallings, Linda Huber and Paula Newton.
Russell also served as the chair of the Department of Chemical Engineering from 1986 to 1991.

In 1990, Russell was elected a member of the National Academy of Engineering and also received the Francis Alison Award, UD's highest faculty honor.

"THE PRESENCE OF ARTHUR METZNER AND ROBERT PIGFORD, CHEMICAL ENGINEERS WITH BOTH AN EXCEPTIONAL ACADEMIC AND PROFESSIONAL REPUTATION, WHO UNDERSTOOD PEOPLE AND HOW TO EFFECTIVELY INTERACT WITH THEM, MADE COMING TO UD SEEM LIKE A GOOD IDEA."

NIIMBL

MANUFACTURING USA HEADQUARTERS

UD will be the headquarters for a new institute to advance U.S. leadership in pharmaceutical manufacturing. The National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL) is the 11th Manufacturing USA Institute. This network of institutes aims to promote U.S. manufacturing through innovation, collaboration and education.

Kelvin Lee, Gore Professor of Chemical and Biomolecular Engineering and director of the Delaware Biotechnology Institute, spearheaded NIIMBL's application, which was chosen from among nearly two dozen proposals. Universities, state governments, nonprofits and companies of various sizes, including ILC Dover, Biogen and Eli Lilly, just to name a few, rallied around the idea of creating what Lee calls a "transformative" institute. Lee now serves as the director of NIIMBL.

"It's a natural coalescence of a lot of different groups at the local level as well as at the national level," Lee said, pointing to the strength of pharmaceutical manufacturing in the region and UD's record of excellence in chemical and biomolecular engineering.

"UD has a long history of significant contributions in the fields of manufacturing, materials and engineering, exemplified by Nobel laureate Richard Heck's work that revolutionized pharmaceutical manufacturing," said University President Dennis Assanis. "We are committed to developing the innovative tools and techniques of tomorrow's advanced-manufacturing facilities. We are also proud to contribute our efforts to improve the well-being of individuals and society."

The demand for disease-treating biopharmaceuticals, which often succeed where traditional drug treatments have failed, is skyrocketing. Biopharmaceuticals, prescription drugs made living cell, can be complex to manufacture on a mass scale.

Most drugs are chemistry based. Whereas production of chemistry-based drugs involves a set discrete number of steps with results that can be replicated over and over, production of biology-based drugs involves thousands more steps with far more variability.

The biopharmaceutical category includes vaccines, cancer drugs and drugs to treat autoimmune diseases, as well as emerging drugs for cell and gene therapies.

Innovations in biopharmaceutical manufacturing will mean more patients have access to the most beneficial therapies. The institute will also help ensure the nation can rapidly scale up manufacture of these advanced treatments to respond to pandemics and other biological threats, and eliminate drug shortages that can result from quality control issues in manufacturing. The institute will also focus on bringing safe drugs to market faster.

"The awarding of NIIMBL signals affirmation on the national scale of the excellence in research and innovation at the University of Delaware. This consortium is a wonderful example of the role federal investment in research and manufacturing can play in spurring and accelerating technological advances to benefit the U.S. economy," said Charlie Riordan, UD's vice president for research, scholarship and innovation.

A team of companies, educational institutions, nonprofits and state governments will operate NIIMBL under a newly formed nonprofit. Expected total investment from all stakeholders totals $250 million, including $70 million of federal investment.

The University of Delaware will handle administrative duties for the institute in partnership with the Commerce Department's National Institute of Standards and Technology (NIST). Its headquarters will be on UD's campus in a location to be determined.

Former Secretary of Commerce Penny Pritzker visited campus in December to announce the new institute.

"In communities from coast to coast, the Manufacturing USA network is breaking down silos between the U.S. private sector and academia to take industry-relevant technologies from lab to market," Pritzker said. "The institute announced today is a resource that will spread the risks and share the benefits across the biopharmaceutical industry of developing and gaining approval for innovative processes. The innovations created here will make it easier for industry to scale up production and provide the most ground-breaking new therapies to more patients sooner."

NIIMBL's academic members represent both research universities and community colleges. Community colleges, such as Delaware Technical Community College, pledged to develop workforce training, curriculum development and certification standards that will ensure a pipeline of skilled workers. The biopharmaceutical field has a negative unemployment rate, with more jobs available than there are qualified workers.

U.S. Sen. Chris Coons, Delaware's junior senator who holds a degree in chemistry, championed the creation of the Manufacturing USA Network. "I'm thrilled to mark this tremendous victory for the University of Delaware and all the partners in this new institute," Coons said. "This announcement makes official what I've long known – the University of Delaware is a true hub of manufacturing innovation. This new institute brings together leading academic, nonprofit and private sector organizations from across the country to accelerate innovation that ensures the United States remains the world leader in biopharmaceutical manufacturing."

UD to lead major node of new national chemical manufacturing institute

The University of Delaware has been tapped to lead a major node in the new Rapid Advancement in Process Intensification Deployment (RAPID) Manufacturing Institute led by the American Institute of Chemical Engineers (AIChE).

Headed by Chief Executive Officer **KAREN FLETCHER '81 M'82**, former chief engineer and vice president of engineering, facilities and real estate at DuPont, RAPID will leverage $70 million in federal funding from the Energy Department over five years and an additional $70 million in private cost-share commitments from partners.

The University of Delaware, led by Dion Vlachos, Allan and Myra Ferguson Chair of Chemical Engineering, will lead a major node of RAPID focusing on catalysis and reactors, and also will be involved in other dimensions of RAPID's research and development agenda led by other universities.

The U.S. Department of Energy announced RAPID as the tenth member of the national network of Manufacturing USA Institutes on Dec. 9 at the U.S. Council on Competitiveness' 2016 National Competitiveness Forum in Washington, D.C. RAPID's role will be to develop breakthrough technologies and processes that will boost energy productivity and efficiency and decrease environmental impacts, especially related to chemical manufacturing. To tackle this work, RAPID already has enlisted 130 partners from companies, academic institutions including UD, national and government laboratories and non-governmental organizations across the U.S.

"Our goal is to work in partnership with industry to make better, smaller, more energy efficient, lower cost chemical manufacturing processes and technologies," Vlachos said. "Our work will have application in such areas as clean water, the paper industry, and the conversion of wood waste and other biomass into fuels and other useful chemicals."

UD has a legacy of pioneering research on catalysis, especially via the Center for Catalytic Science and Technology, which has been part of our department for over 40 years. Current activities also include the Catalysis Center for Energy Innovation, the DOE Energy Frontier Research Center that Vlachos directs, involving universities, national labs and industry. Catalysis research elsewhere at UD includes the legendary work of the late Richard Heck, 2010 Nobel Laureate, whose work revolutionized pharmaceutical manufacturing, DNA sequencing and other fields.

While experts in catalysis from across UD will be involved, collaboration with industries locally and across the nation will be key.

"How will we develop new modular, small-scale devices for work in the middle of the ocean or in the middle of the woods?" Vlachos said. "This is some of the exciting work that lies ahead of us."

"In conjunction with other advanced manufacturing activities already established on campus, this exciting announcement establishes UD beyond any further doubt, as one of the main hubs for 21st-century manufacturing innovation, workforce development and industrial collaborations," said Babatunde Ogunnaike, dean of the College of Engineering. "This opens up a whole new field for UD to make contributions to activities

Researchers lead effort to make more sustainable consumer products

Synthetic rubber and plastics – used for manufacturing tires, toys and myriad other products – are produced from butadiene, a molecule traditionally made from fossil fuels. Those materials could get a lot greener soon, thanks to the ingenuity of a team of scientists from UD, the University of Minnesota and the University of Massachusetts. They have invented a process to make butadiene from renewable sources like trees, grasses and corn.

The findings were published in the American Chemical Society's ACS Sustainable Chemistry and Engineering. The study's authors are affiliated with the Catalysis Center for Energy Innovation (CCEI) based at UD, an Energy Frontier Research Center funded by the U.S. Department of Energy.

"Our team combined a catalyst we recently discovered with new and exciting chemistry to find the first high-yield, low-cost method of manufacturing butadiene," says CCEI Director Dionisios Vlachos, the Allan and Myra Ferguson Professor of Chemical and Biomolecular Engineering at UD and a co-author of the study. "This research could transform the multi-billion-dollar plastics and rubber industries."

The novel chemistry included a three-step process starting from biomass-derived sugars. Using technology developed within CCEI, the team converted sugars to a ring compound called furfural. In the second step, the team further processed furfural to another ring compound called tetrahydrofuran (THF).

It was in the third step that the team found the breakthrough chemical manufacturing technology. Using a new catalyst called "phosphorous all-silica zeolite," developed within the center, the team was able to convert THF to butadiene with high yield (greater than 95 percent).

The team called this new, selective reaction "dehydra-decyclization" to represent its capability for simultaneously removing water and opening ring compounds at once.

UD researchers were also part of a project to invent a new soap molecule made from renewable sources instead of fossil fuels.

The study was published in the American Chemical Society's ACS Central Science. Authors of the study include researchers from UD, the University of Massachusetts, the University of Minnesota, Sironix Renewables and Argonne National Laboratory. The work was funded by the CCEI.

Researchers from the CCEI developed a new chemical process to combine fatty acids from soybeans or coconut and sugar-derived rings from corn to make a renewable soap molecule called oleo-furan-surfactant (OFS). OFS worked well in cold water and hard water and formed soap particles necessary for cleaning applications at low concentrations, which significantly reduces the environmental impact to rivers and lakes.

"The impact of OFS soaps will be greater than their detergent performance," says Vlachos. "OFS is made from straight carbon chains derived from soybeans or coconut which can readily biodegrade — these are really the perfect soap molecules."

ARRESTED RECURRENCE

Kloxin group looking to stop breast cancer recurrence

Although early detection and improved treatments have resulted in more women with breast cancer surviving past the five-year mark, 20 percent of disease-free patients will experience a recurrence anywhere from five to 25 years later at a metastatic site — most often in the bone marrow or the lungs. And their chances of surviving this secondary cancer are lower because it is often quite advanced before it is detected.

"There's a significant clinical need to understand the mechanism of late cancer recurrence to determine disease markers and improve treatment strategies," says assistant professor April Kloxin. "It has been hypothesized that late recurrences originate from tumor cells that disseminate to these other tissues in the body where they become dormant and are later re-activated."

Kloxin received a $450,000 grant from Susan G. Komen aimed at developing a better understanding of this dormancy and reactivation process so that ultimately recurrence can be prevented.

"While estrogen receptor positive tumors typically have better initial outcomes, late recurrences are a concern," she says. "If we can understand the mechanisms that drive the switch from dormancy to growth of this type of cancer, we can identify predictive biomarkers that may indicate which women are at risk and lay the foundation for the development of more effective treatment."

Kloxin's team plans first to create materials that mimic various metastatic sites and then identify key signaling pathways in cancer dormancy within these 3-D microenvironments. Second, they will focus on determining what regulates re-activation of the cancer cells within this cultured system. Finally, they will establish commonalities of dormancy or activation of patient-derived tumor cells in the culture model.

"This last goal is where we're really excited about our collaboration with the Helen F. Graham Cancer Center and Research Institute in the Christiana Care Health System," Kloxin says. "Evaluating cells from actual patients will provide us with the heterogeneity of real cases and enable us to compare our findings with the traditional markers observed by clinicians."

The funding is part of a $32.7 million package of research grants recently announced by Komen, including more than $16 million to early-career investigators like Kloxin awarded through the organization's Career Catalyst Research Grants.

These grants are intended to foster promising young breast cancer researchers by providing them with support for up to three years for research career development under the guidance of a mentor committee.

"Komen's goal is to end breast cancer forever," Kloxin says. "It's exciting to be part of the global research community working to make this happen by using a variety of approaches and calling on the expertise of a broad range of people."

MAKING THE CASE FOR FUEL CELLS

Yan group sets performance targets for alternative fuel cell technology

The pathway to zero-emission vehicles has taken two forks, one toward battery electric cars like the Tesla and the other toward fuel-cell-powered automobiles like the Toyota Mirai. Yushan Yan, Distinguished Engineering Professor, believes that fuel cell vehicles are the way to go, because they best preserve the advantages of gasoline automobiles: low upfront cost, long driving range and fast refueling.

But he also believes that a new fuel cell technology may be necessary.

For Yan, that approach is a new twist on traditional fuel cells, known as proton exchange membrane fuel cells, or PEMFCs, which rely on costly platinum-based catalysts. Yan and his research team are pursuing an alternative technology, the hydroxide exchange membrane fuel cell (HEMFC), because of its cost advantages.

He sees the rationale for this proposed switch as a matter of very simple arithmetic.

"To make fuel-cell cars a reality, the DOE (Department of Energy) has set a system cost target of $30 per kilowatt, which translates into about $2,400 per car," he says. "Right now, the cost for PEMFCs is $52 per kilowatt, which is a big improvement over where the technology started."

"But the catalyst accounts for only about $12 of that total, leaving $40 worth of other components. So even if we throw in some magic, we can't get the rest of the way down to the target of $30 with PEMFCs."

Yan is co-author on a paper published last year in Nature Nanotechnology that he views as a roadmap to a unified strategy for HEMFC zero-emission cars based on three arguments.

"First, to become a commercial reality, fuel cell engines have to be at cost parity with their gasoline counterparts," he says, "and moving from an acid platform with the PEMFC to a base system with the HEMFC will enable a collateral benefit in bringing down all of the associated costs.

"Then, if we agree that this is the best approach, we need to get everyone in the HEMFC research community on board. If we want to succeed, we have to work together."

Finally, Yan warns that it is insufficient just to have a lower cost.

"It doesn't work to compare our results today with those from yesterday or the day before," he says. "To succeed commercially with HEMFCs, we have to match or beat the performance of PEMFCs. It's that simple — we can't succeed without achieving performance parity."

$30
PER kW
Department of Energy (DOE) cost target

$2400
PER CAR
Total DOE energy cost target per car

The paper, "Activity Targets for Nanostructured Platinum Group Metal-Free Catalysts in Hydroxide Exchange Membrane Fuel Cells," was co-authored by Brian P. Setzler, Zhongbin Zhuang, Jarrid A. Wittkopf, and Yushan Yan. Setzler is a postdoctoral researcher in Yan's group, and Wittkopf is a doctoral student advised by Yan. Zhuang is a professor at Beijing University of Chemical Technology and a former postdoctoral researcher in Yan's group.

For research on polymer-based hydroxide exchange membranes (HEMs), Yan's group has been awarded $1.8 million in funding from the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) through its new IONICS (Integration and Optimization of Novel Ion-Conducting Solids) program. IONICS project teams are paving the way for technologies that overcome the limitations of current battery and fuel cell products.

"Our HEMs provide excellent mechanical robustness while maintaining chemical stability and high conductivity," says Yan. "Our goal is to develop a process to easily synthesize the polymer at scale, creating large area membranes for testing that are thinner than human hair. Production costs will be minimized by using lower cost ingredients in the manufacturing process."

This membrane work is a critical part of a larger overall effort at UD to make platinum-free fuel cells a commercial reality for zero-emission cars. Yan's group is addressing what is perhaps the biggest challenge facing fuel cells — cost.

The project, "Highly Conductive, Stable and Robust Hydroxide Exchange Membranes Based on Poly (Aryl Piperidinium)," is one of 16 funded through the $37 million program, which is aimed at transforming energy storage and conversion.

The Delaware-led team includes Yan, Bingjun Xu, Shimshon Gottesfeld, Junhua Wang, and Yun Zhao of the Department of Chemical and Biomolecular Engineering; Shuang Gu, a former student, postdoc, and research faculty with Yan, now at Wichita State University; Hui Xu of Giner Inc. in Massachusetts; and Bamdad Bahar of Xergy Inc. in Delaware. According to ARPA, developments made under the IONICS program have the potential to increase the energy storage content for vehicle batteries by more than 30 percent over today's lithium-ion batteries, reduce the cost of fuel cells for vehicles by 25 percent through a reduction of precious metal catalysts and expensive metal plates, and significantly reduce battery system costs for the grid to about $150/kWh (for a five-hour discharge time).

The funded projects also have the potential to improve U.S. energy security by enabling the production of more domestic, renewable energy while increasing economic competitiveness and reducing the country's carbon footprint.

Old enzyme, new role

Researchers in our department have discovered a new function for an enzyme that has long been known to have a central role in bacterial metabolism.

"Many of the core metabolic pathways are shared across widely diverse branches of life, and fundamental understanding of the enzymes involved is a central effort of cell biology and biochemistry," says Maciek Antoniewicz, Centennial Junior Associate Professor. "This basic knowledge is also critical for efforts such as using models of metabolism to rationally re-engineer microbes for the production of biofuels or chemicals — that is, metabolic engineering."

He and his team investigated a system of four enzymes that work together both to bring sugar into the cell and to carry out a downstream step in its breakdown in a process called glycolysis.

Coupling the steps in this system, known as PTS (short for phosphoenolypyruvate-carbohydrate phosphotransferase), allows the cell to match how fast it "eats" to how fast it is able to "digest," so that it can grow most efficiently when sugar is available. It also allows the cell to sense and adapt when sugars are no longer available.

Enzyme I, the final step of the PTS reaction chain, carries out the downstream reaction converting the metabolite known as PEP to pyruvate. The Antoniewicz group demonstrated that Enzyme I is also able to perform the reverse reaction, converting pyruvate to PEP.

Their findings were published online in Nature Communications in January.

"We've shown for the first time that Enzyme I plays a major role when the pathway runs in the reverse direction to generate sugars from non-sugar substrates like acetate and pyruvate in a process called gluconeogenesis," Antoniewicz says.

"Additionally, we've shown that even when sugar is being consumed, and the major direction of carbon flow is from PEP to pyruvate, Enzyme I still facilitates some 'back-flow' in the opposite direction. We also studied some of the dynamics of the PTS reaction chain by observing that this back-flow is altered when the other PTS enzymes are removed one at a time."

Since the PTS system is used by most bacteria, Antoniewicz believes that these results are likely to be replicated in other species as well. "E. coli is by far the most well-studied bacterium, so it is remarkable that we still are learning new things about its central pathways," he says.

"It is also an important industrial microorganism, and sugar uptake and regulation in particular are areas of frequent interest for metabolic engineers. These results also challenge the conventional textbook wisdom about the energy and regulation of glycolysis, which says that the PEP to pyruvate reaction has a large energy drop and is thus irreversible."

BIOFUEL BREAKTHROUGH

Bio-fuels and bio-based chemicals have gained traction over the past decade as a means to produce alternatives to fossil fuels and to replace bulk chemical production methods that rely on petrochemicals.

"Methanol, which can be produced inexpensively from natural gas or renewably through the reduction of carbon dioxide by hydrogen, can serve as a feedstock to produce biofuels, amino acids, and polymers," says Wilfred Chen, Gore Professor. "However, the initial reaction in the conversion of methanol to formaldehyde is highly reversible."

To overcome this obstacle to methanol utilization, Chen teamed with Eleftherios (Terry) Papoutsakis, Eugene DuPont Professor, to develop a biological approach that renders the process irreversible.

Their work is reported in a paper, "Scaffoldless Engineered Enzyme Assembly for Enhanced Methanol Utilization," published in the Proceedings of the National Academy of Sciences.
"In effect, we broke the reversibility of the process by coupling the initial reaction with a pair of irreversible reactions to assemble enzymes into supramolecular clusters," Chen says.
The combined strategies improved in vitro production of fructose-6-phosphate, or F6P, by almost 100-fold compared with unassembled enzymes. F6P is a key intermediate in the biosynthesis of fuel molecules such as butanol.

The beneficial effect of supramolecular enzyme assembly was also realized in culture experiments, where the engineered enzyme assembly resulted in a nine-fold improvement of the whole-cell methanol consumption rate.

"This approach provides a platform for the direct coupling of enhanced F6P synthesis with many other metabolic engineering strategies such as the methanol condensation cycle for biological conversion of methanol to higher value chemicals," Chen says.

NSF GRANT SUPPORTS RESEARCH ON ASSEMBLY OF COMPLEX HYBRID NANOMATERIALS

An old saying suggests that great things come in small packages, but when "small" means nanoscale, putting those packages together can be a challenge—particularly when they involve diverse components.

"The intimate combination of inorganic nanoparticles and organic polymers within nanoscale packages of controlled sizes and shapes presents challenges in terms of production, while also offering opportunities for unique material properties," says associate professor Arthi Jayaraman.

Funded by a four-year grant from the National Science Foundation, Jayaraman — along with Darrin Pochan of UD Materials Science and Engineering, William Johnson from the University of Utah and Karen Wooley from Texas A&M — will address those challenges so that the potential of these materials can be realized in a broad range of applications.

The research is aimed at developing computational and experimental tools that will guide the discovery and manufacture of hybrid inorganic-organic nanostructured objects, or HIONs.

According to Jayaraman, computer-based assembly of polymers is usually accomplished in a stationary manner, but in the proposed work these hybrid materials will be assembled using a more dynamic approach. Pochan and Jayaraman liken this sequential process to building a shopping cart at the grocery store, then filling it in a prescribed, ordered way — for example, meat, vegetables, dairy, baked goods — and finally unloading it in the reverse order.

"As the material is built, the molecules move along a surface and collect various particles in a sequential manner, introducing new chemistries along the way — for example, hydrophobic, hydrophilic, and charged, in that order," Jayaraman says. "At the end, we have a new material with properties designed in layers, each layer intended for a specific role in the eventual application."

These hybrid materials can interact with complex natural materials like soils and water, so one potential application is pollution remediation, as HIONS can be designed to collect pollutants left behind by processes like fracking that take place in porous rock.

"Our ultimate goal is to enable high-throughput, tunable manufacturing of complex HIONs that exhibit compositions, structures, morphologies and properties for diverse technological applications," Jayaraman says. "We've already started to incorporate these concepts into our upper-level undergraduate and graduate-level polymer course in chemical engineering and materials science at UD."

Epps team highlights work on tuning block polymers for nanostructured systems

A research group led by Thomas H. Epps, III, Thomas and Kipp Gutshall Professor, is making strides in the development of block polymers.

These materials, two or more polymer chains with different properties linked together, show promise in energy generation and digital information storage.

"We are using synthesis, processing and characterization methods that are robust and widely applicable, with an eye toward scaling these methods to facilitate the future industrial adoption of block polymers," says Epps.

The group aims to tune and characterize block polymers in bulk and thin film geometries. They manipulate the phase behavior, thermal transitions and mechanical and transport properties of block polymers to optimize materials design. The group uses nanoscale structures to improve device performance and processing. They have developed high-throughput and combinatorial computational methods that allow nanoscale structures to be visualized with relatively low-cost optical techniques.

"Basically, this approach enables us to minimize the number of samples that need to be measured with expensive techniques such as atomic force microscopy and transmission electron microscopy," Epps says.

The group also has developed universal design rules to understand key factors that link surface characteristics to nanostructure formation.

"These rules enable us to predict which polymers will work well with which surfaces, so, for example, we can create self-cleaning coatings that can resist fingerprint smudges on touchscreens," Epps says.

Materials strong enough for Mars

Norm Wagner, Unidel Robert L. Pigford Chair, wants to go to Mars.

But to live on Mars, humans will need flexible, robust protection against punctures, abrasions, and micrometeoroids.

Wagner's startup company, STF Technologies, develops flexible materials that can withstand impact, including advanced space suits. The team works on shear thickening fluids, dispersions of nanoparticles in a fluid that respond to an applied force or stress such that the harder you try to make them flow, the stiffer they become.

Cofounder **RICHARD DOMBROWSKI '03**, runs the company's day-to-day operations. They have funding from and collaborate with the Army Research Labs and NASA as well as private industry. Wagner recently told Inside Science: "We really want to develop materials that will be able to protect astronauts, both on the way and when they're on the surface of the planetary surface. And these advanced nano-structured materials require science that we don't have yet. So, that drives a need for scientific understanding and how homogeneous gels can be created, and how we can control that through the processing of these materials."

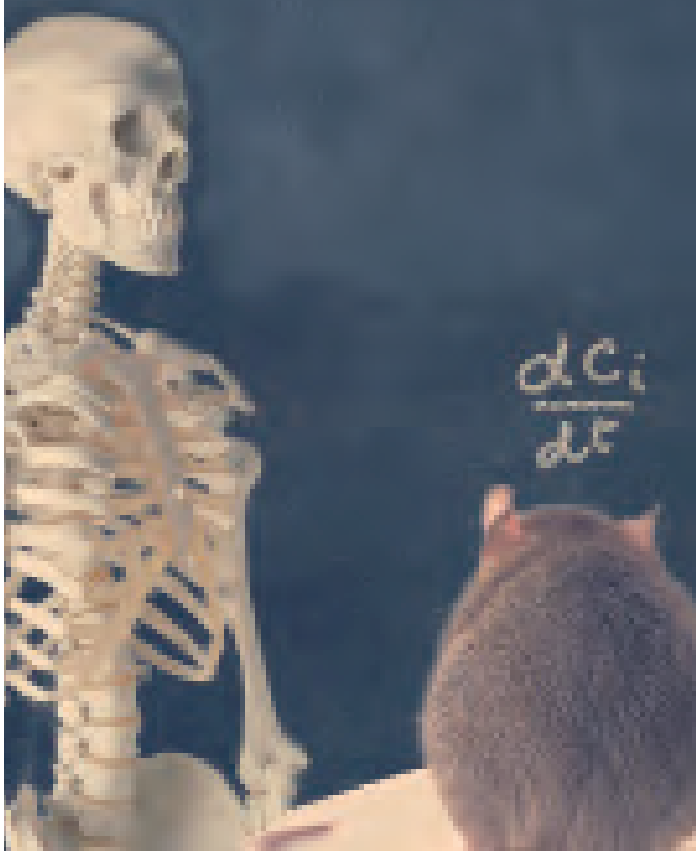
Wagner's work was also showcased in a video premiered by the American Chemical Society at the 2017 South by Southwest festival.

Engineering stronger bones

More than 10 million people in the United States live with osteoporosis and the resulting fractures demand more than $17 billion in related health care each year.

Now two research teams have joined forces to point the way to a promising remedy. Anja Nohe, an associate professor in biological sciences, has shown that treating a mouse with a peptide known as CK2.3 increases bone mineral density. Then Prasad Dhurjati, a professor in CBE, calculated estimated dosages for human beings.

According to their model, injections of CK2.3 can raise bone mineral density of bones badly degraded by osteoporosis back to healthy levels. Their work was published earlier this year in Pharmacometrics and Systems Pharmacology. Dhurjati developed part of the model using the concepts in physiology-based pharmacokinetic (PBPK) models pioneered by the late Kenneth Bischoff, Unidel Professor of Chemical Engineering. Such models can be used to calculate how a pharmaceutical molecule distributes in different parts of the body.



Rise and Science

Two of our grad students are bringing their passion for science to the general public through a new radio show called "Rise and Science."

Katherine Wiley and Rashida Ruddock, doctoral students in CBE, co-direct the show, which was founded by **LISA SAWICKI, D'17.** They have five teams of hosts.

Wiley and Ruddock are passionate about sharing exciting science with the general public, as science plays an integral in our daily lives, from healthcare to the environment to technology and more.

"Since science plays such an essential role in the future of our world, it's crucial that as many people as possible are engaged in the dialogue so that they can contribute their opinions and help to guide the direction of science," they say. "We believe that by taking complex scientific topics, breaking them down, and bringing them to the public, we can help our listeners to become more informed and arm them with the knowledge necessary to contribute to the conversation."

In a typical show, they might feature an interview with a professor or industrial scientist, but they're also interested in starting conversations with other "players in the science space, such as policy makers, funding agencies, and scientific publishing agencies."

The team also includes recurring "Science News" segments to discuss current events and "Science for You" segments that break down everyday topics in science. They also hope to introduce a new segment soon.

"Rise and Science" airs Tuesdays from 8:30 to 9 a.m. on 91.3 WVUD. You can also catch the podcast on udriseandscience.com, iTunes and GooglePlay.

Assistant Professor April Kloxin (second from left) with Rise & Science students on The Green at UD.

STUDY ABROAD TO AUSTRALIA

January 2017 saw another enthusiastic group of UD chemical engineering students spend the winter session on a Study Abroad trip at the University of Melbourne, in Australia. The program was launched by Prof. Stanley Sandler and is now organized every other year, with courses offered that allow both juniors and seniors to participate. While Prof. Sandler was on the trip again this year, the group was led for the first time by Prof. Millie Sullivan, who taught one of the courses offered. A second, on Australian literature, was taught by Prof. Ellen Pifer, professor emerita of English, and a third by our own alumnus, **RAY DAGASTINE, '97,** who is a faculty member in chemical engineering at the University of Melbourne. The student group numbered 32 and their experience was enriched by their being joined by a few Melbourne students, which helped to integrate them more extensively into local culture. The trip is a demanding one academically but certainly also allows time for the group to enjoy Australia in the summer. Outings included a visit to Sydney, a trip on the Great Ocean Road and the opportunity to meet Australian wildlife.

TYLER ROBERTS SELECTED TO RECEIVE THE AICHE-DVS SCHOLARSHIP

TYLER ROBERTS, '18, won the AIChE Delaware Valley Section's Scholarship for Excellence in Technical Writing on Sustainability and the Environment, sponsored by the FMC Corporation. His essay emphasized the role that chemical engineers can play in reducing global energy consumption. For example, he wrote: "We are in a fortunate situation to be at the front lines of cutting edge research that has the capacity to forever change energy consumption. We have the tools to optimize chemical processes and we have the business backing to make educated decisions based on energy outlooks. We can participate in these efforts not only to protect the environment, but also to project those around us and around the world." As part of the award, Tyler was the keynote speaker at the section's annual awards banquet, which was held in April at UD's Trabant University Center. He used the 30 minutes to recount his experience doing emergency home repairs on a University of Delaware Alternative Spring Break (UDaB) trip to West Virginia and explain how chemical engineers can use their problem-solving skills to help others in need. Efficiency gains, capital investments, adoption of solar and wind technology, and formation of new companies could make a difference.

"WE ARE IN A FORTUNATE SITUATION TO BE AT THE FRONT LINES OF CUTTING EDGE RESEARCH THAT HAS THE CAPACITY TO FOREVER CHANGE ENERGY CONSUMPTION."

Gerhard Wittreich receives Excellence in Graduate Student Teaching Award

Gerhard Wittreich (far right in photo), a graduate student in the department, was one of four recipients of this year's campus-wide Excellence in Graduate Student Teaching Award. Each awardee received $1,500. "I taught a graduate math class for chemical engineering Ph.D. students," he said. "This class is foundational to vector and tensor calculus and brings together key tools for solving complex engineering problems. It was my philosophy to not only focus on the theory but to connect the theory to practical applications. I did this in a way that shared my passion for teaching and interacting with bright minds, my excitement about the math and my empathy for the difficulty of the topic. My goal was that these tools become an important part of their arsenal as they approach their research."

GRADUATE STUDENT HONORS

RU CHEN was selected to participate in the Delaware Launchpad Startup Accelerator through the Horn Program in Entrepreneurship last year. She was also selected to present her work at the Student Innovation Showcase at the National Academy of Inventors 6th Annual Conference. Her invention, "Ultra-stretchable Conductive Polymer and Muscle Strain Sensor Muscle Vector Patch (MVP)," is a wearable, stretchable, electronic material that could be used for a variety of consumer products.

JOSHUA CONDON won a best poster award from the American Chemical Society Division of Polymeric Materials: Science and Engineering. The poster, "Molecular Simulation Studies of Phase Transitions in Diblock Polymer Conjugates of Elastin-Like Peptides and Collagen Mimicking Peptide Triple Helices," was co-authored by doctoral student Tyler Martin and associate professor Arthi Jayaraman.

CHAD GRECO is part of a team that was selected as a finalist in the BIOT-ESBES First Annual Biotechnology Design Competition. This competition, in which each team works on a problem facing the biopharmaceutical industry, is organized by the European Society for Biochemical Engineering Sciences (ESBES) in cooperation with the American Chemical Society's Biochemical Technology Division (ACS-BIOT). Chad and his team members will attend the WCCE10 meeting in Barcelona in October to present their project.

WESLEY LUC has been chosen to receive the 2017 Bill N. Baron Fellowship for his contribution to the solar energy field and research conducted under assistant professor Feng Jiao.

ALEXANDER MIRONENKO was selected to participate in the 67th Lindau Nobel Laureate Meeting in June. He is one of 420 chemistry researchers under age 35 who passed a multi-stage international selection process to attend this meeting with 28 Nobel Laureates.

CAMERON SHELTON won first place in the Division of Polymer Physics (DPOLY) poster session at the American Physical Society (APS) meeting. His poster was titled "Quantifying lithium salt distributions in nanostructured ion-conducting polymer domains: a neutron reflectometry study."

Congratulations TO THE CLASS OF 2017!

UNDERGRATUATES

Yousuf Al Lawati
Abdulmalik Al Mawali
Abdullah Albalushi
Ahmed Al-Marjibi
Jason Andrechak
Matthew Ballweg
Fatma Bu Khamseen
Thanh Chinh
Aditya Chinmaya
Shea Cole
Charles Collins
Jessica Cowan
Clayton Cuddington
Joshua Culver
Morgan Dezendorf
Brian Dinkelacker
Andrew Dorfman
Josh Dubey
Kyle Ducharme
Kaitlyn Engler
Tyler Flematti
Bhavin Gala
Kyle Gomes
Courtney Green
Anthony Grippe
Theodore Groth
Jonathan Grunewald
Juan Guzman Tinoco
Alex Halvey
Nathan Hamilton
Kelsey Harrison
Joseph Hasse
Sarah Heether
Shally Hernandez Texis
Alexander Hillsley
Mark Kai Leung Ho
Matthew Ingham
Chelsea Keefe
Benjamin Keeper
Lindsay Kelly
James Kennedy
Isaac King
Mae Langrehr
Michael Lehrich
Bonnie Limpawuchara
Charlie Lin
Jingya Ling
Yangchen Liu
Alexis Mattio
Robert McAllister
Thomas McDonald
Roxana Mitrut
Ashwin Monian
Hannah Mushock
Marisa Myrick
Brian Phillips
Robert Pifer
Blake Prescott
Kaelan Reed
Wesley Ricker
Sara Rutch
Austin Ryan
Alexander Sadat
John Saltwick
Rebecca Sassone
Jamie Schwartz
Nicholas Seymour
Zachary Shirk
Curtis Strab
Wenxin Wang
Matthew Weber

Evan Wells
Jake Wiley
Minghan Xian
Jaclyn Zimmermann

MChE

Trishelle Copeland-Johnson
Emma De Baets
Lauren Dorsey
Laurens Heusele
Jeffrey Heyes
Garam Lee
Taylor Robie

MEPT

Debanwita Banerjee
Yuze He
Matthew Maille
Michael Stevenson

PhD

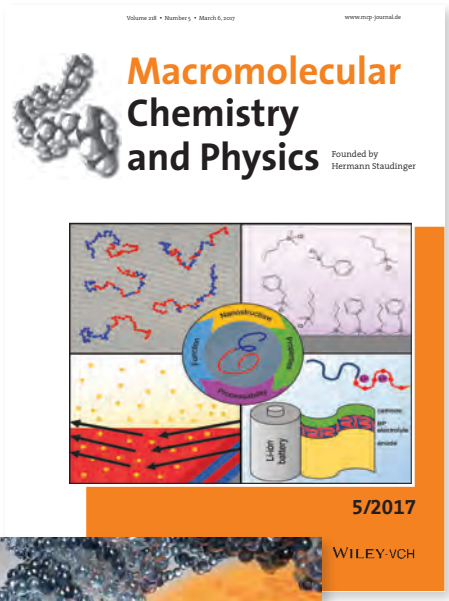
Jennifer Au
Bahar Ipek
Daniel Cook
Jillian Emerson
Jingsi Gao
Melissa Gordon
Daniel Greene
Lilian Lam Josephson
Tyler Josephson
Heejae Kim
Benjamin Kremkow
Amalie Levy
Robert Lovelett
Ming Luo
Eyas Mahmoud
Kyle McHugh
Patrick McNeely
Olga Morozova
James Park
Devesh Radhakrishnan
Matthew Rehmann
Lisa Sawicki
Chia-Hung Tsai
Jarrid Wittkopf
Mariah Woodroof

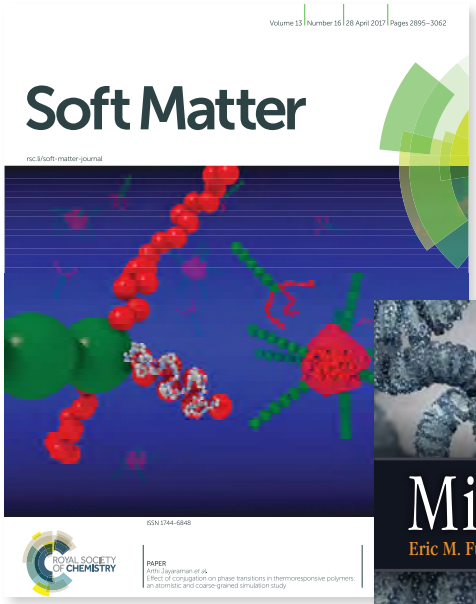
Chemical engineering doctoral students and faculty who participated in the Doctoral Hooding Ceremony as part of Commencement events at UD.

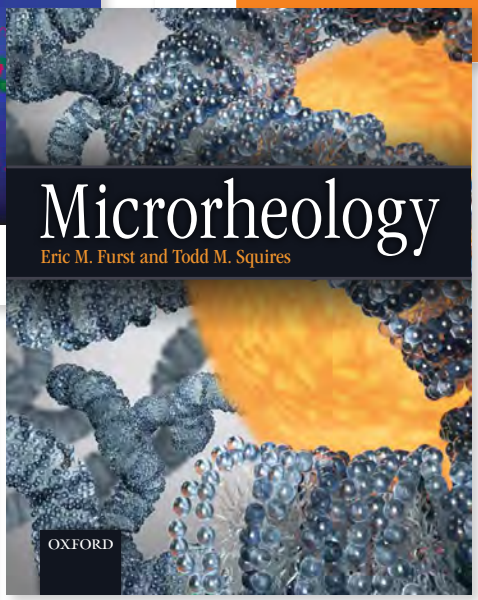
MORTON COLLINS '58 enabled a long-time goal of the department by his pledge to endow a transformative fund that would supplement institutional funding to allow us to support all first-year graduate students through the first year of study. That endowment is well on its way and we reached a landmark this year in being able to support the full first-year graduate class for both academic semesters. Collins celebrated the occasion with the students in June.

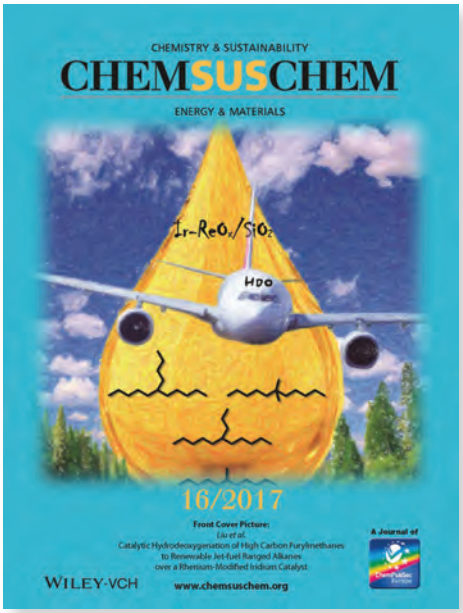
Seated (L to R): Priyanka Ketkar, Summer Tein, Emily Jeng, Mort Collins, Muyuan Li, Jacob Anibal, Daniel Yur. Standing (L to R): Elvis Ebikade, Doug Nmagu, Nate Hamaker, Colleen Fridley, Michiel Wessels, Natalia Rodriguez, Yifan Wang, Arnav Malkani.

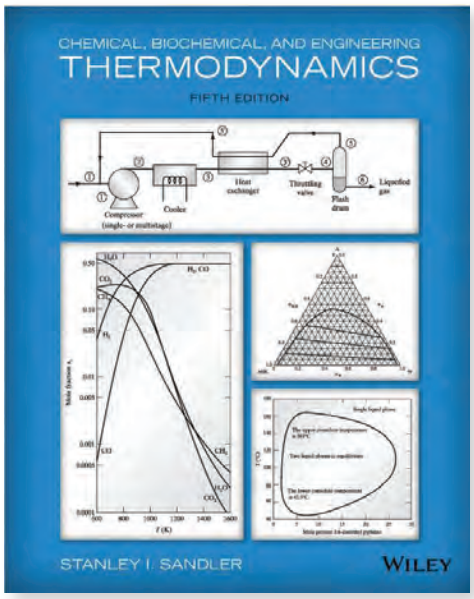
BOOKS & JOURNAL COVERS











MICHAEL STRANO ELECTED TO THE NATIONAL ACADEMY OF ENGINEERING

MICHAEL STRANO, D'01, was elected to the National Academy of Engineering. The academy reports that he was selected "for contributions to nanotechnology, including fluorescent sensors for human health and solar and thermal energy devices." Strano, the Carbon P. Dubbs Professor of Chemical Engineering at MIT, is an author on 355 peer-reviewed publications. Strano is principal investigator of the MIT Energy Initiative, which was recently selected as a collaborator in the Rapid Advancement in Process Intensification Deployment (RAPID) Manufacturing Institute. Strano has won numerous awards and honors, including being named a top young innovator by MIT Technology Review in 2004, when he was an assistant professor at the University of Illinois. He was cited for arriving at a new understanding of carbon nanotube surface chemistry, a breakthrough that paved the way for the use of nanotubes use in devices. Strano joins 25 other UD alumni, as well as 10 current and former faculty, elected to the National Academy of Engineering.

KARA ODOM WALKER HEADS DELAWARE'S DEPARTMENT OF HEALTH AND SOCIAL SERVICES

KARA ODOM WALKER '99 has been chosen by Delaware governor John Carney to run the state's Department of Health and Social Services. Walker previously served as deputy chief science officer at the non-profit Patient-Centered Outcomes Research Institute (PCORI), where she was responsible for managing a $1.6 million research budget.

"Kara has deep knowledge about how our health care system works and knows how important that access to quality, affordable health care is for all Delawareans," Carney said in a news release.

Walker received her doctor of medicine degree from Jefferson Medical College and her master of public health degree from the Johns Hopkins University. She completed postgraduate training at the University of California, San Francisco, and served as a Robert Wood Johnson Clinical Scholar at the University of California, Los Angeles, where she conducted research on the impact of hospital closure on underserved minority populations.

"KARA HAS DEEP KNOWLEDGE ABOUT HOW OUR HEALTH CARE SYSTEM WORKS AND KNOWS HOW IMPORTANT THAT ACCESS TO QUALITY, AFFORDABLE HEALTH CARE IS FOR ALL DELAWAREANS."

ALUMNI HONORS

RAKESH AGRAWAL, M'77, won the 2016 American Chemical Society Award in Separations Science and Technology. The Winthrop E. Stone Distinguished Professor of Chemical Engineering at Purdue University, Agrawal received UD's Presidential Citation for Outstanding Achievement in 1995. He has received a number of other awards and honors, including being named a fellow of the National Academy of Inventors and the American Institute of Chemical Engineers as well as being elected a member of the American Academy of Arts and Sciences. Agrawal's research focuses on energy production issues, especially from renewable sources such as solar. He serves on the department's Advisory Council.

MICHAEL BETENBAUGH, D'88, won the Society for Biological Engineering's D.I.C. Wang Award for Excellence in Biochemical Engineering. The award is named after Daniel I.C. Wang, an MIT professor who contributed to the biochemical engineering field for 50 years. Betenbaugh, a professor of chemical and biomolecular engineering at Johns Hopkins University, does research in glycoengineering, cell engineering and micro-algae engineering.

TERESA (PLUMLEY) KARJALA, D'92, has been named a fellow of the Society of Plastics Engineers. Only 325 people have received this honor since it was established in 1984. Karjala is a principal research scientist at The Dow Chemical Company for Packaging and Specialty Plastics. Karjala is an inventor on 60 U.S. patents and 30 European patents.

LYNN WALKER, D'95, has been named editor in chief of Rheologica Acta, a journal that advances the science of rheology. A professor of chemical engineering at Carnegie Mellon University, she is a member of our department's Advisory Council.

MARK SHIFLETT, M'98, D'02, is the recipient of the AIChE 2016 Industrial R&D Award. Shiflett is the Foundation Distinguished Professor at the University of Kansas in the Department of Chemical and Petroleum Engineering. Shiflett was recognized for his two decades of work at DuPont, where he was a Technical Fellow before making the jump to academia in 2016. At DuPont, Shiflett developed and commercialized three environmentally safe refrigerant mixtures and studied new applications of ionic liquids. He was also an active adjunct professor in the department while at DuPont.

SULJO LINIC, D'03, received the 2017 Paul H. Emmett Award in Fundamental Catalysis. This award is sponsored by W.R. Grace & Co. and administered by The North American Catalysis Society. Linic is the Class of 1938E Faculty Scholar in chemical engineering at the University of Michigan. He was recognized for his contributions in heterogeneous catalysis, surface chemistry, nanoscience, and computational catalysis. Linic received the award at the 25th NAM meeting in Denver, where he gave a plenary lecture.

PETER TESSIER, D'03, received the 2016 Biochemical Engineering Journal Young Investigator Award. He is the Richard Baruch MD Career Development Professor in the department of chemical and biological engineering at Rensselaer Polytechnic Institute and in 2017-18 will become the Albert M. Mattocks Professor of Pharmaceutical Sciences and Chemical Engineering at the University of Michigan. Tessier works on designing, engineering, and optimizing antibodies, proteins used by the immune system to fend off disease. The award is given by the editors of the Biochemical Engineering Journal in cooperation with the ESBES Society.

WILLIAM TISDALE, '05, and **MICHELLE O'MALLEY, D'09,** were selected as Camille Dreyfus Teacher-Scholars for 2017. These awards were given to 13 young faculty members who excel in both scholarship and education. Tisdale is the ARCO Career Development Professor in chemical engineering at MIT. He was honored for his work with energy transport in semiconductor nanomaterials. O'Malley is an assistant professor of chemical engineering at the University of California, Santa Barbara. She was recognized for her work in deconstructing microbial consortia for sustainable chemistry.

SEAN HUNT, '11, made the Forbes "30 Under 30" list for his success in manufacturing and industry. He is a co-founder of Solugen Inc., which has developed a scaled, sustainable process to create hydrogen peroxide from plants.

JONATHAN GALARRAGA, '16, a Unidel Eugene du Pont Scholar as a student at UD, has received an NSF Graduate Research Fellowship. The prestigious competition marks its 65th year. Galarraga is pursuing his doctorate at the University of Pennsylvania, studying tissue engineering, biomaterials, 3D-printing and cartilage repair in Penn's Polymeric Biomaterials Lab. At UD, Galarraga worked in the research group of Christopher Kloxin, assistant professor. "Throughout my time in the CJK lab, I gained a strong appreciation for collaborations in research, developed intimate knowledge of the materials science research landscape, and enjoyed the privilege of learning from many great mentors," he said.

LINDA BROADBELT, D'94, has been named associate dean for research at Northwestern University's McCormick School of Engineering, effective September 1. Linda is the Sarah Rebecca Roland Professor and was previously chair of the Department of Chemical and Biological Engineering. She is a member of our department's Advisory Council.

A TALE OF TWO JOHN ANDERSONS

John Anderson retires from a stellar career in academia

"MAN PLANS, GOD LAUGHS."

This ancient proverb certainly applies to the life of **JOHN L. ANDERSON, '67**, but he says the result was better than the plan, in looking back at the 50 years that have passed since his graduation from UD. After receiving his doctoral degree from the University of Illinois in 1971, he accepted an appointment as assistant professor at Cornell University. This year he retires as a Distinguished Professor of Engineering at Illinois Institute of Technology. His accomplishments have been widely recognized with national awards, including election to the National Academy of Engineering in 1992.

"In between, much has happened, and I am grateful for most of it," he says. Career positions included department chair and dean at Carnegie-Mellon University, provost and senior vice president at Case Western Reserve University, and president of Illinois Institute of Technology. "My career in higher education and research has given my life more meaning than I imagined," he says. He also served as an officer in the US Army Reserves during the Vietnam War period. Several of our faculty -- Norm Wagner, Eric Furst, Millie Sullivan -- and a significant number of our students benefited from Anderson's mentorship and leadership during their time as students at Carnegie-Mellon.

"The good things really started at UD," he says. He met Pat Siemen (B.S. Math/Physics) during their freshman year, and they have been married since 1968. They share two children and five grandchildren. They have lived in Champaign, Illinois; Ithaca, New York; Pittsburgh;, Cleveland; and Chicago.

Anderson didn't just meet his wife at UD -- he also made lifelong friendships. He was a member of Alpha Tau Omega, and he and his ATO brothers still get together on campus every two years to, as Anderson puts it, "reminisce and exaggerate the memories of our adventures."

He still appreciates the education he received here. "The faculty members at UD who had an impact on my outlook and career include Fraser Russell, Jon Olson, Bob Pigford, Jack Gerster and Mort Denn," he says. "Most memorable was the distillation tower; Professor Gerster selected me to climb to the top on a rainy, windy day to get the condenser water temperature – he called it a 'character builder.' Hard work, good times, great memories." Interestingly, classmate Rich Hawthorne also mentioned the formative impact of working with Prof. Gerster on the distillation tower (see alumni notes, page 42).

Even in retirement, there's no rest for John Anderson

Most grandparents rely on their kids or grandkids to help them navigate their computer, but **JOHN E. ANDERSON, M'63 D'64**, isn't one of them.

The 83-year-old Corpus Christi resident has shown no signs of slowing down since he retired from his chemical engineer career with Celanese Corp. in 1999.

In fact, Anderson is always keeping up with the latest technology, signing up for at least one college course every semester. He was recently featured in a Del Mar College #VikingProudWednesday post on the college's Facebook page, a project of the Department of Media Relations' student assistant Meagan Falcon.

Anderson has always loved school, he said. He graduated from the University of Texas with a bachelor's degree in 1957 before getting his master's and doctorate from the University of Delaware in 1963 and 1964, respectively.

"You get exposed to new ideas," Anderson said.

Education is important to nearly everyone in his family. Anderson's father was a principal. His sister, wife, aunts and daughter made a career of teaching as well.

Anderson audits courses that he's interested in, keeping up to date on the latest computer software. He admitted students are surprised to see him there.

"I've had them ask me 'Are you planning on getting a job?' " Anderson laughed. "I tell them no, I've got all the degrees I need and I certainly don't need another job."

But he loves that interaction with younger generations, Anderson said.

"I find the association with the students invigorating," he said.

Retirement is not just about relaxing, Anderson said.

"Traveling and entertaining yourself up to a point is good, but I don't want to do just that," Anderson said. "I enjoy doing things I consider worthwhile and I want to stay busy."

In his free time, Anderson is focused on giving back. He volunteers at his church and also teaches courses at Jobs for Life, a Christian-based job training program.

"John has been instrumental for this ministry and helping out where he is needed," said Maria Guerrero, the Corpus Christi site coordinator of Jobs for Life. Guerrero said she doesn't often come across someone as selfless as Anderson. She calls him to come in any time they need a substitute to teach computer courses, and he's always willing to help, she said.

"You can tell from talking to him that he wants to help other people grow," Guerrero said. "The way he stays on top of his skill set proves he wants to help people. He truly has a servant's heart."

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ALUMNI NOTES

'60s

BOB ZUMWALT, M'60, D'66, reminisced about his UD experience and especially the early years of his career. After two years with Dow Chemical, he was a lieutenant in the US Army at Edgewood, MD, during which he also attended classes at UD that prompted him to enroll full-time in the doctoral program. He fondly recalls the instructional skills of faculty John Ferron, Jack Gerster, Art Metzner and Jon Olson and was especially inspired by Bob Pigford's course "Application of Differential Equations to Chemical Engineering Problems". [The bound Marshall and Pigford notes on that topic, published by UD in 1947, are still highly prized by those aware of them.] Bob began a rewarding career with Exxon and its affiliates, specializing in dynamic simulation and computer process control. After retiring in 1994, he returned to Hallettsville, TX, where he continued part-time consulting with ExxonMobil. Bob recently published his memoir "Trapped by a Mouse and Other Stories." This includes humorous stories about how he met his wife, Doris Wild, AS59, AS61M in the Memorial Student Center's music room and the couple's lively experiences while on Exxon assignments in Normandy, France, and London, England.

LLOYD GOETTLER, D'67, spanned the industry–academia divide in his career. He worked in various aspects of materials R&D with Monsanto Company and later its chemical spinoff business, Solutia, for over 33 years, during which time he achieved the rank of Science Fellow. His focus was on processing and structure-property relationships in polymeric materials, including blends and composites of plastics and elastomers. Following his retirement he embarked on an academic career as a faculty member and administrator in polymer engineering at the University of Akron. Now retired for ten years, he enjoys travel, volunteering and the company of his inclusive family from wife, Grace, to great-grandchildren. He attributes his professional accomplishments to the education and training he received at UD, especially the mentoring from his research professor, Bob Pigford. He remembers the support he received from Pigford in the hectic days as he was trying to finish up writing and defending his dissertation just as Pigford was in the final stages of moving from UD to Berkeley, from where he later returned in 1975.

RICH HAWTHORNE, '67, went on to obtain a Master's degree from Carnegie-Mellon and then completed a career of 35 years with DuPont as a technical associate specializing in distillation, enhanced by advances in process control technology. His interest in distillation was seeded by Prof. Jack Gerster and the distillation column he taught from, located next to Brown Lab until the '60's; Rich's classmate John Anderson was similarly influenced by Gerster and the column, as noted earlier. Rich also cited the privilege of personally knowing Jack Gerster, Bob Pigford, Fraser Russell and Jon Olson through having grown up in Newark, and noted his debt to Dr. Pigford for advising him to drop ROTC and hence get a critical deferment. Rich attended our Centennial celebrations in 2014 together with Dr. Pigford's son, who was his boyhood friend and DuPont colleague, and was impressed to learn that the founding of the chemical engineering program in 1914 was at the recommendation of two members of Sigma Phi Epsilon, Rich's own fraternity! Rich continues to take courses at the Osher Lifelong Learning Institute at UD in Wilmington. His wife of 50 years, Shirley, was a UD art education graduate who developed a career for herself in art while moving around the US on Rich's work postings. Their two children and five grandchildren include a daughter, **SUSANNE WOLFF, M'02,** who also followed Rich to UD and then DuPont, working on process development and solid-liquid separations; we at UD are fortunate to see her when she teaches some classes in our Particle Technology program.

JOE HUGGINS, '67 had an opportunity to reminisce while representing the Class of 1967 at this year's commencement ceremony. He, too, appreciated being taught by leaders in the field such as Gerster and Pigford, while also being a charter member of Lambda Chi Alpha and playing varsity lacrosse. Joe was hired by Sinclair Refining and worked for 8 months at their Trainer, PA, refinery, before meeting his military commitment over two years at Fort Bliss, TX, in the Test and Evaluation Command as a Second Lieutenant, thanks to his engineering degree. However, the Trainer refinery was to be his professional home for the next 42 years, under seven different companies, in numerous positions: eight years leading the control systems group, four years as a process supervisor, five years as a process superintendent, technical manager when the refinery was owned by BP, senior technical advisor and major project manager when it was purchased by Tosco Refining, and engineering manager under ConocoPhillips. Projects included replacing the process computer with a distributed control system and managing a $75M dock replacement project while maintaining operations. Joe continues to live in the Newark area with his wife of 50 years, who also graduated from Delaware.

'70s

GEORGE DINGILIAN, '72, attributes the direction of his entire career to his first job, as a process development engineer at Borg-Warner Chemicals and Plastics (now part of SABIC) in West Virginia. His task was to reduce monomer emissions from manufacturing of acrylonitrile-butadiene-styrene (ABS) polymers, and he was so successful that the bugs (microorganisms) in wastewater treatment ponds to reduce residual monomer were dying, creating a major stench. While the W.Va. plant was demolished in 2013, the same ABS manufacturing processes remain in use on a bigger scale and in larger plants elsewhere. George's perseverance, as in that initial task, led to his earning an MS in chemical

engineering and then branching out into finance by getting an MBA, a Ph.D. in business and a number of certifications, while keeping a firm footing in engineering. Although his portfolio of engineering publications is currently limited to the one seminal paper that was published with his UD mentor, Eli Ruckenstein, George feels that his current research on chitosan and polymer composites will increase that number soon.

JIM SEFERIS, D'77, had a thirty-year long academic career at the University of Washington, from where he retired in 2007 as the Boeing / Steiner Professor after supervising over 100 Master's and PhD degrees, following the model of his UD advisor, Roy McCullough. A significant accomplishment was a unique public / private partnership, still active today, that he established with the help of colleagues from UD, focusing on carbon fiber reinforced polymeric composites, used primarily in commercial aircraft. However, Jim's broader educational focus on teaming, innovation and entrepreneurship continues to find applications and usage in a variety of areas utilizing chemical engineering principles; a recent example is his role advising UW's successful Hyperloop team. Jim splits his time between Seattle and Athens and his life still holds professional, personal and business opportunities. His family is being productive and successful too, his daughter having made him a grandfather in 2016 and his son living and working in Shanghai.

JANE TSAI, M'77, worked for BASF (1977-1978) and GAF (1978-1981) before joining Exxon, where she worked in process development, market development, process design, pilot plant design and construction, project engineering, offsite processing, and optimization of supply chain and logistics. The lubricant division of Exxon Chemical formed a joint venture with Shell and became Infineum in 1999, and Jane was accountable for global procurement of contract manufacturing before retiring in 2014. She and her husband are very happy being retired, especially having time to read and travel. Their two daughters, aged 33 and 31, are a surgeon and in finance respectively. Jane – the only female student in her class – recalls transport phenomena with Art Metzner and thermodynamics with Bob Pigford as being particularly challenging. Overall, she remembers her UD experience as being tough but honing her skills in critical thinking, giving her a foundation to believe in herself and making her comfortable in making decisions based on available data.

ROCHELLE YOUNG PRYOR'S, '77, UD experience was a family affair – her father was a professor in Mechanical and Aerospace Engineering, and her brother and sister also graduated as UD engineers. Her husband of 41 years, Glenn Pryor, BA '77 in History & American Studies, is a social worker, and indeed Rochelle's career also involves people support. She has a MAIOP (Industrial/ Organizational Psych) degree from the University of New Haven and owns Pryority Training, a consulting firm helping companies and organizations to run with lower turnover and lower health insurance costs. She coaches in areas such as work/life balance, employee well-being, stress management, performance management systems, emotional intelligence, organizational development, conflict resolution and hiring practices. Rochelle and Glenn live in eastern Connecticut and have 3 daughters and 3 grandsons. Rochelle also helps Veteran's Base Camp, a program for veterans including housing, career training and more.

'80s

RON BOVE, '82, retired from W. L. Gore & Associates, Inc., this year after a 37+ year career, essentially all with the Fabrics Division. During this time he progressed through being a thermal lab research analyst, a process design engineer, a quality and product development engineer, a product specialist for structural firefighting personal protective apparel, the Fire & Safety Services business segment leader, the Fire & Public Safety business leader and a Fabrics Division intellectual property champion. In these roles his contributions included verifying novel material properties, developing new fabrics and processes, defining new industry standards, growing business areas and prosecuting and managing intellectual property. His work pursuits and responsibilities at Gore enabled him to travel the world and to engage with technical and business people everywhere, including a formal presentation to the principals of the Tokyo Fire Brigade. Along the way, among other things, Ron met his wife (also a UD grad), pursued general aviation as a private pilot, became a leader/elder (and drummer) in a local church, and put three daughters through debt-free college careers.
Ron attributes much of his success to the Gore Enterprise culture, leadership and environment. However, he also specifically notes that his excellent and very rewarding career came despite what he describes as "a not-anywhere-near stellar academic record", an experience that he hopes will inspire similar students today who lack self-confidence as they enter the workplace. He feels that regardless of their GPA, all UD ChE graduates "have had solid principles and application strategies ingrained into who they are, which they will be able to lean on considerably as they continue their learning (most important!) in whatever field they pursue."

CHUCK HERAK, '85, completed his PhD in chemical engineering at MIT and then returned to Delaware to work for Hercules, where he spent 20 years in positions of increasing responsibility, finishing as global manager of coatings adhesives. During this period Chuck spent five years in Singapore leading the Asia-Pacific region and also completed an MBA at UD in 1994. In 2009 he moved to the J. M. Huber Corporation as VP and general manager of the silica unit and in 2015 was appointed president of Huber Engineered Materials (HEM); he is also a director of the HEM management board and serves on the Huber Management Council. Despite those appreciable professional responsibilities Chuck finds time to serve society in numerous ways, and in 2017 hosted a group of UD students on an Alternative Spring Break visit in Atlanta; he has also launched an endowment for the UD Engineers Without Borders chapter.

DAVE HASSE, '87, was back at UD for an important event in May: the graduation of the latest chemical engineer in the Hasse family, **JOE HASSE, '17**. Dave's father, who also attended the graduation ceremonies, is also a chemical engineer, albeit from Wisconsin.

VIC JANAS, D'87, worked on structural polymeric composites with the late Roy McCullough at UD and spent the first half of his career in other areas of composites. He first worked on ceramic matrix composites for jet engine components at Corning Inc. in 1986, and later on ceramic honeycomb

extrusion. As a post-doc/research associate at Rutgers University starting in 1993, he worked on the processing of piezoelectric ceramic/polymer composites and then in 1996 he made his last career move, joining the Corporate Biomaterials Center (CBC) at Johnson & Johnson to work on bioresorbable ceramics and polymer/ceramic composites. Vic accumulated nineteen US patents in composite material devices and processing and remains fascinated by inventions and the process of obtaining US patents. This led him to a career change in 1999 to intellectual property (IP) manager at J&J, where he is the liaison between J&J patent attorneys and scientists, engineers and marketing people. Initially this was at the CBC but since 2007 has been in the J&J Consumer Sector. Among Vic's many fond memories of UD the most important is that he met his wife, Bernadette (UD '84), here. They have been married for over 30 years and have two sons and a daughter. Other fond memories including tailgating with other graduate students at Blue Hen football games, as well as intramural softball, basketball and volleyball teams.

OLIVER SMITH IV, '87, earned a PhD in chemical engineering from Carnegie-Mellon University and then went to work for Air Products in Allentown, PA, where he has stayed for the past 26 years. Oliver has held various technical positions in the industrial gas business and is currently the global hydrogen process lead, where he develops and implements productivity and reliability projects across the Air Products fleet of about 45 hydrogen plants. Oliver and his wife, Carolee, have sons aged 15 and 13 and live on a farm with their horses, dogs and cats.

MARSHA STALKER BISCHEL, '87, went on from UD to do a Master's in materials science at the University of Connecticut, then moved to Lancaster, PA, to work for Armstrong World Industries, Inc., subsequently returned to UD for a PhD in materials science with Jerry Schultz. Marsha has been back at Armstrong as a senior research scientist since 2000, working on materials for internal building finishes – everything from cementitious materials and glasses to metal and wood. She previously worked part-time for Winterthur Museum in their analytical laboratory and still maintains close ties with the museum and the art conservation program. She is an expert in sustainable materials, and contributed a chapter to a book on the subject. Marsha met her husband, Wesley, at Armstrong; they have just celebrated their 25th wedding anniversary and have a 15-year old son, who is active in Boy Scouts, as are Marsha and Wesley. Marsha does science demos for elementary school children as well, encouraging them to stay interested in science.

'90s

SCOTT LAMB, '92, was a distinctive presence as a student at UD in being one of the few chemical engineers in recent decades on the Blue Hens football team. Scott has thrived in his career as well, mainly around innovation and the intersection of science and business. The journey via Procter & Gamble (OTC Medicines, 1992-1998) in Cincinnati, Johnson & Johnson (Consumer, OTC Medicines, Medical Devices, Pharma; 1998-2012), Catalent (CMO, 2012-2014), Lamb Consulting & Ventures (varied endeavors, 2014-2015) and Revlon (Beauty, 2015-present) has led to his present position as VP of Portfolio and PMO for Revlon's Global Beauty business. Scott writes, "I still use the most valuable lesson I learned from my UD training: how to solve problems and work collaboratively with talented, diverse people." Scott and his wife, Mary Byrne Lamb (UD '91), live in Doylestown, PA, with their four children and two dogs. The children, ranging from sophomore year at Lafayette to first grade, seem to have Scott's athleticism, participating variously in football, track and field, and soccer. In the summer the Lambs can be found "down the shore", in Stone Harbor, NJ, whenever life allows. Scott and Mary often say that they are glad that their life at UD isn't preserved on social media; that sentiment can probably be expressed quite widely in these columns...

CHRIS PEDERSEN, M'92, has spent the 25 years since graduation in aerospace/advanced materials, starting from being a composites engineer at Boeing in Seattle. He moved to Cytec in 2001 and spent 15 years in growing roles as product development manager for composite materials, VP Technology, leading global R&D, and VP Aerospace, serving as the business leader for the $1B unit. After Cytec was sold to Solvay in 2015, Chris took a year off, traveling and consulting, but in 2017 he joined Hexcel as VP Strategy, where he is responsible for working with the R&T and business units to develop and execute a R&T collaboration and M&A roadmap. Chris married Jean, who works in real estate, in 1992 and they have a daughter and a son; they currently live in Scottsdale, AZ, although daughter Samantha is studying in our vicinity at U Penn.

TOM TARKA, '96, continues to work at the US DOE National Energy Technology Lab (NETL) in Pittsburgh, where he is the lead engineer on NETL's work with the city. This year he was named a Green Instigator by the Green Building Alliance, which has been writing "Pittsburgh's Green Story", about how the city has transformed itself from its industrial roots.

CARRIE (LOEHR) SMOLINSKI, '97, has a (busy) family life outside Chicago with husband Mike and three daughters aged from 12 to 3. They enjoy outdoor activities, including an annual week-long lake house trip in summer and a recent first Cubs game for the girls. Carrie and Mike both compete in swimming, running and triathlons and Carrie helps coach a masters swim team. Carrie's professional career is still active too. She worked 8 years after graduation with ExxonMobil, then took 5 years off after having her first child. Since 2010, she has worked 3/4 time (or slightly more!) for a local consulting company, Beaird Group, on a wide range of projects such as market analysis and customer prospecting, system implementation and process optimization. One particularly fun job since 2014 has been the implementation of a 1:1 computing program in the public school district that her children attend. By this fall, all students in grades 2-12 will have their own Chromebooks and all K-1 students will share iPads in a 2:1 ratio.

CBE ALUMNI ACROSS THE NATION

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2000s

AARON CHOCKLA, '07, thought that process control with Tunde Ogunnaike would be the end of his studies, but far from it, as he has spent seven of the past ten years in school. He did his PhD at the University of Texas and became an indoctrinated member of the Burnt Orange Nation, with Austin holding a special place in his heart. Although he didn't have the courage to ask his high school crush on a date until 7 years after they met, they were married after he earned his PhD, and they moved to New Jersey where he had an R&D position with Bristol-Myers Squibb for 1-1/2 years. They then returned to Texas, where Aaron worked in Samsung's semiconductor plant and helped launch two cleantech startups. For one of the startups he was a co-founder, and the process of starting and growing companies piqued his interest in business and law, so he enrolled in the JD/MBA program at Kellogg School of Management / Northwestern Pritzker School of Law. Aaron has since taken to venture capital and now works for a cleantech firm in Chicago, where he and his wife are also proud parents of a two-year old daughter.

ANDY MAY, '07, went on from UD to complete an MS in civil and environmental engineering at Clarkson University, followed by a PhD in mechanical engineering at Carnegie Mellon-University in 2012. At CMU he encountered fellow alums **SCOTT EPSTEIN '05, REZA ROCK '08, MATT REICHERT '08, MELISSA DAY '09 AND AARON REINICKER '10,** all of whom were graduate students in chemical engineering. After post-docs at Carnegie-Mellon and Colorado State University, Andy took a faculty position in the Department of Civil, Environmental, and Geodetic Engineering at The Ohio State University in Columbus, OH, where he also has affiliations with the Center for Automotive Research and Environmental Science Graduate Program. His research program focuses on the emissions, transport/transformation and impacts of combustion sources (mainly on-road mobile sources and open biomass burning) on air quality.

SEAN LEWIS, '12, moved to the Raleigh area after graduation and has been working there in the pharmaceutical industry since, mostly supporting global technology transfer projects, primarily in India. For the past two years he has been at Pfizer, where he recently moved into the area of gene therapy via a startup called Bamboo, which Pfizer acquired last year. The company hopes to bring novel therapies to patients suffering from genetic disorders. Sean was back in Newark for alumni weekend, which brought back fond memories of those long nights in Colburn.

PRIANKA MURALIDHAR CHAPIN, '12, started her career as a process control engineer at Johnson Matthey, with responsibility initially for monitoring equipment that produces auto catalysts and subsequently for organizing the batching of platinum group metal slurries. She then relocated to New Hampshire in a developmental role at Ebner Furnaces, where she is working on a process to grow sapphire for LED. Senior design was an important part of Prianka's personal life in that she was assigned to work with **CHRIS CHAPIN, '12,** a friendship that blossomed into marriage; Prianka and Chris now have a son.

ALLAN ROBERT FERGUSON, '65, died peacefully at his home in Meriden, N.H., on September 3, 2017. A quietly passionate man of great integrity and humility, Allan was steadfast in his devotion to his family, community and his many business ventures. Allan's pride was his family, their interests and education. The slightest interest expressed was met with enthusiastic conversation, research and support. He reveled in his family's successes and supported them in their challenges. Cheering them on in sports, chasing them down a snowy mountain or sending books, articles or just making a call to check in. He was always enthusiastically present for his family. His career began as a chemical engineer at Johnson & Johnson where he rose to executive positions developing experience in operational safety and efficiency and biotech. After 20 years with J&J, he moved to the Boston area to take subsequent senior operating positions at two biotech companies. After a few years, he transferred his passion for medical advancement to international venture capital investing in biotech and medical device companies at 3i Group plc, Aspen and then Atlas Ventures. In 2007, he retired as head of U.S. operations from 3i Group plc to join his wife, Myra, full-time in New Hampshire. There they managed a tree farm together and Allan applied his operational acumen to community organizations and supporting education by reducing energy usage in the local school to improve learning environments and reduce operational spending. In addition to many corporate boards, Allan served as a member of the Advisory Board at the Tuck Entrepreneurial Center, a member of the board of directors of the National Venture Capital Association, chairing the research and outreach committees and on the board of More Than Wheels. A self-made man, he never forgot his alma mater, the University of Delaware, where he earned a bachelor of science in Chemical Engineering. He served on the UD Advisory Board for the Department of Chemical Engineering and in 2003, was inducted into the Wall of Fame. In 2016, Allan and Myra, both UD alumni, funded a chair in the Department of Chemical and Biomolecular Engineering. Born June 21, 1942, in Montclair, N.J., Allan is survived by his beloved wife of 51 years, Myra; his siblings, David Ferguson and his wife Laurel of Duxbury, Mass. and Karen Ferguson, M.D. of Vero Beach, Florida; his daughters, Marcie Campbell and her husband Lindy of Somerville, Mass. and Jane Ferguson, Ph.D. of San Ramon, California; his grandchildren Fiona and Liam Campbell and Olivia and James Horton and, of course, his devoted dog, Maisie.

ROBERT D. FLECK, JR., '69, of New Castle, Delaware, passed away after a brief battle with cancer on September 22, 2016. Bob earned a bachelor's degree in chemical engineering at UD. In 1971, he received a master's degree in chemical engineering from the University of Virginia. He worked briefly as an engineer but spent most of his career running Oak Knoll Books, a bookseller he founded in 1976, and Oak Knoll Press, a publisher he opened two years later. Among his survivors is his son Rob, a UD alumnus who joined his dad in business at Oak Knoll.

NATHAN D. HOULD, D'12, passed away on May 7, 2017, at age 32, in Oswego, NY. He was born on September 26, 1984, in Marietta, Georgia to Daniel and Joyce Keen Hould. In 2002, Nathan graduated from G. Ray Bodley High School and continued on to SUNY Stony Brook where he received his bachelor's degree in chemical engineering. He earned a PhD in 2012 from UD. Nathan spent time as a chemical engineer at Saudi Aramco in Saudi Arabia. He enjoyed hiking, traveling the world, ice hockey, playing guitar and photography.

Department benefactor **JACQUELINE COBB SEVERNS** died May 9, 2017, in Urbana, Illinois. With her husband, **WILLIAM SEVERNS JR., D'50**, she established the William and Jacqueline Severns Scholarship in continuing education at UD and the William H. Severns Jr. Distinguished Chair in Chemical Engineering. Jacquie was a member of Chi Omega Alumnae Chapter in Wilmington, Del., a member of Cooch's Bridge Chapter DAR, an associate member of Job Winslow Chapter DAR in Traverse City, Mich., Lower Brandywine Presbyterian Church, and Dupont Country Club. She was initiated into PEO in 1950. She had a keen interest in providing scholarships to students pursuing university degrees or education to advance their careers. In addition to the UD scholarship she and her husband established, she created the Jacqueline Scott Severns Scholarship at Richland Community College in Decatur, Illinois. Her husband is among her survivors.

STEVEN ALCUS THREEFOOT, D'91, of Arden, DE passed away on February 18, 2017 at age 60. Born January 25, 1957 in New Orleans, LA, he was the son of Dr. Henry Kutcher Threefoot and the late Barbara Alcus Threefoot.

Steven was a graduate of St. Martin's Episcopal School in Metairie, LA. He continued his scholarship by obtaining a

bachelor's degree in biomedical engineering from Northwestern University, a master's degree in chemical engineering from Tulane University, and a doctoral degree at UD. Between his MS and PhD, he worked as a Biomedical Researcher at MIT and started his own consulting business in Wilmington, DE.

After completing his PhD, Steven joined DuPont where he continued his passion for learning and leadership for over 25 years. Working initially in polymer characterization, he led the development of the product quality system for a novel polyester technology. Building on his product quality foundation, he applied statistically-based Project Management (Six Sigma) to improve the success of subsequent research projects, including commercialization of DuPont's first major biotech product, PDO. He shared his knowledge of project leadership and quality as an instructor, mentor, and leader of students and projects globally across DuPont and as an adjunct professor in chemical engineering at UD.

JOHN M. DESTEFANO, '58, died on December 3, 2016. He was a veteran who had been honorably discharged from the U.S. Marine Corps. He was a former director of the Strategic Planning Resins Group at Hercules Incorporated and general manager of two wholly owned subsidiaries. He lived in nine states and two foreign countries. He retired in 1992 and moved to Florida in 1994. Then, he worked at DeWitt and Company as vice president, CS Derivatives. He published "The Hydrocarbon Resin Report" from 1994 to 2005 and traveled extensively to every continent except Africa and Antarctica. He was active in volunteer work at the Venice Little Theater (1995), the Ladies Business Association of Sarasota County (1996), Smithsonian's Whipple Observatory (2008-2016) and Pima County Sheriff Volunteers in Green Valley (2010-2016). He retired in Hockessin, DE, in 1992, Venice, FL, from 1993 to 2005, and Green Valley, AZ, from 2005 until his death. His body was donated to science at Banner's Arizona University Medical Center. John was extremely proud to be a Blue Hen. A strong family man, he was married to his wife, Bonnie, for 51 years. They had three daughters, including Jonette M. Sullivan, '88. Her daughter, Allie, will graduate next spring.

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Australia **2**
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Canada **14**
Chile **1**
China **5**
France **3**
Germany **5**
Greece **3**
Haiti **1**
Honduras **1**
Hong Kong **2**
India **13**
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