Fall/Winter 2022
Massachusetts Institute of Technology
Course X News
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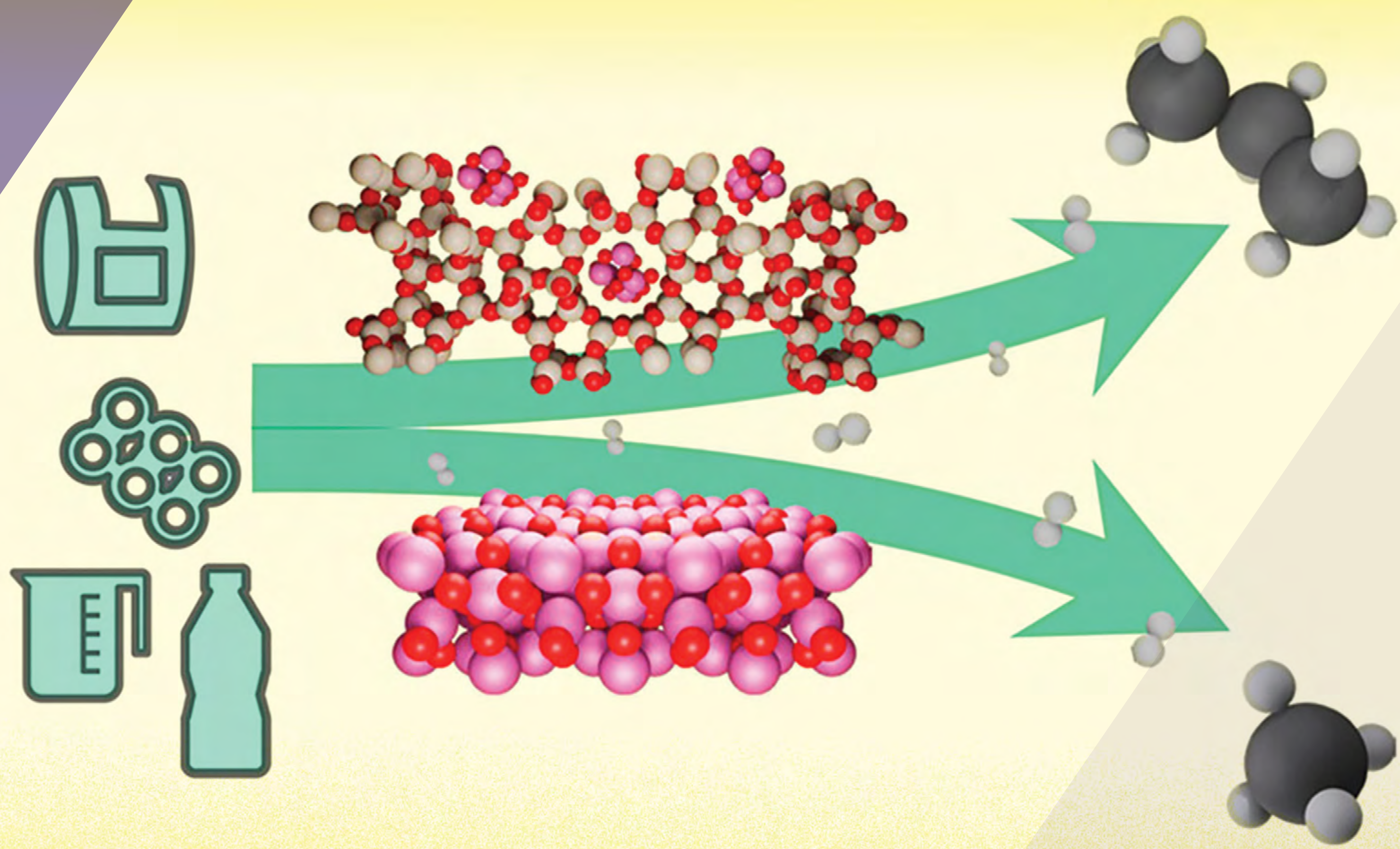
MIT Chemical Engineering Alumni News

X Currents



New process could enable more efficient plastics recycling

Cobalt-based catalysts could be used to turn mixed plastic waste into fuel, new plastics, and other products.

Grad student Nidhi Juthani bridges the worlds of research and industry

Massachusetts Institute of Technology

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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

Many new things are happening around campus and the Department! If you are around Kendall Square, I highly recommend visiting the new Welcome Center and MIT Museum that have opened just next to the Kendall Square T Stop, which is almost done with its own renovation. Behind the T is an inviting Open Space with many opportunities to relax and engage with friends, colleagues, and the community. The changes were designed to make this area a new "entrance" to the MIT campus. It puts a welcome spotlight on Building 66 as a main conduit to the Infinite Corridor from Kendall Square, which has evolved from a sleepy corner of Cambridge to becoming a bustling center for technology and biomedical research.

Here in the Department, we've also added to our engagement with the biomedical community by introducing a new named lecture: the Charles L. Cooney Lecture. We are grateful to Noubar Afeyan, who gave us this opportunity to honor Charlie and his many accomplishments. The goal of this lecture is to highlight some of the amazing work young researchers and entrepreneurs are doing in the biotechnology space. Our first lecturer Armon Sharei gave an engaging and informative talk on his company SQZ Biotechnologies, from its beginnings here in the Jensen Lab to its current status as a successful clinical-stage company. You can learn more about the lecture on page five.

Being a successful leader in industry is a learned skill, one we cultivate through our PhD in Chemical Engineering Practice (PhDCEP) degree. This program builds on existing strengths within the Department's research activities, the unique resources of the David H. Koch School of Chemical Engineering Practice, and the world class resources of the Sloan School of Management. Our student cover story on page eight shares the experience of one of our PhDCEP students, Nidhi Juthani. Nidhi's experience highlights the importance of real industry experience for our students as they learn core chemical engineering concepts. The Practice School helps to teach skills that can be difficult to translate in a classroom setting.

Nidhi is just one of the many students that have taken advantage of the Practice School, which would not be possible without its Station Directors. Practice School Station Directors are the heart of the program, as they serve critical role: not only do they develop, guide and mentor the student teams they work with, they act as liaisons with our host companies, making sure communication is open and goals are being met. We are currently looking for new Directors: please check out the job description on the next page as it may be of direct interest to you and share it with other qualified candidates whom you know, including fellow alumni who have the industrial experience combined with the ability to engage and mentor our Practice School students.

One other bittersweet event this year was the well-earned retirement of Dr. Barry Johnston, our inimitable Undergraduate Officer (and previous Practice School Station Director). Many of you should remember Barry: in his 30-year tenure in the Department, he has been a steady, positive, and uplifting advocate for our students. He has been a consummate mentor, advisor and guide to Course X – every single undergraduate in the Department has benefitted from his presence since he joined us. Not only was he a dedicated teacher, but he has been an amazing contributor to Course X and the ChemE community. We are so grateful for all Barry has done for our Department and our students, and wish him well as he spends more time with his grandkids and musical endeavors.

Dr. Barry Johnston, recently retired Course X undergraduate officer.

The Department is so proud of the accomplishments of our alumni, and I'm glad that we can share so many in this edition of the newsletter. We want to hear from you and the interesting things you are doing – please email chemealum@mit.edu and let us know.

Here's to a wonderful new year to all of our Course X friends and family — looking forward to seeing how ChemE will continue to shape and impact lives in 2023!

Best regards,

Paula T. Hammond
Department Head

Greetings from the MIT Practice School

Students from the AstraZeneca station enjoy a teambuilding dinner.

The Practice School continued to operate quite effectively over the past two years despite the constraints imposed by the pandemic. While the spring and summer 2021 stations were exclusively remote, in later sessions our students were once again able to work in-person with their industrial hosts. Some highlights:

During spring 2021, the students worked with Corning and AstraZeneca (AZ), two seasoned host companies who were great partners in optimizing the remote experience. At Corning, the team tackled several projects, including the design of tougher optical fiber secondary coating through a priori prediction of coating properties using machine learning models, designed improvement to Single-Use Technology (SUT) components in the biopharma industry, and three core areas crucial for the scale-up of a bioreactor.

The remote environment allowed work on projects balanced between AZ's Cambridge, England and Gaithersburg, Maryland, sites; in fact, two of our students worked from Canada. Computational Fluid Dynamics (CFD) modelling of reactor parameters and development of new analytical methods (including spectroscopy) through the use of AI algorithms to detect unknown correlations in biological processes were our main objectives. Good progress was made on all projects and we were invited back for spring 2022 – in person this time!

During the summer of 2021, virtual stations were Merck and Sclumberger. Once again, remote work was an advantage: the students addressed real-world projects originating from many different sites, most stateside (Rahway, Kenilworth, and West Point) but one project included a plant in Oss, Netherlands. Many projects involved data mining and AI to improve process outcomes, however, we also had one project targeting reduction of a site's carbon footprint and one project regarding development of an apparatus. Similar to 2020, the MIT Practice School partnered with Schlumberger New Energy on three exciting projects central to the new division's mission. The students successfully completed projects in the optimization of materials to produce lithium-ion batteries, analysis and optimization of carbon capture options, and the analysis and optimization of renewable energy options to produce green ammonia.

In fall of 2021, our students visited St. Gobain, Via Separations and Schlumberger. At St. Gobain, all six projects were highly visible platforms within the corporation. Each project required major experimental (and/or data mining) and modeling efforts, which provided results well received by the sponsors and the general R&D audiences that attended the presentations. Via, a newcomer to the Practice School program, is an entrepreneurial venture in its infancy. We were able to work on site with company leadership on a project exploring new applications for their proprietary membrane technology while a Via applications team managed a pilot test of the membrane. The students successfully identified some options as well as limitations for the new application. For the second half of the fall, the students continued work from the previous Schlumberger station.

AstraZeneca Biotechnology Development (AZ BTD) hosted Spring 2022 and Summer 2022 stations, directed by Tom Blacklock. Projects were selected for their virtual feasibility should Covid restrictions be reinstated. The projects during the Spring station focused on 1) new and improvements to biological manufacturing technologies applicable to current vaccine manufacture and products that are about a decade from commercialization, and 2) improvements to cutting-edge analytical tools using artificial intelligence.

The Summer station projects included development of a real time location system for laboratory equipment, use of AI to predict druggability of biologic proteins, modeling of futuristic manufacturing techniques, and design of advanced devices for self-medication. We look forward to continuing our relationship with AZ BTD next term.

A second Summer 2022 station was held at National Renewable Energy Laboratories (NREL), directed by Douglas Harrison. The students addressed three research projects, ranging from the very preliminary stages of long term research to one which was well along the path toward commercialization. The Practice School teams studied available technologies and compared alternative pathways to renewable energy using a technique called TechnoEconomic Analysis (TEA). TEA provides methods for estimating carbon emissions reductions and commercial economics using standardized techniques for capital cost and economic analysis. Our teams developed models which can be used in further analyses to be conducted by NREL following the completion of our program.

As Paula mentioned in her letter, we are looking to hire a station director to work with our students and host companies. As you can see, it is a challenging, unique and rewarding experience. I encourage those interested to apply.

Take care!

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

SCAN ME

Scan this QR code for more information about the job opening for Practice School Station Director.

Announcing the Charles L. Cooney SM ’67 PhD ’70 Lectureship

Endowed by Dr. Noubar Afeyan PhD ’87, the Charles L. Cooney Lectureship was established in the fall of 2022 to recognize Professor Cooney’s many contributions to the fields of biochemical engineering and pharmaceutical manufacturing, as well as his leadership in the translation of technical innovation into new company creation. The Lectureship showcases rising talent in the biotechnology arena, and brings emerging leaders in both the academy and industry to campus to discuss aspects of innovation in biotechnology.

This theme is a fitting tribute to Cooney, who has served as a trusted mentor to so many students and young alumni as they have made pivotal early decisions in their careers in the biotechnology field, and who has served in many capacities to help establish, support or guide biotechnology companies launched from MIT and beyond. The lectureship is intended to present and recognize engineers whose achievements reflect this innovative spirit.

The inaugural Cooney Lecture was presented on Friday, September 23, 2022, by Armon Sharei PhD ’13, CEO and founder of SQZ Biotechnologies. SQZ is a clinical-stage company built around a unique cell engineering technology with the potential to enable a new generation of cell therapies. The company was founded in 2013 based on Sharei’s PhD work in the laboratories of Professors Klavs Jensen and Robert Langer. To date, SQZ has raised over $300M in investor capital, has a $1B+ partnership with Roche, and is actively conducting 3 oncology clinical trials. In his lecture, Sharei covered the exciting science behind the discovery, the cell therapies they’ve have created, and the encouraging initial patient data from a Phase 1/2 trial in solid tumors. I also touched upon the journey from an early observation in the lab to launching a startup which later transformed into a public clinical-stage biotech.

Charles L. Cooney received his BS in chemical engineering from the University of Pennsylvania in 1966 where he was inspired to pursue biochemical engineering by Prof. Arthur Humphrey and the SM in 1967 and PhD in in 1970 in biochemical engineering from MIT as Prof. Daniel Wang’s first PhD student. After a short post-doc at Squibb doing experiments in 40m3 fermentors, he joined the MIT faculty as an assistant professor in 1970, becoming full professor in 1982. He was executive officer of Chemical Engineering 1995-2001 and from 2002 to 2014 he was the founding faculty director of the Deshpande Center for Technological Innovation. He is an advisor to SMART (Singapore MIT Alliance for Research and Technology) Innovation Center and previously, the faculty lead for innovation programs associated with the Skoltech (Russia) and the MIT Portugal Programs and the MIT-Masdar Institute (Abu Dhabi).

Prof. Cooney’s research and teaching interests span a range of topics in biochemical engineering, pharmaceutical manufacturing and technological innovation. He has published over 250 research papers, over 25 patents and co-authored or edited 6 books including Development of Sustainable

L–R: Noubar Afeyan, Charles Cooney, Armon Sharei, and Paula Hammond. (photo: Jake Belcher)

Bioprocesses: Modeling and Assessment, 2006 and soon to be published, Adaptive Innovation 2022. His teaching has focused on bioprocess development and manufacturing, and translating technological innovation into new company creation. He has taught Fermentation Technology (52 years) and Downstream Processing (36 years) in the School of Engineering Short Programs and served as faculty director of multiple custom programs in Sloan Executive Education. X

▶ **The next Cooney Lecture will be held in fall of 2023. For more information, go to cheme.mit.edu/cooney-lecture/**

Three Course X alumni named to MIT Corporation

The MIT Corporation — the Institute's board of trustees — has elected nine full-term members, who will each serve for five years; and three life members. Corporation Chair Diane Greene SM '78 announced the election results in June 2022.

The nine full-term members include two Course X alumni: Noubar Afeyan PhD '87 and Elaine H. Wong '97. Leslye Miller Fraser '78, SM '80 was also named a life member.

Noubar Afeyan, founder and CEO, Flagship Pioneering

Afeyan earned his PhD in biochemical engineering at MIT in 1987. He has written numerous scientific publications and is the inventor of over 100 patents. He was a senior lecturer at the MIT Sloan School of Management from 2000 to 2016, and a lecturer at Harvard Business School until 2020. During his 35-year career as an inventor, entrepreneur, and CEO, Afeyan has co-founded and developed over 70 life science and technology startups. He is founder and CEO of Flagship Pioneering, a company that advances groundbreaking science to invent and build first-in-category bioplatform companies to transform human health and sustainability. He is also co-founder and chair of the board of Moderna, the pioneering company of mRNA medicines which developed and supplied novel vaccine technology to address the global Covid-19 pandemic.

Elaine H. Wong, co-founder and partner, H+ Partners

Wong graduated from MIT in 1997 with a BS in chemical engineering and a minor in economics. She subsequently received an MBA in 2003 from the Stanford Graduate School of Business. Wong has over 20 years of private equity experience and has helped build, fund, and take companies public in Hong Kong, Shanghai, Frankfurt, London, and New York. She is currently a co-founder and a partner of H+ Partners, a private equity fund dedicated to investing in and building companies that accelerate decarbonization, with a particular emphasis on the hydrogen ecosystem; it was established in 2021 in Hong Kong. Prior to that, in 2006 she co-founded HAO Capital, a Beijing-based China growth equity fund that invested in companies in the health care, fintech, and cleantech sectors.

Leslye Miller Fraser, former environmental appeals judge, U.S. Environmental Protection Agency

Fraser earned her bachelor's and master's degrees in chemical engineering from MIT and her JD from the University of California at Los Angeles School of Law in 1992. Fraser is a retired environmental appeals judge for the U.S. Environmental Protection Agency. Upon graduating from MIT, she worked for nine years as a research engineer and manager at TRW, an aerospace company, before attending law school. She practiced labor and environmental law at Gibson Dunn for two years, then joined the EPA in 1995 as a staff attorney. In 2001, she was promoted into the Senior Executive Service (SES), which comprises the key positions just below the top presidential appointees, as the associate director for regulations at the U.S. Food and Drug Administration. Fraser's subsequent SES appointments were to the positions of director of the Office of Regulations, Policy and Social Sciences at FDA's Center for Food Safety and Applied Nutrition; associate general counsel for pesticides and toxic substances in the EPA's Office of General Counsel; and environmental appeals judge on the EPA's Environmental Appeals Board, where she was the first person of color in this position. **X**

Ariel Furst recognized for entrepreneurship work

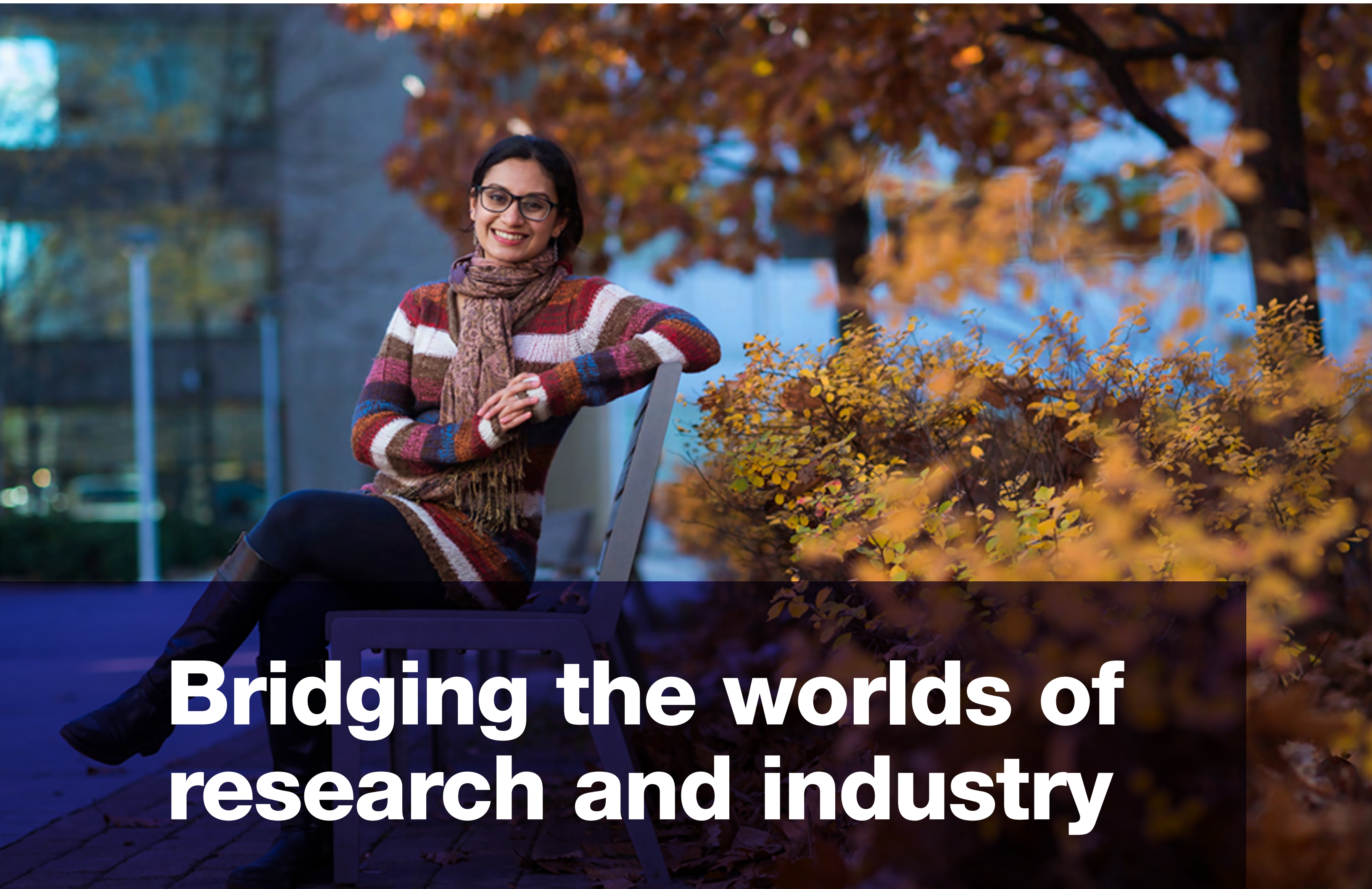
Assistant professor wins inaugural Female Founders Pitch Night, finalist in Future Founders Competition

On June 14, 2022, eight founders took the stage at the MIT Sloan Club of NY for the first annual MIT Female Founders Pitch Competition. Applications were open to all startups with founder(s) who are affiliated with the Massachusetts Institute of Technology. Women receive less than 3% of venture capital funding, and the event focused on changing the ratio.

Of the eight finalists, Ariel Furst won first place with her company Pharmor, which she describes as "A Microbial Suit of Armor." From her pitch: "Soil microbes are essential for crop growth and ecosystem health, but current farming practices have mostly killed these microbes off. Significant effort has been focused on developing microbial fertilizers to replenish the soil, decrease the need for chemical fertilizers and pesticides, and improve crop stress tolerance. However, these efforts are limited by the fact that target microbes are currently impossible to manufacture. PHARMOR has developed an inexpensive, easy-to-apply protective coating that enables the production and transport of microbes under non-ideal conditions and harsh environmental stresses, enabling the global restoration of soil microbiomes and increasing crop yields from treated farmland."

In November 2021, Furst was named to the MIT faculty cohort that participated in the first MIT Future Founders Prize Competition, announced by the MIT Future Founders Initiative and supported by Northpond Ventures. The competition, led by IMES core faculty member Sangeeta Bhatia, MIT Professor and President Emerita Susan Hockfield, and MIT Amgen Professor of Biology Emerita Nancy Hopkins, was conceived to encourage women to pursue entrepreneurship in biotech. The competition was structured as a learning cohort in which participants are supported in commercializing their existing inventions with instruction in market assessments, fundraising, and business capitalization, as well as other programming. At the end of the program, the cohort members pitched their ideas to a selection committee composed of MIT faculty, biotech founders, and venture capitalists. X

Ariel Furst, third from left, accepts first place at the MIT Female Founders Pitch Night on June 14th, 2022. 2nd Place Winner Claire Beskin, cofounder of Empallo, is second from the right, and Audience Choice Winner Loewen Cavill, cofounder of AuraBlue, is on the far right. Courtesy of the MIT Sloan Club of NY



Bridging the worlds of research and industry

Image credit: Gretchen Ertl

PhD student Nidhi Juthani has built a deep foundation in science to inform a career in the private sector.

Olivia Young, Office of Graduate Education

Graduate student Nidhi Juthani was not content with just one graduate degree. Instead, she decided to earn two in one fell swoop, via MIT's PhD in Chemical Engineering Practice (PhDCEP) program, which allows her to obtain a doctorate and an MBA concurrently. The combination is a perfect fit for Juthani, who wants to pursue a career bridging scientific research and industry.

An undergraduate internship helped spark her interest in combining the two fields. As a chemical engineering manufacturing process intern at Procter and Gamble, she worked in the business unit that produced feminine care products, starting her days on the manufacturing floor at 6:30 a.m. There, she gained an appreciation for the efficiency, procedures, and processes required to manufacture a product. "I could also see how a material [the absorbent core of the pads] that was conceivably once a lab project maybe 10 years ago had to be scaled up to get mass produced," she says.

Now in her fifth year at MIT, Juthani has already completed her PhD, working in the lab of chemical engineering professor Patrick Doyle. Her research involved designing a microRNA-based diagnostic that could potentially help with early detection of certain cancers.

Juthani began the MBA portion of the program at the Sloan School of Management last fall. She misses the freedom she had as a doctoral student to work on her own schedule. But the experience has been worthwhile. "My worldview has definitely been expanded," she says. "I've learned about different industries and fields that I didn't know existed, learned about different cultures and countries, ranging from Brazilian New Year's traditions to how hierarchy works aboard a Navy ship, and developed a great support network."

Finding a "perfect fit" graduate program

A native of Waterloo, Ontario, Juthani knew early on that she wanted to pursue a PhD. When she was 16, her family attended an open house at the University of Waterloo's new Institute of Quantum Computing. The connections she made there led to the opportunity to work in Professor David Cory's lab as a high schooler. She credits Cory, a physical chemist, with "opening up this whole world of academia to me, [a world] that I quite literally didn't know existed before that." Moreover, he planted the seed in her mind that she should pursue engineering and maybe a PhD. He even suggested that she consider MIT — a school that seemed out-of-reach to her at the time.

Juthani went on to study chemical engineering at the University of Waterloo. She was particularly enthralled by the school's co-op program, which enabled her to try out a diverse array of careers. "You get to know what you like, but more importantly, you get to know what you don't like," she recalls.

Her first internship took her to Cambridge, Massachusetts, where she did research in the Aizenberg Lab at Harvard's Wyss Institute for Biologically Inspired Engineering. "I had an immense amount of freedom to structure my entire project," Juthani recalls. She immersed herself in her work, which ultimately helped lead to the publication of two papers.

Employing a different set of skills, Juthani worked at an energy sector-focused materials science and data analytics startup that had spun out of the Aizenberg Lab. As employee number five, she learned how to be a jack-of-all-trades doing anything and everything, including taking calls at 6 a.m. from customs officials to ensure orders arrived on time. (Happily, she also met her now-husband that summer, at another startup in the same building.)

In all, Juthani tackled five distinct internships during her undergraduate career. While each one helped inform her thinking about her professional trajectory, there was no question in her mind that she still wanted to pursue a PhD after graduation. However, she also recognized that a lifelong research career would not fulfill her. She desperately wanted the scientific foundation that can only be provided by a doctorate, but ultimately hoped to focus on the business management of science. To succeed at this kind of career, Juthani wanted to learn to be "bilingual" in both the language of science and the language of business, so that she can serve as a bridge between the technical and business teams on a project.

A friend suggested that the unique PhD in Chemical Engineering Practice program at MIT would be a perfect fit. The program is very small, with only two to four students per year. "It's so specifically geared for people who want to go into business out of a PhD that it just made sense for me," Juthani says.

Making every minute count

Asked to describe her research, Juthani excitedly launches into a detailed technical discussion, noting that she hasn't been able to explain her work in such depth to her MBA classmates. Her PhD focused on developing hydrogel microparticles for microRNA and extracellular vesicle detection (EVs), which both serve as biomarkers for a variety of diseases, including cancer, and may make cancer detection possible before it manifests into a tumor. "There is a need for better tools to enable research and diagnostics with EVs, since it is such a nascent field and there is much to learn," she says.

Juthani developed a colorimetric assay using the microparticles, whose different shapes enable detection of multiple targets simultaneously. The round particles can be used for one specific microRNA, and the cuboid particles can be used to identify a different microRNA. Moreover, the process doesn't require specialized equipment; the particles can be imaged with just a phone camera. Her animated description of the color theory involved in creating "perfect images" of the microparticles for her thesis is just one more manifestation of her many diverse passions.

Ever since she arrived at MIT, Juthani has had to grapple with the aggressive deadline of the PhDCEP program, which typically requires completing the PhD within three years. Despite a year-long setback due to the pandemic, she defended last August and started the MBA in September.

Changing gears has been eye-opening. "The MBA experience has been completely different from anything I've experienced in engineering — grad or undergrad — and in research," she says. "There is a significant emphasis on group work, discussion-driven learning, and learning from each other's experiences … and I've also learned how to think in a more systematic, framework-driven manner." After she graduates, Juthani is considering life sciences consulting or venture capital, so she can use her business experience, satisfy her scientific side, and be exposed to a wide variety of companies and projects.

Outside the lab and classroom, Juthani seems to make the most of every minute. She has attended countless seminars, taken pottery classes, participated in MIT Figure Skating, joined a Bollywood dance group, and makes time for coffee dates with friends. And yet, her advice to other students is to "take time to look back and see how far you've come." It's a practice that has served her well. During some difficult weeks of her PhD experience, when she was overwhelmed by seemingly impossible problem sets, she would take a slow stroll down the Infinite Corridor. She says seeing the stream of flyers that line the walls prompted her to savor all the possibilities that MIT offers — and to remind herself of how lucky she is.

"I have this great opportunity to be here at MIT, and I want to try to do as much as possible," she says. "I want to come out of MIT satisfied that I learned and tried new things." True to form, Juthani politely says goodbye and rushes off to her glassblowing class, one of MIT's most iconic experiences. **X**

Faculty Highlights

Martin Bazant named inaugural president of International Electrokinetics Society
The International Electrokinetics Society (IES), officially founded March 29, 2022, promotes interdisciplinary research in the field of electrokinetics and supports young scientists, as well as the exchange of scientific ideas and dissemination of knowledge. It aims to be a link between the respective members of the Electrokinetics Society and the public as well as to support cooperation among respective members. The society does not primarily pursue its own economic purposes.

The next meeting of IES will be in Sevilla, Spain, in 2024. For more information on the Society, go to electrokinetics.net.

Fikile Brushett earns AIChE's 2022 Allan P. Colburn Award
The Allan P. Colburn Award for Excellence in Publications by a Young Member of the Institute is presented to a member of AIChE for significant contributions to chemical engineering through publications. The award candidate must have earned his or her highest academic degree within twelve calendar years of the year in which the award is presented. Brushett is being honored for "pioneering advances in understanding and controlling fundamental processes governing performance, cost, and lifetime of flow electrochemical systems for energy storage and conversion."

Arup Chakraborty wins APS's Max Delbruck Prize, earns honorary degree
Institute Professor Arup Chakraborty received the 2023 Max Delbruck Prize in Biological Physics for his role in "initiating the field of computational immunology, aimed at applying approaches from physical sciences and engineering to unravel the mechanistic underpinnings of the adaptive immune response to pathogens, and to harness this understanding to help design vaccines and therapy."

The Delbruck Prize is named in honor of the physicist and Nobel Laureate Max Delbruck, whose influential quantitative study of genes and their susceptibility to mutations has inspired generations of physical scientists to work on biology, starting with Erwin Schroedinger's book "What Is Life?" The annual $10,000 Delbruck Prize recognizes and encourages outstanding achievement in biological physics research.

Chakraborty has also received an honorary Doctor of Science from the University of Delaware, his graduate alma mater, for his work as a "pioneering researcher… professor and mentor."

Brandon DeKosky wins the 2022 James S. Huston Antibody Science Talent Award
The James S. Huston Antibody Science Talent Award is sponsored by The Antibody Society to recognize and encourage upcoming scientists in the field of Antibody Engineering and Therapeutics. Early career research scientists, i.e., those within 10 years of their most recent advanced degree (Ph.D., M.D., or equivalent), are eligible for the Award. The scientist is recognized for making important contributions to the antibody field and/or the dissemination of antibody knowledge.

Brandon DeKosky is an Assistant Professor and a Core Member of the Ragon Institute of MGH, Harvard, and MIT. Research efforts at the DeKosky lab have developed a suite of high-throughput single-cell platforms for large-scale analyses of adaptive immunity. These efforts are advancing new approaches in biologic drug discovery, and for the cataloguing the vast genetic and functional diversity of adaptive immune cells in multiple disease settings. Key application areas include infectious disease interventions, especially malaria and HIV-1 prevention, and the development of personalized cancer therapeutics.

Patrick Doyle Is AIChE's Alpha Chi Sigma Award Recipient for 2022
The recipient of the 2022 Alpha Chi Sigma Award is Patrick S. Doyle, the Robert T. Haslam (1911) Professor. Doyle is being recognized for the invention of new microfluidic approaches to synthesize and manipulate soft matter, including flow lithography to create highly encoded microparticles and advanced materials. His field-transforming

work involving microfluidic approaches to particle synthesis is enabling the large-scale generation of particles with previously unimagined functionality.

The Alpha Chi Sigma Award recognizes outstanding accomplishments in fundamental or applied chemical engineering research, and is sponsored by the Alpha Chi Sigma Educational Foundation and the Alpha Chi Sigma Fraternity.

Bob Langer wins 2022 Balzan Prize

The Balzan Prize honors internationally recognized scholars for their outstanding achievements in the natural sciences and humanities. Langer was recognized "For pioneering research on biopolymers and biomaterials, and their synthesis, and developing the field of nanomedicine, including advances in mRNA vaccines and tissue engineering."

The Balzan Prize is an international prize by the International Balzan Prize Foundation with headquarters in Italy and Switzerland. Currently, four awards are given annually: two each in the fields of literature, the moral sciences, and the arts, and two each in the fields of the physical, mathematical, natural sciences, and medicine. In addition, at intervals of not less than three years, the special Prize for Humanity, Peace and Fraternity among Peoples is presented.

Yuriy Román named a finalist for the 2022 Blavatnik Awards

The Blavatnik Family Foundation and the New York Academy of Sciences announced 31 finalists for the 2022 Blavatnik National Awards for Young Scientists, the world's largest unrestricted prize honoring early-career scientists and engineers. From that exceptional group, three winners were chosen as a Blavatnik National Awards Laureates. The honorees were chosen from a highly competitive pool of 309 nominees from 150 leading universities and scientific institutions from 38 states across the United States.

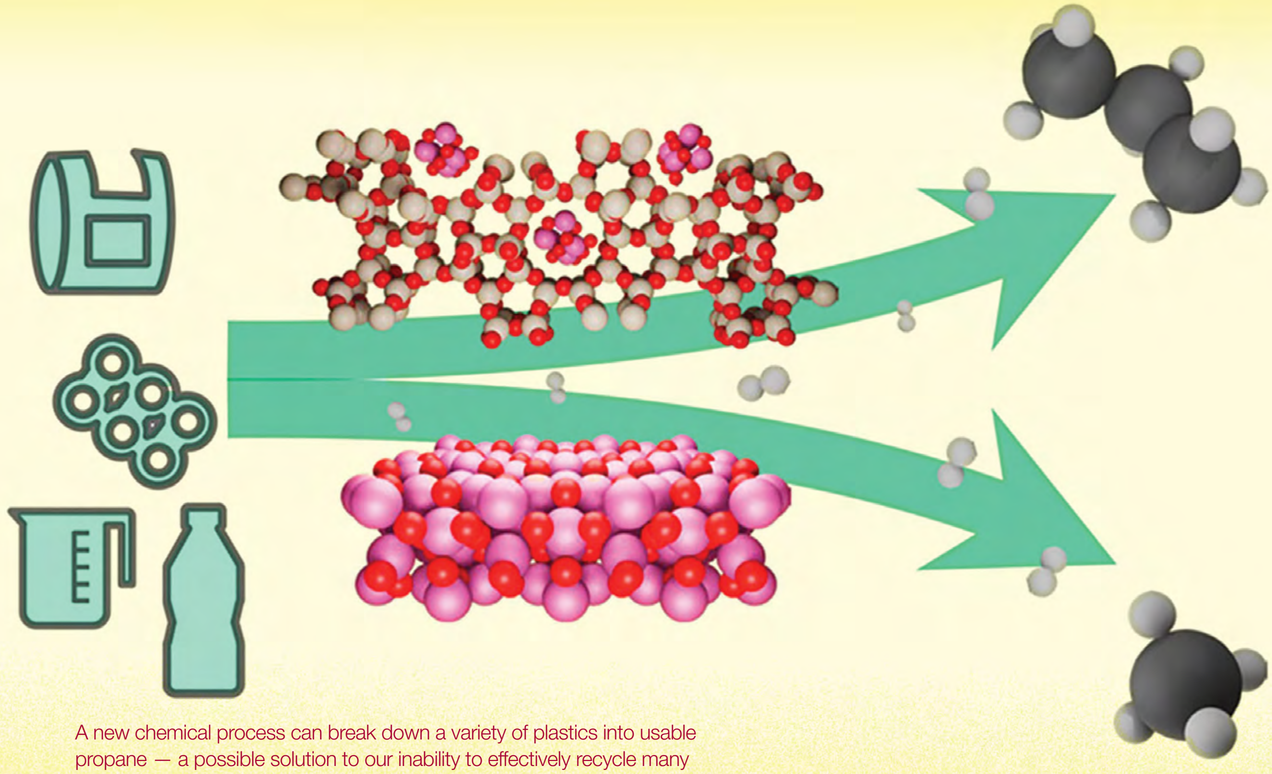
Román was chosen because he "is sustainably transforming earth-abundant materials into fuels and consumer chemicals by dramatically exploring new ways to control chemical reactions… He confines molecules in small spaces or applies electric fields to molecules bound to surfaces. These techniques enable his team to enhance reactions that require less energy and use fewer rare and toxic chemicals. Román is expanding our toolkit for chemical reactions and paving the way for industry to use less energy and fewer rare materials."

Zachary Smith earns two recognitions

Zachary Smith has earned the 2022 AIChE FRI/John G. Kunesh Award. This award is presented in memory of John G. Kunesh, past Separations Division Chairman and Technical Director of Fractionation Research, Inc. (FRI). His dedication to the distillation industry and service to those working in it serve as models for all those practicing engineering disciplines. John actively challenged, mentored, and encouraged young engineers to succeed. This award continues this encouragement by recognizing outstanding contributions to the academic, scientific, technological, industrial, or service areas involving separations technologies. Candidates must be age 39 or less at the time of nomination.

Smith also earned an NSF CAREER Award. The Faculty Early Career Development Program of the National Science Foundation (NSF) is one of the NSF's most prestigious awards. It supports early-career faculty who have the potential to serve as academic role models in research and education and to lead advances in the mission of their department or organization. Activities pursued by early-career faculty should build a firm foundation for a lifetime of leadership in integrating education and research.

This award supports his work in the "Systematic Design of Polymers to Reveal the Anomalous Role of Fluorine on Membrane-based Separations." X



A new chemical process can break down a variety of plastics into usable propane — a possible solution to our inability to effectively recycle many types of plastic. Image: Courtesy of the researchers. Edited by MIT News.

New process could enable more efficient plastics recycling

Cobalt-based catalysts could be used to turn mixed plastic waste into fuel, new plastics, and other products.

David Chandler, MIT News Office

The accumulation of plastic waste in the oceans, soil, and even in our bodies is one of the major pollution issues of modern times, with over 5 billion tons disposed of so far. Despite major efforts to recycle plastic products, actually making use of that motley mix of materials has remained a challenging issue.

A key problem is that plastics come in so many different varieties, and chemical processes for breaking them down into a form that can be reused in some way tend to be very specific to each type of plastic. Sorting the hodgepodge of waste material, from soda bottles to detergent jugs to plastic toys, is impractical at large scale. Today, much of the plastic material gathered through recycling programs ends up in landfills anyway. Surely there's a better way.

According to new research from MIT and elsewhere, it appears there may indeed be a much better way. A chemical process using a catalyst based on cobalt has been found to be very effective at breaking down a variety of plastics, such as polyethylene (PET) and polypropylene (PP), the two most widely produced forms of plastic, into a single product, propane. Propane can then be used as a fuel for stoves, heaters, and vehicles, or as a feedstock for the production of a wide variety of products — including new plastics, thus potentially providing at least a partial closed-loop recycling system.

The finding is described in the open access journal *JACS Au*, in a paper by MIT professor of chemical engineering Yuriy Román-Leshkov, postdoc Guido Zichitella, and seven others at MIT, the SLAC National Accelerator Laboratory, and the National Renewable Energy Laboratory.

Recycling plastics has been a thorny problem, Román-Leshkov explains, because the long-chain molecules in plastics are held together by carbon bonds, which are "very stable and difficult to break apart." Existing techniques for breaking these bonds tend to produce a random mix of different molecules, which would then require complex refining methods to separate out into usable specific compounds. "The problem is," he says, "there's no way to control where in the carbon chain you break the molecule."

But to the surprise of the researchers, a catalyst made of a microporous material called a zeolite that contains cobalt nanoparticles can selectively break down various plastic polymer molecules and turn more than 80 percent of them into propane.

Although zeolites are riddled with tiny pores less than a nanometer wide (corresponding to the width of the polymer chains), a logical assumption had been that there would be little interaction at all between the zeolite and the polymers. Surprisingly, however, the opposite turned out to be the case: Not only do the polymer chains enter the pores, but the synergistic work between cobalt and the acid sites in the zeolite can break the chain at the same point. That cleavage site turned out to correspond to chopping off exactly one propane molecule without generating unwanted methane, leaving the rest of the longer hydrocarbons ready to undergo the process, again and again.

"Once you have this one compound, propane, you lessen the burden on downstream separations," Román-Leshkov says. "That's the essence of why we think this is quite important. We're not only breaking the bonds, but we're generating mainly a single product" that can be used for many different products and processes.

The materials needed for the process, zeolites and cobalt, "are both quite cheap" and widely available, he says, although today most cobalt comes from troubled areas in the Democratic Republic of Congo. Some new production is being developed in Canada, Cuba, and other places. The other material needed for the process is hydrogen, which today is mostly produced from fossil fuels but can easily be made other ways, including electrolysis of water using carbon-free electricity such as solar or wind power.

The researchers tested their system on a real example of mixed recycled plastic, producing promising results. But more testing will be needed on a greater variety of mixed waste streams to determine how much fouling takes place from various contaminants in the material — such as inks, glues, and labels attached to the plastic containers, or other nonplastic materials that get mixed in with the waste — and how that affects the long-term stability of the process.

Together with collaborators at NREL, the MIT team is also continuing to study the economics of the system, and analyzing how it can fit into today's systems for handling plastic and mixed waste streams. "We don't have all the answers yet," Román-Leshkov says, but preliminary analysis looks promising.

The research team included Amani Ebrahim and Simone Bare at the SLAC National Accelerator Laboratory; Jie Zhu, Anna Brenner, Griffin Drake and Julie Rorrer at MIT; and Greg Beckham at the National Renewable Energy Laboratory. The work was supported by the U.S. Department of Energy (DoE), the Swiss National Science Foundation, and the DoE's Office of Energy Efficiency and Renewable Energy, Advanced Manufacturing Office (AMO), and Bioenergy Technologies Office (BETO), as part of the the Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment (BOTTLE) Consortium. **X**

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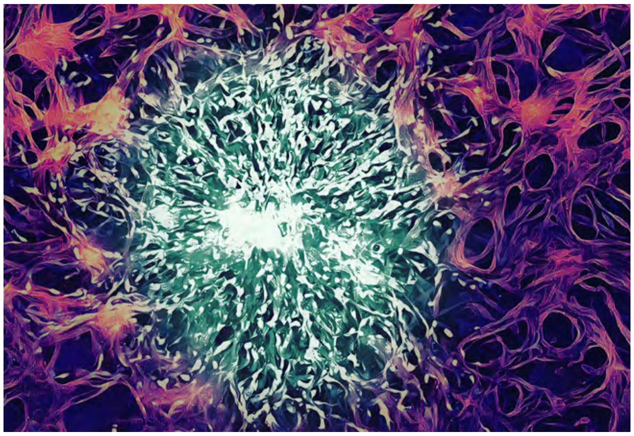
Research Highlights

Engineers develop nanoparticles that cross the blood-brain barrier

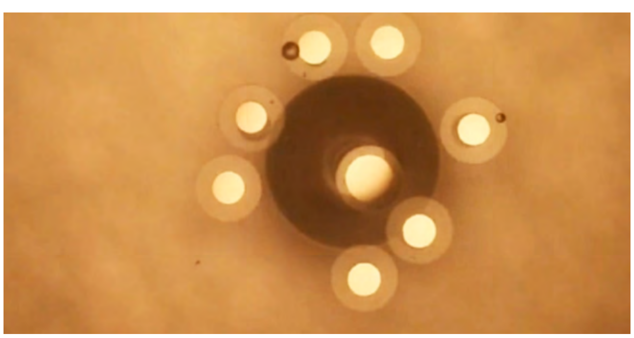


MIT researchers have created a tissue model that allows them to model drug delivery to brain tumors. Tumor cells (green) are surrounded by endothelial cells (purple).

There are currently few good treatment options for glioblastoma, an aggressive type of brain cancer with a high fatality rate. One reason that the disease is so difficult to treat is that most chemotherapy drugs can't penetrate the blood vessels that surround the brain.

A team of MIT researchers, including Paula Hammond, is now developing drug-carrying nanoparticles that appear to get into the brain more efficiently than drugs given on their own. Using a human tissue model they designed, which accurately replicates the blood-brain barrier, the researchers showed that the particles could get into tumors and kill glioblastoma cells.

Tiny particles work together to do big things



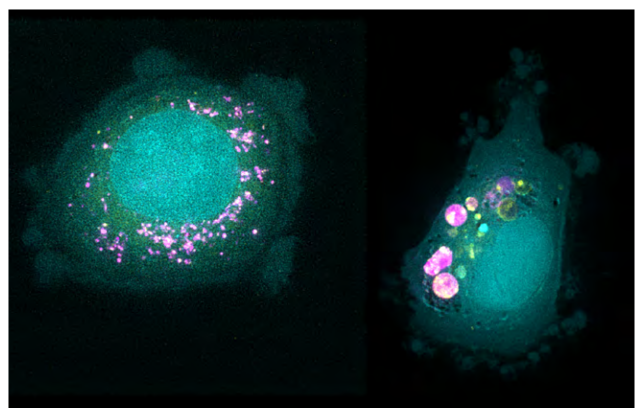
MIT chemical engineers have shown that specialized particles can oscillate together, demonstrating a phenomenon known as emergent behavior.

Taking advantage of a phenomenon known as emergent behavior in the microscale, the Strano Lab has designed simple microparticles that can collectively generate complex behavior, much the same way that a colony of ants can dig tunnels or collect food. Working together, the microparticles can generate a beating clock that oscillates at a very low frequency. These oscillations can then be harnessed to power tiny robotic devices, the researchers showed.

"In addition to being interesting from a physics point of view, this behavior can also be translated into an on-board oscillatory electrical signal, which can be very powerful in microrobotic autonomy. There are a lot of electrical components that require such an oscillatory input," says Jingfan Yang PhD '22, one of the lead authors of the new study.

The particles used to create the new oscillator perform a simple chemical reaction that allows the particles to interact with each other through the formation and bursting of tiny gas bubbles. Under the right conditions, these interactions create an oscillator that behaves similar to a ticking clock, beating at intervals of a few seconds.

How different cancer cells respond to drug-delivering nanoparticles



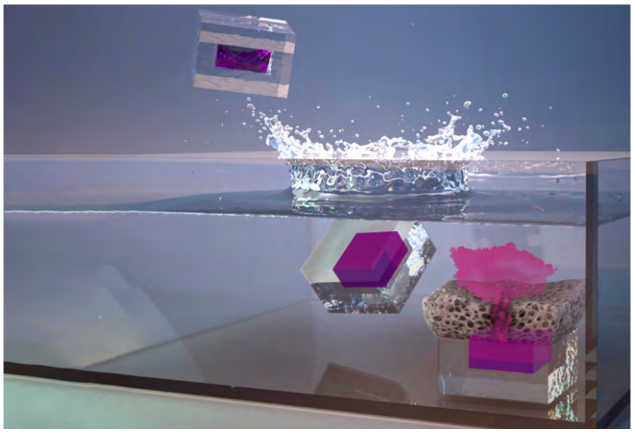
MIT researchers have identified biomarkers that predict whether different types of cancer cells will take up specific nanoparticles. In this image, cells with low levels of a protein called SLC46A3 (left) take up particles called liposomes (pink), while cells with high levels of SLC46A3 (right) do not.

Using nanoparticles to deliver cancer drugs offers a way to hit tumors with large doses of drugs while avoiding the harmful side effects that often come with chemotherapy. However, so far, only a handful of nanoparticle-based cancer drugs have been FDA-approved.

A new study from the Hammond Lab, partnering with Broad Institute of MIT and Harvard researchers, may help to overcome some of the obstacles to the development of nanoparticle-based drugs. The team's analysis of the interactions between 35 different types of nanoparticles and nearly 500 types of cancer cells revealed thousands of biological traits that influence whether those cells take up different types of nanoparticles.

The findings could help researchers better tailor their drug-delivery particles to specific types of cancer, or design new particles that take advantage of the biological features of particular types of cancer cells.

Microparticles could be used to deliver “self-boosting” vaccines



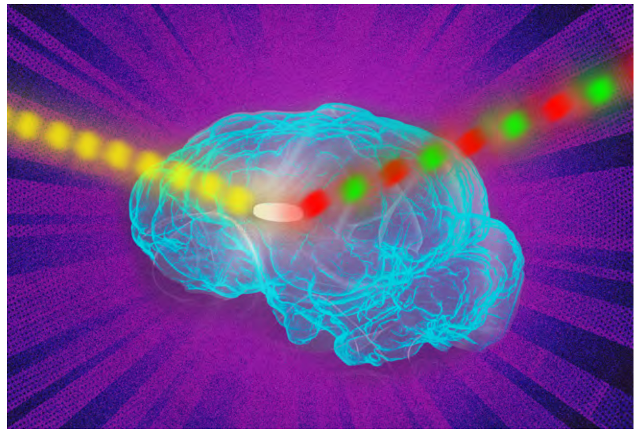
MIT researchers have developed microparticles that can be tuned to deliver their payload at different time points, which could be used to create “self-boosting” vaccines.

Most vaccines, from measles to Covid-19, require a series of multiple shots before the recipient is considered fully vaccinated. To make that easier to achieve, the Langer Lab has developed microparticles that can be tuned to deliver their payload at different time points, which could be used to create “self-boosting” vaccines.

In a new study, the researchers describe how these particles degrade over time, and how they can be tuned to release their contents at different time points. The study also offers insights into how the contents can be protected from losing their stability as they wait to be released.

Using these particles, which resemble tiny coffee cups sealed with a lid, researchers could design vaccines that would need to be given just once, and would then “self-boost” at a specified point in the future. The particles can remain under the skin until the vaccine is released and then break down, just like resorbable sutures. This type of vaccine delivery could be particularly useful for administering childhood vaccinations in regions where people don’t have frequent access to medical care, the researchers say.

MIT engineers boost signals from fluorescent sensors



MIT engineers found a way to dramatically improve the signal emitted by fluorescing nanosenors. The researchers showed they could implant sensors as deep as 5.5 centimeters in tissue and still get a strong signal.

Fluorescent sensors, which can be used to label and image a wide variety of molecules, offer a unique glimpse inside living cells. However, they typically can only be used in cells grown in a lab dish or in tissues close to the surface of the body, because their signal is lost when they are implanted too deeply.

The Strano Lab has now come up with a way to overcome that limitation. Using a novel photonic technique they developed for exciting any fluorescent sensor, they were able to dramatically improve the fluorescent signal. With this approach, the researchers showed they could implant sensors as deep as 5.5 centimeters in tissue and still get a strong signal.

This kind of technology could enable fluorescent sensors to be used to track specific molecules inside the brain or other tissues deep within the body, for medical diagnosis or monitoring drug effects, the researchers say. X

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Making hydropower plants more sustainable

Natel Energy, founded by Course X alumna Gia Schneider '99 and her brother Abe '02, SM '03, is deploying hydropower systems with fish-safe turbines and other features that mimic natural river conditions.

Zach Winn, MIT News

A fish-safe turbine designed by Natel Energy. Courtesy of Natel Energy

Growing up on a farm in Texas, there was always something for siblings Gia Schneider '99 and Abe Schneider '02, SM '03 to do. But every Saturday at 2 p.m., no matter what, the family would go down to a local creek to fish, build rock dams and rope swings, and enjoy nature.

Eventually the family began going to a remote river in Colorado each summer. The river forked in two; one side was managed by ranchers who destroyed natural features like beaver dams, while the other side remained untouched. The family noticed the fishing was better on the preserved side, which led Abe to try measuring the health of the two river ecosystems. In high school, he co-authored a study showing there were more beneficial insects in the bed of the river with the beaver dams.

The experience taught both siblings a lesson that has stuck. Today they are the co-founders of Natel Energy, a company attempting to mimic natural river ecosystems with hydropower systems that are more sustainable than conventional hydro plants.

"The big takeaway for us, and what we've been doing all this time, is thinking of ways that infrastructure can help increase the health of our environment — and beaver dams are a good example of infrastructure that wouldn't otherwise be there that supports other populations of animals," Abe says. "It's a motivator for the idea that hydropower can help improve the environment rather than destroy the environment."

Through new, fish-safe turbines and other features designed to mimic natural river conditions, the founders say their plants can bridge the gap between power-plant efficiency and environmental sustainability. By retrofitting existing hydropower plants and developing new projects, the founders believe they can supercharge a hydropower industry that is by far the largest source of renewable electricity in the world but has not grown in energy generation as much as wind and solar in recent years.

"Hydropower plants are built today with only power output in mind, as opposed to the idea that if we want to unlock growth, we have to solve for both efficiency and river sustainability," Gia says.

A life's mission

The origins of Natel came not from a single event but from a lifetime of events. Abe and Gia's father was an inventor and renewable energy enthusiast who designed and built the log cabin they grew up in. With no television, the kids' preferred entertainment was reading books or being outside. The water in their house was pumped by power generated using a mechanical windmill on the north side of the house.

"We grew up hanging clothes on a line, and it wasn't because we were too poor to own a dryer, but because everything about our existence and our use of energy was driven by the idea that we needed to make conscious decisions about sustainability," Abe says.

One of the things that fascinated both siblings was hydropower. In high school, Abe recalls bugging his friend who was good at math to help him with designs for new hydro turbines.

Both siblings admit coming to MIT was a major culture shock, but they loved the atmosphere of problem solving and entrepreneurship that permeated the campus. Gia came to MIT in 1995 and majored in chemical engineering while Abe followed three years later and majored in mechanical engineering for both his bachelor's and master's degrees.

All the while, they never lost sight of hydropower. In the 1998 MIT $100K Entrepreneurship Competitions (which was the $50K at the time), they pitched an idea for hydropower plants based on a linear turbine design. They were named finalists in the competition, but still wanted more industry experience before starting a company. After graduation, Abe worked as a mechanical engineer and did some consulting work with the operators of small hydropower plants while Gia worked at the energy desks of a few large finance companies.

In 2009, the siblings, along with their late father, Daniel, received a small business grant of $200,000 and formally launched Natel Energy.

Between 2009 and 2019, the founders worked on a linear turbine design that Abe describes as turbines on a conveyor belt. They patented and deployed the system on a few sites, but the problem of ensuring safe fish passage remained.

Then the founders were doing some modeling that suggested they could achieve high power plant efficiency using an extremely rounded edge on a turbine blade — as opposed to the sharp blades typically used for hydropower turbines. The insight made them realize if they didn't need sharp blades, perhaps they didn't need a complex new turbine.

"It's so counterintuitive, but we said maybe we can achieve the same results with a propeller turbine, which is the most common kind," Abe says. "It started out as a joke — or a challenge — and I did some modeling and rapidly realized, 'Holy cow, this actually could work!' Instead of having a powertrain with a decade's worth of complexity, you have a powertrain that has one moving part, and almost no change in loading, in a form factor that the whole industry is used to."

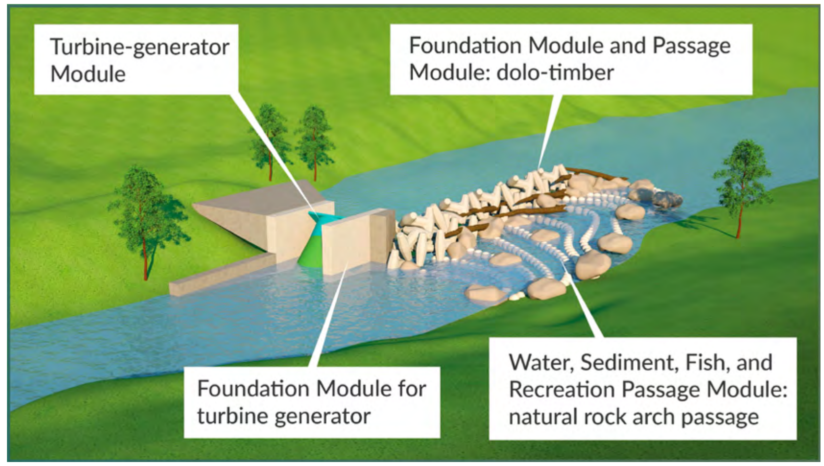
The turbine Natel developed features thick blades that allow more than 99 percent of fish to pass through safely, according to third-party tests. Natel's turbines also allow for the passage of important river sediment and can be coupled with structures that mimic natural features of rivers like log jams, beaver dams, and rock arches.

"We want the most efficient machine possible, but we also want the most fish-safe machine possible, and that intersection has led to our unique intellectual property," Gia says.

Supercharging hydropower

Natel has already installed two versions of its latest turbine, what it calls the Restoration Hydro Turbine, at existing plants in Maine and Oregon. The company hopes that by the end of this year, two more will be deployed, including one in Europe, a key market for Natel because of its stronger environmental regulations for hydropower plants.

Since their installation, the founders say the first two turbines have converted more than 90 percent of the energy available



Natel Energy, founded by sibling MIT alumni, is deploying hydropower systems with fish-safe turbines and other sustainable features to advance the industry. Courtesy of Natel Energy

in the water into energy at the turbine, a comparable efficiency to conventional turbines.

Looking forward, Natel believes its systems have a significant role to play in boosting the hydropower industry, which is facing increasing scrutiny and environmental regulation that could otherwise close down many existing plants. For example, the founders say that hydropower plants the company could potentially retrofit across the U.S. and Europe have a total capacity of about 30 gigawatts, enough to power millions of homes.

Natel also has ambitions to build entirely new plants on the many nonpowered dams around the U.S. and Europe. (Currently only 3 percent of the United States' 80,000 dams are powered.) The founders estimate their systems could generate about 48 gigawatts of new electricity across the U.S. and Europe — the equivalent of more than 100 million solar panels.

"We're looking at numbers that are pretty meaningful," Gia says. "We could substantially add to the existing installed base while also modernizing the existing base to continue to be productive while meeting modern environmental requirements."

Overall, the founders see hydropower as a key technology in our transition to sustainable energy, a sentiment echoed by recent MIT research.

"Hydro today supplies the bulk of electricity reliability services in a lot of these areas — things like voltage regulation, frequency regulation, storage," Gia says. "That's key to understand: As we transition to a zero-carbon grid, we need a reliable grid, and hydro has a very important role in supporting that. Particularly as we think about making this transition as quickly as we can, we're going to need every bit of zero-emission resources we can get." X

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Ravinder K Oswal SM '80
Thomas H Ottenjohn
Walter J Paciorek Jr '65
Nicole A Palmer '02
Athanassios Z Panagiotopoulos PhD '86
Chandrasekar Papudesu SM '98
Trueman D Parish SM '63
Robert P Petrich '63, SM '64
David G Pickering '85
Anna Pisania SM '03, PhD '07
John H Pohl SM '73, ScD '76
Baris E Polat PD '11, PhD '11
John R Poliniak
Neil S Portnoff CHE '73
Cordelia M Price '78, SM '82
John J Prior ScD '97
Christopher D Pritchard SM '09, MBA '12, PhD '12
Anna Protopapas SM '88
Waqar R Qureshi PhD '90
William P Raiford SM '85, PhD '89
Dilip Rajagopalan PhD '91
Alonso R Ramos Vaca ScD '78
Xing Ran SM '01
Michael J Rappel SM '03, PhD '07
Charles L Reed III SM '61
Ronald A Reimer SM '69
Eric S Reiner '83
Brandon J Reizman SM '11, PhD '15
Todd M Renshaw '87
James W Rice SM '57
Llewellyn B Richardson PhD '06
Bradford D Ricketson '97
Auguste E Rimpel Jr SM '60, CHE '61
Carlos M Rinaldi SM '01, PhD '02
Kimberly E Ritrievi ScD '85, SM '85
Sandra J Roadcap SM '81
John M Roblin SM '55
Philippe Rose SM '90
Gregory C Rutledge PhD '90
Lisa M Ryan SM '81
Albert Sacco Jr PhD '77
Hiroshi H Saito SM '91, PhD '95
Jeffrey B Sakaguchi '82
Todd R Salamon PhD '96
Rola K Sangodeyi '98
Catherine M Santini PhD '02
John T Santini Jr PhD '99
Deborah E Savage PhD '92
Rhonda J Schaefer '83, SM '84
Elise W Schmidt
John P Schmidt ScD '63
Hanno K Schmidt-Gothan SM '90, SM '92
William J Schmitt PhD '85
Steven F Sciamanna SM '81
Thomas F Seamans SM '59
Carole M Semonian W '50 CH
Michael A Serio PhD '84
Sonja A Sharpe SM '99, PhD '04
Dongying Shen SM '16, PhD '18
Margaret T Shen '99
Shuaichen S Shi '97
John W Shield PhD '89
Rosemarie R Shield SM '86
Deborah R Shnek '89
Kenneth R Sidman '67, SM '68
Jeffrey E Silliman ScD '72
Ronald A Sills SM '66, PhD '70
Harsono S Simka PhD '98
Irwin B Simon '68, SM '69
Melinda M Simon S '68 CH
James A Sinclair '64
Mansour Sindi '01
Marvin I Singer '63
Frank G Smith III ScD '81
Michael Smith
Arnold F Stancell ScD '62
Constance N Stancell S CH '62
Maureen Stancik Boyce SM '91, SM '93, PhD '95
Harvey G Stenger Jr ScD '84
Herbert L Stone ScD '53
John M Storey
Pieter Stroeve SM '69, ScD '73
Kim Strubbe
Mighan Sung
Michael D Supina '85
Dennis V Swanson '68, SM '69
William Taggart SM '59
Jonathan S Tan SM '92, PhD '95
Frank A Tapparo '60
Kris Taylor
Jefferson W Tester PhD '71
Michael P Thien ScD '88
Katherine Thornton
Jean Tilly SM '83
Sonja L Tong '01
Rowena J Torres-Ordonez SM '81, PhD '86
Richard H Tromel '58, SM '59
Theodore D Trowbridge SM '59
Mosum E Tsui SM '82
Antonio Tuells Juan SM '65
Gheorghios Varsamis '92, SM '93
Iacovos A Vasalos SM '67, PhD '69
Nancy P Vespoli SM '79
Gerard F Vetromile SM '63
Preetinder S Virk ScD '67
Chitra Viswanathan '95
David E Voit SM '68
Antonia J Von Gottberg SM '92
Friedrich K Von Gottberg SM '92, PhD '97
Beatrice Wang '99
Chen Wang SM '99, PhD '03
Mark Y Wang 87, ScD '94
Victoria D Wang W '59 CH
Wechung M Wang '04
Zhihong Wang SM '00, PhD '03
Robert A Ware ScD '84
Douglass J Warner SM '59
Camille A Wasden '13, SM '14
Alfred E Wechsler 55, SM '58, ScD '61, '76
Christopher P Wedig SM '73
Randy D Weinstein PhD '98
Harold N Wells SM '54
Lawson E Whitesides Jr SM '71
Richard J Wilcox PhD '85
John A Wilkens PhD '77
Lucile S Wilkens PhD '77
Steven R Wilson SM '75
Eugene B Wilusz SM '68
Kimberly Wissemeier
Graham A Woerner SM '76
Elaine H Wong '97
Michael S Wong SM '97, PhD '00
Patrick S Wong SM '62
Alexandra A Wright '11
Alyse Wu '08
Michelle H Wu SM '02
Hiroshi Yagi SM '79
Charles R Youngson Jr SM '72
Andrea Zanzotto PhD '05
Michael Zeltkevic SM '99
Lei Zhang SM '95, PhD '98
Xinjin Zhao SM '90, ScD '93
Yizu Zhu PhD '92
Allyn J Ziegenhagen SM '59
Samuel Znaimer SM '81
Andrew L Zydney PhD '85

Javit Drake ’94 named a 2022-23 MIT Martin Luther King Jr. Visiting Scholar

“[These scholars] bring a range and depth of knowledge to share with our students and faculty, and we look forward to working with them to build a stronger sense of community across the Institute.”

The MIT Chemical Engineering Department is proud to announce that Javit Drake ’94 has been named a 2022-23 MIT Martin Luther King Jr. Visiting Scholar.

Says Institute Community and Equity Officer John Dozier, “[These scholars] bring a range and depth of knowledge to share with our students and faculty, and we look forward to working with them to build a stronger sense of community across the Institute.”

A familiar face in the department as lecturer and research affiliate, Drake continues his innovative work with the Brushett Lab, while deepening his commitment to the mentorship and education of our students.

Drake has established himself as an expert in electrochemical engineering for energy storage and conversion, an important component of a sustainable future. After graduating from Course X in 1994 (with a minor in music), he completed doctoral work at UC Berkeley under the supervision of Professors John Newman, the preeminent electrochemical engineer in academia in the US, and Clayton Radke. In 2003, he returned to the Boston area to work on modeling and system development for Proctor and Gamble (P&G), rising to the level of Principal Scientist in Modeling and Simulation and Measurement Sciences. At P&G, he used transport, including multi-component diffusion, generalized Newtonian and viscoelastic fluid mechanics, and solid mechanics, to innovate in-market consumer products and experiences such as fluid-cushioned, safe shaving with Gillette razors and longer lasting batteries for Duracell (formerly in P&G).

Javit Drake ’94 was named a 2022-23 MIT Martin Luther King Jr. Visiting Scholar.

In 2010, Drake re-engaged with MIT ChemE, serving as a part-time lecturer, while maintaining his full-time job at P&G. His popular IAP electrochemical energy course describes the fundamentals of batteries and fuel cells including theory, experimentation, and written and oral communication. Students attending this class have benefitted from Drake’s experiences as both a Course X undergraduate and as a professional researcher working on product development in a large company (real-world impact). In 2016, Drake began working with the Brushett Lab, helping to advance modeling and experimental research on mass transport in redox flow batteries (RFBs) and, more recently, convection-enhanced batteries.

As an MLK Jr. Visiting Scholar, Drake plans to develop opportunities for students to engage with alumni, work with electrochemical energy concepts and real-world challenges, and learn about prospects in the important and burgeoning field of electrochemistry. We look forward to working with him and are grateful to have him here as a member of our community.

Since its inception in 1990, the MLK Scholars Program has hosted more than 135 visiting professors, practitioners, and intellectuals who enhance and enrich the MIT community through their engagement with students and faculty. The program, which honors the life and legacy of MLK by increasing the presence and recognizing the contributions of underrepresented scholars, is supported by the Office of the Provost with oversight from the Institute Community and Equity Office. X

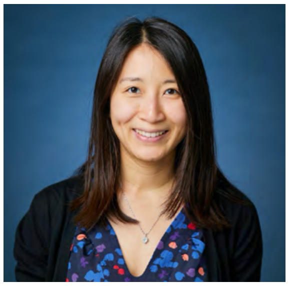
Alumni Highlights

Angela Thedinga MS ’10 has joined the Board of Directors for Nkarta, Inc. (Nasdaq: NKTX), a clinical-stage biopharmaceutical company developing engineered natural killer (NK) cell therapies to treat cancer. “The speed of manufacturing innovation in cell and gene therapies in recent years has accelerated significantly. Angela is one of a handful of people who have been at the center of this activity,” said Paul J. Hastings, President and CEO of Nkarta. “Her expertise and insight in technical operations, supply chain and commercial manufacturing will be instructive for Nkarta’s operational strategy and the planned expansion of our in-house cell therapy manufacturing capabilities. We welcome her to our Board and look forward to her contributions.”

Thedinga most recently served as Chief Technology Officer of Adverum Biotechnologies, where she led the process development, manufacturing and supply chain functions that supported the development of ocular gene therapies. Before joining Adverum in 2019, she held executive roles in manufacturing and supply chain management and strategy at AveXis, now Novartis Gene Therapies, to deliver the first approved gene therapy for Spinal Muscular Atrophy. Her earlier industry experience includes manufacturing strategy roles in bioprocess engineering at Abbott Laboratories and vaccine development at Novartis Vaccines and Diagnostics.

Sean Hunt SM ’13 PhD ’16 was named one of Tech Review’s “Innovators under 35.” Says Tech Review, “Many chemicals used in households and factories today are manufactured from petroleum. Sean Hunt, 33, cofounded Solugen, which uses enzymes and metal catalysts to turn sugar into industrial chemicals with a much lower carbon footprint. The company’s first facility, in Texas, can crank out 10,000 tons per year of chemicals used in water treatment, agriculture, and industrial cleaners, offsetting more than 30,000 tons of carbon dioxide equivalents. It operates on 100% renewable electricity and doesn’t generate any emissions or wastewater.”

Alex Abramson PhD ’19 was named one of Tech Review’s “Innovators under 35.” Abramson is an assistant professor in the Chemical and Biomolecular Engineering Department at Georgia Tech. His research focuses on drug delivery and bioelectronic therapeutics. Tech Review states, “Imagine if you could replace a vaccine jab or an insulin shot with a pill. Alex Abramson, 29, is developing a way to make it possible. Until now, pills haven’t been capable of delivering drugs based on proteins and nucleic acids, since these molecules are rapidly degraded by the enzymes in the gastrointestinal tract. Further, the biological molecules are too large to pass through the tissue wall of the stomach. Abramson’s innovation is a pill that falls to the bottom of the stomach and reorients itself, inserting the medicine directly into the stomach tissue.”

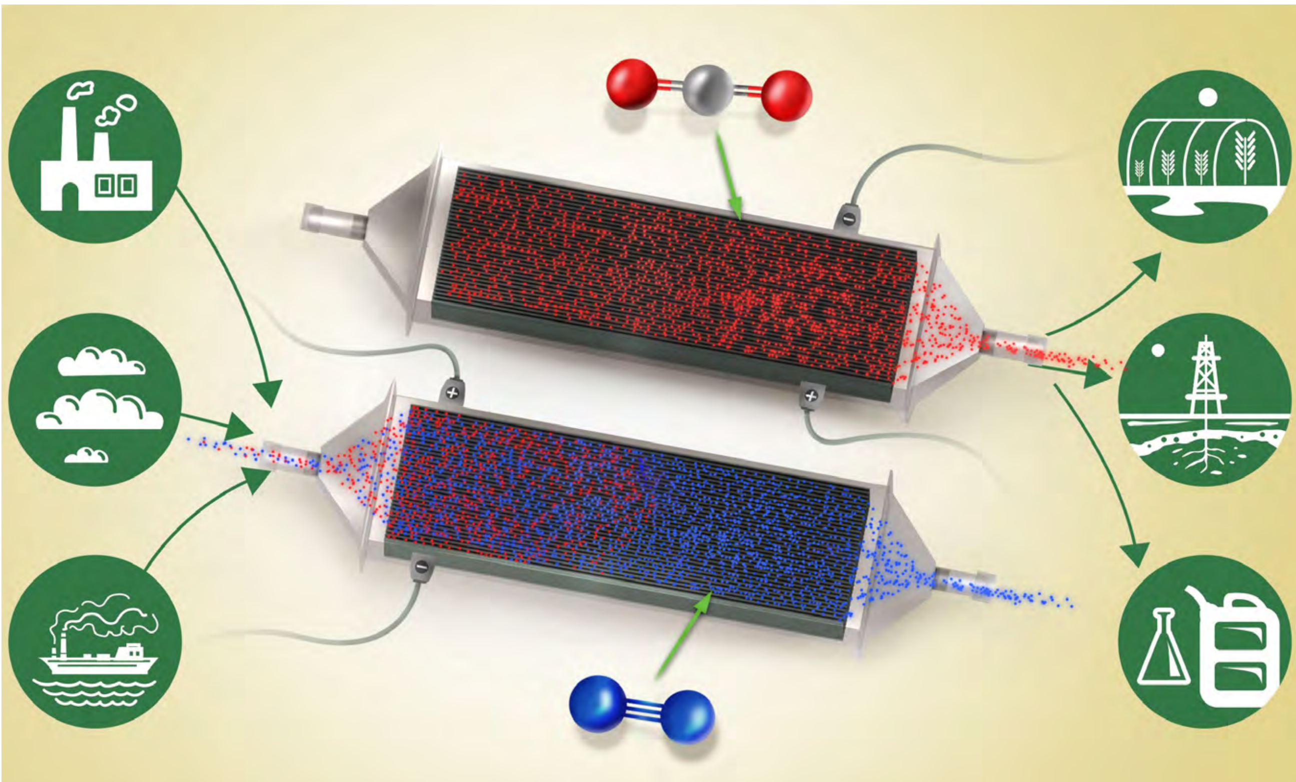


Beatrice Soh PhD ’20 has earned the 2022 Ruth Lynden-Bell PhD Prize on Statistical Mechanics and Thermodynamics. This Prize is awarded on a biannual basis by the Statistical Mechanics and Thermodynamics Group of the Royal Society of Chemistry. Soh is a former member of the Doyle Lab, where her research areas were in microfluidics and polymer physics of DNA. She is currently a research scientist at the Institute of Materials Research and Engineering, Agency for Science Technology and Research (A*STAR). X

Cracking the carbon removal challenge

Founded by MIT chemical engineers and winner of an XPRIZE Carbon Removal milestone award, Verdox is working to move the needle on climate change.

Leda Zimmerman



First developed at MIT, the technology enabled by Verdox enables a flow of air or flue gas (blue) containing carbon dioxide (red) to enter the system from the left. As it passes between thin battery electrode plates, carbon dioxide attaches to the charged plates while the cleaned airstream passes on through and exits at right. Image courtesy of the Hatton Lab

By most measures, MIT chemical engineering spinoff Verdox has been enjoying an exceptional year. The carbon capture and removal startup, launched in 2019, announced $80 million in funding in February from a group of investors that included Bill Gates' Breakthrough Energy Ventures. Then, in April — after recognition as one of the year's top energy pioneers by Bloomberg New Energy Finance — the company and partner Carbfix won a $1 million XPRIZE Carbon Removal milestone award. This was the first round in the Musk Foundation's four-year, $100 million-competition, the largest prize offered in history.

"While our core technology has been validated by the significant improvement of performance metrics, this external recognition further verifies our vision," says Sahag Voskian SM '15, PhD '19, co-founder and chief technology officer at Verdox. "It shows that the path we've chosen is the right one."

The search for viable carbon capture technologies has intensified in recent years, as scientific models show with increasing certainty that any hope of avoiding catastrophic climate change means limiting CO_2 concentrations below 450 parts per million by 2100. Alternative energies will only get humankind so far, and a vast removal of CO_2 will be an important tool in the race to remove the gas from the atmosphere.

Voskian began developing the company's cost-effective and scalable technology for carbon capture in the lab of T. Alan

Hatton, the Ralph Landau Professor of Chemical Engineering at MIT. "It feels exciting to see ideas move from the lab to potential commercial production," says Hatton, a co-founder of the company and scientific advisor, adding that Verdox has speedily overcome the initial technical hiccups encountered by many early phase companies. "This recognition enhances the credibility of what we're doing, and really validates our approach."

At the heart of this approach is technology Voskian describes as "elegant and efficient." Most attempts to grab carbon from an exhaust flow or from air itself require a great deal of energy. Voskian and Hatton came up with a design whose electrochemistry makes carbon capture appear nearly effortless. Their invention is a kind of battery: conductive electrodes coated with a compound called polyanthraquinone, which has a natural chemical attraction to carbon dioxide under certain conditions, and no affinity for CO_2 when these conditions are relaxed. When activated by a low-level electrical current, the battery charges, reacting with passing molecules of CO_2 and pulling them onto its surface. Once the battery becomes saturated, the CO_2 can be released with a flip of voltage as a pure gas stream.

"We showed that our technology works in a wide range of CO_2 concentrations, from the 20 percent or higher found in cement and steel industry exhaust streams, down to the very diffuse 0.04 percent in air itself," says Hatton. Climate change science suggests that removing CO_2 directly from air "is an important component of the whole mitigation strategy," he adds.

"This was an academic breakthrough," says Brian Baynes PhD '04, CEO and co-founder of Verdox. Baynes, a chemical engineering alumnus and a former associate of Hatton's, has many startups to his name, and a history as a venture capitalist and mentor to young entrepreneurs. When he first encountered Hatton and Voskian's research in 2018, he was "impressed that their technology showed it could reduce energy consumption for certain kinds of carbon capture by 70 percent compared to other technologies," he says. "I was encouraged and impressed by this low-energy footprint, and recommended that they start a company."

Neither Hatton nor Voskian had commercialized a product before, so they asked Baynes to help them get going. "I normally decline these requests, because the costs are generally greater than the upside," Baynes says. "But this innovation had the potential to move the needle on climate change, and I saw it as a rare opportunity."

The Verdox team has no illusions about the challenge ahead. "The scale of the problem is enormous," says Voskian. "Our technology must be in a position to capture mega- and gigatons of CO_2 from air and emission sources." Indeed, the International Panel on Climate Change estimates the world must remove 10 gigatons of CO_2 per year by 2050 in order to keep global temperature rise under 2 degrees Celsius.

To scale up successfully and at a pace that could meet the world's climate challenge, Verdox must become "a business that works in a technoeconomic sense," as Baynes puts it. This means, for instance, ensuring its carbon capture system offers clear and competitive cost benefits when deployed. Not a problem, says Voskian: "Our technology, because it uses electric energy, can be easily integrated into the grid, working with solar and wind on a plug-and-play basis." The Verdox team believes their carbon footprint will beat that of competitors by orders of magnitude.

Left to right: Verdox co-founders Sahag Voskian, Brian Baynes, and T. Alan Hatton. Photo: Brian Baynes

After hurtling past critical milestones, Verdox is now working with its first announced commercial client: Norwegian aluminum company Hydro, which aims to eliminate CO_2 from the exhaust of its smelters as it transitions to zero-carbon production.

Verdox is also developing systems that can efficiently pull CO_2 out of ambient air. "We're designing units that would look like rows and rows of big fans that bring the air into boxes containing our batteries," he says. Such approaches might prove especially useful in locations such as airfields, where there are higher-than-normal concentrations of CO_2 emissions present.

All this captured carbon needs to go somewhere. With XPRIZE partner Carbfix, which has a decade-old, proven method for mineralizing captured CO_2 and depositing it in deep underground caverns, Verdox will have a final resting place for CO_2 that cannot immediately be reused for industrial applications such as new fuels or construction materials.

Can Verdox meaningfully reduce the planet's growing CO_2 burden? Voskian is sure of it. "Going at our current momentum, and seeing the world embrace carbon capture, this is the right path forward," he says. "With our partners, deploying manufacturing facilities on a global scale, we will make a dent in the problem in our lifetime." X

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

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Address service requested

Keep in touch! We hope to see you soon! Save the dates:

Friday, March 10, 2023

The Alan S. Michaels Distinguished Lectureship in Medical and Biological Engineering
Aviv Regev, Head, Executive Vice President
Genentech Research and Early Development

March 23-24, 2023

Warren K. Lewis Lectureship
Doros Theodorou MS '83 PhD '85, Professor of Chemical Engineering
National Technical University of Athens

June 2, 2023

MIT Commencement Alumni Reception
Time and location on MIT campus TBD

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