

MASS Transfer

News from Chemical and Biomolecular Engineering at Illinois

Spring/Summer 2016

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Department of Chemical and Biomolecular Engineering

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About cover:

Efficient glucose-xylose co-utilization is critical for economical biofuel production from lignocellulosic, or dry plant, biomass. To enable glucose-xylose co-utilization, a highly active xylose specific transporter without glucose inhibition is desirable. But understanding the structure-activity/specificity relationship of sugar transporters has been limited. In a recent study, Huimin Zhao and colleagues, through homology modeling, directed evolution, and analysis of sugar transporter HXT14 mutants, identified a highly conserved YYX(IT/P) motif that plays an important role in controlling the activity and specificity of sugar transporters. The cover image shows the top view of the molecular surface of the homology model of the engineered HXT14 sugar transporter protein. The green represents the glucose molecule while the red shows the solvent-accessible channel surface formed by the YYGT motif of HXT14. Image provided by Huimin Zhao.

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From the Department Head's Desk

Dear Alumni and Friends,

With the summer now upon us, we reflect and celebrate our successes of the past academic year. We're proud to report that several undergraduates have won prestigious awards, such as the Goldwater Scholarship, and graduate students have received competitive fellowships from the National Science Foundation, Department of Defense and other agencies. Assistant Professor **David Flaherty** won the National Science Foundation CAREER award. Associate Professor **Hyunjoon Kong** received the outstanding research award from the College of Engineering and Associate Professor **Mary Kraft** was named a Robert W. Schaefer Faculty Scholar. In April we honored Professor **Huimin W. Zhao** as the inaugural holder of the Steven L. Miller Chair, made possible through the generosity of **Steve Miller** (BS ChemE '67), and his wife **Sheila Miller** (BS Ed '67). It was heartwarming to hear from Steve at the investiture as he reflected on his time at Illinois, on the quality of education and support he received from our department, and his appreciation for receiving a liberal arts education.

It's always a pleasure to welcome back alumni to campus. This past semester, we enjoyed visiting with many graduates of our department, including **Ray Mentzer** (BS '74), who has been a senior lecturer at Texas A&M following a distinguished career at ExxonMobil. **Ro Vukovich** (BS '89) from Dow AgroSciences, **Aimee Nugent** (BS '15) from PepsiCo; **Sarah Kuhl** (BS '15) from Clorox, **Paul Jahn** (BS '81) from Middough, plus **Shawn Cullen** from LyondellBasell, a longtime supporter of the department, served as judges at our annual undergraduate research symposium. This year's convocation address was provided by **Kathryn 'Kit' Gordon** (BS '83), who had a fulfilling career with two semiconductor firms in Silicon Valley and credits her time at Illinois for her success. This May, 104 seniors received their BS degrees in Chemical Engineering and three students received their PhDs. Many of our BS degree recipients and all of our PhDs have jobs or further education (e.g., graduate school) lined up by the time they graduate. We're proud of what they've accomplished here and wish them all the best in their careers!

Unfortunately, this summer we will say goodbye to **Jerrod Henderson** (PHD '10), who will join the College of Engineering at the University of Houston. Jerrod has been with our department as a lecturer since 2010. Every graduating senior between then and now has had him for our capstone Unit Operations Lab! We will remember him for his tireless efforts in outreach activities, such as the GAMES camp, which encourages high school-age girls to pursue degrees in science or engineering, and the St. Elmo Brady Academy, which aims to increase the number of underrepresented students pursuing STEM careers. This past year we also said goodbye to **Lauren Dodge** and **Matt Campion**, our alumni advancement staff. Lauren moved to Mechanical Engineering here on campus, while Matt moved to the College of Nursing at the U of I in Chicago. We thank them for all they did for the department and wish them success in their future endeavors. This summer, we will welcome a new major gifts officer. **Braden Shain**, an Illinois native, joins us from Ohio University.

We always take great pride in hearing from our alumni. Please continue to connect with the department via Facebook, Twitter (ChBE_Illinois), and the School of Chemical Sciences' LinkedIn group, and keep sending us your updates, photos, and stories so we can feature them in future newsletters! Looking ahead to the fall semester, we hope to see you at **Homecoming on October 28-29**, featuring our annual tailgate before the football game.

We also hope that some of the state budget woes will be behind us by then. The lack of a state budget has created some concern and uncertainty here at the university. We, like other departments, have been hit with budget cuts and anticipate additional cuts for next year. As we navigate these obstacles, our guiding principles have been protecting our quality and reputation. Rest assured, we shall prevail in fulfilling our mission of providing a world-class education to our students. We remain strong because of contributions from our generous alumni, friends, and corporate partners.

Thank you all for your loyalty and support, and I wish you a great summer.



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Huimin Zhao invested as Steven L. Miller Chair in Chemical Engineering

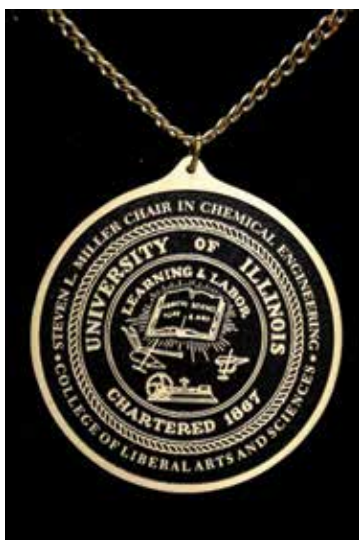
Professor Huimin Zhao was named the inaugural Steven L. Miller Chair in Chemical Engineering at an April 13, 2016, investiture ceremony attended by donors Steven and Sheila Miller, colleagues, administrators, students, friends, and family.

A member of the Chemical and Biomolecular Engineering faculty since 2000, Zhao is an internationally recognized leader in synthetic biology. His Ph.D. is from CalTech and his B.S. is from the University of Science & Technology of China. To read more about Zhao's life and research, please turn to page 20.

Huimin Zhao thanked his mentors, colleagues, students, friends, and family at the ceremony.

"From the bottom of my heart, I'm truly grateful to the university," said Zhao, who thanked his mentors, collaborators, students, friends, and family. His parents, he said, instilled in him the value of education and hard work. "I also feel honored to be associated with Steven Miller. Thank you, Steven and Sheila, for your generous and longtime support to our department. This investment is not only a celebration of my accomplishments, but also of their accomplishments," Zhao said.

Steven L. Miller, who received his B.S. in Chemical Engineering from Illinois in 1967, is the retired chairman, vice president and CEO of Shell Oil Company and retired managing director of the Royal Dutch Shell Group. He's currently chairman and president of SLM Discovery Ventures. Active in both the business and not-for-profit communities, he serves or has served on the boards of a number of local and national organizations. Miller is on the University of Illinois Foundation's board of directors and served as its chairman from 2005 to 2006. He was an active volunteer in the university's Brilliant Futures fundraising campaign and was instrumental in its planning. A former convocation speaker and the inaugural



Huimin Zhao with Steven Miller (BS Chemical Engineering, '67), and Sheila Miller (BS Education, '67), who established the Steven L. Miller Chair in Chemical Engineering.





Paul Kenis, Department Head, Chemical and Biomolecular Engineering; Feng Sheng Hu, LAS Associate Dean for Life and Physical Sciences; LAS Dean and Interim Chancellor Barbara Wilson; Huimin Zhao; Steven and Sheila Miller; Jonathan Sweedler, Director, School of Chemical Sciences.

Samuel W. Parr Lecturer, he's been a longtime supporter of the Department of Chemical and Biomolecular Engineering.

In his speech at the investiture, Miller reflected on what has made it possible for him to endow a named chair. He expressed several thank yous: to the department, for providing quality education and support; to the College of Liberal Arts & Sciences, for providing education in areas outside of engineering, such as poetry and rhetoric; to the university, for providing him with the opportunity to learn about leadership in a safe environment; and for the opportunity to meet Sheila, his future wife, while a student on campus. Sheila Miller received a bachelor's degree in elementary education from the university in 1967.

Miller also stressed the importance of the university's upcoming fundraising campaign, which is planned to coincide with the university's 150th anniversary in 2017.

"The reason it's important is because the University of Illinois is one of the premiere land grant, research-based universities in this country. ... The reason this country is where it is, is because in the latter part of 20th century we had the most, the best educated folks in the world. The challenge is we're slipping. And we can't make it up with just graduates from private universities. The publics, like the University of Illinois, must not only survive, but they have to prosper. And that is the challenge in this new campaign."

"Sheila and I would hope that by lighting this one point of light with this endowment and chair for Professor Zhao, so richly earned, that maybe that is a way to light a thousand lights in this campaign," Miller said.

“Sheila and I would hope that by lighting this one point of light with this endowment and chair for Professor Zhao, so richly earned, that maybe that is a way to light a thousand lights in this campaign.”

Steven L. Miller

Huimin Zhao with members of his research group.



New scholarships to support top students

Thanks to generous donors, the Department of Chemical and Biomolecular Engineering has been able to reward outstanding students, provide financial support to those who need it, and enhance the diversity of our student body by awarding scholarships annually. This year the department launched a new scholarship initiative, **Pathways to Success**, aimed at improving student diversity.

"Hispanic and African American students continue to be underrepresented in science and engineering, but this is not always because of lack of talent or interest. Often it is because of lack of access, exposure and funding," said Dr. Jerrod Henderson, Chemical and Biomolecular Engineering Lecturer and chair of the department's scholarship committee.

The department aims to increase the number of students traditionally underrepresented in chemical engineering. As of Fall 2015, Chemical and Biomolecular Engineering had 681 undergraduates enrolled. Of those, approximately 11 percent were considered underrepresented (African American, Hispanic/Latino, American Indian & Alaskan Native, Native Hawaiian and Pacific Islander).

"Through the Pathways to Success scholarship, we can remove these financial and access hurdles. Students who may not have been able to attend the University Illinois will be able to enroll here and excel in the program," Department Head Dr. Paul Kenis said.

The Pathways to Success scholarship is for a select number of outstanding underrepresented admitted students. For its inaugural year, 12 admitted freshmen for Fall 2016 were offered the scholarship, in the hopes that six will accept the scholarship and

enroll in Chemical and Biomolecular Engineering at Illinois.

It's a \$10,000 award, with \$5,000 for the student's freshman year and \$5,000 for his or her sophomore year, as long as the student maintains satisfactory academic progress. The department would like to expand this program to all four years, pending funding of a scholarship endowment.

"With a more diverse student population we hope to experience a diversity of ideas, approaches, and perspectives, which make for more exciting group projects and solutions to engineering problems," Henderson said.

Schiff-Berger Scholarship

Also new this year, the department is raising funds to establish an endowed scholarship to honor and remember Rebekah Schiff-Berger, a bright sophomore in the chemical engineering program who passed away in September 2015.

Rebekah was a James Scholar and active in various student organizations at the University of Illinois, including the Illinois chapter of the American Institute of Chemical Engineers, the Society of Women Engineers, the department's Undergraduate Advisory Board, and others.

Once endowed, the scholarship will provide financial support to a freshman or sophomore in chemical engineering who exemplifies characteristics similar to Rebekah's: someone with strong academic standing and active involvement in the program.

The scholarship is being supported by an initial investment from the department and Rebekah's family and friends. Fellow students have been raising money for the scholarship as well, including the Engineering Spelling Bee on campus sponsored by the Society of Women Engineers.

"A kind, promising student, Rebekah touched many lives during her time here, and through this scholarship she will continue to touch the lives of many more," Dr. Kenis said.



Every spring ChBE scholarship recipients and their families are invited to attend a recognition ceremony on campus. This year, the department invited scholarship donors to the event, allowing donors the opportunity to meet students. Alumni and ChBE supporters Ray Pasteris and Sally and Ed Heerd (pictured above) meet before the ceremony.

Scholarship recipients 2015-2016

John Martin Ankenbauer Memorial Scholarship
Ashley May

Franklin A. Boyle Scholarship
Brandon Rodgers

Chemical Engineering Alumni Scholarship
Benjamin Pedretti
Timothy Chen

Donald E. Eisele Scholarship
Nicholas Connolly

Robert S. Frye Scholarship
Dongkwan Lee

Clarence G. Gerhold Memorial Scholarship
Dawna Peterson

Dr. Joseph and Donna Glas Scholarship in Memory of Professor James Westwater
Vitaliy Dushnov

Chester W. Hannum Scholarship
Alex Baci
Ethan Dukovic
Joshua Jones
Amanda Pritchard

Edmund D. and Sara J. Heerdtschmidt Scholarship
Lauren Schmitt
Noah Wood

Earp Jennings Chemical Engineering Scholarship
Aza Walker

John W. Latchum, Jr. Scholarship
Kenan Al-Bardan

Arthur F. and Harriett Neville Limper Scholarship
Brandon Rodgers

Dr. Ray A. Mentzer Scholarship
David Ugweje

Elwood Edward Nelson Scholarship
Pacharapol Charoensuk
Matthew Miller

Omega Chi Epsilon Scholarship
Shayta Roy

Edward I. Onstott Scholarship
Sasha Ebrahimi
Anthony Tapia

Raymond M. Pasteris Scholarship
Francisco Canales Gonzalez

Worth Huff Rodebush Scholarship
Rebecca Boehning

Thomas R. and Yolanda S. Stein Scholarship
Jae Kwan Song
Jake Gold

R. J. Van Mynen Chemical Engineering Scholarship
Lingqing Yan
Weikun Zhu

Bruno H. Wojcik Scholarship
Omotola Okesanjo

ExxonMobil Scholarship
Xuxia Chen

Phillips 66 Scholarship
Jordan Blake Banks

Clorox Scholarship
Alejandro Urbina Leon De La Barra

Shell Scholarship
Seo Woo Choi

UOP Foundation Scholarship
Sisto Andrea Perciballe

Scholarships recipients and winners of the 2016 Undergraduate Research Symposium were honored in April.



FACULTY ACHIEVEMENTS

Flaherty earns NSF CAREER award

Assistant Professor of Chemical and Biomolecular Engineering **David W. Flaherty** has received a 2016 National Science Foundation CAREER Award for his research proposal, "Molecular Understanding and Catalyst Design for the Direct Synthesis of H₂O₂." Dr. Flaherty's work aims to develop the fundamental insight needed to develop catalysts for on-site, efficient production of hydrogen peroxide. This approach could potentially eliminate use of environmentally-taxing chlorine-based oxidants in many industrial processes.

The National Science Foundation's Faculty Early Career Development Program's CAREER Awards are prestigious and competitive awards given to junior faculty who exemplify the role of teacher-scholar through outstanding research, excellent education, and the integration of education and research within the context of the mission of their respective organizations.

Dr. Flaherty is a Dow Chemical Company Faculty Scholar in Chemical and Biomolecular Engineering. He joined the department in 2012. He applies mechanistic and kinetic investigations of chemistry at surfaces to the design of more reactive and selective catalytic materials.

Kong honored for research excellence

Congratulations to **Hyunjoon (Joon) Kong**, winner of the prestigious College of Engineering Dean's Award for Excellence in Research. The Excellence in Research Award is given annually to faculty in recognition of their outstanding research. Kong is Associate Professor and Centennial Scholar in Chemical and Biomolecular Engineering and is affiliated with the Departments of Bioengineering and Pathobiology. His research focuses on the synthesis, characterization, and processing of nanobiomaterials for diagnostic imaging and molecular/cell therapies of wounds and vascular diseases.

Dr. Kong joined the University of Illinois faculty in 2007. At Illinois he has developed several biomaterial systems research. Highlights include decoupled control of stiffness and permeability of a hydrogel for 3D cell culture and transplantation; biomaterial systems enabling the

control of growth direction and spacing of vascular networks; and a self-folding hydrogel capable of controlling molecular release rate with its shape change. He developed nanomaterial that can guide therapeutic stem cells to target inflamed vasculature. And he is conducting a project looking at self-assembly of multi-functional nanoparticles for image-guided drug delivery, termed "theranostics," and also a project looking at engineering complex and functional 3D organ-like tissue, termed "organoid" by regulating emergent behavior of "living" biological cells.

Diao named emerging investigator

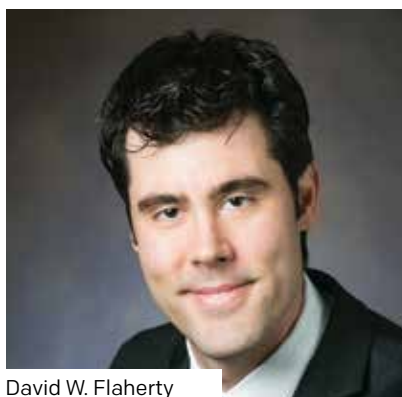
The Journal of Materials Chemistry of the Royal Society of Chemistry named Assistant Professor **Ying Diao**, Dow Chemical Company Faculty Scholar, an Emerging Investigator and invited her to contribute to a themed issue. The issue gathered "the very best work from materials chemists in the early stages of their independent career, with a special focus on novel design strategies for new functional materials," according to the journal. In her article with graduate student Hyunjoong (Tim) Chung, Diao presented a unique perspective of polymorphism as a

design tool to enhance electronic performance and fundamental understanding of the relationship between charge transport and molecular packing in organic electronics.

New grants for Harley

Associate Professor and I.C. Gunsalus Scholar **Brendan A. Harley** received new funding that will advance his research group's work. The first grant, from the National Institutes for Health, is entitled, "Biomimetic hydrogel niches to study the malignant phenotype of glioblastoma multiforme." The five-year grant continues Harley's development of an artificial brain tumor platform to study the means by which glioblastoma multiforme avoids current generation therapies. Glioblastoma multiforme is the most common and lethal form of brain cancer. Collaborators include Drs. Jann Sarkaria and Ian Parney from the Mayo Clinic in Rochester, Minn. and Dr. Steven George, Professor and Chair of the Department of Biomedical Engineering from Washington University in St. Louis.

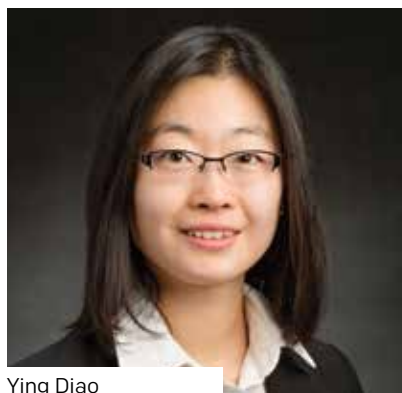
The second grant, from the U.S. Army Medical Research and Materiel Command, is entitled, "Polycaprolactone-collagen composite biomaterials for mandible regeneration." The work entails



David W. Flaherty



Hyunjoon Kong



Ying Diao



Brendan A. Harley

generating patient-customizable implants that induce regeneration in complex mandible injuries, such as jaw defects due to injuries from improvised explosive devices. Collaborators include Professor of Animal Sciences **Dr. Matthew Wheeler** from the University of Illinois and Professor of Biomedical Engineering **Dr. Scott Hollister** from the University of Michigan.

\$8M for nucleome program

A team of investigators has been awarded an \$8 million, five-year grant from the National Institutes of Health as part of the 4D Nucleome Program. The project, "Combined cytological, genomic, and functional mapping of nuclear genome organization" is headed by **Andrew Belmont**, Professor of Cell and Developmental Biology, and includes **Huimin Zhao**, Steven L. Miller Chair in Chemical Engineering and **Jian Ma**, Associate Professor of Bioengineering from Illinois, plus David Gilbert at Florida State University and Bas van Steensel at the Netherlands Cancer Institute. Belmont, Ma, and Zhao are also members of the Carl R. Woese Institute for Genomic Biology at Illinois.

The group is one of six 4D Nucleome Center grants studying organization and function within the nucleus.

Now in Korean

Professor **Ed Seebauer's** textbook on ethics, co-authored with Robert L. Barry, has been translated into Korean. The book, *Fundamentals of Ethics for Scientists and Engineers*, was first published in 2001 by Oxford University Press. It was translated into Korean by Kyungpook University Press in 2013. Seebauer is the James W. Westwater Professor in Chemical and Biomolecular Engineering and was department head from 2005 to 2011. The book employs a "virtue ethics" approach to the subject that can be used in stand-alone engineering ethics courses, or in a modularized way as part of courses aimed mainly at other topics. His research focuses on the control of atomic-scale defect behavior in semiconducting materials for applications in energy, environment, and electronics. He maintains a website on engineering ethics, and continues to write and lecture on the subject.



Edmund G. Seebauer



Huimin Zhao



Mary L. Kraft

Masel highly cited

Seven Illinois researchers, including retired Chemical and Biomolecular Engineering Professor **Richard Masel**, were named to the Thomson Reuters Highly Cited Researchers list for 2015. The list is based on an analysis of journal article publication and citation data, an objective measure of a researcher's influence over the past 12 years. After retiring from Chemical and Biomolecular Engineering in 2011, Dr. Masel started the company Dioxide Materials. The company pursues technology for the conversion of CO₂ to fuels as well as CO₂ sensor technology to enhance the efficiency of HVAC systems of buildings. Masel also is a researcher in the University of Illinois Department of Electrical and Computer Engineering.

Innovative cancer imaging

The National Cancer Institute has awarded a new four-year grant of more than \$1.6 million to Beckman Institute researchers for development of innovative cancer imaging. In most cancers, especially in prostate cancer, it is difficult to predict if a diagnosed tumor will actually prove dangerous. This lack of precision in charting the course of the cancer means that many people who may benefit from a milder form of treatment are over-treated, leading to losses in quality of life and great financial cost to society.

Currently there are no good methods to predict whether a specific tumor is dangerous.

Researchers in the lab of University of Illinois Bioengineering Professor **Rohit Bhargava**, a member of Beckman's Bioimaging Science and Technology Group, have proposed a new imaging method to determine the risk of lethal prostate cancer upon initial diagnosis. Bhargava is an affiliate faculty member in Chemical and Biomolecular Engineering.

Kraft named Schaefer Faculty Scholar

Associate Professor Mary L. Kraft has been named a Robert W. Schaefer Faculty Scholar, a position established by the late Robert Schaefer, a chemical engineering alumnus. Kraft, who joined the department in 2007, investigates bioimaging, drug delivery, single cell analysis, and multivariate statistics. Her research group is developing new approaches in which compositional signatures acquired from individual cells are used to understand and predict biological function. They use these techniques for applied research, such as detecting stem cell differentiation for tissue engineering, and for basic research on the roles of plasma membrane organization in influenza virus replication and other important biological processes. The faculty scholar appointment is effective August 16, 2016.

Robert W. Schaefer graduated *summa cum laude* from Illinois in 1956. After earning his BS in Chemical Engineering, Schaefer worked at the Shell Chemical Company in Houston, followed by Monsanto, where he spent 28 years. While with Monsanto, he worked in Food and Fine Chemicals, Rubber Chemicals, and on Roundup. He was part of the team which introduced L-Dopa, the breakthrough Parkinson's Disease drug, to the marketplace.

RESEARCH HIGHLIGHTS

Research reveals mechanism for direct synthesis of hydrogen peroxide

New research from Assistant Professor of Chemical and Biomolecular Engineering **David Flaherty** and graduate student **Neil Wilson** reveals the mechanism for the direct synthesis of hydrogen peroxide on palladium cluster catalysts. Their research paves the way to design improved catalysts to produce H_2O_2 to use in place of harmful chlorine, regardless of the scale of the production facility.

The research appeared earlier this year in the *Journal of the American Chemical Society*.

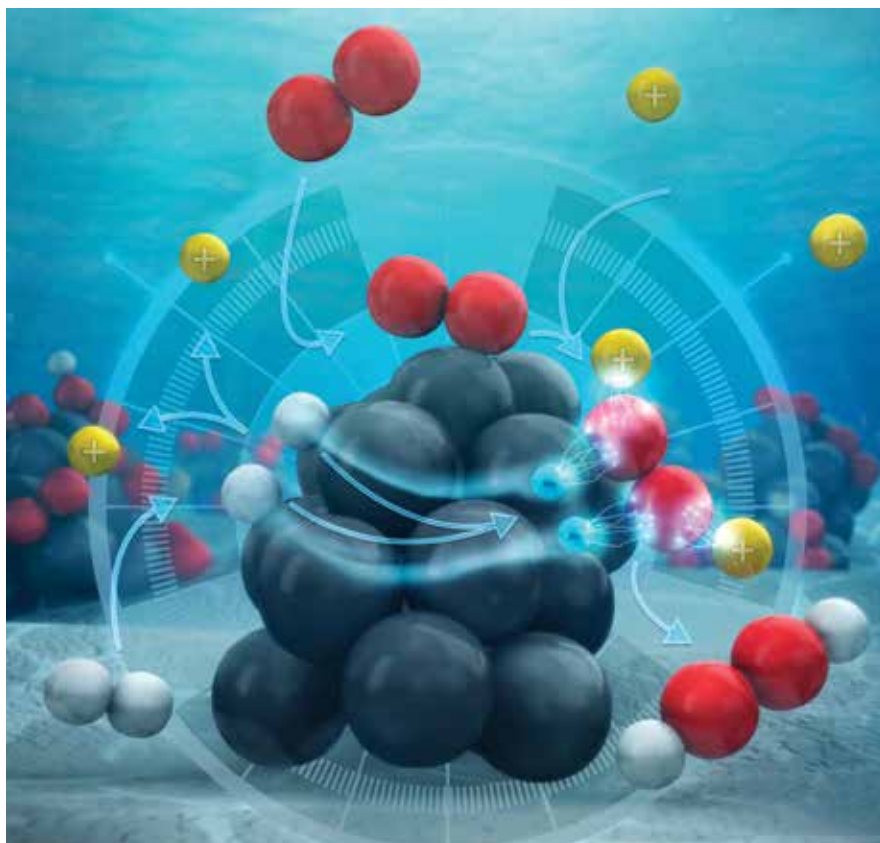
The commonly accepted mechanism for direct synthesis of H_2O_2 essentially states that hydrogen and oxygen atoms bind adjacent to one another on the catalyst surface and then react, Wilson said. To better understand what was going on, he spent over a year building a reactor, fine-tuning experimental procedures, then collecting and analyzing reaction rate data.

“What people thought was happening is after the hydrogen atoms broke apart and they’re adsorbed onto the palladium surface, that they just reacted with the oxygen on the surface. But that’s not really consistent with what we saw,” Wilson said.

Featured on the journal’s cover is an image that depicts their findings: Instead of reacting together on the surface of the catalyst (the palladium cluster), the hydrogen atoms dissociate into their components—protons and electrons. The protons enter the surrounding solution of water and methanol, while the electrons flow through the palladium itself into oxygen molecules.

“When oxygen comes down onto the surface, it can react with pairs of protons and electrons to form hydrogen peroxide,” Wilson said.

“The reason this is critical,” Flaherty said, “is because it gives us guidance for how to make the next generation of these materials. This is all



Instead of reacting together on the surface of the catalyst (the palladium cluster), the hydrogen atoms dissociate into their components—protons and electrons. The protons enter the surrounding solution of water and methanol, while the electrons flow through the palladium itself into oxygen molecules. Credit: American Chemical Society.

motivated by trying to make hydrogen peroxide more cheaply so it can be manufactured more easily, so we can use it in place of chlorine. But we didn’t know how to go about making a catalyst that was better than what we have now.”

Researchers will now have a better sense of what is happening at the catalyst surface and an appreciation for the role of proton and electron transfer processes in this chemistry. It was not recognized that the oxygen on the surface reacted with liquid phase species, and that the formation of H_2O_2 by direct synthesis is, therefore, strongly influenced by the solution itself. However, the formation of water (the undesired side reaction) is mostly influenced by properties of the catalyst surface.

“Now that we understand what’s happening on the surface, we can

start pushing towards rational catalyst design,” Wilson said. The research group is now looking into another catalyst, gold-palladium, which has been shown in previous work to be very selective towards H_2O_2 . “People still don’t entirely know why gold-palladium is so selective,” Wilson added, but it seems that this new mechanistic insight will help to explain the selectivity of these materials.

Several students in Dr. Flaherty’s lab are currently exploring different ways of “coupling this chemistry directly with reactions that use hydrogen peroxide for green oxidations within very short length scales,” that is, micrometers away, Flaherty said. “If we can put these H_2O_2 formation catalysts very close to something which performs the oxidation reaction, we can avoid the entire problem of concentrating and transporting hydrogen peroxide,” he said.

RESEARCH HIGHLIGHTS *continued***Researchers develop method to trap multiple particles**

Precise control of an individual particle or molecule is a difficult task. Controlling multiple particles simultaneously is an even more challenging endeavor. Illinois researchers have developed a new method that relies on fluid flow to manipulate and assemble multiple particles. This new technique can trap a range of submicron- to micron-sized particles, including single DNA molecules, vesicles, drops, or cells.

"This is a fundamentally new method for trapping multiple particles in solution," said Associate Professor of Chemical and Biomolecular Engineering **Charles M. Schroeder**. He conducted the research with mechanical science and engineering graduate student **Anish Shenoy** and Chemical and Biomolecular Engineering Professor **Christopher V. Rao**.

The study's results were reported in the *Proceedings of the National Academy of Sciences*.

Many methods exist for particle trapping, with each type using a different modality for trapping

– including optical, magnetic, acoustic and electrical forces. However, many of these techniques change or perturb the system that is being observed.

"The existing techniques can be very restrictive in particle properties required for trapping, and we wanted to study a broad range of systems like bacterial cells and different types of soft particles like vesicles, bubbles and droplets," Shenoy said. None of the prevailing techniques can be used for studying this broad range of systems across multiple length scales, he said. Thus, the researchers wanted to build a technique that could be generally applied to arbitrary numbers of arbitrary kinds of particles.

Called the Stokes Trap, the method developed by Schroeder's team relies on gentle fluid flow to manipulate particles. Schroeder's group is the first to implement multiple particle trapping and assembly using fluid flow.

Using the Stokes Trap, the researchers can manipulate particles to follow any predetermined path.

In order to control the movement of the particles from a set starting position to a set ending position,

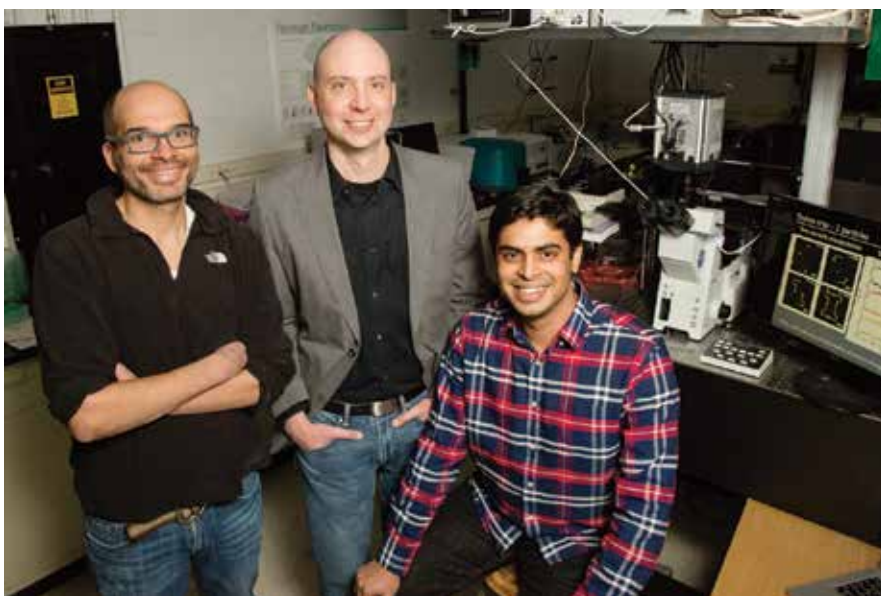
Shenoy and his colleagues developed an automated control algorithm that calculates which pressures are required to drive the flow fields and precisely move the particles in a small microdevice. The algorithm can solve the complex optimization problem in half a millisecond, he said.

"There are multiple parameters involved in the controller, and that's the complicated part of it," Schroeder said.

The control program is designed to calculate the particles' distance from a target position and move them efficiently by minimizing the flow rate necessary to move the particles. It also will allow researchers to assemble multiple particles into arbitrary, complex structures and to probe interactions between two or more particles.

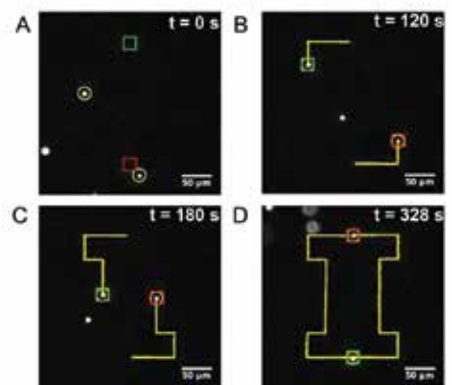
The group hopes the Stokes Trap will become as universal as other commonly used trapping methods.

By Sarah Banducci, University of Illinois News Bureau



From left, Illinois professors Christopher Rao and Charles Schroeder with graduate student Anish Shenoy developed a new method for controlling multiple particles.

Photo by L. Brian Stauffer.



Using the Stokes Trap, the researchers can manipulate particles to follow any predetermined path. Image courtesy of Anish Shenoy.



Gabriel Popescu, Hyunjoon Kong, Martha Gillette, Taher Saif, EBICS Director Roger Kamm of MIT, Rashid Bashir, and Program Coordinator Carrie Kouadio. Photo by Gregory Pluta.

Scientists build bio-machines to improve health

By studying and engineering the cross-talk and behavior of living cells, Illinois researchers are creating “biological machines” to deliver drugs more effectively, function as internal diagnostic tools or serve as contaminant sensors in the field.

The work is facilitated by a multi-institution effort known as the Emergent Behaviors of Integrated Cellular Systems, or EBICS, which received \$25 million in National Science Foundation renewal funding for the next five years to build living, multicellular machines to solve environmental, health and security problems.

The goal of the project is to build non-natural functions with cells, according to **Rashid Bashir**, EBICS co-principal investigator and head of the Department of Bioengineering at Illinois. “Take vascular disease, for example. One could approach the problem from the standpoint of, ‘What if we could take passive vascular cells and combine them with cardiac muscle cells to create vascular tissue that could pump?’ Such devices would allow patients’ own bodies to become part of the solution.” The group’s efforts aren’t limited to improving

human health. “We’re also interested in building living machines that can do things like sense toxins in water and potentially neutralize them,” he said.

In the first phase of the project, the researchers examined the behaviors of muscle, neuronal and vascular cells. Although much is known about how these cells function, little was known about integrating them.

“We needed to learn how to grow diverse cells together, as each has its own ideal growing conditions,” Bashir said. “We also needed to learn how to get them to communicate with each other.”

Bashir is joined on the Illinois EBICS team by professors **Hyunjoon Kong**, of the Department of Chemical and Biomolecular Engineering; **Martha Gillette**, of cell and developmental biology; **Gabriel Popescu**, of electrical and computer engineering; and **Taher Saif**, of mechanical science and engineering.

Kong develops new, soft biomaterials to “house” the cells and the machines and nanoparticles to “stimulate” them. Gillette’s group develops neuronal circuits to provide sensing and processing. Popescu develops new imaging techniques to visualize and study the emergent behavior of living cells over time.

In particular, Kong’s group demonstrated that the mechanical softness of biomaterials, on which embryonic stem cell clusters were cultured, can regulate emergent cellular behavior involved in vascularized cardiac muscle and three dimensionally interconnected neural networks. He is currently integrating these organoids to engineer a functional neuromuscular junction characterized by innervation of motor neuron cells into muscle layer. The engineered neuromuscular junction would be further integrated with bio-bots to create a biological machine with self-recognition and actuation capability.

The engineered neuromuscular junction alone would be broadly useful to better understanding a series of biological processes involved in development, regeneration, and pathology, according to Kong. It also would help in further evaluating newly developed drug molecules and biomedical devices used to enhance the treatment quality of neuromuscular diseases in a fast and precise manner, he said.

UNDERGRADUATE ACHIEVEMENTS

Sophomore wins Goldwater Scholarship

Chemical and Biomolecular Engineering sophomore **Elijah Karvelis** has been awarded the prestigious Barry M. Goldwater Scholarship for demonstrating leadership and academic promise.

The Barry M. Goldwater Scholarship and Excellence in Education Program provides a continuing source of highly qualified scientists, mathematicians, and engineers by awarding scholarships to sophomores and juniors from the United States who intend to pursue doctorates in these fields.

As a first-semester freshman at Illinois, Karvelis worked with Associate Professor of Chemical and Biomolecular Engineering **Charles Schroeder** to synthesize structurally defined polymers.

"Eli is mature beyond his years and is always asking the deep scientific questions of 'how' and 'why' in research," said Schroeder, who nominated Karvelis for the scholarship. "In my group, Eli synthesized 'structurally-defined' polymers, which are macromolecules with precise topologies and architectures. On this project, he quickly became proficient in a broad area of techniques in biopolymer synthesis and characterization. He has a very promising future ahead and represents some of the best intellectual student talent that Illinois has to offer."

Karvelis, of Pecatonica, Illinois, is a member of the Campus Honors and James Scholar programs. He plans to

pursue a Ph.D. in chemical or biological engineering and conduct research in biotechnology to advance health sciences.

Last summer, Karvelis participated in a National Science Foundation-sponsored Research Experience for Undergraduates at the Massachusetts Institute of Technology, which introduced him to topics in tissue engineering and biomaterials. As his interest in tissue engineering grew, Karvelis in January moved to the research group of Associate Professor of Chemical and Biomolecular Engineering **Brendan Harley**.

Karvelis is one of three University of Illinois students being recognized this year.

Knights of St. Patrick Honors

Congratulations to senior **Nicholas Connolly**, recipient of the 2016 Knight of St. Patrick Award, and **Patricia Simpson**, Director of Academic Advising and Career Services for the School of Chemical Sciences, for winning the Golden Shamrock award by the 2016 Knights of St. Patrick.

The Knight of St. Patrick award is given to students who represent leadership, excellence in character, and exceptional contributions to the College of Engineering. It's one of the highest honors a student can receive from the College of Engineering.

Connolly has been involved with AIChE (president, 2014-2015), undergraduate research at the Center for Plasma-Material Interactions, the Engineering

Open House, Newman Center Service and Justice Outreach, and the music group Illini Contraband. In addition to majoring in Chemical Engineering, he graduated this spring with minors in Electrical and Computer Engineering and Technology & Management.

Connolly, who's from Flossmoor, Ill., chose to study Chemical and Biomolecular Engineering because he knew he wanted to be an engineer, and chemical engineers have a broad range of career opportunities.

"I have academic and extracurricular interests inside and outside of chemical engineering, and was amazed at how many of them I was able to explore and develop during my time at the University of Illinois. I love ChBE at Illinois because ChBE here feels like a family. Although it is a tough four years, classmates study together, mentor each other, and really get to know each other by senior year."

The Knight of St. Patrick is an annual award given to approximately 10 to 15 engineering students.

The Golden Shamrock award is given to a staff member who supports students of the College of Engineering, an individual who has demonstrated leadership and service, who has contributed to the enhancement of student activities, and maintained a high level of character. **Patricia Simpson** joined the University of Illinois' School of Chemical Sciences in August 2007.



Elijah Karvelis



Nicholas Connolly



Patricia Simpson

Top seniors recognized

Congratulations to the four Chemical and Biomolecular Engineering seniors whose names will be inscribed on the university's **Bronze Tablets: David S. Braker, Timothy Linghau Chen, Sasha B. Ebrahimi, and Jae Kwan Song.** Tablets are on view in the Main Library.

Bronze Tablet students must have at least a 3.5 cumulative GPA through the academic term prior to graduation, and rank in the top 3 percent of their graduating class. The Bronze Tablet tradition dates back to 1925.

James Scholars who graduated this spring included **Zeynep Ali, Timothy Chen, Sasha Ebrahimi, Kevin Erning, Sophie Friedman, Pawel Grimm, Christopher Janke, Alexander Olenskyj, Amanda Pritchard, Shayta Roy, Jae Kwan Song,**



Illinois Chemical and Biomolecular Engineering student Michael Jorgensen

Brandon Sprenger, Amelia Witcoski, and Rosa Wu. The James Scholars honors program encourages academically gifted students to fully develop their intellectual abilities and achieve the college's highest academic recognition.

Chancellor's Scholars who graduated this year included **Nicholas Connolly and Benjamin Rosenberg.** Chancellor's Scholars are selected for the Campus Honors Program for their academic excellence and leadership potential.

AICHE members honored

Congratulations to undergraduate students honored at the Fall 2015 AIChE annual conference.

Undergraduate **Scott Kieback** received the 2014-2015 Donald



Illinois Chemical and Biomolecular Engineering student Scott Kieback

F. Othmer Sophomore Academic Excellence Award. This is presented to one AIChE student member in each student chapter who has attained the highest scholastic grade-point average during his or her freshman and sophomore years.

Michael Jorgensen received the **2014-2015 Freshman Recognition Award.** This award is presented to one AIChE student member in each student chapter who has been the most active in their student chapter during his or her freshman year.

Excellent Classroom Assistants

Congrats to ChBE undergrads who worked as classroom assistants and were included in the list of Teachers Ranked as Excellent by their Students this year: seniors **Timothy Chen, Kevin Erning, Christopher Gerhard, Pawel Grimm, Scott Kieback, Matthew Mille** and **Jae Kwan Song,** plus **Hariom Agarwal,** who graduated in Spring 2015. The results are based on Instructor and Course Evaluation System (ICES) surveys maintained by the university's Center for Innovation in Teaching and Learning.

Ninth Annual Undergraduate Research Symposium

As part of their undergraduate experience, many Chemical and Biomolecular Engineering students work in research labs of the department's world-class faculty. The Undergraduate Research Symposium provides students with the opportunity to showcase their work on topics ranging from biofuels to tissue engineering.

The annual event is organized by Omega Chi Epsilon, the national honor society for chemical engineering. The department invites alumni and friends from industry to judge the poster presentations. Thanks to this year's symposium judges: **Shawn Cullen,** LyondellBasell; **Paul Jahn,** BS '81, Middough; **Sarah Kuhl,** BS '15, Clorox; **Aimee Nugent,** BS '15, Pepsico; and **Rouema Vukovich,** BS '89, Dow AgroSciences.

Congratulations to this year's winners.

First place: **Shayta Roy** (Harley Group), "Multi-compartment Biomaterial Scaffolds to Promote Mesenchymal Stem Cell Differentiation and Proliferation at Tendon Bone Junction."

Second place: **Rebecca Boehning** (Diao Group), "Vapor Diffusion for Fabricating Large Single Crystals for Flexible Electronics."

Third place: **SiiHong William Lau and Yasheen Jadidi** (Guironnet Group), "Selective Upgrading of Biomass Fuels by Continuous-Flow Homogeneous Catalysis."

In addition to the winners, this year's symposium's participants included **Kevin Erning, Christian Coonrod, Jake Gold, Byeongjin Kang, Dongkwan Lee, Xun Lu, Pimpisa Pechvijitra, Mark Triezenberg, Alan Vucetic, Yuying Wu.**



2016 ENGINEERING OPEN HOUSE

Students win EOH honors for building distillation column

Thousands of curious students, from elementary to high school age, explored the halls of the University of Illinois engineering buildings in March as part of the 96th annual Engineering Open House. The popular outreach event, called “The STEM of Innovation” this year, featured over 250 exhibits, four design competitions, the giant Tesla coil, and many other attractions. Chemical and Biomolecular Engineering students set up exhibits in Loomis Laboratory on a range of topics, such as crystal structures, beer fermentation, and soap manufacturing. New this year was a functioning distillation column built from scratch by students.

“I was interested in chemical engineering when I graduated high school, but I didn’t really know what chemical engineers dealt with,” said senior Andrew Stolcers. “What we really wanted to do was give kids a visualization of what actually goes on in the chemical engineering world. A lot of that is seen through continuous distillation. Almost every engineer that graduates and goes into industry will work with distillation. Our goal was to show visual separation of components.”

The students did that by using an acid indicator along with a dilute amount of vinegar in water so visitors “could see the pH change across the tower, which gives little kids and idea of, ‘Oh, I can see something is changing in concentration as it goes up or down the tower.’”

“We wanted to do it in the way that distillation is actually occurring, rather than just bubbling up liquid and running water down the top. We wanted to show kids what distillation is and give adults an idea of the applications of distillation, ranging from production of plastics to consumer products all the way to petrochemicals,” Stolcers said.

“What I loved about this project is it’s exactly what chemical engineers do,” said ChBE student Samantha Sutton. She will graduate in December and

plans to go into process engineering. Last year she worked in a chemical plant and this summer she will work at a food manufacturing plant.

The students worked on the project for almost two months and met regularly with Lecturer Dr. Troy Vogel to share ideas and provide updates on progress.

“It’s very cool. I’m very impressed with what they put together,” Vogel said.

“It’s been a hands-on way for me to enjoy the design aspect, to get creative and build from scratch,” said Vishaal Yepuri, who took CHBE 422: Mass Transfer Operations this spring. Last summer he worked for a pharmaceutical company in Puerto Rico and will work for a consumer products company this summer.

“We wanted to show kids what distillation is and give adults an idea of the applications of distillation, ranging from production of plastics to consumer products all the way to petrochemicals.”

-Andrew Stolcers



Brendan Schedler and Andrew Stolcers explain the distillation column to visitors at the 2016 Engineering Open House.

EOH 2016 Award Winners from Chemical Engineering

The STEM of Innovation (Engineering Open House Theme)
First Place: Continuous Distillation

Back to School category
Second Place: Liquid Nitrogen Ice Cream

Just for the Fun of It—Just Because
Third Place: Organic ChapStick

In addition to Stolcers, Sutton and Yepuri, the distillation project involved students Brendan Schedler, Morgan Folino, Ryan Sanders, Paul Schochat, and Therese Brown.

Learning from past mistakes: CHBE INTRO COURSE FOCUSES ON SAFETY

Six years ago, when a heat exchanger failed at the Tesero refinery in Washington, causing an explosion and the deaths of seven employees, the U.S. Chemical Safety Board launched an investigation, released a report, and issued recommendations.

The catastrophic accident was one of nearly 60 process safety incidents that Chemical and Biomolecular Engineering students, most of them freshmen, studied this semester. They read board reports, summarized findings, provided recommendations for future companies working with similar hazards, and shared their insights at a poster session at the Illini Union. Seniors, many of whom will soon be in charge of these processes, offered feedback to the students. Departmental faculty, who will soon have the students in upcoming classes, also came to offer feedback on their posters.

The process safety exhibits have been included in the class, "CHBE 121: The Profession," since Spring 2012. They're part of the department's "design across the curriculum" efforts, which calls for students completing design projects in core chemical engineering courses throughout their undergraduate career. In addition to analysis of a process safety incident, CHBE 121 includes lectures and discussions on the history and scope of chemical engineering as well as trips to plants. Over 175 students were enrolled in the class this spring semester.

In 2012 the accreditation board ABET expanded program criteria for chemical

engineering to require curriculum to include the hazards associated with engineering processes. The department's process safety projects are sponsored by Shell.

"This project allows students to start their chemical engineering education with an in-depth analysis of a major safety incident and critically evaluate actions moving forward," said Chemical and Biomolecular Engineering Lecturer Dr. Troy Vogel, who teaches the course. "The same students are then reminded three years later, right before graduation, of the impact they have on the lives of individuals and communities if something were to go wrong."

Vogel assigns each group a different major process safety incident that happened within the last 15 years. Most incidents are taken from completed Chemical Safety Board investigations to provide the students with at least one in-depth source of information.

"It is a very sobering experience to stand in a room with nearly 60 different projects of major industrial accidents which have all happened within the student's lifetime," Vogel said. "Every time I create the list, I reflect on the

continued mistakes our industry makes, compromising the integrity of property, but more importantly affecting the lives of people and families," he said.

For their project, freshmen Maddy Chalifoux and Matt Daminato reviewed the Patridge-Raleigh oilfield explosion in Mississippi in 2006. Daminato said he's enjoyed learning more about what he could do with a degree in chemical engineering in CHBE 121, but also, "how to avoid incidents like this one" in Mississippi.

The one-credit-hour class "is not as intensive as other classes" in the ChBE curriculum, Chalifoux said. "But it's interesting because, coming in as freshmen, we don't know a lot about what chemical engineering is. The class gives us some insight into what we could do (with our degree) and what we will be doing for the next four years," she said.

The class often includes visits from alumni who work in a variety of industries. Seniors also talk to the class and share their experiences in internships or co-ops and studying abroad and other classes in the ChBE curriculum.

"It's given us information that we just don't get in chemistry class," said sophomore Tom Crawshaw.

Upperclassmen talked about their life as ChBE students to freshmen in the CHBE 121 class.



Students discussed their posters about process safety accidents at the Illini Union this spring.





2016 Chemical and Biomolecular Engineering Convocation CONGRATULATIONS GRADUATES!

This May, 104 seniors graduated with bachelor's degrees and three graduate students received their doctoral degrees.



Convocation speaker Kathryn "Kit" Gordon, former director of technology for QuickLogic and co-founder of Botanic Organic, congratulated students on their achievements and said she was eager to experience the world they create.

"Engineers have been changing the world for thousands of years. Today that responsibility and honor is yours," Gordon said in her address to graduates.

The department ceremony was held on Sunday, May 15, 2016, at the Tryon Festival Theater in the Krannert Center for the Performing Arts. A reception followed in a tent on Centennial Plaza, between Noyes Laboratory and Chem Annex.

Rockford native Kit Gordon earned a BS in Chemical Engineering from the University of Illinois in 1983. To learn more about her story, please turn to page 23. Upon graduating, she worked in the semiconductor industry. She was granted 15 patents on amorphous silicon anti-fuse technology obtained during her work at QuickLogic Corp., a Silicon Valley startup where she served as Director of Technology until 1999. Gordon earned an MS in Electrical Engineering in 1989 and an MBA in 2001, both from Santa Clara University. She retired from industry soon after QuickLogic went public on the NASDAQ, and now advises agencies and non-profits on water resource management. She is married with one child and enjoys spending time in nature.

Gordon outlined three pieces of advice for graduates: "Find a workplace that sparks your creativity, embrace teamwork and start creating your advisory board today."

"My message to you is to explore your options and stay curious. Your degree opens doors in a wide range of industries and companies. Be open to opportunities and explore unusual options, ones that come along when

you're looking for something else. Let yourself be surprised by your reactions. You may be energized by environments you were avoiding or unaware of," Gordon said.

She suggested graduates seek out experienced people who can guide them through their career decisions. A mentor can advocate for you and coach you through difficult projects and be a sounding board for important presentations, she said. Don't forget professors, fellow graduates, friends and family—keep in touch with them. "Draw on their wisdom," she advised.

Dr. Paul Kenis, William H. and Janet G. Lycan Professor and Department Head, said he and his colleagues were very proud of the graduates' accomplishments. "We hope we have given you the education that will help you to be successful, and we wish you the best of luck in your professional and personal lives," he said.

Kenis urged graduates to stay in touch with the department. "In years to come, we hope to see many of you back on campus to share your achievements with us, just as Kathryn Gordon did today."

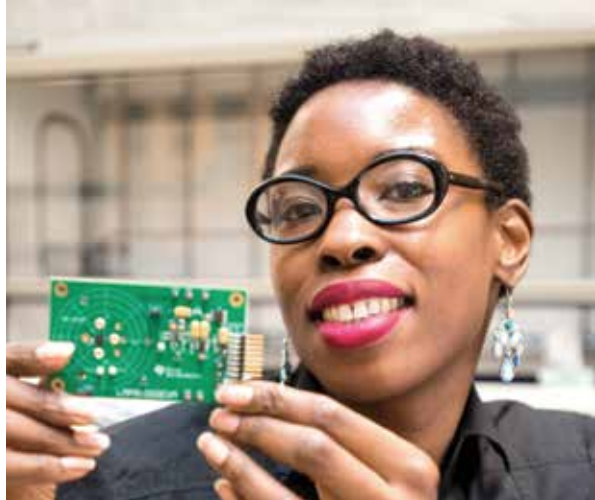


Photo credit: Robin Scholz, News-Gazette

“ I like that there are many resources at the University of Illinois for women entrepreneurs. I have certainly taken advantage of workshops and resources at the Technology Entrepreneurship Center and EnterpriseWorks in the research park. ”

Leslie Gilliard

Grad student develops PORTABLE ELECTROANALYTICAL SENSOR DEVICES

Leslie Gilliard, Ph.D. student and member of Dr. Ed Seebauer's research group, was named a finalist for the Illinois Innovation Prize, which rewards creative, passionate entrepreneurs on campus.

In addition to pursuing a graduate degree in Chemistry, she's also founder and CEO of Nardo Technology, which develops a smartphone-based electrochemical sensor for the rapid detection of illegal narcotics and explosives. Nardo Technology was a finalist in the Cozad New Venture Competition this spring.

Gilliard, who came to the University of Illinois from Temple University, said she chose the U of I because of the high caliber of its faculty and research.

“I like that there are many resources at the University of Illinois for women entrepreneurs. I have certainly taken advantage of workshops and resources at the Technology Entrepreneurship Center and EnterpriseWorks in the research park,” she said.

When she introduces people to her research, Gilliard said she often shares a quote from physicist Colin Humphreys: “Crystals are like people. It is the defects in them which tend to make them interesting.”

“Defects in a crystal heavily influence their properties and have a range of applications for microelectronics and catalysis to gas sensing and electroluminescence. The Seebauer group has developed novel techniques for defect engineering in metal-oxides using surface chemistry. My research

focuses on how surface chemistry changes the bulk reaction dynamics of self-point defects in Rutile Titanium Dioxide single crystals,” Gilliard said.

This spring Gilliard was featured in the Champaign-Urbana *News-Gazette* as part of its series “Wired In,” which highlights local high-tech difference makers. Here is an excerpt from that article.

Nardo is in the early stages of making an inexpensive handheld device that public safety workers can use to detect narcotics and explosives. Nardo is named for Leonardo da Vinci.

Q: How did you become an entrepreneur?

After my undergrad work (in chemistry) at Temple University, I worked in labs, first for an oil company, then three years with the Philadelphia Police Department. While in the forensic lab, I thought about improving the devices used to analyze samples. I didn't care for the 12-hour shifts and wanted to be more of my own boss.

Q: Was the forensic lab like one you see on “CSI”?

We got some weird stuff from the police to analyze. In one case, an officer submitted what he said was a syrup, and it turned out to be urine.

Q: With this tool, officers can eliminate some of the work by correctly analyzing in the field, right?

Yes. The Nardosensor will be able to detect synthetic marijuana, for instance. Drug dealers have been changing the formula to make new versions that get around the law. Because law enforcement agencies have budget constraints, we're making it very inexpensive, around \$200. We've incorporated data analytics, so they can geo-map it, identify drug trends, for instance. It will replace things like test strips, which are often inaccurate — testing chocolate or Tylenol as positive for drugs.

Q: What do you do when you're not in school or at Nardo?

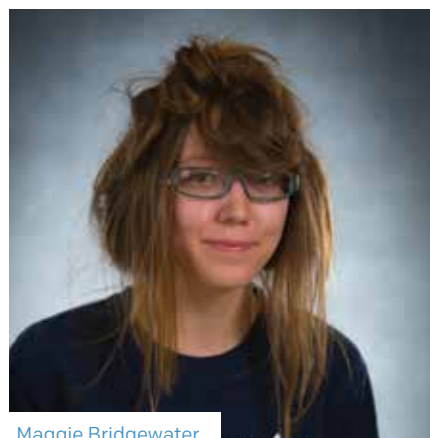
I take great pride in giving back to the UI and the Champaign-Urbana community. I am an entrepreneur mentor for the Young Entrepreneur Program at the Champaign Unit 4 School District. I also mentor a senior at Centennial High School to develop her business idea. We are constructing a business plan to start an arts outreach non-profit for teenagers and kids.



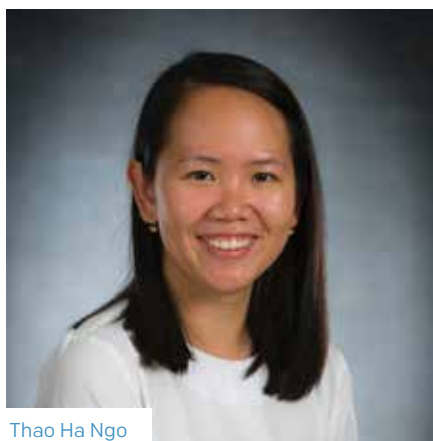
Mai Ngo



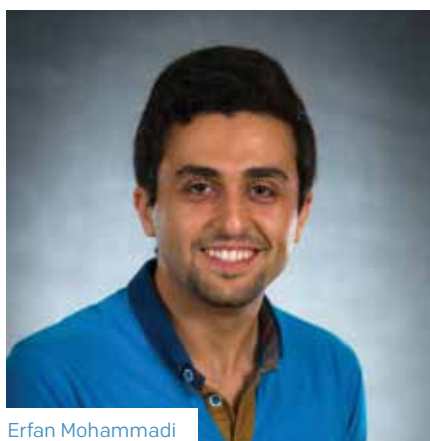
Daniel Bregante



Maggie Bridgewater



Thao Ha Ngo



Erfan Mohammadi



Joe Whittenberg

Graduate Student Achievements

NSF Fellowships

Congratulations to Chemical and Biomolecular Engineering graduate students who recently won graduate research fellowships from the National Science Foundation. **Mai Ngo** has won an NSF Graduate Research Fellowship and honorable mentions have been awarded to **Daniel Bregante**, **Maggie Bridgewater**, and **Katelyn Dahlke**.

Launched in 1952, the NSF Graduate Research Fellowship program is the nation's oldest and largest fellowship program for graduate students. It is also one of the most prestigious. This year 36 University of Illinois students have won NSF Graduate Research Fellowships. Of the 36 awardees, 31 are graduate students, and five are undergraduates. An additional 51 students were accorded honorable mentions.

Ngo joined the Department of Chemical and Biomolecular

Engineering as a graduate student in Fall 2015 after earning a BS in Chemical Engineering from Virginia Tech. A member of **Dr. Brendan Harley's** lab, she is incorporating vascular structures into a hydrogel platform used to model glioblastoma multiforme, one of the deadliest forms of brain cancer.

"In doing so, I will study the impact of vessels on tumor invasion and tumor response to hypoxia, as well as the effect of the perivascular niche on the cancer stem cell population," she said.

Bregante, a member of **Dr. David Flaherty's** research group, focuses on understanding the mechanism behind olefin epoxidation on metal-oxide catalysts with hydrogen peroxide and what descriptors they can find to help develop more selective and active catalysts. His undergraduate degree is from the University of California-Berkeley.

Bridgewater, whose undergraduate degree is from the University of Michigan, is a member of **Dr. Damien Guironnet's** research group. She is working on developing a new type of polymeric dye to be used as a sensitizer in photoelectrochemical cells. The polymeric dye consists of porphyrins incorporated into a conjugated polymer backbone, and the bandgap can be tuned via backbone modification, thereby allowing optimization of energy transfer within the cell, according to Bridgewater.

Dahlke, who received her bachelor's degree from Iowa State University, conducts research in computational polymer physics. As a member of **Dr. Charles Sing's** research group, she studies the cooperative behavior of DNA and protein interactions specific to prokaryotic cells, and eventually would like to use the coarse-grained



Katelyn Dahlke

Bregante is trying to understand the mechanism behind olefin epoxidation on metal-oxide catalysts with hydrogen peroxide “and what descriptors we can find to help develop more selective and active catalysts.”

“By using framework substituted zeolites, I can directly compare different transition metals and understand how their intrinsic properties affect their ability to epoxidize olefins,” he said.

Bregante joined the graduate program in Fall 2015.



Vahid Mirshafiee

Department of Energy award

Thao Ha Ngo, a graduate student in **Dr. Hong Yang**'s research group, will conduct research this coming fall at Argonne National Laboratory following her selection for an award from the U.S. Department of Energy Office of Science Graduate Student Research. Ngo, an NSF Graduate Research Fellow, received her B.S. in Chemical Engineering from Arizona State University in 2013.

Ngo won for her proposal, “Durability Study of Electrocatalysts for Oxygen Reduction Using In Situ Quick Scanning Extended X-ray Absorption Fine Structure.” In the proposed project, in situ quick scanning extended X-ray absorption fine structure (QEXAFS) and X-ray absorption near-edge spectroscopy (XANES) will be used to investigate, in real time, the compositional evolution of electrocatalysts during the oxygen reduction reaction. These findings will be coupled with observation in structural changes of these electrocatalysts, obtained via in situ liquid Transmission Electron Microscopy to gain insight into the mechanism and kinetics of the degradation of ORR catalysts.

The goal of the Department of Energy program is to prepare graduate students for science, technology, engineering, or mathematics careers critically important to the Department of Energy's Office of Science mission

by providing graduate thesis research opportunities at Department of Energy laboratories.

Research Live

Congratulations to the Illinois graduate students who participated in the Graduate College's first-ever Research Live event last semester. Chemical and Biomolecular Engineering graduate student **Vahid Mirshafiee** tied at second place for his talk, “Targeted Delivery of Anticancer Drugs to Tumors.” Mirshafiee is part of **Dr. Mary Kraft**'s research group.

Biochemistry graduate student **Ipek Tasan**, who is in **Dr. Huimin Zhao**'s research group, took home a first place. She presented, “Finding the Partners in Crime Causing Colon Cancer.”

Also among the finalists: Biochemistry graduate student **Ismaeel Muhamed**, who is in **Dr. Deborah Leckband**'s research group.

For Research Live, the college invited graduate students to deliver an engaging presentation of their work and its impact. They were allowed three minutes and two slides. Presentations were scored on delivery, clarity, effectiveness of visual material, and accessibility of language. Sixty-five graduate students entered the competition.

Excellent TAs

Congrats to graduate students who were included in the list of Teachers Ranked As Excellent by their Students for this year: **Arkaprava Dan, Erfan Mohammadi, Dylan Walsh, Megan Witzke, Joe Whittenberg**. The results are based on Instructor and Course Evaluation System (ICES) surveys maintained by the university's Center for Innovation in Teaching and Learning.

simulation methods she develops to simulate an entire nucleoid.

Approximately 17,000 students applied for NSF Graduate Research Fellowships this year, and 2,000 were offered awards.

Defense fellowship

Daniel Bregante, a graduate student in **Dr. David Flaherty**'s research group, has won the National Defense Science and Engineering Graduate Fellowship.

The National Defense Science and Engineering Graduate Fellowships are prestigious awards given annually to about 200 students nationwide. It's sponsored by the Air Force Office of Scientific Research, the Army Research Office, the High Performance Computing Modernization Program, and the Office of Naval Research, under the direction of the Director of Defense Research and Engineering.



Huimin Zhao Invested as STEVEN L. MILLER CHAIR IN CHEMICAL ENGINEERING

Illinois professor is a leader in
synthetic biology

Back when Huimin Zhao was a college student in the early 1990s, many people predicted that the 21st century would be the “century of biology,” much like the 20th century was called the “century of physics.”

A bright student with a range of interests, Zhao was intrigued by the promise and opportunities a “century of biology” could bring. Early into his undergraduate career, he followed his passion for biology and research and was able to participate in several research projects, first in immunology and later in molecular dynamics simulation related to drug design.

Now well into the 21st century, Zhao has become a pioneer in synthetic biology. He and members of his research group aim to harness the power of synthetic biology, developing and applying tools to address global challenges in human health and energy, and investigating the fundamental aspects of enzyme catalysis, cell metabolism, and gene regulation.

“It’s an exciting time” to be in this emerging synthetic biology field, Zhao said, given recent developments such as the iBioFAB, a “living foundry” developed at

the University of Illinois, and the establishment of numerous synthetic biology centers around the world.

Zhao directs research labs in Urbana and Singapore, consults often with industry, and teaches Illinois chemical engineering students about biotechnology and bioengineering. He has published more than 230 research articles and delivered more than 260 plenary, keynote, or invited lectures around the world. He has over 20 patents that have been issued or are pending, some of them licensed by industry. Fourteen of his former graduate students and postdocs have become professors while the rest (more than 40) are pursuing industrial careers.

In April, the Department of Chemical and Biomolecular Engineering celebrated Dr. Huijin Zhao's investiture as the Steven L. Miller Chair in Chemical Engineering.

Early years

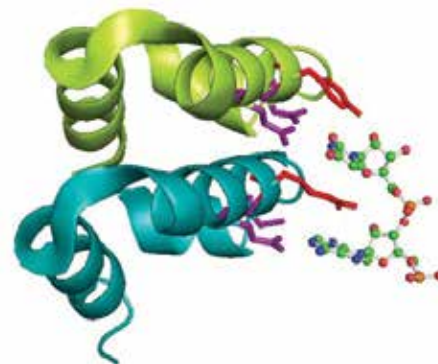
Zhao grew up in Haiyan, not far from Shanghai, where his father was a primary school teacher and his mother was a farmer. He left home at 13 years old when he was selected to attend a middle school about 20 miles away. From there, he and other top students enrolled at an elite high school. He then

gained admission into the University of Science and Technology of China in Hefei.

Unlike many of his peers at the time, Zhao was able to participate in research early on during his undergraduate years. That experience—using computer modeling for drug design—cemented his decision to continue his studies and earn a Ph.D. He applied to about a dozen graduate schools in the United States and was accepted at the California Institute of Technology.

Because of his background in molecular simulations and interest in protein engineering, Zhao decided to join the lab of CalTech Professor **Frances Arnold**. Arnold pioneered a new field called directed evolution, which is essentially to interrogate and engineer biological systems by mimicking the Darwinian evolution process in the test tube. Mainly because of that contribution, Arnold became the first female scientist to be elected to all three national academies in the United States, an honor that less than two dozen scientists have achieved.

"I was lucky to be in that environment and develop a few technologies for directed evolution, using them to engineer enzymes to improve performance, so that they could be used as catalysts for making chemicals or



Crystal structures of proteins PUF and PPR motifs from a 2015 article in *Molecular Biosystems*.

drugs," Zhao said.

Although he was interested in pursuing an academic career, while Zhao was finishing his Ph.D., Dow Chemical asked him to help establish the company's industrial biotechnology program. After he completed his Ph.D., Zhao joined the company and was involved in hiring new scientists, setting up the lab, and negotiating research collaborations with other companies.

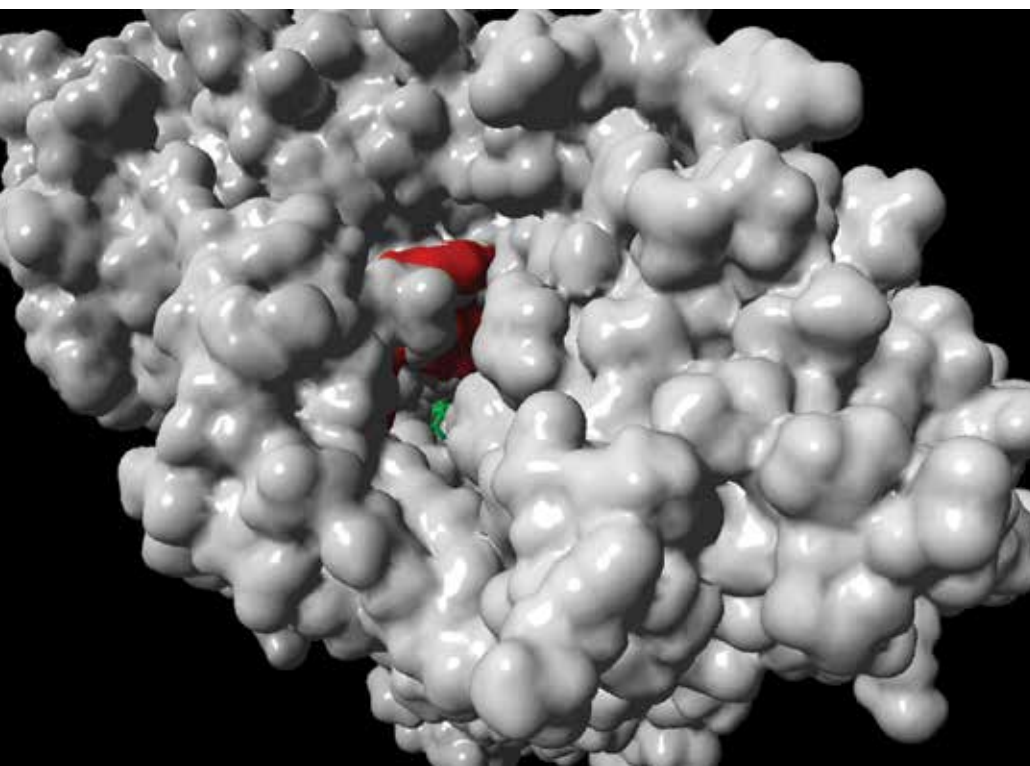
"As a scientist, though ... I wanted to do the research myself. I had ideas I wanted to pursue," he said.

After about two years with Dow, Zhao sought a job in academia. In 2000, he joined the University of Illinois, where he was impressed by the department's early recognition of the importance of bioengineering and biotechnology. It's been a great place for him to start and grow his career, said Zhao, who has fond memories of spending Thanksgivings with **Charles Zukoski**, Elio Eliakim Tarika Chair Emeritus and his family.

New developments

When he first arrived at Illinois, Zhao's work involved applying directed evolution technologies to the metabolic engineering field. His lab, initially called the enzyme and metabolic engineering lab, focused on engineering enzymes and whole cells for production of chemicals.

Currently his lab is focused on development and application of synthetic biology tools for the engineering of biological systems at different levels—protein levels, pathway levels, and whole cell levels.



"We are exploring applications in several areas, some in industrial biotechnology to produce chemicals or biofuels," he said.

In the past few years his lab also has been involved in the engineering of mammalian cells, including human cells, for gene therapy applications and to address some fundamental biology problems as well.

Last year the university received an \$8 million grant from the National Institutes of Health to study nucleus structure as part of its 4D Nucleosome Initiative. The project, "Combined cytological, genomic, and functional mapping of nuclear genome organization" is headed by **Andrew Belmont**, University of Illinois Professor of Cell and Developmental Biology. The team of investigators also includes Zhao; **Jian Ma**, Associate Professor of Bioengineering; **David Gilbert** from Florida State University's Department of Biological Sciences; and **Bas van Steensel** from the Netherlands Cancer Institute.

"We try to apply synthetic biology tools to study the chromatin structure and dynamics. What we want to do is develop genetic tools to label certain regions and then we can visualize the movement inside the cell. We can also use these tools for treating some genetic diseases as well," such as cystic fibrosis, he said.

Zhao has also collaborated with **Charles Schroeder**, Associate Professor of Chemical and Biomolecular Engineering at Illinois, on observing the dynamics of TALE proteins, or, transcription activator-like effectors. They are exploring how TALE proteins can be used to treat sickle cell anemia, which is caused by a mutation in a link of the DNA chain.

"The genome editing field is growing rapidly, and we are aggressively pursuing research in this direction," Zhao said.

Zhao leads the Biosystems Design theme at the Carl R. Woese Institute for Genomic Biology and is involved in the Illinois Biological Foundry for Advanced

Biomanufacturing, or iBioFAB (see video on YouTube: <http://youtu.be/Hwb735qZ-IQ>). It's a computational and physical infrastructure that supports rapid design, fabrication, validation/quality control, and analysis of genetic constructs and organisms.

"If it works well, it really can revolutionize how people do biological engineering," he said.

Another area of research is in drug discovery, uncovering novel natural products that could be used as antibiotics or anticancer drugs—and using the foundry to do so.

"Natural products are a very rich source of drugs and antibiotics. Almost 80 percent of our antibiotics we use are natural products or natural products derived," he said. Since most antibiotics used now were discovered in the 1950s and 1960s, "there's a huge need to discover new antibiotics, because microorganisms can develop resistance very quickly.

That's why, to address this challenge, we try to use synthetic biology tools to activate those silent gene clusters involved in the synthesis of natural products ... and then do the biological assays to see what kind of activity they have. That's also a very exciting area. In particular, we want to leverage the foundry so that we can discover not just one or two (natural products), but thousands of them," Zhao said.

Zhao also wants to leverage the foundry for his study of mammalian cells.

"In mammalian biology, in the past it took at least six months to knock out a gene or develop a transgenic mouse. Now, with new gene editing tools based on TALEN or CRISPR (methods for genome engineering), we can develop those transgenic cell lines in a month," he said.

Most recently, in collaboration with **Gene Robinson**, Director of Carl R. Woese Institute of Genomic Biology, Zhao received a \$2 million grant from the Defense Advanced Research Program Agency, or DARPA. In this project, he will develop an automated bee rearing

system based on the foundry.

The new DARPA-funded project draws on Robinson's background in honey bee genomics and Zhao's expertise in advanced bio-manufacturing to develop new tools to address the crisis of plummeting bee populations worldwide.

"At the present time honey bees can only be mass-reared in beehives with traditional beeswax honeycombs outside.

But new evidence indicates that beeswax, once held up as a paragon of purity, actually absorbs many different environmental toxicants, posing as-yet unknown hazards to baby bees (brood) while they are being reared," Robinson said.

"We will use advanced biomanufacturing to develop a high-throughput method of mass-rearing millions of honey bees in the laboratory. Developing this capacity will give investigators an unprecedented experimental platform to rear bees free from environmental toxicants, thus allowing them to test specific compounds for toxicity under controlled conditions," he added.

In his Singapore lab, Zhao has been developing and applying synthetic biology and metabolic engineering to address challenges in advanced biomanufacturing, with a focus on sustainable manufacturing, nutrition, and healthcare. There is a great synergy between his two labs.

Even though he left industry as a full time employee more than 16 years ago, Zhao continues to engage with a variety of industries. His involvement has ranged from a few trips to companies to offer technical advice to longer term research projects and serving on scientific advisory boards for companies. He also is exploring options for starting new companies to translate his scientific discoveries and technologies for the public good.



2016 CONVOCATION SPEAKER

Kit Gordon, BS '83:

TECH INNOVATOR AND WATERSHED PROTECTOR



As she tests water from creeks near her home in Los Altos Hills, Kit Gordon reflects on her successful career in semiconductors and volunteer work with environmental groups.

"Thanks to Illinois, I've had a fabulous career and live in the center of tech innovation."

As a newly-minted chemical engineering graduate in the early 1980s, Gordon was drawn to Silicon Valley's young, informal, and innovative start-up culture. Her Illinois Chemical Engineering degree enabled Gordon to succeed in the semiconductor industry along with her determination and appreciation for hard work and teamwork.

"The U of I taught me to work hard and to rebound after setbacks. You persevere and keep trying. The university taught me to take risks, something every engineer must do," Gordon says.

After Illinois, Gordon went on to earn master's degrees in electrical engineering and business administration and obtained numerous patents in anti-fuse semiconductors. As someone with a lifelong interest in chemistry and the environment, she also co-founded a natural cosmetic company and in recent years has volunteered with a number of organizations devoted to improving watershed health and protecting the Santa Clara Valley water supply.

Focused on ChemE

Gordon grew up the youngest of three children in Rockford, Illinois. Shortly after she was born, her father developed a brain tumor and became disabled. He passed away when she was 12 years old. Gordon's mother, raised on a farm during the Depression Era, worked as a grade school teacher. When considering

majors and careers, Gordon wanted a career that would provide financial stability—and she knew chemical engineering could do that.

At Rockford West High School, she excelled in chemistry and math and planned to attend the University of Illinois. Even though she was a star student in chemistry, her high school did not offer honors or Advanced Placement classes. She took the required chemistry placement exam for Chemical Engineering majors and didn't pass.

This was a setback, but she was determined to persevere. An advisor tried to steer her to another major, but Gordon was not deterred.

"I knew what I wanted. I wanted to be a chemical engineer. And I knew that the University of Illinois was the school for ChemE. U of I had a great reputation in chemical engineering. I knew myself better than they knew me. I never wavered," she says.

Her first year on campus was tough, but she knew once she started taking chemical engineering classes, she would be fine. In fact, Gordon excelled. She enjoyed many classes—fluid dynamics, physical chemistry, organic chemistry, and all the chemical engineering classes. In her classes, she learned the value of not only hard work, but also how to "divide and conquer" the work through teamwork, she recalls.

Gordon joined the university's chapter of the American Institute of Chemical Engineers and recalls attending a meeting during which R. Byron Bird, Warren Stewart, and Edwin Lightfoot

(authors of the classic textbook *Transport Phenomena*) stood in the same room. She and others were in awe of the chemical engineering legends. During her senior year, she received the prestigious Daniel Eisele Award for outstanding student leadership in chemical engineering which included a \$400 award. She used the money to buy her first car—a 1969 AMC Rambler, fondly known as "The Scrambler."

During her senior year, Gordon interviewed with a number of corporations. The one that made an impression on her was Monolithic Memories (MMI), a Silicon Valley semiconductor firm. Unlike her other job interviews, which took place in nondescript boardrooms during which she was asked formulaic questions, her interview at MMI was different. In Silicon Valley no one wore a suit, most employees were young, and their enthusiasm was contagious. She toured the site, met employees, and learned about their projects. She was asked many technical semi-conductor-related questions, and found herself answering, "I don't know," to many of them.

Given that her background was in chemical engineering and not electrical engineering, she asked her interviewer, "Why are you asking me these technical questions outside my major?" "He told me, 'A good engineer knows when to say, 'I don't know'. I wanted to hear you say, I don't know. I don't want to hear you making things up.'" When she asked about standard promotion schedules the interviewer laughed and said, "You can be president tomorrow if you can do the job."

Gordon was sold on the culture of Silicon Valley. She moved to the Bay Area and was thrilled to see her name and Linus Pauling's name, along with many other Nobel laureates,

in the same phone book. (At Illinois, she studied the Pauling Principle on electroneutrality.) While working at MMI, she attended Santa Clara University and earned a master's degree in electrical engineering and later, an MBA.

Her time at the University of Illinois, particularly the group work and risk-taking, prepared her for the industry, Gordon says.

"Working in semiconductors is a fast-changing, high-pressure, taking-lots-of-risks kind of a job. It involves groups of people doing complicated engineering to get a product out."

In one of her early chemical engineering courses, she scored 19 out of 100 on the first exam, she recalls. The high score was 21.

"That taught me, you can fail and still be OK. It helped reinforced the grit which is what I needed when working in an innovative industry."

Environmental work

After five years into her tenure, MMI was purchased by Advanced Micro Devices and the three inventors of the PAL (programmable array logic) device spun off to form a new company which ultimately became QuickLogic. Gordon was the first person they hired. She invented the technology (amorphous silicon anti-fuse) for the company's first products, field programmable gate arrays or FPGAs. After the company went public in 1999, she took time off of work, got married, and in 2002, gave birth to her daughter Isabel.

The career change allowed her to devote her time to raising her daughter. Around the same time, because of a growing concern about the type of chemicals her daughter was being exposed to, Gordon began experimenting with natural skincare remedies. She and a friend established Botanic Organic, a plant-based skincare line. Gordon has stepped back from day-to-day operations in that business, but continues to make and use natural products for her family, mixing hydrosols, oils, and extracts. Currently, she's interested in learning more about skincare products based on bacteria.

Her focus on living sustainably and caring for the environment has its roots in Illinois. Her grandfather, an agricultural engineer, taught her at an early age about understanding the interdependence of watershed health and human health. When her grandparents retired, they moved to a small farm along the Rock River and as a child, Gordon spent many Sundays tromping around the farm, exploring the apple orchard, the woods and fields where farmers grew corn and oats. Her naturalist grandmother taught her to identify various birds and insects. And she recalls her grandfather telling her in the 1970s that her generation would need to fix the problems inflicted on the Ogallala Aquifer and other groundwater basins.

"He instilled in me a sense of environmental responsibility," she says.

In Santa Clara Valley, aka Silicon Valley, Gordon has been heavily involved in a number of environmental organizations, including the Santa Clara Valley Water District, the public agency which manages water supply, flood protection, and stewardship of area streams. She's served on several committees for the water district: the environment and water use committee, independent monitoring committee, and the One Water planning committee looking holistically at flood control, water supply, and environmental protection.

She's also involved with Acterra Stewardship, a watershed restoration group; Streamkeepers, which performs local water quality monitoring; and Permanente Reimagined, which is restoring steelhead trout to Permanente Creek in the Santa Clara Valley.

Gordon also is considering taking classes at Stanford University, possibly in hydrology or ecosystems. As a chemical engineering student at Illinois, one of her electives was ecology of a meadow and another was poetry, both subjects she continues to enjoy and appreciate.

She's not sure what her next degree or project will be, but with her daughter off to high school and other family responsibilities reducing, she's looking forward to her next adventure.

"I'm sure chemistry will lead my way."

KIT GORDON

Education

B.S. Chemical Engineering, Illinois, 1983
M.S. Electrical Engineering, Santa Clara University, 1987

M.B.A., Santa Clara University, 2002

Career highlights

- Monolithic Memories, Engineering Manager, Research and Development, 1983-1989
- QuickLogic, Engineering Director, Research and Development, 1989-1999
- Co-founded skincare company Botanic Organic, 2011

Family

Husband, Tony Alvarez; daughter, Isabel

Residence

Los Altos Hills, CA

Volunteer activities

- Acterra Stewardship, Advisory Board on watershed restoration
- Committee for Green Foothills, Watershed Tour Coordinator
- GreenTown Los Altos, former Chair of Water Stewardship
- Los Altos Hills Open Space Committee
- Los Altos Hills Water Conservation Committee, former chair
- Permanente Reimagined, Co-founder, restoring steelhead trout to Permanente Creek
- Santa Clara Valley Water District: Environmental Water Resource Committee, Independent Monitoring Committee, Watershed Master Plan Committee
- Silicon Valley Water Conservation Awards Committee
- Sierra Club, Loma Prieta Chapter, former executive committee
- Streamkeepers, water quality monitoring

Patents

Semiconductor antifuse structure and method, programmable interconnect structures and programmable integrated circuits, programming of antifuses.

CATCHING UP WITH...THE CLASS OF 2005

Written by Sarah Williams

Ten years ago Chemical and Biomolecular Engineering students left the halls of the University of Illinois with hopes, dreams, goals and memories of their undergraduate years. After earning their bachelor degrees, these students embarked on new journeys around the world. We caught up with some of these alumni to see where life has taken them these past 10 years, to share their stories and show the diverse career paths taken by graduates of the department.

Dawn Symonds Zink



As a product support representative living in Paris, France, Dawn Zink works with Caterpillar dealers to improve their customer service interactions. She lives in Paris with her husband, Brian Zink, and their 3-year-old son, Eli.

Zink, BS '05, has been with Caterpillar for eight years and has worked in similar positions across the globe. Prior to being based in Paris, she worked with Caterpillar dealers on the West Coast in the United States.

Zink's relationship with Caterpillar began when she was an intern there and after graduation she took a full-time position with the company. She worked as a chemical

engineer, creating formulas for rubber compounds in Caterpillar's hydraulic hoses.

"However, I quickly realized that I wasn't interested in doing the same thing for my entire career, and with Caterpillar, it is possible to change careers," she said.

In 2007, she moved to their technical marketing program. Zink now helps dealers enhance their marketing capabilities and how to improve customer service.

"I love my job," she said. "Every day is different, and I work with all types of different people in different countries. I'm glad I was able to switch careers into the "marketing side" of the business."

Looking back on her time at Illinois, she says the critical learning skills and the confidence gained by completing the more difficult chemical engineering course work not only helped her land her first job at Caterpillar, "but gave me the confidence that I can clearly perform well and understand most other careers available," she said.

As an undergraduate, Zink worked with Dr. Paul Kenis in his lab where she learned a lot about chemistry and engineering.

"But the main thing I remember was that he had moved all over the world with his education and skill set; I wanted to do the same," she said.



Doug Powers, Doug Kolak and Dawn Symonds (now Zink) in Dr. Paul Kenis' class in 2002.

Chris Arges



Moving to Illinois at the age of 14 set the course for Chris Arges, BS '05, to attend the University of Illinois. Growing up in Northwest Indiana, he had a strong bias toward Indiana public universities. But once he came to Illinois, "I came to discover how great the University of Illinois was."

As an undergraduate, he participated in research and was a co-author on two peer-reviewed publications. "Those two papers are testaments that I helped contribute new knowledge to the field during my tenure at Illinois," he said.

He worked with Professor Chris Bardeen in Physical Chemistry while being co-advised by Professor Richard Alkire in Chemical Engineering. While working in those labs he met success and failure, something he now realizes is part of research. "Persevering through those early failures in the lab gave me the confidence later on in my career to work around problems or to embark on new projects when existing ones are not working," he said.

He says the top-notch education he received at Illinois played a prominent role in securing a job offer before graduation. "Although I had a nice paying job in industry at a young age, I yearned to return to academia," he recalls. "I wanted to continue working in research and publishing papers."

Arges is now an Assistant Professor at Louisiana State University where he pursues research in sustainable, economical and efficient uses of energy and water resources. He said the energy-water nexus represents a symbiotic relationship because it takes significant amounts of water to generate electricity and it requires a

great deal of electricity to purify water. Arges' research group is working to create new electrochemical devices and materials that could help to store or convert energy from renewable and green sources, such as solar and wind. And they're working on how to generate carbon neutral chemical fuels and purify water from sea water and brackish water streams.

He chose the academic career path because "I genuinely want to help young people in their professional development and I like to talk about my research to the general public." Arges said his days at Illinois not only included pursuing rigorous undergraduate research and academic courses, but developing valuable friendships. "We often challenged and learned from each other while working on homework or studying for exams," he said. "We still remain friends today. We often like to reminisce about the hard work and the fun times together."

He and his wife, Hiral Arges, BS '08, welcomed their baby daughter, Mira, in the past year and they moved from Chicago to Baton Rouge, Louisiana. Outside of work, he enjoys spending time with his family, going for runs and bike rides and traveling domestically and abroad.

Sravan Pappu



Sravan Pappu, BS '05, joined the oil and energy industry after graduation.

"It is a field where I needed my textbooks and used my training every day," he said. "I felt like I worked hard to learn these concepts, and I wanted to use them in a meaningful way."

Pappu is the Industry Manager at Johnson Matthey for their PURASPEC product. He helps to prepare and

“Persevering through those early failures in the lab gave me the confidence later on in my career to work around problems or to embark on new projects when existing ones are not working.”

Chris Arges, LSU Professor

implement a strategic plan for the products and services for the refinery purification markets. Before that he worked for BP's Whiting Refinery as a process engineer.

"I love it (Johnson Matthey), as I am exposed to areas I have grown to enjoy and I set the direction that our business goes in," he said. "I travel the world to talk to refiners about their purification problems and our solutions, and bring expertise in the various contaminant-removal processes. It is rewarding to be an expert, and I have experienced environments and cultures that I wouldn't have expected to."

When not working, Pappu says he enjoys traveling with his wife and playing soccer in Chicago. "My job has allowed me to experience places and cultures I haven't seen before, something that really affects my world view," he said.

Ajay Virkar

Ajay Virkar says Illinois gave him an excellent foundation in the physical sciences and engineering.

That educational path led Virkar to complete his Ph.D. in Chemical Engineering at Stanford University. While there, he and some colleagues began a side project to develop new materials for solar cells. After winning the NASA technology prize at the Rice Business Plan Competition and first prize at the MIT Clean Energy competition, he co-founded C3Nano, where Virkar is the Chief Technology Officer. The company is headquartered in Silicon Valley with manufacturing and research and development in South Korea.

The company focuses on transparent electrode materials and also is targeting applications ranging from consumer electronics (like touch screens in smart phones and tablets) to clean energy

(smart windows, photovoltaics, and OLED lighting).

At Illinois he worked in Professor Paul Kenis' research lab where he discovered an enjoyment for research.

"It certainly was the positive experience in Professor Kenis' group that led me to pursue graduate school," he said. "Understanding my specific interest in materials, he also helped direct me to Stanford for my Ph.D. studies."

The Thermodynamics class remains the most useful class he took to understand basic physical phenomenon including reactions and states of matter. Other faculty who played a role in his time at Illinois included Nancy Makri and Vitaly Voloshin and the late Linn Belford. Belford's class on quantum mechanics led Virkar to become more interested in quantum physics.

"I have now made pilgrimages as far as Europe to visit Niels Bohr's famed institute in Copenhagen and Albert Einstein's apartment during his miracle year in Bern," Virkar said.

Laura Banovic Flessner



Participating in a high school Model United Nations group about water pollution helped Laura Flessner, BS '05, decide on a career in chemical engineering.

"It opened my eyes to the unfortunate world water situation where millions of people don't have access to clean water," she said. "That experience moved me to want to help others. I thought I might be able to tackle the

clean water problem with a chemical engineering degree.”

After deciding to attend the University of Illinois, she went to a career fair and landed an internship with Procter & Gamble. At that time the company owned PUR, a water purification brand, which made the internship a natural fit for Flessner.

She worked at P&G in process engineering, packaging engineering and products research.

“I fell in love with products research because it married two of my interests, technology and people,” she said. “By understanding what people want, I am able to influence the product design. I became a translator, a bridge between real people and scientists/engineers

since technical people can have a language of their own.”

She later found a position at Pfizer Consumer Healthcare in New Jersey and was hired as one of its first product researchers. During her five years with the company she has worked on many global brands including Centrum, Emergen-C, ChapStick and Children’s Advil. She works on projects ranging from exploratory to testing early ideas to finalizing products and validating formulations.

“I’m no longer working on water, but love the fact that I’m still in the health care space helping people stay healthy and make their day just a little bit better,” Flessner said.

She is married to fellow classmate Ryan Flessner, ‘05 BS. The couple met at the

U of I and married after Ryan completed his Ph.D. at the University of Wisconsin. He now works at Merck in the small molecule process development and commercialization group.

They have three children: Jack, age 5; Lily, age 3 and Luke, age 1.

She says Professor Paul Kenis and Lecturer Marina Miletic had the most influence during her time at Illinois.

“Dr. Miletic pushed and challenged me beyond my comfort level allowing me to grow further. She showed me that it was possible for a female to be a leader in the technical world.”

Class Notes

Rear Adm. Brian Corey, BS ‘86, rejoined the Naval Air Warfare Center Weapons Division in China Lake, Calif. last fall as its commander. A native of Granite City, Ill., Corey is a graduate of the Naval Reserve Officer Training Corps at the University of Illinois and received his BS in Chemical Engineering in 1986. He is a distinguished graduate of the U.S. Naval Test Pilot School and holds a master’s degree in national security and strategic studies from the Naval War College.

Dr. Scott Fogler, BS ‘62, received an honorary doctorate from Universitat Rovira i Virgili in Spain this spring. He is the first chemical engineer to receive an honorary doctorate from the university. Dr. Fogler, who earned his PhD from the University of Colorado after completing his undergraduate at Illinois, has been on the faculty of the University of Michigan’s Department of Chemical Engineering since 1965. He holds the title of Ames and Catherine Vennema Professor of Chemical Engineering and Arthur F. Thurnau Professor. Dr. Fogler’s research has focused on the application of chemical reaction engineering principles to the petroleum industry,

transport and reaction in porous media, gelation kinetics, and asphaltene stability multiphase flows. He is a past president of the American Institute of Chemical Engineers (2009). He spoke about how chemical engineering can help solve the world’s energy challenges and discussed alternative sources of energy.

Brian Kwok, BS ‘00, joined the Palo Alto, Calif. office of Haynes and Boone, LLP as a partner in the firm’s intellectual property practice group. His practice focuses on patent strategy, licensing, and litigation.

Dr. Anne Skaja Robinson, PHD ‘94, received the Biotechnology Progress Award for Excellence from the American Institute of Chemical Engineers at its annual meeting in November. Robinson is the Catherine and Henry Boh Professor in Engineering and Department Chair at Tulane University’s Department of Chemical and Biomolecular Engineering. AIChE’s Biotechnology Progress Award recognizes outstanding contributions to the literature in biomedical

engineering, biological engineering, biotechnology, biochemical engineering, and related fields. Robinson’s award celebrates excellence and foundational contributions to the biotechnology and biological engineering studies of membrane proteins.

Dr. Andrew Miller, BS ‘03, was named to MedTech Boston’s 40 Under 40 Healthcare Innovators list. The winners were chosen based on their commitment to changing the healthcare system in disruptive ways. Dr. Miller is a Vice President at PureTech, where he works to identify innovative healthcare ideas and develops strategies for new technologies. He currently serves as the Chief Operating Officer for Tal Medical, which uses low field magnetic stimulation technology to treat psychiatric disorders. Miller also is a co-founder of Karuna Pharmaceuticals, which is developing clinical stage therapies for the treatment of schizophrenia. After graduating from Illinois, he received his PhD from MIT.

SHARE YOUR NEWS WITH US!

Email us at chemeng@illinois.edu, fill out the online form: go.illinois.edu/chbe_alumni_form, or mail the enclosed card found at the back of this newsletter.

Giving to Chemical and Biomolecular Engineering

As the academic year comes to a close, we would like to thank you, our generous alumni, friends, and corporate partners for investing your time, talent, and financial resources in the Department of Chemical and Biomolecular Engineering.

For example, thanks to **Dr. Francis Ihejirika** for his gift to the Brady STEM Academy, the outreach program designed to improve participation in STEM among underrepresented groups; **Dr. Ray Mentzer**, for support of a faculty scholar and an undergraduate scholarship in his name; **Al and Jan Widiger**, in support of two summer graduate fellowships; **Dennis and Cathy Houston**, for support of their named professorship held by Dr. Jonathan Higdon; **Dr. Ed and Sally Heerd**, for undergraduate scholarship support; and so many more!

In previous years, we recognized all our annual donors to the department in the spring/summer issue of Mass Transfer. Moving on with the times, we will continue to acknowledge our valuable donors, but do this by publishing the complete donor honor roll on our website. We will continue to send you our award winning newsletter to share with you stories about how your support has tremendous impact for our students, faculty, programs, and facilities.

In other advancement news, we are pleased to announce **Braden Shain** is the newest member of the College of Liberal Arts & Sciences Office of Advancement. Braden will work exclusively with alumni of Chemical



Alumnus and ChBE supporter Ray Mentzer meets with undergraduate student leaders during a spring visit to the department.

and Biomolecular Engineering. He comes to us from Ohio University, where he has been Assistant Director of Development. Braden is an Illinois native who earned his bachelor's degree in psychology from Eastern Illinois University.

"I am excited to continue my career in advancement at the flagship campus of the University of Illinois, and it's an honor to work with such a prestigious department. I'm looking forward to meeting Chemical and Biomolecular Engineering alumni, learning about the amazing work they do around the world, and thanking them for their loyalty and support," he said.

Thanks again for your investment in the department. Financial contributions can be made online at chbe.illinois.edu, by phone at (217) 244-9214, or by using the enclosed envelope in this newsletter.

"I'm looking forward to meeting Chemical and Biomolecular Engineering alumni, learning about the amazing work they do around the world, and thanking them for their loyalty and support."

Braden Shain

Assistant Director of Development

Dr. Paul Kenis



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In Memoriam



Photo credit: University of Pennsylvania
School of Engineering and Applied
Science

John Quinn: 1932-2016

John A. Quinn, Illinois chemical engineering graduate and faculty member from 1958 to 1971, passed away on Monday, February 8. John Quinn's distinguished career in chemical and biomolecular engineering spanned more than 50 years, during which he played a leadership role in research, education, and institutional and professional service.

In the course of his pioneering research on mass transfer and interfacial phenomena, Dr. Quinn and his students devised a number of simple yet elegant experiments to elucidate the role of the interface in transfer between phases. In later years, his work focused on problems relating to bioengineering and biotechnology, to transport through synthetic membranes, and to the application of membranes in chemical processes and in systems of medical and biological relevance. He is author or co-author of about 100 research papers and review articles.

Dr. Quinn received his B.S. in Chemical Engineering from the University of Illinois in 1954 and his Ph.D. from Princeton University in 1958.

Bill Schowalter, former Emeritus Professor of Chemical Engineering at Princeton and dean of the University of Illinois College of Engineering, first met Quinn and his wife, Frances, in 1957. At that time, Schowalter had recently finished his Ph.D. final oral exam at Illinois, driven to Philadelphia, picked up his wife, and was on his way to Princeton, where he would join the faculty there as an assistant professor. John Quinn was finishing his Ph.D. work at Princeton and was on the cusp of beginning a position similar to Schowalter's at Illinois. The couples swapped information and tips about the area, such as where to buy good food and spirits.

"From those beginnings there followed innumerable impromptu reunions, usually at AIChE or NAE meetings, where the four of us would pretend it was only yesterday that the Quinns introduced the Schowalters to Princeton and vice-versa. Conscious though we are of the good fortune to have those memories, it is difficult to know they will not be extended," Schowalter said.

Dr. Quinn was on the Illinois faculty from 1958 to 1971, when he moved to the University of Pennsylvania. In 1978, he was named the first recipient of the Robert D. Bent endowed professorship. He served as Penn's Chairman of the Department from 1980 to 1985. Among other appointments, he held a National Science Foundation senior postdoctoral fellowship and was visiting professor at Imperial College, London, visiting scientist at MIT, Sherman Fairchild Scholar at Caltech, and visiting professor at the University of Rome.

In recognition of his research contributions, Dr. Quinn received the Colburn Award of the American Institute of Chemical Engineers in 1966 and the Institute's Alpha Chi Sigma Award in 1978. He delivered the Mason Lectures at Stanford, the Katz Lectureship at Michigan, and the Reilly Lectures at Notre Dame. He was elected to membership in the National Academy of Engineering in 1978 and to the American Academy of Arts and Sciences in 1992. He was the inaugural 1995 Alan

S. Michaels Lecturer in Biological and Biomedical Engineering at the Massachusetts Institute of Technology as well as Carnegie Mellon University's 1997 Distinguished Research Lecturer in Chemical Engineering. He served as a member of several commissions and boards operating under the auspices of the National Research Council, including the Engineering Research Board, the Board of Chemical Sciences and Technology, the Committee on Separation Science and Technology, and the Amundson Committee on Chemical Engineering Frontiers.

During his long career, Dr. Quinn taught hundreds of undergraduate and graduate students, supervised more than 40 doctoral dissertations, and mentored numerous junior colleagues. Known by many as "Dr. Q," he often became lifelong friends with many of his students. In 2004, his former students and colleagues endowed the John A. Quinn Lecture in Chemical Engineering at Pennsylvania in recognition of his extraordinary career as a researcher, mentor, and educator.

His former graduate students, four of whom have been elected to the National Academy of Engineering, populate the most distinguished ranks of their profession. His standards of scholarly excellence, innate appreciation for creativity, and his deep humanity left an indelible mark in the work and in the lives of those people fortunate to have worked alongside him.

By the University of Pennsylvania School of Engineering and Applied Science and the University of Illinois.

William H. Bentley, MS '61, PHD '65, of Kinston, NC, died February 14, 2016, at age 78. Born in Huntsville, Ala, Dr. Bentley received his B.S. in Chemical Engineering from the University of Alabama in 1959. In 1965, he received his Ph.D. in Chemical Engineering from the University of Illinois. After graduate school, Dr. Bentley began working for DuPont's experimental station in Wilmington, Del. In 1976, he transferred to DuPont's offices in Kinston, where he would spend the bulk of his 37-year career. His work took him all over the world, including a four-year period that he spent living in Germany. Shortly after his return to the U.S., he joined DuPont's Technology Transfer group in a managerial capacity, which gave him the opportunity to travel to 33 countries, including China, India, Russia, Pakistan, and Venezuela. Known for his sense of humor and gentle nature, Dr. Bentley enjoyed gardening, reading, listening to bluegrass and opera music and much more.

Paul Cullen Bradford, BS '48, of Chandler, AZ, died April 17, 2015. Born and raised in a small community in West Central Illinois, Mr. Bradford enrolled in the University of Illinois in 1941. During World War II, from 1943 to 1946, he served in the Army, earning several medals, including a Bronze Star. After his discharge, he returned to Illinois and graduated with his B.S. in Chemical Engineering in 1948. Mr. Bradford worked at Shell Oil for 38 years, with assignments in operations supervision and in technical capacities at refineries and the head office for manufacturing. He developed expertise in the catalytic cracking process and developed a process using centrifugal force that improved the output of usable/saleable product from a 55-gallon barrel of crude from approximately 50 percent to more than 90 percent. Mr. Bradford played the trumpet and baritone in bands, performed in choirs, quartets, a barbershop chorus, and enjoyed dancing, traveling, and creating jewelry.

B. Neal Harman, BS '60, of North Ridgeville, Ohio, died April 16, 2016. Mr. Harman received his B.S. in Chemical

Engineering from Illinois in 1960 and M.S. in Chemical Engineering from the University of California, Berkley, in 1962. He was a member of Beta Theta Pi fraternity. Mr. Harman spent most of his career with Rohm and Haas in sales. A pianist, he enjoyed classical music and the Cleveland Orchestra as well as classic cars, bicycling, and spending time with friends and family.

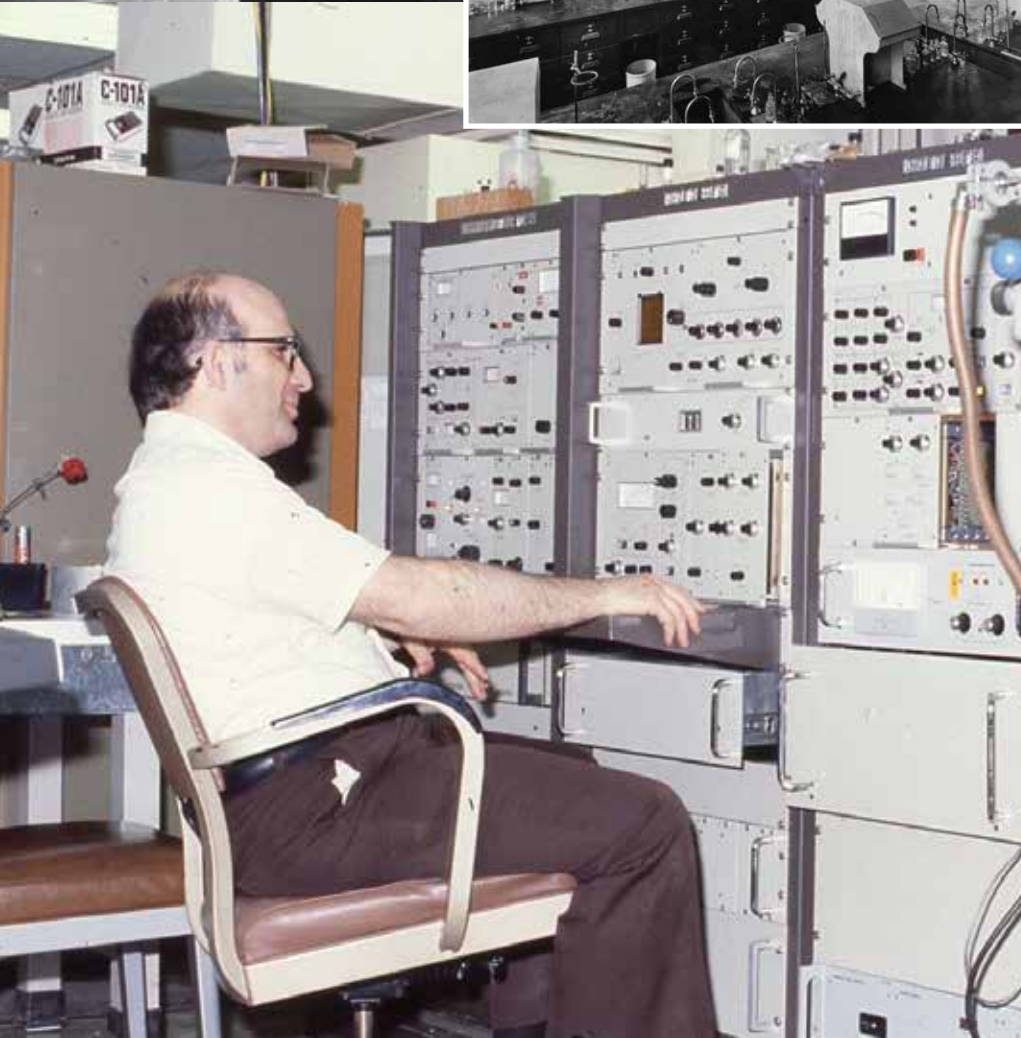
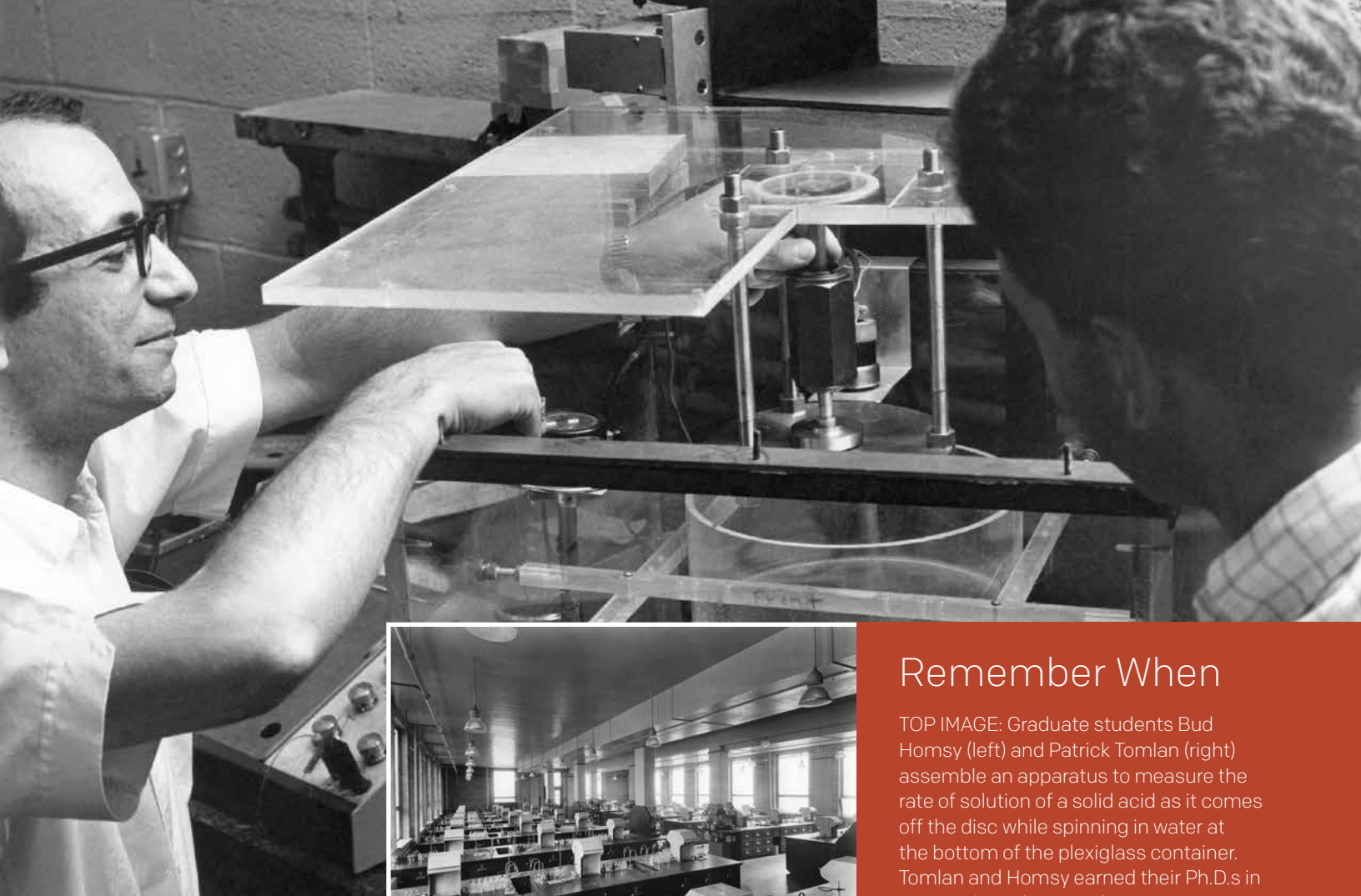
Robert J. Langel, BS '52, of Philadelphia, formerly of Cherry Hill and West Deptford, NJ, passed away on October 29, 2015, at the age of 86. Born in Chicago, Mr. Langel earned his B.S. in Chemical Engineering from Illinois in 1952. He was a chemical engineer with Hercules Inc. for 37 years, and with the EPA for another 20 years. Mr. Langel loved to travel, especially with his wife, Ruth, by his side.

James R. Nichols, MS '54, of Seven Lakes, NC, died Feb. 22, 2016. Born in 1931, he graduated from DuPont High School and the University of Delaware. He earned a bachelor's degree in chemical engineering from Illinois in 1954. Mr. Nichols worked for Union Carbide and Rhone-Poulenc for many years, including time spent in Switzerland and France.

Thomas A. Verachtert II, BS '88, of Palatine, Ill., died March 29, 2016, after a seven-year battle with Amyotrophic Lateral Sclerosis, or ALS. Mr. Verachtert was a 1984 valedictorian graduate of Wheeling High School and graduated from Illinois in 1988 with a bachelor's degree in chemical engineering. He later obtained a master's degree in chemical engineering from IIT and an MBA from the University of Chicago. He spent 15 years working for UOP in Des Plaines, followed by Eastman Chemical Company in Kingsport, Tenn. In 2005, he joined Solutia Chemical in St. Louis. Before ALS ended his career in 2010, he worked as Corporate Development Manager for Novus Chemical. Mr. Verachtert was a lifelong learner with many interests, including sailing, antiques, cooking, reading, and listening to classical music. He was a ranked chess player online throughout his battle with ALS.

Ernest Edward Waggoner, MS '48, of Oakdale, Calif., died December 21, 2015, at the age of 91. Born in Urbana, Mr. Waggoner graduated from high school in Kewanee, Illinois. During World War II, he served in the Navy and met his future wife, Charlotte, while stationed on Treasure Island in San Francisco Bay. Mr. Waggoner worked as a chemical engineer for Shell Oil from 1948 to 1953, in Pittsburg, CA. In 1953, he joined his father-in-law at Burchell Nursery as propagation manager of orchard trees, where he would spend the next 26 years of his career, modifying nursery equipment to increase efficiency, developing his own walnut and almond orchards, and walnut dehydrator plant. He partnered with his wife to manage the Waggoner Christmas Tree Farm. In 1979, he turned to farming his own walnuts and almonds until 1996. Even in retirement, he continued to help with farming, including harvest this past fall. College electives of beekeeping and woodworking became life-long hobbies.

James L. Wood, BS '57, died earlier this year in his home in Northridge, CA. Mr. Wood was born in Jacksonville, IL and received his bachelor's degree in chemical engineering from Illinois in 1957. He went on to earn a master's degree in aerospace operations management from the University of Southern California. In retirement, he earned an M.S. in Environmental & Occupational Health from California State University Northridge. Mr. Wood and his wife Bobbie loved traveling the world, visiting every continent and developing friendships worldwide. He loved playing golf, slow pitch softball, watching the Fighting Illini, and rooting for the St. Louis Cardinals.



Remember When

TOP IMAGE: Graduate students Bud Homsy (left) and Patrick Tomlan (right) assemble an apparatus to measure the rate of solution of a solid acid as it comes off the disc while spinning in water at the bottom of the plexiglass container. Tomlan and Homsy earned their Ph.D.s in 1969 under John L. Hudson. Homsy is an emeritus faculty member at Stanford, the University of California at Santa Barbara, and University of British Columbia. He is an affiliate faculty member in mechanical engineering at the University of Washington. Tomlan passed away in 2014 after a battle with cancer. He worked at DuPont until his retirement in 2006.

MIDDLE IMAGE: A look inside a typical laboratory in the Chemistry Annex, circa 1964. The building, designed by James White, dates back to 1930 and was added due to rapid growth of chemistry at the University of Illinois. The East Chemistry Annex was added in 1951. The most recent, major renovation and expansion, began in 2014. The project is expected to wrap up in late 2016.

BOTTOM IMAGE: Richard Milberg in the School of Chemical Sciences' Mass Spectrometry Lab in 1980. Later, Milberg would become the lab's director (1987-2002). This photo was sent to us from Bob Yui, BS '80, who sent us numerous photos that were part of a slide show he organized about the department for the 1980 Engineering Open House. The College of Engineering celebrated the 96th annual Open House in March.

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Save the date: Homecoming 2016

October 29, 2016

Cheer on the Fighting Illini and new Coach Lovie Smith as they take on the Minnesota Golden Gophers!

Visit the department's alumni tent for free food and drinks. Visit chbe.illinois.edu for more details as we get closer to Homecoming.

Students and family members celebrate at the 2016 Chemical and Biomolecular Engineering Convocation