Fall/Winter 2021
Massachusetts Institute of Technology
Course X News
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MIT Chemical Engineering Alumni News

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About ChemE

Education
To offer academic programs that prepare students to master physical, chemical, and biological processes, engineering design, and synthesis skills; creatively shape and solve complex problems, such as translating molecular information into new products and processes; and exercise leadership in industry, academia, and government in terms of technological, economic, and social issues.

Research
To provide a vibrant interdisciplinary research program that attracts the best young people; creatively shapes engineering science and design through interfaces with chemistry, biology, and materials science; and contributes to solving the technological needs of the global economy and human society.

Social responsibility
To promote active and vigorous leadership by our people in shaping the scientific and technological context of debates around social, political, economic, and environmental issues facing the country and the world.

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We want to hear from you!

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Acknowledgments

From the Department Head

Hello and Happy Fall to our Course X Community! I hope this summer has brought you opportunities to visit and see people and places that have been out of reach for a while. While things are still in flux due to the advent of the Delta variant, we are moving ahead with caution and rigorous safety protocols that have allowed our labs to be back at full capacity, and we're gearing up to have all students and staff here for the Fall semester. In walking around campus, I see faculty members chatting with each other in the hallways and wave to grad and undergrad students as they pass through Hockfield Court on their way to lab and orientation events.

Our faculty continue to do excellent and amazing things, as you will read about in this issue, including the receipt of significant awards and recognitions and the development of new and exciting science. We will also be celebrating an important faculty member whom we lost last Fall, Institute Professor Daniel I.C. Wang, with a special Frontiers Symposium event this November.

I'm excited to announce we have two new faculty members joining us in this upcoming academic year: Brandon DeKosky and Maggie Qi. Brandon Dekosky received his BS in Chemical Engineering from University of Kansas, and his PhD in Chemical Engineering from the University of Texas at Austin, working with Dr. George Georgiou, where he led in developing the first high-throughput single-cell method for sequencing paired heavy and light chain antibody sequences. He then did postdoctoral research at the Vaccine Research Center of the National Institute of Infectious Diseases in Bethesda, MD working with Dr. John Mascola. In 2017, Brandon launched his independent academic career as an assistant professor at the University of Kansas in a joint position with the Department of Chemical Engineering and the Department of Pharmaceutical Chemistry.

Starting this Fall 2021, Brandon will be joining us in a newly introduced joint faculty position between the Department and the Ragon Institute of MGH, MIT and Harvard. His research program focuses on developing and applying a suite of new high-throughput experimental and computational platforms for molecular analysis of adaptive immune responses, and to accelerate precision drug discovery. Brandon's independent research efforts have generated major advances and exciting data for a host of applications in human immunology and molecular biotechnology across infectious disease, autoimmunity, and cancer research. His work has also outlined new fundamental mechanisms that lead to the personalization of human antibody immunity. Brandon's work bridges chemical engineering and the biomedical sciences at the interface with infectious disease, and he will represent this important interface at MIT and at the Ragon Institute in this inaugural joint position. Brandon is very excited about engaging with students and has strong interests in mentoring and promoting diversity.

Brandon DeKosky

Maggie Qi

After growing up in Qingdao, China, Maggie Qi received two BS degrees in chemical engineering and in operations research at Cornell University, before moving on to Stanford for her PhD. There, she worked with Eric Shaqfeh, a computational fluid mechanics faculty member in Chemical Engineering. Maggie then took on a postdoctoral position with Samir Mitragotri, a chemical engineer and experimentalist at Harvard University and the Wyss Institute. There, she investigated the use of ionic liquids in transdermal drug delivery and developed a microfluidic chip to mimic the subcutaneous space. Maggie's proposed research includes combining extensive theoretical and computational work on predictive models that guide experimental design. She seeks to investigate particle-cell biomechanics and function for better targeted cell-based therapies. She also plans to design organ-on-chip systems that elucidate hydrodynamics in complex organs, including delivery of drugs to the eye, and to examine complex fluids as matrices for biomaterial hydrogels. She aims to push the boundaries of fluid mechanics, transport phenomena and soft matter for human health and innovate precision healthcare solutions.

Among her accomplishments, Maggie was a participant in our inaugural class of the MIT Rising Stars in ChemE Program in 2018! We look forward to her many contributions to the Department, and the opportunity to engage her in our community through her research work, collaborations, teaching, advising, and participation in our community. She plans to start her appointment in January 2022, though she will be participating in Department events as she can in the interim.

Another alumna of our Rising Stars program, and former postdoc in the Langer Lab, is Ritu Raman, who just accepted a faculty position in MIT's Mechanical Engineering Department. It is great to see the accomplishments of these young faculty members and those of our other Rising Stars alumnae. Despite having to move to a virtual platform for our 2020 and 2021 symposia, we have been able to continue our work toward more inclusivity in the faculty hiring process.

These recent faculty hires are only one aspect of the ongoing efforts to foster diversity, equity, and inclusion (DEI) in the Department and at MIT. I'm so proud of the level of engagement and thoughtfulness in our students, staff, and faculty as they've undertaken important and effective initiatives. Just of a few examples of outreach include trainings and social gatherings sponsored by the student group DICE (Diversity in Chemical Engineering) and NOBCChE (National Organization of Black Chemists and Chemical Engineers) Chapter to our Graduate Admissions ChAMP (Chemical Engineering Application Mentorship Program), to the ongoing work of our Department DEI committee which has begun the difficult task of creating our strategic plan; it is inspiring and exciting to be a part of this work toward change. I encourage you to visit the DEI section of our website to learn more about our many current programs.

I sincerely welcome your thoughts and ideas on how we can promote and effect an equitable and welcoming community, and keep moving toward a better world in every way. As you can see, despite the pandemic, we have not slowed down! I hope you haven't either, as we continue to work toward a better world through chemical engineering.

Best regards,

Paula T. Hammond
Department Head

Greetings from the MIT Practice School

Despite this year's unprecedented challenges, the David H. Koch School of Chemical Engineering Practice has been able to continue its legacy of promoting real-world problem solving and project-management skills among Course X students. We are still the only academic program of its kind—a true example of MIT's tenet of "mens et manus."

Due to the global pandemic, the Practice School program was suspended for Fall 2020, but we were able to resume operations for the Spring and Summer 2021 Stations, albeit remotely. Despite the physical distances between us, our skilled station directors continued to foster the strong relationships we have come to expect with our sponsors, and to find ways to engage our students on challenging projects. We are pleased to note that the remote work during the sessions did not hinder the student productivity, as all projects were brought to a very successful conclusion. found ways to continue and strengthen our students experience and skills, as well as the Practice School legacy.

The two Spring 2021 stations were at Corning Glass in Corning NY, and AstraZeneca in Gaithersburg MD. An advantage of working remotely is that projects could be distributed over many sites rather than be concentrated at the sites at which the students would normally have been present physically.

Corning Incorporated specializes in specialty glass, ceramics, and related materials and technologies including advanced optics, primarily for industrial and scientific applications. Corning's five major sectors are display technologies, environmental technologies, life sciences, optical communications, and specialty materials. It is one of the main suppliers to Apple Inc. and develops and manufactures Gorilla Glass, which is used by many smartphone makers. Station director Mike Sarli and our students worked virtually on six separate projects with the sponsors, and produced meaningful results with successful developments for the company.

Tom Blacklock directed the virtual AstraZeneca station, which took advantage of its "remote" status: the sponsors were based in the UK, seven of students in the US and one in Thailand! Despite the time zone challenge, the seven separate projects were feasible. Projects included mainly required data analysis and coding. They ranged from cell imaging enhancements employing advanced visualization techniques to development of new tools to model various physical processes, using computational fluid dynamics (CFD) and machine learning techniques.

Dalzell as station director at Mitsubishi in Mizushima, Japan, late 1990s

Dalzell (third from left), his wife Pat (center), and Practice School students visit the Taj Mahal while at the Mawana Sugars station in Mawana, India, 2009.

An easily overlooked, but nonetheless important, challenge of virtual teams is the opportunity to team-build and socialize. Our station directors arranged for a weekly dinner allowance for each Practice School student. The cohort had weekly Zoom dinners together where each student would manage his/her own meal, take out or cook in, and join the group to dine together. Dinner conversations were themed, often initiated by the students, and designed to inform, encourage questions, promote debate, and solicit opinions. It was a very successful format and allowed some of the more passive participants to engage in this less formal setting.

As of the writing of this letter, the Summer 2021 stations, based at Merck (West Point, PA) and Schlumberger New Energy (Cambridge, MA) were wrapping up, and we will report on these activities in a future newsletter.

I'm sad to share that this year we lost a pillar of the Practice School community: Bill Dalzell '58, SM '60, ScD '65, passed away this spring. A Practice School alumnus and director, Bill epitomized the concept of "Learning by Practice" and spent his career helping others develop this skill. He and his wonderful wife Pat made sure that students at each of his stations not only succeeded academically, but also got to get out and experience the culture around them, be it through sushi dinners, boating on the Ganges, or local hikes. Bill's contributions through his knowledge, generosity, and wit are innumerable, and we will miss him greatly. More on Bill's legacy can be found on page 22.

Take care!

T. A. Hatton
Director
David H. Koch School of Chemical Engineering Practice

Arup Chakraborty and Paula Hammond named Institute Professors

The two chemical engineers are awarded MIT's highest faculty honor.

Two distinguished MIT chemical engineers, Arup K. Chakraborty and Paula Hammond, have been named Institute Professors, the highest honor bestowed upon MIT faculty members.

Hammond, who chairs MIT's Department of Chemical Engineering, is renowned for her work in developing novel polymers and nanomaterials, while Chakraborty, the founding director of MIT's Institute for Medical Engineering and Science (IMES), is a pioneer in applying computational techniques to challenges in the field of immunology, including vaccine development.

"At MIT, the distinction of Institute Professor designates the best of the best — and that is exactly how I would describe Paula Hammond and Arup Chakraborty," says MIT President L. Rafael Reif.

"Paula's boldness and creativity as an engineer, her excellence as an educator, and her leadership on issues of equity and inclusion have long made her an MIT star," Reif says. "Arup is perhaps best known as the visionary founding director of IMES and, of course, for his seminal contributions toward the development of a vaccine for HIV. I have always admired his extraordinary ability to explain complex issues — across a range of disciplines — with precision and clarity. Paula and Arup are great ambassadors for the Institute and our community. More than that, they are among MIT's finest citizens."

Arup K. Chakraborty

Chakraborty, a chemical engineer by training, has wide-ranging research interests that span biology, chemistry, and physics. His work in immunology has led to discoveries pertinent to T cell activation, the nature of human T cell repertoires, and antibody and T cell responses to infection and vaccination. He has also contributed to the development of potential new vaccines for highly mutable pathogens such as HIV.

"Arup has made seminal contributions in creatively addressing complex interdisciplinary issues at the confluence of molecular engineering, theoretical immunology, and the physical sciences, resulting in — as just one of many examples — advances toward the development of a vaccine for HIV," Schmidt and Danheiser wrote in their announcement. At the University of California at Berkeley, where he began his faculty career, Chakraborty pioneered the integration of quantum chemical calculations with macroscopic approaches in chemical engineering. For over two decades, much of his work has focused on developing and applying approaches rooted in statistical physics to tackle questions in immunology. "Over 20 years ago, I had a hunch, which proved to be correct, that the convergence of physics-based theoretical/computational approaches and experimental immunology would lead to a deep understanding of how the immune system functions, and this knowledge could be harnessed to advance health," says Chakraborty, who joined the MIT faculty in 2005. "I have truly enjoyed working with basic and clinical immunologists, as well as physicists, chemists, and engineers."

His work with immunologists led to discoveries such as how the immune synapse functions during T cell activation, how T cells respond to minute numbers of antigens, and why such responses are "on" or "off." With MIT professor of physics Mehran Kardar, he provided new insights on how developmental processes shape a T cell repertoire that can mount pathogen-specific responses to a diverse and evolving world of microbes.

Being named an Institute Professor is the most meaningful recognition he has received, because it comes from his MIT colleagues, Chakraborty says.

"When I look at the list of past and present Institute Professors, I'm deeply humbled and I hope that I can live up to the trust that MIT has placed in me," he says. "This recognition really belongs to my inspiring faculty colleagues, the students in my classrooms whose immense curiosity makes me a better teacher, and the students and postdocs in my research group who have taught me so much."

Paula Hammond

Hammond, who is the David H. Koch Professor of Engineering and a member of the Koch Institute for Integrative Cancer Research, is renowned for her work developing polymers and nanomaterials for a variety of applications in drug delivery, noninvasive imaging, solar cells, and battery technology.

"Paula is a pioneer in nanotechnology research and has made substantial contributions to the science and engineering of macromolecular systems, with applications ranging from non-invasive imaging technologies for cancer diagnosis to sustainable solutions for battery technology," Schmidt and Danheiser wrote in their announcement.

Early in her career, Hammond developed new techniques for building polymers with highly controlled architectures. This approach, known as layer-by-layer assembly, allows polymer layers with different properties to be laid down by alternately exposing a surface to positively and negatively charged particles.

Hammond has used layer-by-layer assembly to develop novel polymers for a variety of medical applications. Some of her polymer nanoparticles zoom in on tumors and release their cargo when they enter the tumor's acidic environment, and she has also developed nanoparticles and thin polymer films that can carry multiple drugs to a specific site and release the drugs in a controlled fashion.

In her energy-related work, she has developed polymer films that dramatically improve the efficiency of methanol fuel cells. She is also working on batteries and solar cells that self-assemble with the help of genetically engineered viruses.

"There's a sense at MIT that almost anything can happen if you bring the right people together," she says. "It has always been exciting to me to work with others who are equally enthusiastic and completely gung-ho about exploring new areas and new ideas, and also about impacting the world with their science.

"It's a real honor to become an Institute Professor alongside Arup, who has always been such a universal contributor," Hammond says. "I've always thought of this group as just amazing, incredible people because of the things that they've done. Each Institute Professor is at the cutting edge of their field and they've also done great things for MIT. When I look at the list of current and past Institute Professors, I am both extremely humbled and greatly inspired by their achievements and impact on MIT and the greater world. I'm very honored to be among this group." X

This is a condensed version of the original article. For the full version, go to cheme.mit.edu.

Martin Z. Bazant's COVID-19 app and MOOC expanding the reach of his research

Bazant's focus on physics drives a new approach to modeling COVID-19 exposure risk.

Martin Z. Bazant, E. G. Roos (1944) Professor of Chemical Engineering and professor of applied mathematics

In spring 2020, Martin Z. Bazant, along with much of humanity, was watching the rapid spread of the Covid-19 outbreak with alarm. But Bazant, E. G. Roos (1944) Professor of Chemical Engineering and professor of applied mathematics, had cause for concern beyond the immediate, deadly impacts of SARS-CoV-2.

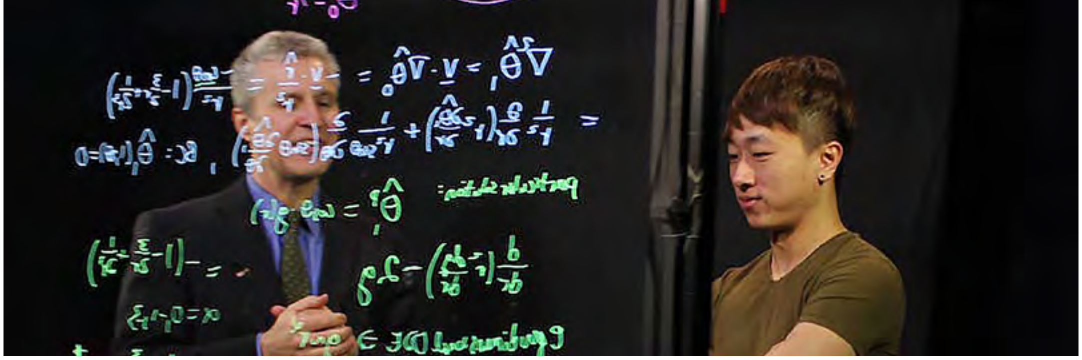
"From the beginning, I really felt that fear and emotion were driving much of the official response to the pandemic," he says. "I was worried that public discourse, especially during a presidential election year, would reduce the role of science in pandemic decision-making."

After reviewing early studies by other scientists on airborne transmission of the virus, Bazant found himself particularly troubled by public health policies advising surface cleaning and the "6-foot rule" of social distancing as the principle means of containing viral transmission, even when facemasks were worn.

"I thought this guidance might not be rooted in the principles of physical science and saw that there could be huge unintended consequences from implementing these policies uniformly to all indoor spaces," he says. "I became alarmed that some spaces were still at high risk of airborne transmission over longer distances, such as nursing homes for the most vulnerable elderly population, while other spaces, such as schools or businesses, were perhaps being shut down unnecessarily."

Seized by the urgency of elucidating the science of transmission, Bazant decided to add Covid-19 to an already bursting research portfolio.

This decision led to a pathbreaking, rigorous model for the airborne spread of SARS-CoV-2; an app based on this model that offers pragmatic guidelines for policymakers, businesses, schools and individuals for estimating the risks of exposure to the virus; and a MOOC (massive open online course) that engages thousands of users worldwide in understanding the science behind the model.



Bazant and Joey Gu at work on the lightboard used in the edX class, "Physics of Covid-19 Transmission."

Finding a New Formula

To develop a more refined understanding of SARS-CoV-2 transmission, Bazant began consuming the expanding corpus of literature on superspreader events and other detailed infection case studies. "I set out to not to create a fancy simulation, but to extract a formula that would help people trying to find out what it takes to be safe in a particular room."

With the help of John W. M Bush, a professor of applied mathematics who had previously worked on the fluid mechanics of coughing and sneezing, Bazant began zeroing in on the behavior of tiny "aerosol" droplets containing the Covid-19 virus, ejected into the air of a room by people breathing, coughing, sneezing, talking, or singing. Studies showed that these droplets remain suspended for long periods of time, and mix throughout a room via air currents.

Given this scenario, the scientists believed that distancing was less relevant to reducing exposure than cumulative time spent in a space. With this in mind, they created a model that yields an estimate of how long it would take for someone to become infected with SARS-CoV-2 after an infected person enters the same indoor location. Their model factors in such parameters as the prevalence and type of masks, number of people and activity in a room, and ventilation and filtration systems. Although they quantified the role of physical distance in protecting against short-range transmission in "respiratory jets," their analysis focused on long-range airborne transmission in well-mixed indoor spaces, building on classic epidemiological models.

"We did perhaps the most sophisticated analysis to date of such models, with greater detail of the roles of different respiratory activities than other studies," says Bazant. The results of this research, first published September 1, 2020 in the health sciences preprint server, MedRxiv, appeared in the April 27, 2021 PNAS paper, co-authored by Bazant and Bush.

A New Guideline

Graduate students put Bazant in touch with a software developer, Kasim Khan, who helped develop an open-access app and website that permit users to enter details of their specific location to determine likelihood of infection after a certain period of time.

"What's really nice about it is it keeps the essential science in there, making it accessible to a broad range of people," says Bazant. In the app's basic mode, users plug in the number of people in a room of given dimensions, engaged in specific activities, to determine their risk of exposure over a period of time. In this mode, there are also presets for classrooms, airplanes and churches.

The app, which went online in October 2020, is updated regularly with new information, such as Covid-19 variants that are more infectious. It has attracted close to a million users across the globe to date.

Another opportunity to introduce the Covid-19 model came courtesy of Joey Gu, Bazant's former doctoral advisee, and now chemical engineering digital learning fellow. "Martin was engrossed in this research, and every time I met with him, he kept talking about his Covid work," recalls Gu. "In September 2020, I said 'Why not make a MOOC?'"

Bazant, who leads the digital learning initiative in chemical engineering, had produced several online courses with Gu, and embraced the idea of a new edX class, "Physics of Covid-19 Transmission." Based on Bazant and Bush's guidelines, as represented in the app, this self-paced course would lay out the physical principles behind airborne transmission of Covid-19, and show how to assess the risk of transmission. The only problem: to launch the course in the next edX cycle meant moving at breakneck speed, without external funding.

"The greatest challenge was the timeline," says Gu. "Usually MOOCs take up to two years, but because of the urgency of the topic, we did everything in two months, ramping up production right away, making lots of videos, and questions to help users learn." In the class, Bazant lays out such fundamental concepts as fluid flow in a room and how to determine the concentration of virus in mixed air. "This has pedagogical value, because we're showing the public how scientists approach a problem," says Gu. Nearly four thousand students have signed up to date, and many have engaged enthusiastically on the website forum, relaying their pandemic experiences.

"These Covid restrictions have affected every area of life, and until you start to talk to people and have this kind of outreach, you don't realize all the impacts on them," he says. "Many people are interested in keeping their places safe, reopening, and trying to base those decisions on some kind of science." **X**

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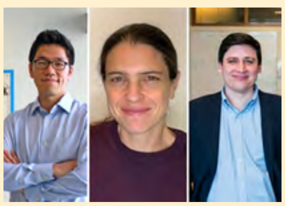
Faculty Highlights

Arup Chakraborty named AIChE's 2021 Prausnitz Institute Lecturer

The annual John M. Prausnitz AIChE Institute Lecturer is a distinguished member of AIChE invited by the Executive Board of the Program Committee to present a comprehensive authoritative review of the chemical engineering science in his or her field of specialization. Previous lecturers from the department include Karen Gleason, Klavs Jensen, Greg Stephanopoulos and Bob Langer.



Professors Chung, Kulik, and Swan earn tenure

The School of Engineering has announced that MIT has granted tenure to eight members of its faculty, three of those in the Chemical Engineering Department. Kwanghun Chung, in the Department of Chemical Engineering, the Institute for Medical Engineering and Science, and the Picower Institute, is devoted to developing and applying novel technologies for holistic understanding of large-scale complex biological systems. Heather J. Kulik leverages computational modeling to aid the discovery of new materials and mechanisms. Her group advances data-driven machine learning models to enable rapid design of open shell transition metal complexes. James Swan focuses on how microstructured, in particular nano-particle, materials can be manipulated for the benefit of society.

Katie Galloway receives NIH Maximizing Investigators' Research Award

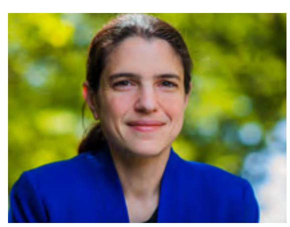
Katie Galloway has received a highly prestigious Maximizing Investigators' Research Award (MIRA or R35) from the National Institute of General Medical Sciences (NIGMS), part of the National Institutes of Health (NIH). The award, which grants $1.94 million over five years, will support Galloway's work to develop multiscale tools and approaches for understanding and engineering cell-fate transitions.

Professor Emeritus Karen Gleason wins 2021 AIChE Margaret Rousseau Pioneer Award

The Margaret Rousseau Pioneer Award, an Institute Award, is presented to a woman member of AIChE who has made significant contributions to chemical engineering research or practice - in academic, industrial, or government settings - over the course of her career. Contributions include a component of service, mentorship or leadership in raising the visibility of women engineers and paving the way for other women to have a greater impact in chemical engineering. Paula Hammond received this award in 2019.

Paula Hammond earns inaugural Black in Cancer Distinguished Investigator Award

The Black in Cancer organization was created to strengthen networks and highlight Black excellence in cancer research and medicine. The inaugural Black in Cancer Distinguished Investigator Award was created in reaction to the incident in which a black man, Chris Cooper, who was birdwatching in Central Park, was racially abused. Several organizations of black academics formed to highlight the contributions of black researchers and to create spaces where black academics can meet and network. These organizations include groups such as Black In STEM, Black in Neuro, and Black in Cancer, the latter of which the Emerald Foundation has partnered with to offer the Black in Cancer Distinguished Investigator Award.



Heather Kulik gains two recognitions for her work

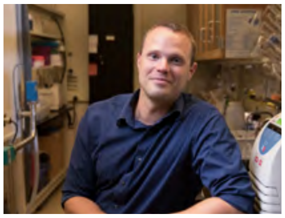
Heather Kulik is the winner of the Molecular Systems Design & Engineering (MSDE) 2020 Outstanding Early-Career Paper Award. This is in recognition of Professor Kulik's leadership of the paper "Enumeration of de novo inorganic complexes for chemical discovery and machine learning." This paper is free to read on the MSDE website until December 31, 2021.

Kulik was also named a 2021 Sloan Research Fellow in Chemistry. The fellowship, which honors pre-tenure faculty members, supports research with a two-year, $75,000 award.

Karthish Manthiram wins Camille Dreyfus Teacher-Scholar Award, named 2021 Sloan Research Fellow in Chemistry

Manthiram was one of the Camille and Henry Dreyfus Foundation's 16 Camille Dreyfus Teacher-Scholars for 2021. These faculty are within the first five years of their academic careers, have each created an outstanding independent body of scholarship, and are deeply committed to education. Manthiram is the second member of the MIT Department of Chemical Engineering faculty to win this award; Associate Professor William Tisdale also won the award in 2017.

Manthiram was also named a 2021 Sloan Research Fellow in Chemistry. The fellowship, which honors pre-tenure faculty members, supports research with a two-year, $75,000 award.



Brad Olsen earns 2021 ACS Macro Young Investigator Award

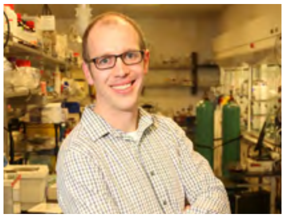
The ACS journals *ACS Macro Letters, Biomacromolecules, and Macromolecules* in partnership with the Division of Polymer Chemistry selected Bradley Olsen as a winner of their Young Investigator Award. Olsen was honored during an award symposium at the ACS Fall National Meeting, August 22 – 26, 2021.

Olsen was selected in recognition of "his pioneering studies of protein-based polymeric materials and protein-polymer hybrids including the discovery of nucleoporin-like proteins (NLPs), block copolymers, and coacervates for applications in catalysis and biosensing; for the incorporation of topological defects in polymer network theory; and advancing line notation for data-driven polymer science through the invention BigSMILES built for polymer structures."

Kristala Prather receives 2021 AIChE Andreas Acrivos Professional Progress Award, named AIChE Fellow

The Andreas Acrivos Award for Professional Progress in Chemical Engineering is endowed by the AIChE Foundation in the name of fluid-dynamics pioneer Andreas Acrivos of the City College of New York. The prize recognizes outstanding progress in chemical engineering by a member of AIChE in their early career.

AIChE Fellows are nominated by their peers and must have significant chemical engineering experience, have demonstrated significant service to the profession, and have been a member of AIChE for at least 10 years.



Zach Smith wins Office of Naval Research Young Investigator Award

The Office of Naval Research (ONR) Young Investigator Program supports academic scientists and engineers who are in their first or second full-time tenure-track or tenure-track-equivalent academic appointment, who have received their doctorate or equivalent degree in the past seven years, and who show exceptional promise for doing creative research. The objectives of this program are to attract outstanding faculty members to the Department of the Navy's Science and Technology (S&T) research program, to support their research, and to encourage their teaching and research careers.

Professor Emeritus Jeff Tester elected to the National Academy of Engineering

Jefferson Tester is a member of the new class elected to the National Academy of Engineering. Election to the academy is among the highest professional distinctions for an engineer, with membership honoring those who have made outstanding contributions to "engineering research, practice, or education… and to the pioneering of new and developing fields of technology, making major advancements in traditional fields of engineering, or developing/implementing innovative approaches to engineering education."

Tester, currently the David Croll Sesquicentennial Fellow at Cornell University, was elected for his "leadership in development of novel renewable energy systems." His research on geothermal and biomass energy as well as environmental control technologies has resulted in more than 300 scientific publications and 13 co-authored books. X

New drug-formulation method may lead to smaller pills

MIT chemical engineers have devised a new way to formulate hydrophobic drugs by turning them into a nanoemulsion, which can be poured into a mold and dried into tablets. The nanoemulsion can also be used to form small particles, seen in the vials. Credit: Felice Frankel

Chemical engineers have found a way to load more drug into a tablet, which could then be made smaller and easier to swallow.

Anne Trafton, MIT News Office

About 60 percent of drugs on the market have hydrophobic molecules as their active ingredients. These drugs, which are not soluble in water, can be difficult to formulate into tablets because they need to be broken down into very small crystals in order to be absorbed by the human body.

A team of MIT chemical engineers has now devised a simpler process for incorporating hydrophobic drugs into tablets or other drug formulations such as capsules and thin films. Their technique, which involves creating an emulsion of the drug and then crystallizing it, allows for a more powerful dose to be loaded per tablet.

"This is very important because if we can achieve high drug loading, it means that we can make smaller dosages that still achieve the same therapeutic effect. This can greatly improve patient compliance because they just need to take a very small drug and it's still very effective," says Liang-Hsun Chen, an MIT graduate student and the lead author of the new study.

Patrick Doyle, the Robert T. Haslam Professor of Chemical Engineering, is the senior author of the paper, which appeared in the June 7, 2021, edition of *Advanced Materials*.

Nanoemulsions

Most medicines consist of an active ingredient that is combined with other compounds called excipients, which help to stabilize the drug and control how it is released in the body. The resulting tablets, capsules, or films are called formulations.

Currently, to create formulations of hydrophobic drugs, pharmaceutical companies use a process that requires milling the compound down to nanocrystals, which are easier for human cells to absorb. These crystals are then blended with excipients. One excipient that is often mixed with hydrophobic drugs is methylcellulose, a compound derived from cellulose. Methylcellulose dissolves easily in water, which helps drugs to be released faster in the body.

This method is widely used, but has many inefficiencies, according to the MIT team. “The milling step is very time consuming and energy intensive, and the abrasive process can cause changes in active ingredient properties, which can undermine the therapeutic effects,” Chen says.

Patrick Doyle, the Robert T. Haslam Professor of Chemical Engineering

He and Doyle set out to come up with a more efficient way to combine hydrophobic drugs with methylcellulose, by forming an emulsion. Emulsions are mixtures of oil droplets suspended in water, such as the mixture formed when an oil and vinegar salad dressing is shaken up.

When these droplets are on the scale of nanometers in diameter, this kind of mixture is called a nanoemulsion. To create their nanoemulsion, the researchers took a hydrophobic drug called fenofibrate, which is used to help lower cholesterol, and dissolved it in an oil called anisole. Then they combined this oil phase with methylcellulose dissolved in water, using ultrasonication (sound waves) to create nanoscale oil droplets. Methylcellulose helps to keep the water and oil droplets from separating again because it is amphiphilic, meaning that it can bind to both the oil droplets and the water.

Once the emulsion is formed, the researchers can transform it into a gel by dripping the liquid into a heated water bath. As each drop hits the water, it solidifies within milliseconds. The researchers can control the size of the particles by changing the size of tip that is used to drip the liquid into the water bath.

“The particle formation is nearly instantaneous, so everything that was in your liquid drop gets converted to a solid particle without any loss,” Doyle says. “After drying, we have nanocrystals of fenofibrate uniformly distributed in the methylcellulose matrix.”

Smaller Pills, More Drug

Once the nanocrystal-loaded particles are formed, they can be crushed into powder and then compressed into tablets, using standard drug manufacturing techniques. Alternatively, the researchers can pour their gel into molds instead of dripping it into water, allowing them to create drug tablets in any shape.

Using their nanoemulsion technique, the researchers were able to achieve drug loading of about 60 percent. In contrast, the currently available formulations of fenofibrate have a drug concentration of about 25 percent. The technique could be easily adapted to load even higher concentrations by increasing the ratio of oil to water in the emulsion, the researchers say.

“This can enable us to make more effective and smaller drugs that are easier to swallow, and that can be very beneficial for many people who have difficulty swallowing drugs,” Chen says.

This method can also be used to make thin films — a type of drug formulation that has become more widely used in recent years, and is especially beneficial for children and older people. Once a nanoemulsion is made, the researchers can dry it into a thin film that has drug nanocrystals embedded in it.

“The flexibility of the system is that we can choose different oils to load different drugs, and then make it into a nanoemulsion using our system. We don’t need to do a lot of trial-and-error optimization because the emulsification process is the same,” Chen says.

The research was funded by the National Science Foundation, the Singapore National Research Foundation, and the Think Global Education Trust. X

This is a condensed version of the original article. For the full version, go to cheme.mit.edu.

Research Highlights

New approach could change how we track extreme air pollution events

In the United States, the primary sources of outdoor air-quality data are from ground-based, government-regulated air-quality monitoring systems that measure pollutants such as ozone and particulate matter. Due to the high cost of these high-performing systems, the number of monitors measuring air quality across a geographic area is relatively sparse. As a result, these systems are not well-suited for monitoring extreme air-quality events, in which pollutant levels can be exceedingly high and variable over relatively short distances.

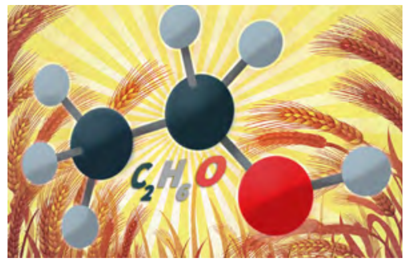
In a new study, Professor Jesse Kroll and colleagues demonstrate an alternate approach for monitoring extreme air-quality events with the use of low-cost sensor (LCS) networks. The work was carried out in mid-2018 on the Island of Hawaii, when the eruption of the Kilauea volcano filled the air with toxic sulfurous gases and particles ("volcanic smog" or "vog"). In response, the researchers developed and deployed a network of 40 low-cost sensors around the island to monitor the vog in real-time, which provided much higher resolution of localized levels of air pollution than existing air-quality measurements.

This MIT solar-powered air quality sensor was installed in remote area of Hawaii.

Engineered yeast could expand biofuels' reach

To try to expand biofuels' potential impact, the Stephanopoulos Lab, working with the Fink Lab in Biology, has now found a way to expand the use of a wider range of nonfood feedstocks to produce such fuels. At the moment, feedstocks such as straw and woody plants are difficult to use for biofuel production because they first need to be broken down to fermentable sugars, a process that releases numerous byproducts that are toxic to yeast, the microbes most commonly used to produce biofuels.

The MIT researchers developed a way to circumvent that toxicity, making it feasible to use those sources, which are much more plentiful, to produce biofuels. They also showed that this tolerance can be engineered into strains of yeast used to manufacture other chemicals, potentially making it possible to use "cellulosic" woody plant material as a source to make biodiesel or bioplastics.



MIT researchers have found a way to achieve high yields of ethanol with different types of cellulosic feedstocks, including switchgrass, wheat straw, and corn stover.

How the surfaces of silicone breast implants affect the immune system

A team led by MIT researchers has now systematically analyzed how the varying surface architecture found in these implants influences the development of adverse effects, which in rare cases can include an unusual type of lymphoma.

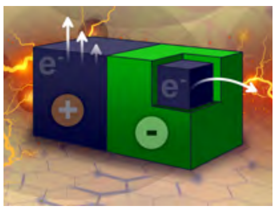
"The surface topography of an implant can drastically affect how the immune response perceives it, and this has important ramifications for the [implants'] design," says Omid Veiseh, a former postdoc in the Langer Lab. "We hope this paper provides a foundation for plastic surgeons to evaluate and better understand how implant choice can affect the patient experience." The findings could also help scientists to design more biocompatible implants in the future, the researchers say.

The team systematically analyzed how varying the surface topography found on silicone breast implants influences the development of health complications such as scarring, inflammation, and a rare type of lymphoma.

Tiny particles power chemical reactions

The Strano Lab has discovered a new way of generating electricity using tiny carbon particles that can create a current simply by interacting with liquid surrounding them. The liquid, an organic solvent, draws electrons out of the particles, generating a current that could be used to drive chemical reactions or to power micro- or nanoscale robots, the researchers say.

"This mechanism is new, and this way of generating energy is completely new," says Michael Strano, the Carbon P. Dubbs Professor of Chemical Engineering at MIT. "This technology is intriguing because all you have to do is flow a solvent through a bed of these particles. This allows you to do electrochemistry, but with no wires." In a new study describing this phenomenon, the researchers showed that they could use this electric current to drive a reaction known as alcohol oxidation — an organic chemical reaction that is important in the chemical industry.



MIT engineers have discovered a way to generate electricity using tiny carbon particles that can create an electric current simply by interacting with an organic solvent in which they're floating. The particles are made from crushed carbon nanotubes (blue) coated with a Teflon-like polymer (green).

A method to assess Covid-19 transmission risks in indoor settings

Professor Martin Bazant, with fellow MIT professor John Bush, has proposed a new approach to estimating the risks of exposure to Covid-19 under different indoor settings. The guideline they developed suggests a limit for exposure time, based on the number of people, the size of the space, the kinds of activity, whether masks are worn, and the ventilation and filtration rates. Their model offers a detailed, physics-based guideline for policymakers, businesses, schools, and individuals trying to gauge their own risks.

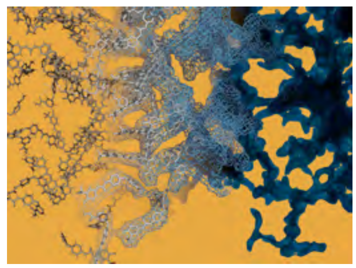
The new approach estimates the risks of exposure to Covid-19 under different indoor settings based on the number of people, the size of the space, the kinds of activity, whether masks are worn, and the ventilation and filtration rates.

Big data dreams for tiny technologies

Small-molecule therapeutics treat a wide variety of diseases, but their effectiveness is often diminished because of their pharmacokinetics — what the body does to a drug. After administration, the body dictates how much of the drug is absorbed, which organs the drug enters, and how quickly the body metabolizes and excretes the drug again.

Nanoparticles, usually made out of lipids, polymers, or both, can improve the pharmacokinetics, but they can be complex to produce and often carry very little of the drug. Some combinations of small-molecule cancer drugs and two small-molecule dyes have been shown to self-assemble into nanoparticles with extremely high payloads of drugs, but it is difficult to predict which small-molecule partners will form nanoparticles among the millions of possible pairings.

The Langer Lab, along with the Traverso Lab, has developed a screening platform that combines machine learning with high-throughput experimentation to identify self-assembling nanoparticles quickly. In a study published in *Nature Nanotechnology*, researchers screened 2.1 million pairings of small-molecule drugs and "inactive" drug ingredients, identifying 100 new nanoparticles with potential applications that include the treatment of cancer, asthma, malaria, and viral and fungal infections.

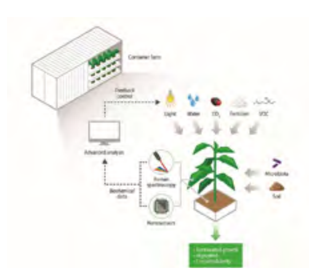


A molecular dynamics simulation (left) is juxtaposed with an electron microscopy image (right) of the cancer drug sorafenib. Sorafenib, like many other small molecule drugs, can spontaneously form intricate nano-scale structures that change how the drug behaves.

Analytical tools to enable next-generation agriculture

The Strano Lab, with the Singapore-MIT Alliance for Research and Technology (SMART), highlights the potential of recently developed analytical tools that can provide tissue-cell or organelle-specific information on living plants in real-time and can be used on any plant species.

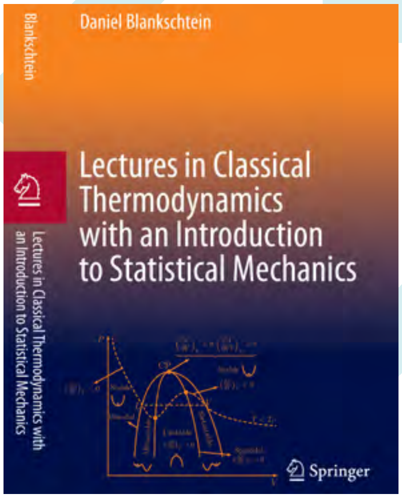
In a perspective paper titled "Species-independent analytical tools for next-generation agriculture" published in the journal *Nature Plants*, researchers review the development of two next-generation tools, engineered plant nanosensors and portable Raman spectroscopy, to detect biotic and abiotic stress, monitor plant hormonal signalling, and characterize soil, phytobiome, and crop health in a non- or minimally invasive manner. The researchers discuss how the tools bridge the gap between model plants in the laboratory and field application for agriculturally relevant plants. The paper also assesses the future outlook, economic potential, and implementation strategies for the integration of these technologies in future farming practices. **X**



Species-independent analytical platforms can facilitate the creation of feedback-controlled high-density agriculture.

For more information on these and other stories, go to cheme.mit.edu/news.

Daniel Blankschtein turns his legendary thermodynamics lectures into a textbook



Daniel Blankschtein's students have a wish coming true. The MIT professor of chemical engineering has written a long-awaited textbook based on lecture notes that he refined while teaching graduate-level thermodynamics 16 times over three decades.

The book draws on existing classical thermodynamics texts, but brings something new to the table in the form of pedagogical explanations of the material taught with many practical problems and detailed solutions such as calculating how dangerous a bit of stray grease on a laboratory gas line can be, or determining how deep a submarine must submerge before the seawater is under enough pressure to produce fresh water inside the submarine from seawater.

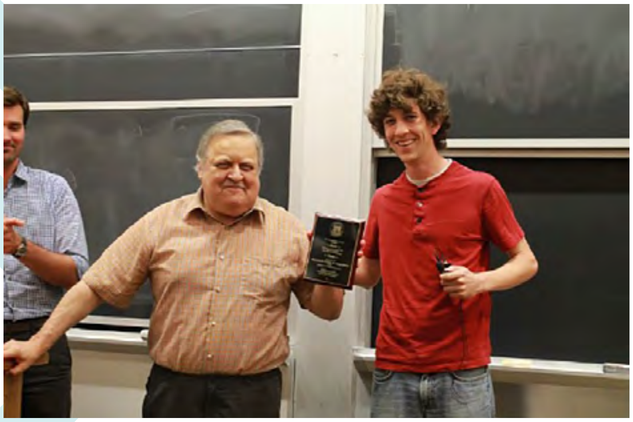
Blankschtein, the Herman P. Meissner (1929) Professor of Chemical Engineering, began teaching in 1986, and has received the annual Course X Graduate Student Council Outstanding Faculty Award nine times.

The textbook, *Lectures in Classical Thermodynamics with an Introduction to Statistical Mechanics*, is published by Springer and became available March 2021. Blankschtein adapted his notes into a book because "the students were not happy with the available books where a pedagogical explanation of many fundamental concepts was lacking. The students also found my class notes easier to understand and used them to study for the course," he said.

Students suggested that he adapt his notes to write a book, but following through on the suggestion was not easy. "For a long time I did not have time," said Blankschtein. "To do this was a big effort. Although I had the notes, I had to refine them. I also had other activities that I was involved with."

Research

One of the other activities was Blankschtein's research. When he began his career at MIT his research involved predicting the properties of surfactants, molecules which reside between a polar material like water and a nonpolar material like oil that do not mix with each other. Surfactants can be used to facilitate mixing of oil and water, to encapsulate oil in order to clean up an oil spill in the sea, or to encapsulate oily fragrances in laundered fabrics to retain a pleasant aroma during storage.



Blankschtein won the "Outstanding Faculty Award, Department of Chemical Engineering, MIT, for the year 2014" in May 2015.

A decade ago, Blankschtein began working with two-dimensional materials, which are only a single or few atoms thick. He worked with carbon nanotubes, which are microscopic rolled-up sheets of carbon atoms, and with graphene, molybdenum disulfide, and hexagonal boron nitride. Carbon nanotubes can be used as filtration agents, he said. "You can use them to separate ions to desalinate seawater. And we are also trying to separate gases using graphene that has small holes called nanopores."

His most recent work is focused on elucidating the importance of many-body effects such as polarization interactions on the thermodynamic and transport properties of electrolytes at solid/water interfaces. This involves understanding and changing the energy landscape of molecules in the presence of electric fields. "A dream would be that we can use it to desalinate water. But fundamental work of this nature will also find applications in other scientific disciplines, including electrochemistry, biophysics, and catalysis," he said.

Blankschtein's research has spawned 15 patents and more than 230 research articles, with his work providing new insights into multi-phase thermodynamics at the molecular level. No wonder that he wanted to include an introduction to statistical mechanics, which provides connections between microscopic and macroscopic phenomena, in his textbook. Typically, many textbooks on classical thermodynamics have not delved into the subject of statistical mechanics. However, "without fully understanding the working of the universe at the molecular level, you cannot develop a deep understanding of the universe at the macroscopic level," he said.

Writing the Book

Blankschtein waited until his research group got smaller, and then dedicated a sabbatical to the process of expanding and refining his lecture notes into the book that the students had requested. The book, which tops 750 pages, took about three years to complete.

The book consists of 50 lectures divided into three parts. The first two parts are on classical thermodynamics, which predicts what will happen at the macroscopic scale without going into details at the molecular level – "what you see with your eyes" said Blankschtein. Classical thermodynamics does not predict microscopic properties, but provides ways to relate macroscopic variables like energy, entropy, volume, pressure, temperature, and number of molecules.

Students learn about single, non-reactive materials in the first part, titled "Fundamental Principles and Properties of Pure Fluids," then move on to mixtures and physical/chemical transformations of materials in the second part, titled "Mixtures: Models and Applications to Phase and Chemical Reaction Equilibria."

The third part of the book provides an introduction to statistical mechanics, which deals with phenomena at the microscopic level. "I show how some of the material that I discuss in the classical thermodynamics part of the book can be derived through statistical mechanics" said Blankschtein.

The Special Sauce

The book shows the reader how to solve challenging problems in classical thermodynamics by applying fundamental principles in a series of solved problems that appear throughout the book, and in 35 additional challenging problems and solutions at the end of the book. Blankschtein's "special sauce" is these solved problems. He has included problems that are practical and easy to picture.

"Consider a problem which is very important in the lab," said Blankschtein. Picture a chemical engineering lab with tanks of gases used for experiments, including oxygen tanks. The assignment is to comment on the safety hazards – what can happen when there is a bit of grease on the line of one of the oxygen tanks. And then to figure out, given the particular conditions laid out in the problem, whether this is something that you will have to worry about. "Can there be an explosion in this particular tank, which is very serious because this has really happened in laboratories," Blankschtein said.

Blankschtein also included problems that guide students into figuring out how to produce freshwater in a submarine and useful work in a sailing ship. Other problems relate to biological systems, including calculating how many ligands can bind to a given protein or showing how a given protein will unfold at a given temperature.

Blankschtein hopes that students, teachers, and researchers will find his book illuminating and useful. X

This is a condensed version of the original article. For the full version, go to cheme.mit.edu.

Traveling the world for global health solutions

After studying and working on three continents, recent graduate Andrea Orji now seeks to become a physician, eventually working in Nigeria.

Hannah Meiseles, MIT News

As a kid, Andrea Orji always loved it when her grandpa would visit from Nigeria. He would share stories about his home to teach Orji, a Texas native, about her family's heritage.

But while she and her family attended school and work, her grandpa remained at the house, frequently alone. She could tell he longed to return to the familiarity of his own country, yet he remained in order to undergo and then recover from cataract surgery. Later on, treatment for other conditions would require him to travel back and forth for months at a time. Despite the inconvenience, the quality of care in Texas was better than what was available to him in Nigeria.

Orji noticed visits by many of her other Nigerian relatives also coincided with medical procedures. Why was it better for her family members to fly halfway around the world for a necessary surgery? The question weighed heavily on Orji's mind.

As she began applying to colleges, Orji decided that she wanted to study biomedical engineering in order to create more affordable, globally available medical devices and procedures. Unlike her three older siblings, who chose to stay in Texas, Orji hoped to attend college out of state. She also knew she wanted to travel internationally and eventually live and work in Nigeria. "It was important for me to get out of my comfort zone and think about how I would deal with settling somewhere completely new," she says.

The search ended when Orji found MIT. Its international education program, the MIT International Science and Technology Initiatives (MISTI), provided plenty of opportunities for her to explore her interest in working overseas. While there were no programs available in Nigeria, Orji says she was amazed at the variety of destinations where she could study and explore future careers.

Andrea Orji '21

> **“I’m glad that I took the engineering route, because I’ve learned a lot of different ways of thinking from doing it. I can understand the technology that lies beneath the public policy.”**

Orji graduated in June with a degree in chemical engineering with a focus in biomedical applications and interests in global health. She has studied and worked abroad in Brazil, South Africa, and India, and credits these global experiences for giving her new perspectives on her Nigerian roots, while also teaching her new solutions to tackle ever-pressing global health challenges.

During her third year, Orji worked through MISTI Global Teaching Lab to introduce biology and chemistry labs to an all-girls summer program in Brazil. While the trip was a far distance from Nigeria, Orji found herself discovering aspects of West African history. “At the time, I didn’t know that Brazil has such a large Afro-Brazilian population. Many of Brazil’s traditions, such as Carnival, are actually influenced by Afro-Brazilian music and costumes,” she says. “It got me thinking more about Black populations around the world and the different ways I can serve them.”

Later that same year, Orji traveled through MISTI to Hyderabad, India, and conducted public health research at a local hospital, LV Prasad Eye Institute. She witnessed firsthand how health disparities differ between regions in a country. While Orji explored India with fresh eyes, Nigeria was still on her mind. “I kept thinking about the influence of colonialism on both countries and how they have similar decentralized health care systems,” she says. “It led me to wonder if the methods used by LVPEI’s hospitals to improve accessibility could also be applied in Nigeria.”

Her idea to implement health solutions between countries was reaffirmed throughout her internship. “The physician I shadowed would collaborate with other doctors to ensure interactions with patients were respectful of the patients’ culture, language, and religion,” she explains. “This is something we still struggle with in America. But at LVPEI, accommodating for patient differences is seamlessly engrained in hospital practice. I think these teachings could be applied everywhere.”

The trip had a lasting impact on Orji; she switched gears and became certain she also wanted to be a doctor. “At the end of a full day of seeing patients, sometimes I’d tear up. The way the hospital prioritized care for everyone, regardless of income or background, was mind-blowing to me. They managed to combine all the things I had been thinking about. I knew that this was what I wanted to do.”

While the pandemic paused Orji’s international travels, she continued to study health disparities outside of her community, through a remote internship helping to digitize contact-tracing in Navajo Nation, which has been hit with a disproportionate number of Covid-19 cases. Since last summer, Orji has been part of a team working to implement a contact-tracing app; her role includes helping to bridge the communication gap between the app development team and local health care workers.

Orji also credits her favorite class, 10.495 (Molecular Design and Bioprocess Development of Immunotherapies), for teaching her about how to adapt medical innovations to local communities. “We studied the complications that come from translating technologies created in higher-income countries to lower-income countries,” she says. “I loved how it taught process design while also considering political challenges that I had struggled to incorporate from my minor classes, such as Africa and the Politics of Knowledge. I think that understanding the disparities in a system can help physicians advocate for their patients better.”

Orji cemented her decision to become a doctor by applying to medical school. She believes her engineering background will be instrumental to her work as a physician. “I’m glad that I took the engineering route, because I’ve learned a lot of different ways of thinking from doing it. I can understand the technology that lies beneath the public policy.”

Orji still plans on one day living in Nigeria but chooses not to focus her future solely on one country. “My experiences abroad have taught me that there’s so much to learn from different countries that could be applied elsewhere. No matter where I end up physically living, I want to be part of a global network of doctors that believes in the power of collaboration,” she says.

“As we’ve seen with Covid-19, we live in a globalized world where disease doesn’t stop at borders. Solutions shouldn’t either.” X

▶ **This is a condensed version of the original article. For the full version, go to cheme.mit.edu.**

Alumni Highlights

Former Dartmouth College Provost **Joseph Helble PhD ’87** is the new president of Lehigh University, as of August 16, 2021. He replaces President John Simon, who took on the role in July 2015. Helble takes over as higher education institutions across the country are feeling the ramifications of the pandemic. Helble earned his doctorate in chemical engineering with a minor in Spanish from the Massachusetts Institute of Technology in 1987. He then spent several years as a research scientist in the private sector, with several months on leave as a science policy fellow with the U.S. Environmental Protection Agency. Later he worked on environmental and technology policy in Washington for a year. In academia, he has been a professor and chair of chemical engineering at the University of Connecticut, and from there went to Dartmouth.

“Joe is the personification of calm leadership,” Dartmouth College President Philip Hanlon said in the message. “As provost, he has steadily guided Dartmouth through the unprecedented turbulence of the last year. His data-driven approach and exacting standards, his willingness to listen and learn, produced decisions that were as wise as they were empathetic. Joe is a leader, a scholar, and a teacher who is leaving Dartmouth a better place than when he arrived 16 years ago.”

Russel Allgor PhD ’97 and **Patricia Hurter PhD ’92** have been elected to the National Academy of Engineering. Allgor, chief scientist, Worldwide Operations and Amazon Logistics, at Amazon, was chosen “for application of operations engineering to design and improve logistics and fulfillment systems for e-commerce.” Hurter, chief executive officer and president of Lyndra Therapeutics, was cited “for leadership in formulation technologies, amorphous dispersions, and continuous processing for hepatitis C and cystic fibrosis treatments.” 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/implementing innovative approaches to engineering education.” Individuals in the newly elected class will be formally inducted during the NAE’s annual meeting on Oct. 3, 2021.

Grace Colón PhD ’95 has been elected to MIT’s board of trustees as a full-term member who will serve for five years. Colón received her bachelor’s degree in chemical engineering from the University of Pennsylvania in 1988 and her PhD in chemical engineering from MIT in 1995. Colón has over 25 years of experience in biopharma, genomics, health care, and industrial biotechnology. She is currently CEO and president of InCarda Therapeutics, a clinical stage therapeutics company developing therapies for areas of high unmet medical need in cardiology, initially focused on atrial fibrillation. Formerly, she was a partner and senior advisor at New Science Ventures, a venture capital firm with over $700 million under management. Before that, she co-founded Pyranose Biotherapeutics, a biologics discovery platform company, and was the founding president of the Industrial Products Division of Intrexon Corporation, where she established a new division and labs focused on leveraging synthetic biology for bioindustrial applications such as biofuels and renewable chemicals.

H. Annita Zhong ’96 has been named one of 95 lawyers in the Los Angeles Business Journal’s list of “Minority Leaders of Influence.” This recognition comes on the heels of a significant win for Zhong. As a principal member of a team at Irell & Manella (where she is a partner), she helped secure a $506.2 million jury award for

PanOptis in an infringement case against Apple. The high-profile trial was the first in-person jury trial in the country during the pandemic. Zhong successfully litigated on behalf of PanOptis in a second-phase bench trial, in which an equitable defense is tried solely in front of a judge.

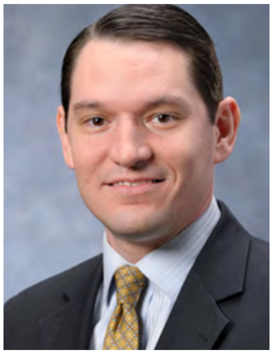
Zhong has also achieved success before the Patent Trial and Appeal Board, an adjudicative body within the U.S. Patent and Trademark Office (USPTO). The Board hears patentability questions raised by third parties, known as AIA trials (named after the America Invents Act). There are three main types of AIA proceedings: inter partes review, post-grant review, and covered business review. Despite the notorious difficulty of these types of proceedings, Zhong has successfully defended 29 inter partes reviews filed by four major handset manufacturers as lead counsel for Fundamental Innovations Systems International LLC. Some of the suits had major ramifications on advancing USB charging and the availability of wall adaptors with fast-charging abilities.

The U.S. Senate confirmed **Tiffany P. Cunningham ’98** to the Federal Circuit, the nation’s top patent court. Cunningham will be the first Black judge on the U.S. Court of Appeals for the Federal Circuit, the only federal appeals court never to have a Black member. Her addition to the 12-member court leaves its membership equally divided between men and women. The Senate voted 63-33 to confirm Cunningham, a partner at Perkins Coie LLP and former Federal Circuit clerk. She replaces Judge Evan J. Wallach, who took senior status at the end of May.

Brian Anderson PhD ’05 has been named Executive Director of the Biden Administration’s Interagency Working Group (IWG) on Coal and Power Plant Communities and Economic Revitalization.

“As the country prepares to undergo one of the greatest energy evolutions, possibly in its entire history, I’m greatly honored that the Biden Administration recognizes what the talented staff of NETL can do to help energy communities,” Anderson said. “Our Lab is home to some of the world’s most outstanding scientists and works with more than 600 partners across the country to help implement the missions of DOE and other federal agencies. As Executive Director of the IWG, I will see to it that we listen to energy community members and leverage our Lab’s resources and people as the driving force for the energy evolution we want to see, bringing a whole-of-government approach to supporting these communities.”

Anderson was also recently named Laboratory Director of the Year award by the Federal Laboratory Consortium for Technology Transfer (FLC) in recognition of his outstanding contributions to support technology transfer activities in the NETL organization and the communities it serves.



Steven R. Little PhD ’05 has received the Controlled Release Society’s (CRS) Distinguished Service. Little, the William Kepler Whiteford Endowed Professor and Chair of the Department of Chemical and Petroleum Engineering at Pitt’s Swanson School of Engineering, is internationally recognized for his research in drug delivery systems that mimic the body’s own mechanisms of healing and resolving inflammation. This is Little’s third honor from CRS; in 2018 he received the society’s Young Investigator Award, and in 2020 was elected to its College of Fellows for “outstanding and sustained contributions to the field of delivery science and technology over a minimum of ten years.”

Rather than traditional drug treatments that are distributed throughout the entire body, Little’s controlled release research focuses on time-released microcapsules that target specific cells on site. In 2020, Little published a groundbreaking discovery of a new immunotherapy system that mimics how cancer cells invade the human immune system and thereby reduces the risk of transplant rejection. He has also made advancements to the fundamentals of delivery science with predictive models enabling rational design of drug delivery systems, leading to the founding of Qrono Inc., a specialty pharma company in Pittsburgh. X

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In Memoriam

William Dalzell, influential lecturer in chemical engineering at MIT, dies at 84

Known for his quick wit, the MIT alumnus spent his career fostering hands-on learning for generations of chemical engineering students.

As a student in the ChemE Practice School, William Dalzell (foreground, left) worked at the Esso Bayway refinery in the late 1950s.

Melanie Miller Kaufman, Department of Chemical Engineering

William H. Dalzell ’58, SM ’60, ScD ’65, a longtime lecturer in chemical engineering at MIT and station director for the David H. Koch School of Chemical Engineering Practice, passed away on April 13 after a protracted battle with cancer. He was 84 years old.

The first person in his family to attend college, Dalzell entered MIT in 1954. In an essay for the MIT Office of the First Year, he recalled humorously, “I had no idea what I was doing when I applied for college. There were no computers, no internet, and no one visited college campuses before applying. I perused college catalogs in the library and thought it might be cool to be an engineer (whatever an engineer was).”

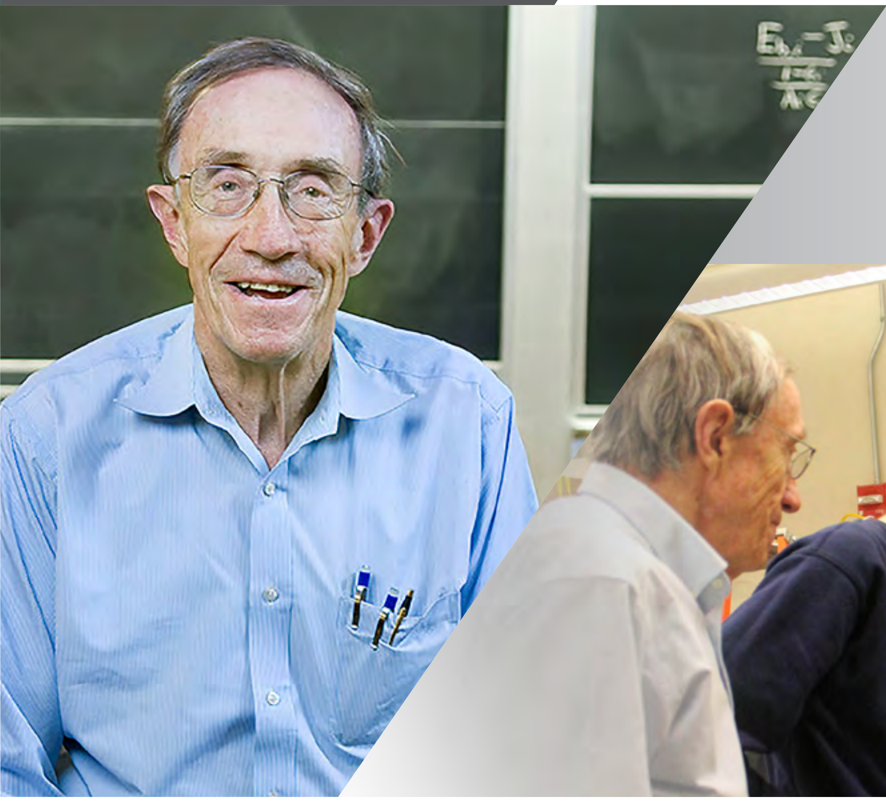
He goes on to explain, “I arrived in Cambridge the day after Carol, a force-3 hurricane, had devastated the area. This storm may have been an omen … By some miracle, I passed all of my first term courses.” He went on to earn his undergraduate (1958), MS (1960), and ScD (1965) in chemical engineering.

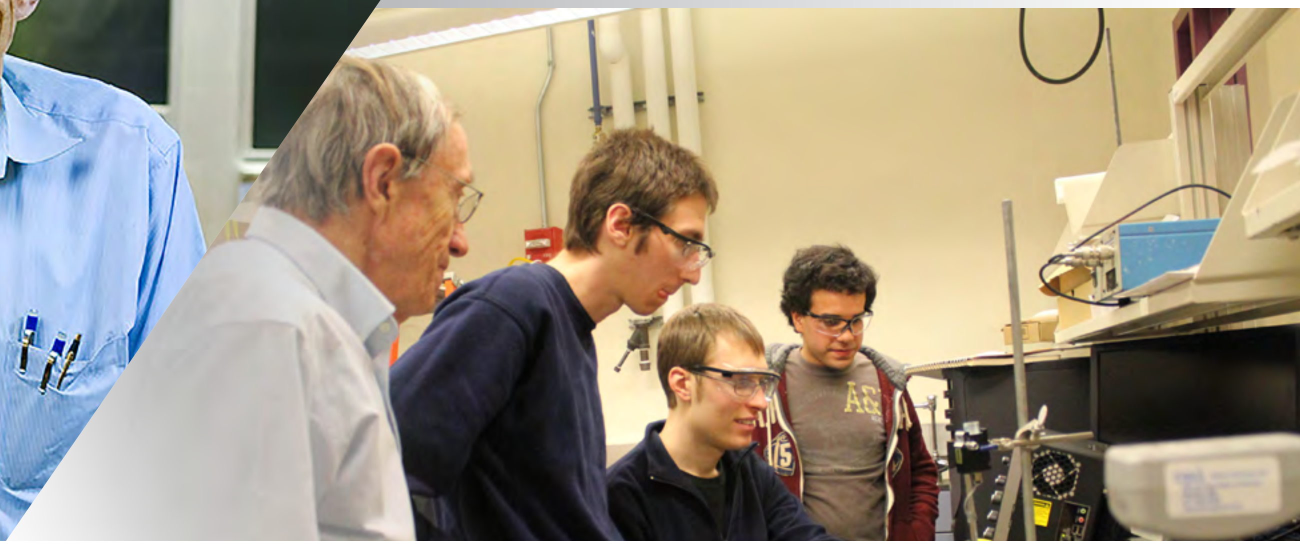
Upon graduation, he was a postdoc at Imperial College London for a year, and then returned to Cambridge, Massachusetts, to become an assistant professor of chemical engineering at MIT. After several years at the Institute, Dalzell spent the next 26 years at Polaroid, where he rose to the role of senior manager and had four patents. While at Polaroid, Dalzell was never far from MIT. He sponsored several student projects in course 10.26 (Chemical Engineering Projects Laboratory) and was an active participant during class presentations.

In 1997, Dalzell returned to MIT to become a lecturer and practice school director, positions he kept until his retirement in 2018.

“Bill was a brilliant engineer and a remarkable teacher,” says Institute Professor Paula Hammond, head of the Department of Chemical Engineering. “As a practice school station director, he guided a generation of our students through their pivotal first encounters with real-world engineering. He pushed them to apply their understanding of fundamental phenomena and be true detectives, guidance that his alumni have told me continues to serve them well in their careers.”

Hammond continues, “In his role teaching our senior design labs, Bill was always encouraging our undergrads to think on their feet and apply their chemical engineering fundamentals to real-world problems. He will be fondly remembered by the many, many students whom he taught, and by all of us who had the good fortune to have him as a colleague. Bill will be deeply missed by the chemical engineering community.”





Dalzell (far left) advises students in the Chemical Engineering Undergraduate Research Lab (2000s).

When he rejoined the chemical engineering department as a lecturer, Dalzell continued to be an advocate for 10.26 as a source of ideas and suggestions to improve the class. He was a committed presence in the lab, advising and working alongside the students. He was also the environmental health and safety coordinator and chemical hygiene officer for the department for many years, providing the chemical engineering community with support and leadership in health, safety, and sustainability while promoting a strong, innovative safety culture within its laboratories.

A pivotal role for Dalzell was as a station director for the David H. Koch School of Chemical Engineering Practice School, a unique program where Course 10 graduate students attend "stations" at different industrial locations around the world, working on real-world problems faced by their host companies. During his tenure, Dalzell managed stations at Mitsubishi Chemical in Mizushima, Japan; GlaxoSmithKline in London, England; and Mawana Sugars in Uttar Pradesh, India, to name a few.

"As a practice school station director, Bill coupled his strong intellect and deep understanding of the physical world with a genuine desire to ensure that the students got the best education they could out of their assignments," recalls Professor Alan Hatton, current director of the practice school. "He brought the same enthusiasm and drive to outside activities, too, be it skiing, whitewater rafting, or other sports to give the students a way to let off steam. Bill was a strong and influential contributor to the success of the practice school program."

Professor Emeritus Kenneth Smith, who had known Dalzell since they were both MIT undergraduates in the 1950s, shares, "Bill was the embodiment of generosity, creativity, enthusiasm, and energy. Generosity because he saw the best in everyone and everything and because he was always prepared to help, even when it was to his own detriment. Creativity because he always wanted to innovate, whether it be in the context of research or the preparation of a gourmet meal. Enthusiasm because of his ability to derive an infectious joy from every endeavor. And energy because that was simply his way, whether it was in research or teaching or tending his enormous garden or playing with his grandchildren. It is no wonder that our students loved him."

In lieu of flowers, Dalzell requested that donations be made to the MIT Chemical Engineering Discretionary Fund. If you'd like to send a note to the family, please visit the funeral home website. **X**

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Thank you to everyone who has supported us throughout the year.

Every effort has been made to ensure the accuracy of this list. Please direct corrections to Melanie Kaufman, editor, at melmils@mit.edu.

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Creating New Polymers, and Upcycling the Old Ones

LaShanda (James) Korley PhD ’05

Catherine Caruso SM ’16 for MIT Technology Review

Korley in her lab at the University of Delaware with graduate research assistant Chase Thompson. Courtesy of the University of Delaware

Most of us either shudder at spider webs or admire their intricacy. LaShanda (James) Korley PhD ’05, sees something else entirely: inspiration for new polymers.

Now a professor of materials science and engineering as well as chemical and biomolecular engineering at the University of Delaware, Korley began her ongoing study of spider silk as a chemical engineering PhD student in MIT’s interdepartmental Program in Polymers and Soft Matter. “The foundation of my work is bioinspiration. We don’t necessarily try to mimic materials—we take inspiration from those materials and translate aspects of those systems into new material development,” Korley explains. For example, she is developing a material that changes shape in response to water—taking its cue from spider silk’s ability to “supercontract,” shrinking drastically and altering its mechanics, when it gets wet. A synthetic material with this property could be used in soft robotics or artificial muscle.

Korley’s research has progressed from simply designing nature-inspired polymers to creating those polymers more sustainably. One aspect of her work is building new polymers from renewable raw materials such as lignin in wood, and designing them to be reprocessed after serving their original purpose, further reducing their environmental impact.

What excites me is what we can achieve by being interdisciplinary and bringing together these levels of expertise to generate more sustainable materials.

More recently, she has taken on the challenge of plastics waste. “There are a lot of single-use plastics, and we don’t have enough landfill space,” Korley says. She and Thomas Epps, III ’98, SM ’99, are leading the Center for Plastics Innovation, one of six new Energy Frontier Research Centers funded by the US Department of Energy. “We are trying to think about ways to augment current mechanical recycling,” says Korley, describing it as an inefficient process that primarily degrades plastics waste into products with limited uses. Instead, the center will develop new chemical and catalytic processes for turning the waste from everyday plastics like water bottles into the building blocks for high-value products such as fuels, lubricants, and functional polymers.

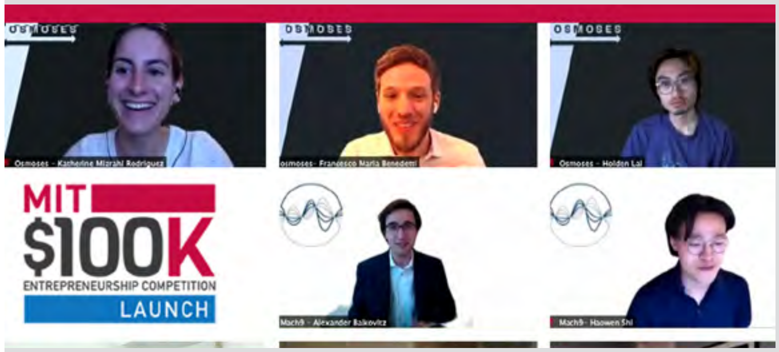
Korley credits MIT—and her advisors Paula Hammond ’84, PhD ’93, and Gareth McKinley PhD ’91—with exposing her to many research disciplines. “MIT was a hub for inspiration and creativity,” she says. These days, Korley works closely with experts on topics as wide-ranging as catalysis, enzyme engineering, and manufacturing. She says, “What excites me is what we can achieve by being interdisciplinary and bringing together these levels of expertise to generate more sustainable materials.” X

Osmoses, a startup out of the Zach Smith Lab, wins MIT $100K competition

Its filtration membranes can make gas and vapor separation much less energy-intensive across multiple industries.

In America's quest to slash greenhouse gas emissions, many have cited the chemical industry as one of the hardest to decarbonize. It's a significant roadblock: Chemical separation alone is responsible for up to 15 percent of the U.S.'s total energy usage.

Osmoses, a startup trying to dramatically increase the efficiency of chemical separations, got a major boost Thursday when it won the MIT $100K Entrepreneurship Competition. The company has developed a molecular filtration solution containing tiny channels that can be precisely sized to separate even the smallest molecules. The company claims its membranes can form channels that are 1/100,000 the width of a human hair, allowing the separation of molecules that differ in size by a mere fraction of an angstrom — less than the size of an atom.



The 2021 MIT $100K Entrepreneurship Competition grand prize went to Osmoses, pictured on top row. Pictured on the bottom row are Payal Kadakia '05, the CEO and founder of exercise scheduling platform ClassPass, who spoke at the event, and the event hosts Carly Chase and Scott Stern.

"This is one of the greatest challenges of the century for our society, but also one of the biggest opportunities for companies that can innovate in this space," Francesco Maria Benedetti, a postdoc at MIT, said in the winning pitch. The company is also led by PhD candidate Katherine Mizrahi Rodriguez '17, Zachary P. Smith, the Joseph R. Mares Career Development Professor of Chemical Engineering at MIT, and Holden Lai, a postdoc at the University of Pennsylvania and former researcher in Smith's lab.

Many chemical separation processes, such as distillation, use huge amounts of energy in the form of heat. Membrane filtration offers a promising alternative form of separation, but Osmoses says most membranes today have poor performance, leading to low adoption rates among chemical plants and higher operating costs.

Osmoses' membranes come in a module that fits in existing separation systems. The company has tested its lab prototype in industrial-like environments, including in high-pressure, variable temperature conditions. The company says its results show a marked improvement over existing membrane filtration technologies.

"We've completely redesigned the materials these membranes are made of, lowering the energy consumption to a minimum and generating unprecedented performance," Benedetti said.

The company is starting by targeting gas and vapor separations in the traditional and renewable natural gas processing space. Osmoses says by switching to its solution, companies in the market can reduce product loss by 85 percent, generating added fuel that could power 7 million additional homes in the U.S. for a year.

Osmoses also believes it can bring efficiencies to oxygen and nitrogen generation, hydrogen purification, and carbon capture.

The company will use the prize money to purchase equipment and scale its prototype later this year. Next year, it hopes to test an early version of its product with potential customers.

Osmoses' first customers will be natural gas plants that produce hundreds of millions of standard cubic feet of gas per day. The team believes it can reduce up to 1 million tons of carbon dioxide emissions from each plant of that size.

The MIT $100K is MIT's largest entrepreneurship competition. It began in 1989 (with a much smaller grand prize value) and is organized by students with support from the Martin Trust Center for MIT Entrepreneurship and the MIT Sloan School of Management. Each team must include at least one current MIT student. X

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