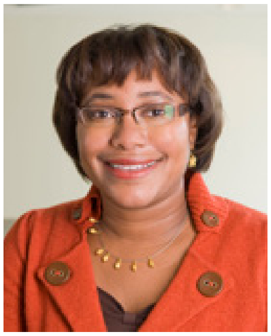
MIT CHEMICAL ENGINEERING ALUMNI NEWS

XCurrents

Letter from *Department Head Paula T. Hammond*



Welcome to the Spring 2017 edition of the Course X Alumni News! I would like to thank you, our alumni and friends, for your consistent and tremendous support for the department, our faculty and our students. It cannot be said enough: without you, we would not be the positioned to lead the field as we are today. I am especially grateful for your ongoing gifts to support the renewal of Building 66. In fact, we are already seeing the fruits of our labor. One of our goals for the renewal was to have a flexible research space where our current and new faculty would be able to continue their world-leading research, helping the department to attract the best and brightest new faculty. I'm happy to announce we have hired two new Assistant Professors who have just started with us: Karthish Manthiram and Zachary Smith. Karthish was a postdoc at Caltech; he received a Bachelor's degree in chemical engineering from Stanford and his PhD in chemical engineering from UC Berkeley. As a graduate student, Karthish developed transition-metal oxide hosts for redox-tunable plasmons and nanoparticle electrocatalysts for reducing carbon dioxide. His research program at MIT focuses on the molecular engineering of electrocatalysts for the synthesis of organic molecules, including pharmaceuticals, fuels, and commodity chemicals, using renewable feedstocks. We are certainly glad to have

Highlights

find the latest news online:

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MITChemEng MITChemE

Massachusetts Institute of Technology

Letter from the Department Head continued

been able to lure him from the West Coast! Zach earned his BS in chemical engineering from the Penn State Schreyer Honors College, and completed his PhD in chemical engineering at UT Austin, where he worked under the guidance of Professors Benny Freeman and Don Paul. His research focuses on the molecular level design, synthesis, and characterization of polymers and inorganic materials for applications in membrane and adsorption-based separations. I look forward to sharing Karthish's and Zach's work with you as they settle in here at MIT.

Our faculty, students and alumni continue to work toward bettering the world through chemical engineering. Just some examples of the past year's exciting work include Michael Strano's explosive-sniffing spinach plants, Klavs Jensen's and Allan Myerson's compact, portable pharmaceutical manufacturing system, and the Anderson Lab's progress toward a Zika vaccine. I'm also proud to share some of the awards our faculty have garnered recently: Arup Chakraborty was elected to the National Academy of Sciences, Jim Swan won an NSF CAREER Award, Greg Rutledge was named a fellow of AIChE while Klavs Jensen won AIChE's Founders Award. And there are several other notable awards and honors earned by many more of our faculty that you will see described in this newsletter.

Postdocs and undergraduates are equally integral parts of the MIT Chemical Engineering Community.

On the cover of this edition of the newsletter, a postdoctoral associate in Fikile Brushett's research group works with an undergraduate who is part of our Undergraduate Research Opportunities Program (UROP). Along with our outstanding graduate students, postdocs and undergraduates are equally integral parts of the MIT Chemical Engineering Community. Postdocs perform much of the groundbreaking research at the Institute and are critical members of research groups, working closely with faculty and students. While our undergraduates learn the fundamentals of chemical engineering, hands-on research experience is invaluable to their understanding of and preparation for their careers in the field. UROPs are just one way that we offer these experiences – our undergraduates learn firsthand how to work as a team and communicate with sponsors through projects in our undergraduate laboratory courses 10.28 and 10.26.

Heather Upshaw, Ellen and Robert Gurnitz SB '60, SM '61, PhD '66, and Paula Hammond celebrate the Practice School at its Centennial Gala Dinner on Saturday, October 1, 2016.

A very special event happened this Fall that only comes every one hundred years: the Centennial of the Practice School. Our director, Alan Hatton, and his team had been planning this celebration for a while, and it was a great event for our students, faculty and, most importantly, our Practice School alumni. 200 alumni joined us on campus September 30 - October 2, 2016, to meet up with old friends, discuss the impact of the Practice School on the field of chemical engineering, and be the first to see a professional full-length documentary chronicling the history and impact of the Practice School during the last 100 years. It was epic. You can find more about the event and how you can own a piece of it for your self on page 4.

I have one more announcement: after several months of hard work and dedication, we are delighted to officially announce the launch our new department website, *cheme.mit.edu*. Our goal with this new website is to give our community an easier way to learn about MIT ChemE's research and people, and to provide useful tools for our students, faculty, alumni and friends. We'd love for you to check it out.

Thank you for taking time to read our newsletter and letting us share some of the interesting things going on around campus. Please do write to us to let us know how you are doing and how we can continue to improve. Thank you for your support and best wishes to all of you in and of Course 10.

Sincerely,

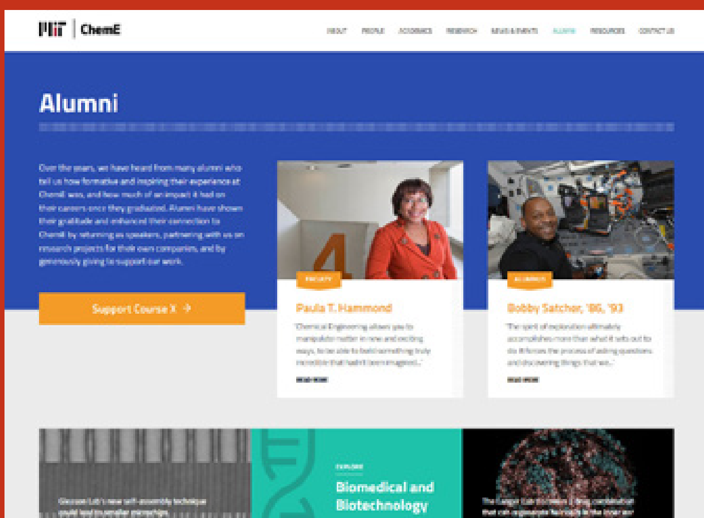
Paula T. Hammond
Department Head
MIT Chemical Engineering Department

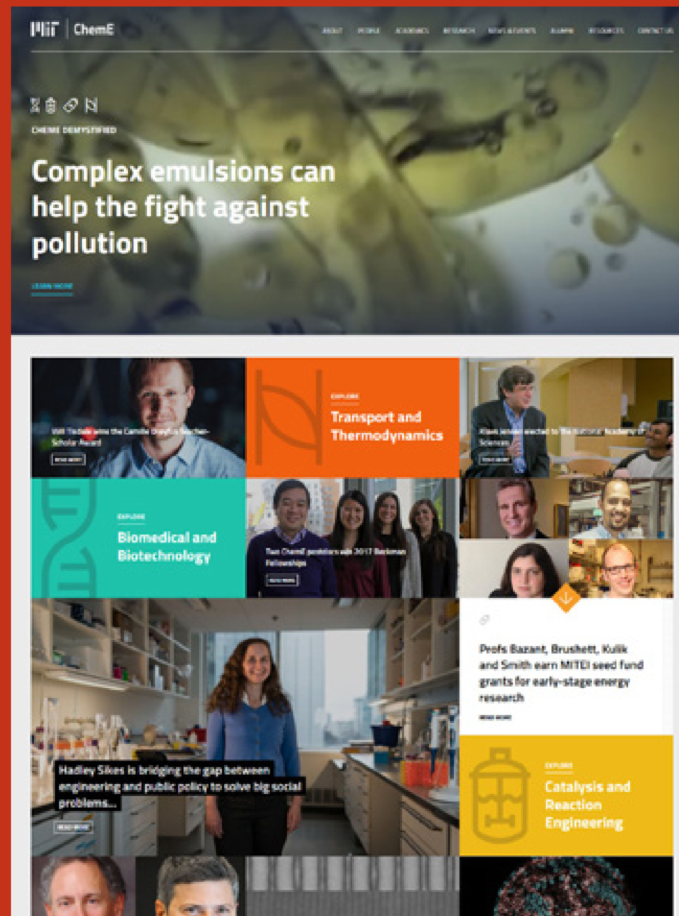
We have a new website

cheme.mit.edu

On our new site, you'll find the latest news on our students, our faculty, research, and *alumni*!

Let us know your own latest news, and we'll include it in our fancy new newsfeed.





XCurrents is a semi-annual newsletter for alumni and friends of the MIT Chemical Engineering Department.

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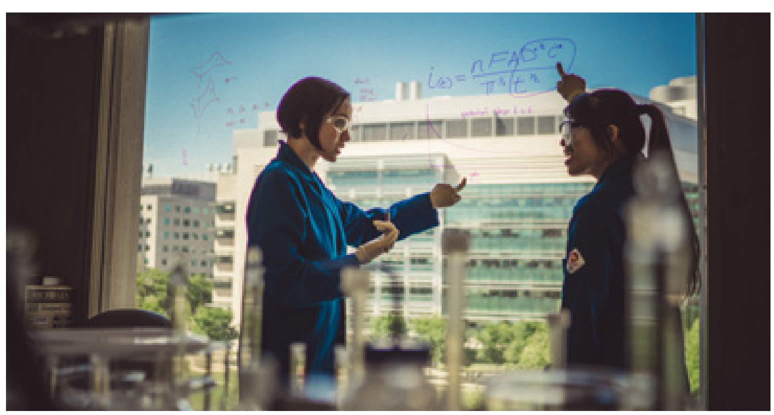


On the cover: Postdoc Emily Carino describes the theory behind current-time responses for electrochemical reactions to UROP student Jessie Hsiao. Performing such measurements at a series of electrode potentials enables researchers to deconvolute complex electrode reactions which are typical of practical electrochemical systems (e.g., batteries, fuel cells). By mastering these techniques, Jessie will be able to identify rate- and life-determining factors for the materials she is studying.

Practice School News

Greetings from the MIT Practice School!

What a year we have had. The highlight being, of course, the centennial event that was September 30th through October 2nd, 2016. It was a weekend of fun, fellowship, and looking towards the future of the program with fellow alumni, students, faculty and friends of the Practice School. It culminated with a gala event on the top floor of the Media Lab, where the view of the Charles is wonderful.

It was thrilling to celebrate 100 years of chemical engineering student engagement with industry, solving some of its most complicated and challenging problems. Since 1916, our students – including many of you – have helped organizations like General Mills, Corning Glass, Novartis Pharmaceuticals, BP, Cabot Corporation, and many other energy, materials, manufacturing, food, pharmaceutical and research companies.

Thanks to the hard work of our faculty, staff and alumni, we had two exciting projects come out of the centennial that I would like to share with you: a documentary of the past, present and future of the Practice School, and a book of interviews of Practice School alumni through the years - three generations!

I'd like to take this moment to thank Bob Hanlon, former station director, who led the massive planning process that went into the creation of the documentary and book, not to mention the weekend event. His enthusiasm and vision drove the planning process, and we are grateful for his effort. Bob directed several stations at Corning Glass; his station and students from 2015 are a major part of the documentary; I doubt he expected part of his job description to be "film star," but he adapted well to the role.

Here you will find some photos from the event. For the full schedule, a viewing of the documentary, and other information from the event, go to *ps100.mit.edu*.

I had so many great conversations with alumni and friends of the Practice School during the Centennial. The enthusiasm was palpable, and I am excited for the next 100 years. In future editions of the newsletter, I will share with you our thoughts and plans for the future of the Practice School.

Best regards,

T. Alan Hatton, Director
David H. Koch School for
Chemical Engineering Practice

In Practice

"As alumni, you know better than anyone the singular rigors, wonders, and lessons of life offered by the Practice School. With this book, we share a cross section of those experiences. Whether students are working with carbon black at Cabot, re-engineering Golden Grahams cereal at General Mills, or analyzing the surface qualities of an antacid pill at Merck, they are contributing to the success of their team and host company, while learning skills one can only earn through such a dynamic and intensive experience. "

T. Alan Hatton, in his foreward to *In Practice*

"Success in Practice School is learning something new, even if it's learning why something won't work."

Ramin Haghgooie SM '03, PhD '06, on page 53

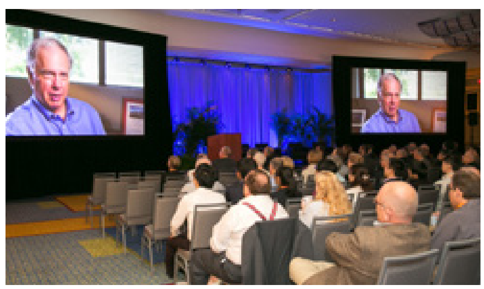
In Practice is a culmination of 100 years of the Practice School through the eyes of its participants. For a free copy of this Practice School Centennial commemorative book, contact Beth Tuths at *btuths@mit.edu.*

2016 Centennial Event

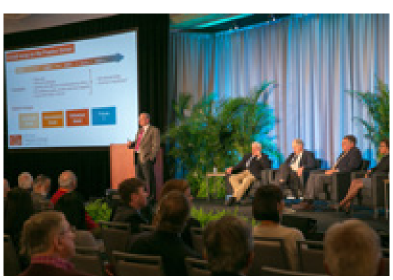
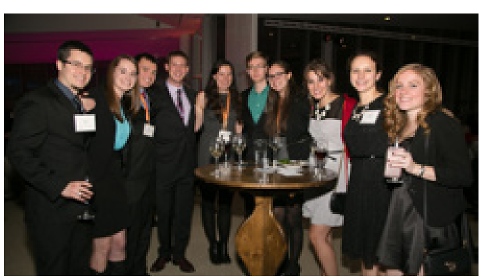











continued on page 8

2016 Practice School Centennial

Alumni Share their Thoughts

A 50+ Year Career Perspective on the World & ChemE Careers Today

Kishore V. Mariwala, SM '59, as told by Lea Poquerusse, SM '13

Over the past couple of months, I've had the good fortune of interacting with a fellow MIT MSCEP alumnus turned business entrepreneur, Kishore V. Mariwala, who graduated 54 years before me, in 1959. As a recent Stanford MBA graduate feeling overwhelmed by the shear number of career opportunities in the world today, conversations I've had with Kishore have provided me a welcomed perspective on one's career evolution in the new world order.

We'd like to share with you some of the key nuggets from conversations we've had. I personally hope you'll find these as useful as I have (**I highlighted the ones I think are most useful**)!

Lea: Kishore, can you share with me what types of roles your ChemE peers went into throughout their careers? I want to understand how different these are from my peers' early careers.

Kishore: After I graduated in 1959, I followed a typical path for many engineers… I opted for operations. I first worked as a chemical engineer and then evolved into a managerial role. My fellow chemical engineer peers opted for:

- Similarly to me, operations – either as an entrepreneur or as an employee
- Consultancy firms involved with technology development or design
- Academia or industrial research
- Further education in management; these peers typically then went into General or Financial management
- Environment protection jobs in industrial organizations and in government agencies (this stemmed from the rapidly emerging awareness of the need for managing the global environment).

Lea: Wow… It seems that the types of jobs ChemE students went into was much narrower then compared to my peers'. Indeed, my MSCEP peers have gone on to become, in addition to the more traditional ChemE jobs, management consultants, IP lawyers, health tech programmers, business founders … to list a few.

The world has clearly changed. What do you see as being some of the major differences in the world in general when you graduated in 1959 vs. today?

Kishore: Today, the challenges facing and opportunities available to today's youth are numerous and different. Some of these are:

- The world's knowledge base is expanding at an increasingly rapid rate. **The explosion of information available today can confuse one's thinking**;
- The advancements in our knowledge bases are due to interdisciplinary interactions in academic and industrial research. Strong interaction between chemistry and biology, intensive use of information technology by almost all sciences and the availability of very advanced computers has enabled many sciences to use rigorous mathematical models and get precise solutions to such problems;
- Business models are changing rapidly all over the globe, emergence of e-commerce being just one such change;
- Businesses have become very competitive. **Every professional person needs to have an understanding the of economics affecting the field (s)he is working on**;

"Do not fear failures. They teach a lot!"
Kishore Mariwala

- Scientists are also called upon to solve innumerable global problems. To cite some examples:
    - Global warming: the need for alternate energy sources to combat global warming and also to alleviate the threat posed by a shortage of fossil fuels;
    - Solutions for alleviation of poverty from third world countries;
    - Fighting infectious disease like malaria, tuberculosis, lifestyle diseases and diseases which have become more prevalent due to increasing life span in developed countries;
    - Ensuring water and food security for the increasing population.

Lea: Interesting... It seems that my peers and I have our work quite carved out for us then! If you had to share a couple tips with my peers and me based on your 50+ year career, what would they be?

Kishore: My advice to youth today would be:

1. You have the opportunity to get exposed to varied subjects. **Use these opportunities to solve problems - any problems.** That is what modern education tries to teach you;

2. **Ensure that your fundamentals are kept honed right through your career.** These will help you in solving any problems;

3. **Do not get overwhelmed by the information explosion. Yet be sharp enough to pick up information useful to you.** Also realize that **you can locate experts who can help you out rather than trying to learn everything yourself** and thus spend valuable time reinventing what is already known;

4. However, since the business environment and opportunities to assist in solving global problems are changing constantly, **be prepared to reinvent yourselves** and when necessary to keep pace with changing opportunities.

Finally:

5. **Do not fear failures.** They teach a lot! If you have taken into consideration all the facts available to you in solving a problem, and yet failed, that failure will be a pointer to some other fundamentals which you will learn and thus improve your knowledge base.

Lea: Kishore, your perspective is appreciated and these 5 tips are incredibly valuable...thank you! ◊

(l.-r.) Lea Poquerusse and Kishore Mariwala discuss the Practice School "Then and Now," at the Practice School Centennial, October 1, 2016.

Faculty Highlights

For more information, go to *cheme.mit.edu/faculty/*

Martin Bazant named inaugural E.G. Roos (1944) Professor

Department of Chemical Engineering establishes new professorship and graduate student fellowship to honor alumnus.

Article by Leda Zimmerman

The Department of Chemical Engineering has announced the appointment of Martin Z. Bazant to a new endowed chair professorship, made possible through a generous gift by Edwin G. Roos '44. In addition to this gift, Roos has also provided a new endowed graduate student fellowship for the department.

An active alumnus for nearly 70 years, Roos has given more than $10 million to MIT, much of it to support chemical engineering, the field in which he majored. Roos feels deeply connected to the department, although he only worked for several years as a chemical engineer before building a lifelong career in real estate.

"I have a bit of regret or guilt that I never fulfilled my training and never went on to do basic engineering research," says Roos. "I want others to do what I didn't do, and because I appreciated the fact that MIT does great research, I felt I had an obligation to give." Roos is the department's most generous living donor.

"This is truly a special event for us," says Paula Hammond, the David H. Koch Professor of Engineering and department head. "These gifts will have a positive impact on the entire department, enabling us to enhance a range of activities central to our mission, and specifically supporting the research enterprise of Professor Bazant, who is extremely dedicated to the exploration of new and creative ideas."

Ed G. Roos '44

Bazant, who arrived at MIT in 1998, is pursuing some of the most challenging problems at the intersection of energy, environment, and sustainability. His recent research has yielded a fundamentally new way to purify salty or contaminated water using an electrical shockwave. He is also investigating the potential of using room temperature ionic liquids (mixtures in which electrically charged molecules themselves comprise a liquid) for battery storage.

Bazant's research interests and accomplishments are all the more remarkable given the fact that he never took chemistry classes past high school. "I'm an oddball, self-taught in every field," Bazant says. "I follow my curiosity, which is the best way to do innovative research." His career evolved through different disciplines, to the point, he says "where the topics of my research and teaching are far removed from my training and education."

With a master's degree in applied mathematics from the University of Arizona, and a PhD in physics from Harvard University, Bazant taught applied mathematics for his first decade at MIT. Around 2001, a singular experience turned his attention toward engineering. "I was doing a pencil-and-paper calculation of fluid flows around a metal sphere in an electric field," he recalls. "It turned out to be an interesting problem that hadn't been studied much at the time."

Together with a graduate student, Bazant began tailoring what he calls a "mathematical exercise" to the harnessing of flows in microfluidics, work that had immediate application to controlling fluid flow in small-scale "lab on a chip" devices. Bazant eventually filed patents in fluid mechanics, and with student and faculty colleagues, developed products for the Institute for Soldier Nanotechnology.

"This is a real MIT story," says Bazant. "I was still in the math department, but didn't feel constrained to just do math." As a result of an "incredible experience of going from abstract exercise to experimental realization, to practical devices," Bazant says, "I got excited, and realized that theoretical physics and mathematics can have a direct impact on the real world."

In 2008, Bazant moved over to the Department of Chemical Engineering, which felt like a more natural home given his expanding interest in conducting research leading to real-world applications. His laboratory supports both theoretical and experimental research, which allows him both to pose basic questions and test hypotheses about the behaviors of particles and chemicals in electrochemical systems.

Among Bazant's current problems, which focus on electric fields and flows, is understanding phase transformations in lithium ion and lithium metal batteries, and learning how to control the movement of ions in the service of more efficient battery storage. "Lithium metal is the ultimate anode material," says Bazant. "You can't have a higher energy density than that."

He is also scaling up his novel water purification system, which harnesses an electric shock wave to drive a current through a flowing stream, separating salty or contaminated water from liquid that is clean and potable. With concern for the world's limited supply of clean water, Bazant hopes to commercialize the system in a few years.

"This was the original motivation for starting my lab, and it took about five years to achieve this vision," he says. "When you're starting a lab from scratch as a theorist, it doesn't always go smoothly, because your resources are limited and it's hard to get grants without a track record."

This is one of the reasons, says Bazant, that "the Roos chair for me is a blessing." The gift will enable Bazant to focus on what he does best, which is to innovate. "It's incredibly liberating for my research, because with a steady source of discretionary money I can try all sorts of new things." ◊

"The Roos chair for me is a blessing. It's incredibly liberating for my research, because with a steady source of discretionary money I can try all sorts of new things."

Professor Martin Bazant

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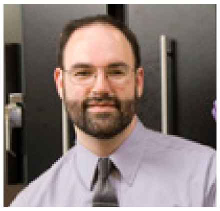
Martin Bazant

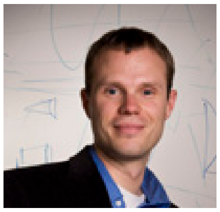
Faculty News



Paula Hammond and Michael Strano elected to the National Academy of Engineering

Election to the National Academy of Engineering is among the highest professional distinctions accorded to an engineer. Academy membership honors those who have made outstanding contributions to “engineering research, practice, or education, including, where appropriate, significant contributions to the engineering literature” and to “the pioneering of new and developing fields of technology, making major advancements in traditional fields of engineering, or developing innovative approaches to engineering education.”

Hammond was recognized for her “contributions to self-assembly of polyelectrolytes, colloids, and block copolymers at surfaces and interfaces for energy and health care applications.” Strano was cited for “contributions to nanotechnology, including fluorescent sensors for human health and solar and thermal energy devices.”



Brad Olsen named Kavli Foundation Emerging Leader in Chemistry

Professor Bradley Olsen was recognized as “a distinguished younger scientist who is highly regarded by his or her peers for significant contributions to an area of chemistry or related area of chemistry.”

The Kavli Emerging Leader Lecture is awarded to an outstanding chemical scientist who is less than 10 years past receipt of his PhD and is under 40 years of age.

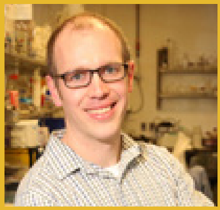
Olsen delivered the Kavli Foundation Emerging Leader in Chemistry Lecture at the American Chemical Society’s 253rd National Meeting on April 3, 2017. The title was, “Classical challenges in the physical chemistry of polymer networks.”

Greg Rutledge elected Fellow of AIChE

Professor Greg Rutledge has been named a Fellow of the American Institute of Chemical Engineers (AIChE), the highest grade of membership by the organization. This is achieved only by election by the AIChE board of directors, generally upon recommendation of the AIChE Admissions Committee through whom all nominations for election to Fellow are processed.

Martin Bazant named ISE Fellow

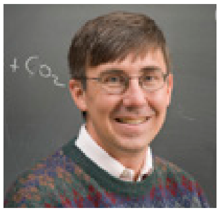
The International Society of Electrochemistry (ISE) has named Professor Martin Bazant as a Fellow. This category of membership is conferred upon an individual in recognition of his continuing outstanding scientific and technical achievement within the field of electrochemistry. ISE Fellow candidates must be fully active in research and must have made significant contributions to electrochemistry in the last few years. The Society may appoint a few of its individual members as ISE Fellows in recognition of their scientific or technical contributions to the field of electrochemistry. Such ISE fellows are selected by the Executive Committee, upon recommendation by the Fellows Nominating Committee, after consultation with the Council.



MIT ChemE welcomes new assistant professors Karthish Manthiram and Zach Smith

Karthish Manthiram received a BS in chemical engineering from Stanford University and his PhD in chemical engineering from the University of California, Berkeley. He received the Dan Cubicciotti Award of the Electrochemical Society, a Department of Energy Office of Science graduate fellowship, a Tau Beta Pi fellowship, the Mason and Marsden prize, a Dow Excellence in Teaching Award, and the UC Berkeley chemical engineering departmental teaching award. As a graduate student, Manthiram developed transition-metal oxide hosts for redox-tunable plasmons and nanoparticle electrocatalysts for reducing carbon dioxide. His research program at MIT focuses on the molecular engineering of electrocatalysts for the synthesis of organic molecules, including pharmaceuticals, fuels, and commodity chemicals, using renewable feedstocks.

Smith earned his BS in chemical engineering from the Penn State Schreyer Honors College, and completed his PhD in chemical engineering at UT Austin, where he worked under the guidance of Profs. Benny Freeman and Don Paul. Smith’s research focuses on the molecular level design, synthesis, and characterization of polymers and inorganic materials for applications in membrane and adsorption-based separations. In particular, these research efforts are promising for gas-phase separations critical to the energy industry and to the environment, such as the purification of olefins and the capture of CO2 from flue stacks at coal-fired power plants. Smith has co-authored over 20 peer-reviewed papers and has been recognized with several awards, including the DoE Office of Science Graduate Fellowship, and he was selected as a U.S. delegate to the Lindau Nobel Laureate meeting on Chemistry in 2013. ◊



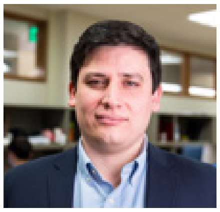
Bill Green elected Fellow of AAAS

Professor Bill Green has been elected as a Fellow of the American Association for the Advancement of Science (AAAS) for 2016. He is among a group of 391 AAAS members elected by their peers in recognition of their scientifically or socially distinguished efforts to advance science. Green was recognized for "developing accurate and useful methods for first-principles predictive chemical kinetics, improving understanding of chemical reactions and facilitating the engineering of complicated reacting systems."

Kwanghun Chung receives two awards

Professor Kwanghun Chung was selected to receive a 2016 NIH New Innovator Award for his project, "Proteome-Driven Holistic Reconstruction of Organ-Wide Multi-Scale Networks." With the award, Chung plans to develop technologies that can enable more holistic understanding of these complex biological systems.

Chung was also selected to receive a 2016 McKnight Technological Innovations in Neuroscience Award for his work on "multi-scale proteomic reconstruction of cells and their brain-wide connectivity."



James Swan wins NSF CAREER Award

The National Science Foundation (NSF) honored Professor James Swan through its Faculty Early Career Development (CAREER) program. Begun in 1995, the CAREER program provides promising junior faculty the opportunity to pursue outstanding research, excellence in teaching, and the integration of education and research.

Swan will focus his efforts on nanoparticle self-assembly.

Klavs Jensen earns AIChE Founders Award

AIChE's Founders Award recognizes outstanding contributions in the chemical engineering field, both technical and professional. It is presented to a member of AIChE who has had an important impact on chemical engineering and whose achievements, either specific or general, have advanced this profession in any of its aspects.

Paula Hammond garners two distinctions

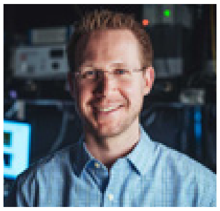
Professor Paula Hammond has been elected to the National Academy of Medicine, in recognition of her distinguished contributions to medicine and health. Membership in the NAM is considered one of the highest honors in the fields of health and medicine and recognizes individuals who have demonstrated outstanding professional achievements and commitment to service.

Hammond has also been named a Fellow of AIChE, the highest grade of membership by the organization. This is achieved only by election by the AIChE board of directors, generally upon recommendation of the AIChE Admissions Committee through whom all nominations for election to Fellow are processed.

Arup Chakraborty elected to the National Academy of Sciences

Professor Arup Chakraborty has been elected to the National Academy of Sciences (NAS) in recognition of his "distinguished and continuing achievements in original research."

Chakraborty was among 84 new members and 21 new foreign associates, from 14 countries, elected to the NAS. Membership in the NAS is one of the most significant honors given to academic researchers.



Will Tisdale earns two recognitions

Professor Will Tisdale has been selected as a 2016 Alfred P. Sloan Research Fellow in Chemistry. Awarded annually since 1955, the Sloan Research Fellowships are given to early-career scientists and scholars whose achievements and potential identify them as rising stars among the next generation of scientific leaders.

Tisdale also earned a Presidential Early Career Award for Scientists and Engineers, the highest honor bestowed by the United States Government on science and engineering professionals in the early stages of their independent research careers. ◊

Research Highlights

For more information, go to *cheme.mit.edu/research/*

3-D antibody arrays offer better sensing

New tool could help diagnose malaria and other diseases.

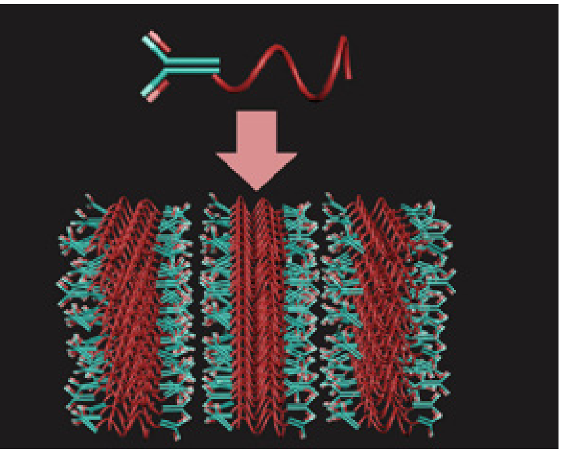
Article by Anne Trafton, courtesy of MIT News.

Exploiting a process known as molecular self-assembly, MIT chemical engineers have built three-dimensional arrays of antibodies that could be used as sensors to diagnose diseases such as malaria or tuberculosis.

These sensors, which contain up to 100 stacked layers of antibodies, offer much more sensitivity than existing antibody-based sensors, which have only a single layer of antibodies.

"The more antibodies you put on a surface, the lower the concentration of molecules you can detect," says Bradley Olsen, an associate professor of chemical engineering at MIT. "You can have a big impact on biosensors by potentially improving the sensitivity by several orders of magnitude."

Olsen is the senior author of the study, which appears in the journal Angewandte Chemie. The paper's lead author is MIT postdoc Xue-Hui Dong, and former postdoc Allie Obermeyer is also an author.



The team discovered that they could force antibodies and other proteins to form layers by attaching each protein to a polymer tail. The proteins and polymers repel each other, so the molecules arrange themselves in a structure that minimizes the interactions between the protein and polymer segments. Image courtesy of the researchers.

Layered assembly

The team's new design approach relies on a phenomenon known as self-assembly, which occurs when thermodynamic interactions drive molecular building blocks to take on certain configurations.

In this case, the researchers discovered that they could force antibodies and other proteins to form layers by attaching each protein to a polymer tail. The proteins and polymers repel each other, so the molecules arrange themselves in a structure that minimizes the interactions between the protein and polymer segments.

"Because the protein and polymer are bonded together, they can't separate like oil and water. They can only get apart from each other by a distance about the size of one molecule," Olsen says. "If you do this in three dimensions, then you get things like cylinders of protein surrounded by polymer, or alternating layers of protein and polymer."

Olsen and his team attached each protein to a polymer chain called PNIPAM. When they coated a solution of these molecules onto a surface, the molecules formed a thin film containing between 10 and 100 layers of the protein-polymer structures.

Boosting sensitivity

A few years ago, Olsen and his colleagues showed that they could use this technique to create nanostructured arrays of simple proteins, including green fluorescent protein and a red fluorescent protein known as mCherry. That success led them to explore whether they could also create arrays of larger proteins, such as antibodies.

"[The antibody] IgG has a complex structure," Olsen says, "with four different molecules that are folded together in a very exquisite way."

The traditional method for creating large arrays of antibodies on a surface is to chemically or physically bond them to the surface. However, this technique only creates a single layer of antibodies. A thermodynamic principle holds that the more antibody molecules there are on a surface, the lower the concentration of molecules they can detect. Therefore, stacking layers of antibodies on top of each other offers a way to dramatically improve the sensors' sensitivity.

Using their new self-assembly strategy, the researchers created three-dimensional arrays of IgG antibodies, the main type of antibodies found in human blood. These densely packed arrays, which have the potential to be 100 times more sensitive than existing antibody sensors, also featured nanoscale channels that allow the sample to flow easily through the entire sensor.

"By controlling the location and density of the antibodies, this method will open up routes to higher sensitivity diagnostics compared to current methods, which randomly place the antibodies," says Matthew Gibson, a professor of chemistry at the University of Warwick, who was not involved in the research. "This publication represents proof of principle, but the methods used are versatile and can be applied to most antibodies, and I would expect this work to make a significant impact in the field."

Olsen is now working with Hadley Sikes, an MIT assistant professor of chemical engineering, to create sensors with antibodies specialized to detect pathogens from blood or urine samples. These types of sensors may also be useful one day for monitoring the health of pilots based on biomarkers found in their sweat or saliva.

The research was funded by the Air Force Office of Scientific Research and the Arnold and Mabel Beckman Foundation. ◊

Course X Alumni meet in San Francisco

On Monday, November 14th, 2016, MIT alumni, faculty and students gathered at the AIChE annual meeting in San Francisco.

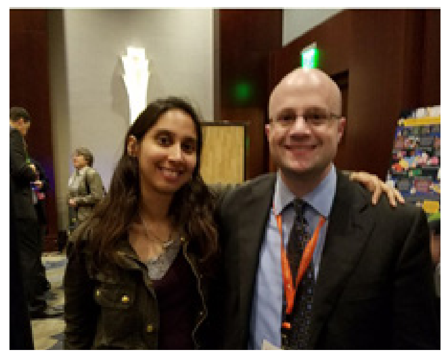
This year, the theme of the reception was to celebrate the centennial of the Practice School. Course X alumni and friends from around the world gathered to mingle and network, as well as honor the MIT faculty who were recipients of AIChE and National Academy awards in 2016:

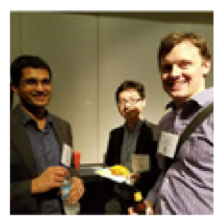
Paula T. Hammond '84, PhD '93
Elected Fellow of AIChE
and
National Academy of Medecine

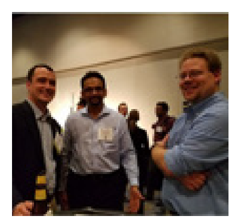
Klavs F. Jensen
AIChE Founder's Award

Arup K. Chakraborty
Elected Member of the National Academy of Sciences

(photos by Melanie Kaufman)







Research Highlights

For more information, go to *cheme.mit.edu/research/*

Study points a way to better implants

Selectively blocking immune cells can prevent formation of scar tissue around medical devices.

Article by Anne Trafton, courtesy of the MIT News Office.

Medical devices implanted in the body for drug delivery, sensing, or tissue regeneration usually come under fire from the host's immune system. Defense cells work to isolate material they consider foreign to the body, building up a wall of dense scar tissue around the devices, which eventually become unable to perform their functions.

Researchers at MIT and Boston Children's Hospital have identified a signaling molecule that is key to this process of "fibrosis," and they have shown that blocking the molecule prevents the scar tissue from forming. The findings, reported in the March 20 issue of Nature Materials, could help scientists extend the lifespan of many types of implantable medical devices.

"This gives us a better understanding of the biology behind fibrosis and potentially a way to modulate that response to prevent the formation of scar tissue around implants," says Daniel Anderson, an associate professor in MIT's Department of Chemical Engineering, a member of MIT's Koch Institute for Integrative Cancer Research and Institute for Medical Engineering and Science (IMES), an affiliate at Boston Children's Hospital, and the senior author of the study.

The paper's lead author is Koch Institute and JDRF postdoc Joshua Doloff.

Preventing fibrosis

Anderson's lab has been working for several years on an implantable device that could mimic the function of the pancreas, potentially offering a long-term treatment for diabetes patients. The device encapsulates insulin-producing islet cells within a material called alginate, a polysaccharide naturally found in algae. Alginate provokes a lesser immune response than human-made materials such as metal, but it still induces fibrosis.

To investigate how fibrosis happens, the MIT team systematically knocked out different components of the immune system in mice. They found that cells called macrophages are necessary for fibrosis to occur, and that when those cells are missing, scar tissue does not form around implanted devices.

The researchers then identified a signaling molecule that appears to help macrophage precursors known as monocytes differentiate into mature macrophages, which then initiate fibrosis. They also discovered that if they blocked the cell surface receptors for this molecule, known as CSF1, they could prevent implant-induced fibrosis from occurring.

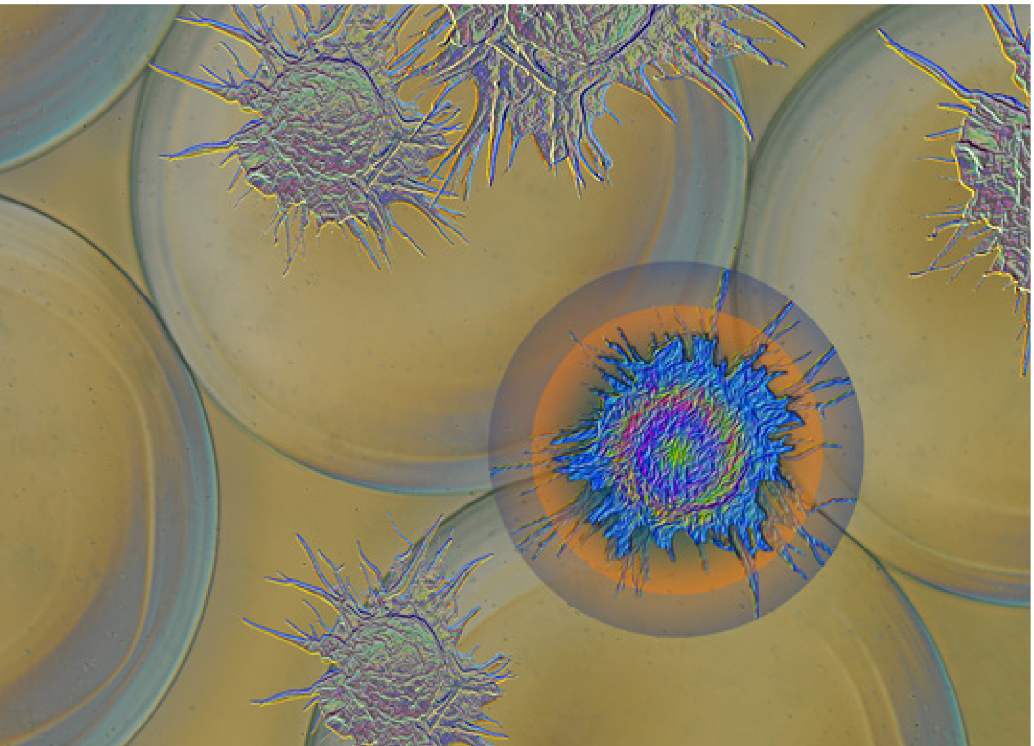
Importantly, this interference did not stop macrophages from carrying out other critical functions.

"We show that you preserve many other important immune functions, including wound healing and phagocytosis, but you lose this fibrotic cascade," Doloff says. "We're preventing the macrophages from toggling into an activated warning state where they sound the alarm for this massive immune response to show up."

In this study, the researchers showed that blocking CSF1 receptors prevented fibrosis not only with alginate but also ceramic and a plastic called polystyrene.

"It's generalizable to many different types of biomaterials, and hopefully will also be generalizable to many platforms for different purposes," Doloff says.

"I am very impressed with this paper, particularly with the identification of CSF1R as a target," says Gordon Weir, the co-head of the Joslin Diabetes Center's section on islet and regenerative biology. Weir, who was not involved with the research, added that further tests will be needed to determine how long the inhibitor would need to be given and how safe it would be. ◊



The immune system often builds up a wall of dense scar tissue around implanted medical devices, a process known as fibrosis. The cell shown in blue represents a macrophage that has been blocked from initiating fibrosis. Image: Felice Frankel

Inside tiny tubes, water turns solid when it should be boiling

MIT researchers discover astonishing behavior of water confined in carbon nanotubes.

Article by David Chandler, courtesy of MIT News.

It's a well-known fact that water, at sea level, starts to boil at a temperature of 212 degrees Fahrenheit, or 100 degrees Celsius. And scientists have long observed that when water is confined in very small spaces, its boiling and freezing points can change a bit, usually dropping by around 10 C or so.

But now, a team at MIT has found a completely unexpected set of changes: Inside the tiniest of spaces — in carbon nanotubes whose inner dimensions are not much bigger than a few water molecules — water can freeze solid even at high temperatures that would normally set it boiling.

The discovery illustrates how even very familiar materials can drastically change their behavior when trapped inside structures measured in nanometers, or billionths of a meter. And the finding might lead to new applications — such as, essentially, ice-filled wires — that take advantage of the unique electrical and thermal properties of ice while remaining stable at room temperature.

The results are being reported today in the journal Nature Nanotechnology, in a paper by Michael Strano, the Carbon P. Dubbs Professor in Chemical Engineering at MIT; postdoc Kumar Agrawal; and three others.

"If you confine a fluid to a nanocavity, you can actually distort its phase behavior," Strano says, referring to how and when the substance changes between solid, liquid, and gas phases. Such effects were expected, but the magnitude of the change, and its direction (raising rather than lowering the freezing point), were a surprise: In one test, the water solidified at a temperature of 105 C or more. (The exact temperature is hard to determine, but 105 C was considered the minimum value in this test; the actual temperature could have been as high as 151 C.)

"The effect is much greater than anyone had anticipated," Strano says.

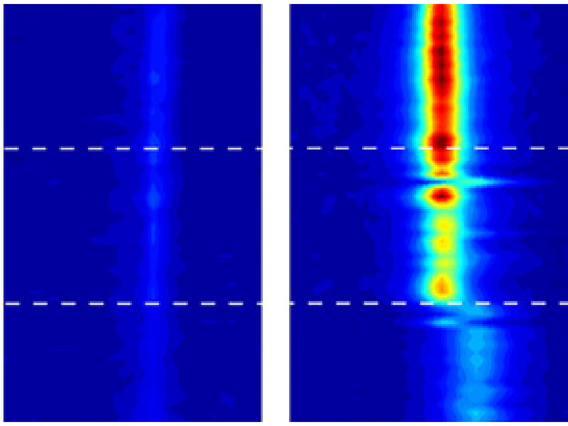
It turns out that the way water's behavior changes inside the tiny carbon nanotubes — structures the shape of a soda straw, made entirely of carbon atoms but only a few nanometers in diameter — depends crucially on the exact diameter of the tubes. "These are really the smallest pipes you could think of," Strano says. In the experiments, the nanotubes were left open at both ends, with reservoirs of water at each opening.

Even the difference between nanotubes 1.05 nanometers and 1.06 nanometers across made a difference of tens of degrees in the apparent freezing point, the researchers found. Such extreme differences were completely unexpected. "All bets are off when you get really small," Strano says. "It's really an unexplored space."

In fact, it's surprising that water even enters into these tiny tubes in the first place, Strano says: Carbon nanotubes are thought to be hydrophobic, or water-repelling, so water molecules should have a hard time getting inside. The fact that they do gain entry remains a bit of a mystery, he says.

Strano and his team used highly sensitive imaging systems, using a technique called vibrational spectroscopy, that could track the movement of water inside the nanotubes, thus making its behavior subject to detailed measurement for the first time.

The team can detect not only the presence of water in the tube, but also its phase, he says: "We can tell if it's vapor or liquid, and we can tell if it's in a stiff phase." While the water definitely goes into a solid phase, the team avoids calling it "ice" because that term implies a certain kind of crystalline structure, which they haven't yet been able to show conclusively exists in these confined spaces. "It's not necessarily ice, but it's an ice-like phase," Strano says.



Inside the tiniest of spaces — in carbon nanotubes whose inner dimensions are not much bigger than a few water molecules — water can freeze solid even at high temperatures that would normally set it boiling. The finding might lead to new applications such as ice-filled wires. Image courtesy of the researchers.

Because this solid water doesn't melt until well above the normal boiling point of water, it should remain perfectly stable indefinitely under room-temperature conditions. That makes it potentially a useful material for a variety of possible applications, he says. For example, it should be possible to make "ice wires" that would be among the best carriers known for protons, because water conducts protons at least 10 times more readily than typical conductive materials. "This gives us very stable water wires, at room temperature," he says. ◊

Alumni Highlights

For more information, go to *cheme.mit.edu/alumni/*

Appelstein Classroom Dedication

Central Building 66 classroom named for alumnus and staunch supporter of MIT and the MIT Chemical Engineering Department.

In January of this year, the department took a moment to celebrate one of our alumni and thank him for his continued support of the ChemE and the Institute. Gerald M. "Jerry" Appelstein and friends and colleagues came together at a luncheon to celebrate the naming of Room 66-144 to the "Gerald M. Appelstein '80 Classroom." It was dedicated in memory of his son, Jason D. Appelstein.

In September 2016, Applestein was honored with the Bronze Beaver award from the MIT Alumni Association for being an "extraordinary volunteer." Appelstein has been a tireless champion for many MIT's initiatives and a dedicated volunteer and leader in countless ways. His Institute service dates back to his graduation year of 1980, with service on the Dormitory Council. After graduation, he immediately volunteered to be an MIT educational counselor, and he remains one today. Appelstein was the first chair of the leadership giving group—the William Barton Rogers Society (WBRS)—and has served as a lively host at WBRS and other MIT events across the US. As a good citizen in the name of MIT, he responded in record time to the Boston Marathon terrorist activities, becoming one of the first to make a gift in Officer Sean Collier's memory.

We are grateful for Jerry's continued support and counsel to the department and the Institute.◊

In Memoriam: Samuel M. Fleming SM ’61 PhD ’70

Sam Fleming SM ’61 ScD ’70, enthusiastic champion of the Practice School and an integral part of October 2016’s Practice School Centennial Celebration, passed away April 21, 2017. As the Director of the Chemical Engineering Practice School from 1970 through 1974, Dr. Fleming had a very meaningful impact on the lives of our students and faculty; his leadership during those years was very important for the continued strength and excellence of the program moving forward. Dr. Fleming did his undergraduate work at Penn State before coming to MIT for his graduate degrees. He completed his Practice School assignment at the well-known Oak Ridge National Lab before completing his doctoral work under Alan Hoffman. He also served as Station Director at Oak Ridge and American Cyanamid before ultimately assuming the role of Director of the Practice School following completion of his doctoral degree. Following his time at MIT, Dr. Fleming worked as the Director of Technology for Badger Industries, followed by similar roles at Fluor Enterprises and Bechtel Corporation. He was most recently the CEO and Founder of Global Resources Development & Management Co. A continuing interest throughout his career centered on commercial-scale Fischer-Tropsch Technology (syngas to liquid transportation fuels).

Fleming (first row, center) with fellow team members at the Practice School station at Oak Ridge National Laboratory, fall 1967.

(l.-r.) Current Practice School director Alan Hatton, Professor Emeritus Ken Smth, and previous Practice School directors Sam Fleming and Jeff Tester at the Practice School Centennial Celebration, fall 2016.

Department Head Paula Hammond shares, “I had the pleasure of getting to know Sam during the planning and execution of the Practice School Centennial. It became clear that he was incredibly dedicated to the Practice School, and that he felt very deeply about the opportunities that it provided to him and to many other students over the years to have a true and meaningful chemical engineering experience. Dr. Fleming was a tireless champion of the Practice School and was deeply influential on many of our students from the ‘60s and ‘70s. As an unofficial but fully adopted member of the Practice School’s Centennial planning committee, he put countless hours into the weekend’s success. He shared his terrific sense of humor, excitement for the field, and enthusiasm for his MIT experience with all of us. He will be fondly remembered by many members of our community, and his memory will no doubt inspire future students who hear about the history of our Practice School.”

We will update the MIT ChemE website with memorial service information as it becomes available. ◊

Have something you’d like to share?
We want to hear from alumni like you!

Please send us your news and photos! We’ll share on our website and alumni news.

Use our contact form at *cheme.mit.edu/contact-us/*
Or direct news to: ***Melanie Kaufman, Editor***
Email: ***chemealum@mit.edu***, Phone: ***617-253-6500***

Alumni News

We want to hear from you!

Have you published new work? Received a great promotion? Are you proud of an accomplishment you'd like to share with the MIT ChemE community?

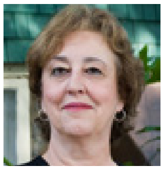
Submissions will appear in the Alumni Magazine and MIT ChemE website. In addition, we will use your news in as many appropriate platforms as possible, which may include social media sites, collateral, or other promotional materials.

Dr. Marvin L. Baker SB '51 SM '53 PhD '56 (above, with (l. to r.) Princess Astrid of Belgium and his wife Virginia) has been awarded the title "Commander of the Order of the Crown," by decree of the King of Belgium. The ceremony took place at the Greater Houston Partnership, with an audience of 150 people, after which he gave an acceptance speech. It was bestowed by Princess Astrid, sister to King Philippe of Belgium.

The title of "Commander" is two levels above Knight. Baker was introduced at the ceremony by the Belgian Ambassador to the USA, Ambassador Dirk Wouters.

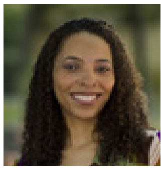
In 2013 and 2014, Baker served as Chairman of the Houston Mayor's International Trade and Development Council – Europe. In 2015, he arranged for the City of Houston to be invited (free of charge) as feature at the International Business Forum, at the ACHEMA in Frankfurt, Germany, a huge chemical engineering process equipment expo with 166,000 attendees.

Baker is still actively working. His company, High Technology Associates, specializes in opening the USA market for European engineered products.



Lita Nelsen '64, SM '66, SM '79 has retired as the director of the MIT Technology Licensing Office (TLO). Nelsen had been part of the TLO since 1986, and was its director since 1992, helping to shape the Institute's highly successful culture of technology spinoffs. In 2014, she was awarded the Lifetime Achievement Award of the organization Global University Venturing.

After leaving MIT, **Dana Woods SM '82** took a job with Union Carbide at the Bound Brook Research lab, investigating Ziegler Natta catalysts for their Unipol polyethylene process. Through a circuitous route, he became an MD, practicing ophthalmology in Connecticut. The Practice School summer of 1982 is one of his cherished memories.



Eboney Hearn '01 has been named the new executive director of the MIT Office of Engineering Outreach Programs (OEOP). She assumed the role on August 22, 2016. An alumna of the Department of Chemical Engineering with deep knowledge of the Institute, Hearn previously served as assistant dean for graduate education and diversity initiatives at MIT's Office of the Dean for Graduate Education (ODGE) from 2014 to 2016 and as program director of the Broad Institute's diversity initiative from 2008 to 2014.

Sean Hunt PhD '13 has been named one of *Forbes's 30 Under 30: Manufacturing and Industry* for 2017. Hunt co-founded the company Solugen, which has developed a scaled, sustainable process to create hydrogen peroxide from plants. Its PeroxyZen product is the first plant-based, food-grade peroxide for spas, hot tubs, pools and cleaning. ◊

Blast from the Past

In honor of the Practice School Centennial, we revisit past stations. Do you see yours?

Do you have photos or images you'd like to share? Email chemealum@mit.edu.

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We have a new website

cheme.mit.edu

On our new site, you'll find the latest news on our students, our faculty, research, and *alumni*!

Let us know your own latest news, and we'll include it in our fancy new newsfeed.