Spring/Summer 2019
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X Currents

MIT Chemical Engineering Alumni News

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Massachusetts
Institute of
Technology

MIT Chemical Engineering Alumni News

XCurrents

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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Many thanks to those who contributed, including Web Chappell, Gretchen Ertl, Felice Frankel, Lillie Paquette, Emily Tebbetts, and members of the MIT News Office.
Acknowledgments

From the Department Head

Welcome to the Spring/Summer edition of XCurrents. Even though the snow just barely fully melted here in Cambridge, you can sense a change in the air as the birds start to return, buds begin sprouting on the trees, and flip-flops once again flourish among the student population.

There are many exciting things going on now in the department and on campus. One notable development to share: for the first time in history, four out of the eight department heads in MIT's School of Engineering will be women. Effective July 1, my friend and colleague Angela Belcher will become the new head of the Biological Engineering Department, joining Asu Ozdaglar of EECS, Evelyn Wang of MechE, and myself to round out the list. Angela is a remarkable researcher, educator, and collaborator, and I look forward to her presence on Engineering Council as we work toward continuing to provide the best research and educational opportunities for our students.

The Chemical Engineering Department itself is also working to help women in chemical engineering navigate academic careers and increase the number of women who pursue faculty positions. Last fall, we hosted our first Rising Stars in Chemical Engineering workshop, a two-day event where participants networked, presented research, and learned best practices to become successful professors of chemical engineering.

My colleagues and I were immediately impressed with the caliber of these women, their research, and their talent. Feedback from the event was very positive, and I welcome this and other opportunities to share lessons I've learned from my own experiences; I know my colleagues feel the same way. Professors Karen Gleason '82 SM '82 and Klavs Jensen headed the development of event, and we look forward to hosting more in the future. You can read more about the October 2018 workshop on page 5. Also of note is the fact that our own graduate women have also formed a new Graduate Women in ChemE organization led by two of our highly engaged students, Lisa Volpatti and Kara Rodby. This group of women has already introduced programs and events that support our students and enhance the culture of the Department.

You may have heard about the recent establishment of MIT's Schwarzman College of Computing. Artificial intelligence is a valuable tool and strong area of research in chemical engineering, and often overlooked when considering our field. One of our professors and a presenter at the Rising Stars workshop, Heather Kulik, has been seminal in the development of computational tools for chemical engineering (as you can see from her list of recent awards on page 8). Heather's work in cheminformatics pioneers computational approaches to the near-infinite chemical space to greatly accelerate identification and design of new chemicals. Also in the realm of computation, graduate student Conner Coley is using machine-learning to reprogram the way pharmaceuticals are designed. For his work, he has been named one of Forbes's 30 Under 30, while Chemical and Engineering News named him the "Machine-Learning Maestro," one of their 2018 Talented Twelve.

Starting in 2019, we have added three new computational tracks to our flexible undergraduate degree, 10-ENG. With options to focus on Engineering Computation, Process Data Analytics, or Manufacturing Design, our students will have the tools to address the unique engineering challenges of today. Over one third of our faculty have computational research programs, and I look forward to sharing with you their work and contributions to this important area.

It is with deep sadness that we also share the passing of one of our beloved emeriti professors, János Miklós Beér. János was thoughtful, soft-spoken, and unassuming, and a giant in the field of combustion and fuel engineering. I urge you to read his full biography on page 18: While living in Hungary during WWII, János helped save countless lives as he worked with Raoul Wallenberg to save Jews who were headed to concentration camps. Despite his accomplishments, János always considered the wellbeing of others first, and he will be remembered and greatly missed. There will be a tribute to János at the 2019 Clearwater Clean Energy Conference in June in Clearwater Beach, Florida. For more information, go to www.ClearwaterCleanEnergyConference.com.

Throughout the pages of this edition of XCurrents, you will see examples of the amazing things going on in our department. I'm proud of the accomplishments and ongoing work of our faculty and students, and look forward to sharing more in the future.

Sincerely,

Paula T. Hammond

Paula T. Hammond
Department Head

Greetings from the MIT Practice School

In the past year, our students have continued the tradition of working to solve real-world problems in industry while honing their own research, communication, and teamwork skills. Here are highlights from our recent stations around the world:

Summer 2018 Stations

MedImmune, Gaithersburg MD
Directed by Thomas Blacklock
At MedImmune, the biopharmaceutical arm of Astra Zeneca, our students were challenged with a diverse set of development problems. They tackled the full automation of a monoclonal antibody isolation process, data mining of CHO-cell genetic pathways through RNA sequencing to predict culture behavior, elucidation of filter fouling mechanisms and avoidance, predictive structure-based degradation of monoclonal antibodies, antifoaming control during mammalian cell culture, and use of AI to assess undiscovered relationships among measurable culture parameters and outcome.

Saint-Gobain Northboro Research and Development Center, Northboro, MA
Directed by Robert Fisher
Despite being over 350 years old, Saint-Gobain has been recognized as one of the 100 most innovative companies in the world. This session consisted of three projects; one focused on developing a more thorough understanding of an existing polymer processing system (extrusion) and need to evaluate alternative control strategies. Another was involved with a proof-of-concept investigation requiring new delivery systems to prevent particle segregation with mixed powder flow to be injected into molds for abrasive wheels. The third was related to a finishing material for the housing industry. All three projects required major experimental (and/or data mining) and modeling efforts, each being highly visible platforms within the corporation.

Students at the EGA station take a break to see the sights in Dubai.

Fall 2018 Stations

Emirates Global Aluminium, Dubai, UAE
Directed by Brian Stutts
Emirates Global Aluminium (EGA) is among the world's largest aluminum producing companies. Consistent with EGA's goal of efficiency improvements, we contributed to cross-industry collaboration opportunities for reducing NOx emission in the UAE, fundamental studies in process measurements to better control the smelting process, reducing process variation in the anode manufacturing process through improved anode modeling, and also design and efficiency improvements to the plant infrastructure. One project was able to conceive a design option that would reduce the capital cost of an infrastructure upgrade by an order of magnitude vs. prior internal estimates.

Shell Technology Center, Houston TX
Directed by Douglas Harrison
Shell has formed the New Energy Research Technology (NERT) group, our host organization, within their Shell Research to identify and implement new technologies in the areas of 1) carbon capture and utilization from the atmosphere, 2) production, transport, and storage of dense energy products, and 3) decentralized manufacture and distribution of energy products. Our teams addressed eight projects, all of which were in the very preliminary stages of long term research. The students would study the technologies currently available, compare them with possible breakthroughs and establish a foundation and plans for the internal research programs to be executed by the NERT over the next 5 years. The basis for the study would be an environment in which carbon emissions were subject to costs (carbon taxes or other premiums) which would catalyze the development of technologies to ultimately result in net negative growth of the concentration of CO_2 in the atmosphere.

I look forward to continuing to share with you the ongoing experiences of the students and their projects in future newsletters.

Best regards,

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

Helping women in chemical engineering navigate academic careers

Inaugural Rising Stars in Chemical Engineering workshop seeks to increase the number of women who pursue faculty positions.

Professors and alumnae Kristala Prather ’94 and Malancha Gupta SM ’05 PhD ’07 share their experiences with workshop attendees.

On a blustery day at MIT, 22 female graduate students and postdocs from around the country converged to gain insight into the world of chemical engineering academia. Nominated by department heads and professors in leading chemical engineering departments around the country, they represented the top early-career women in their field.

The Rising Stars in Chemical Engineering program was based on other successful Rising Stars programs in the School of Engineering and the School of Science, and for two days, participants networked, presented research, and learned best practices to become successful professors of chemical engineering.

“The ChemE Rising Stars program was very helpful for me as someone looking to become a successful professor in the field of chemical engineering,” said attendee Molly Kozminsky, currently a postdoc at the University of California at Berkeley. “The program addressed the multiple components of the interview process and was particularly helpful in demystifying the chalk talk.”

Karen Gleason ’82 SM ’82, the Alexander and I. Michael Kasser (1960) Professor at MIT and head of the workshop’s steering committee, said the goal of the Rising Stars in Chemical Engineering program is to “bring together the next generation of leaders in the field and help prepare them for careers in academia.”

During the two-day event, participants attended workshops, met individually with MIT faculty, presented their own research with feedback, and learned strategies for job searching, building a career, balancing family and research, and thriving as a chemical engineering professor.

Professor Malancha Gupta SM ’05 PhD ’07, one of the speakers during the workshop, was impressed by the caliber of the cohort.

“The attendees were very talented and ambitious,” she recalled. “The networking lunches and dinners were full of fantastic conversations about ways to make a more inclusive chemical engineering community. I am confident that the attendees will become successful leaders in academia, industry, and national labs. I look forward to crossing paths with them in the future.”

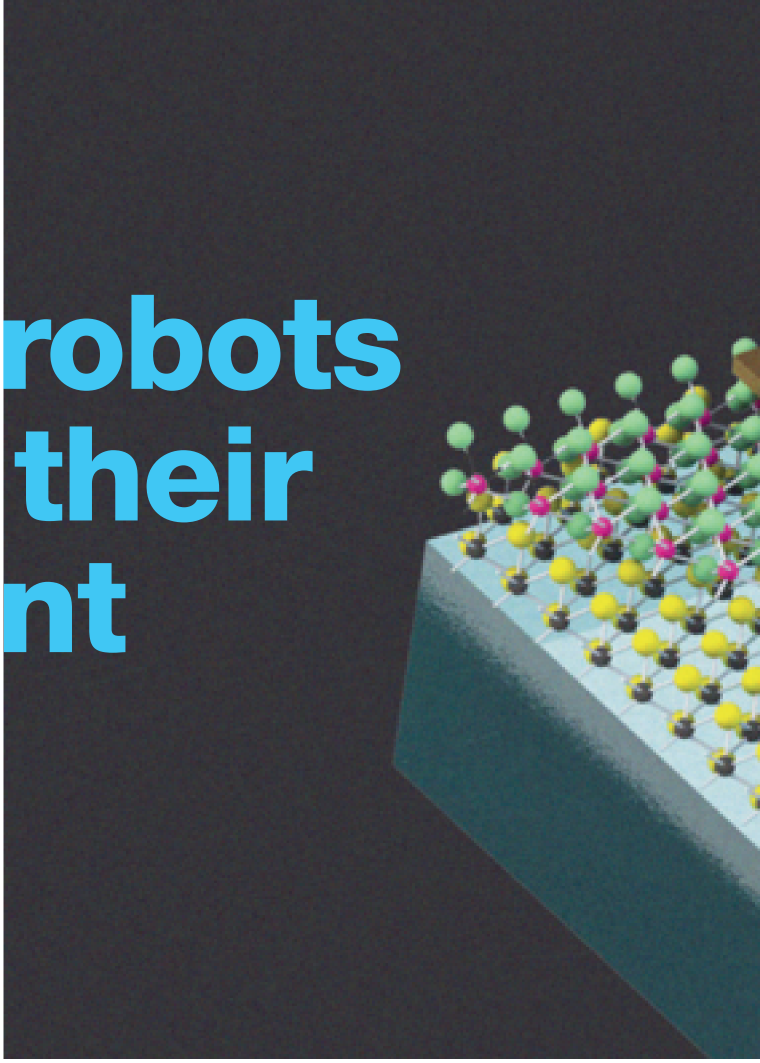
Attendees said the tone of the first Rising Stars in Chemical Engineering workshop was not only educational, but also hopeful.

“As was mentioned throughout the program, and particularly by Dr. Karen Gleason, I do believe that the academic opportunities for women in engineering have greatly improved over the years,” attendee Amber Hubbard recounted. “These professors provided so much wisdom, advice, and encouragement about the future of our field and the potential each one of us has to make a lasting impression wherever we end up in our careers. I certainly walked away from this experience excited and inspired about both chemical engineering and academia.” X

Cell-sized robots can sense their environment

Made of electronic circuits coupled to minute particles, the devices could flow through intestines or pipelines to detect problems.

David L. Chandler, MIT News Office



Researchers at MIT have created what may be the smallest robots yet that can sense their environment, store data, and even carry out computational tasks. These devices, which are about the size of a human egg cell, consist of tiny electronic circuits made of two-dimensional materials, piggybacking on minuscule particles called colloids.

Colloids, which insoluble particles or molecules anywhere from a billionth to a millionth of a meter across, are so small they can stay suspended indefinitely in a liquid or even in air. By coupling these tiny objects to complex circuitry, the researchers hope to lay the groundwork for devices that could be dispersed to carry out diagnostic journeys through anything from the human digestive system to oil and gas pipelines, or perhaps to waft through air to measure compounds inside a chemical processor or refinery.

“We wanted to figure out methods to graft complete, intact electronic circuits onto colloidal particles,” explains Michael Strano, the Carbon C. Dubbs Professor of Chemical Engineering at MIT and senior author of the study, which was published today in the journal Nature Nanotechnology. MIT postdoc Volodymyr Koman is the paper’s lead author.

“Colloids can access environments and travel in ways that other materials can’t,” Strano says. Dust particles, for example, can float indefinitely in the air because they are small enough that the random motions imparted by colliding air molecules are stronger than the pull of gravity. Similarly, colloids suspended in liquid will never settle out.

Strano says that while other groups have worked on the creation of similarly tiny robotic devices, their emphasis has been on developing ways to control movement, for example by replicating the tail-like flagellae that some microbial organisms use to propel themselves. But Strano suggests that may not be the most fruitful approach, since flagellae and other cellular movement systems are primarily used for local-scale positioning, rather than for significant movement. For most purposes, making such devices more functional is more important than making them mobile, he says.

Tiny robots made by the MIT team are self-powered, requiring no external power source or even internal batteries. A simple photodiode provides the trickle of electricity that the tiny robots’ circuits require to power their computation and memory circuits. That’s enough to let them sense information about their environment, store those data in their memory, and then later have the data read out after accomplishing their mission.

Such devices could ultimately be a boon for the oil and gas industry, Strano says. Currently, the main way of checking for leaks or other issues in pipelines is to have a crew physically drive along the pipe and inspect it with expensive instruments. In principle, the new devices could be inserted into one

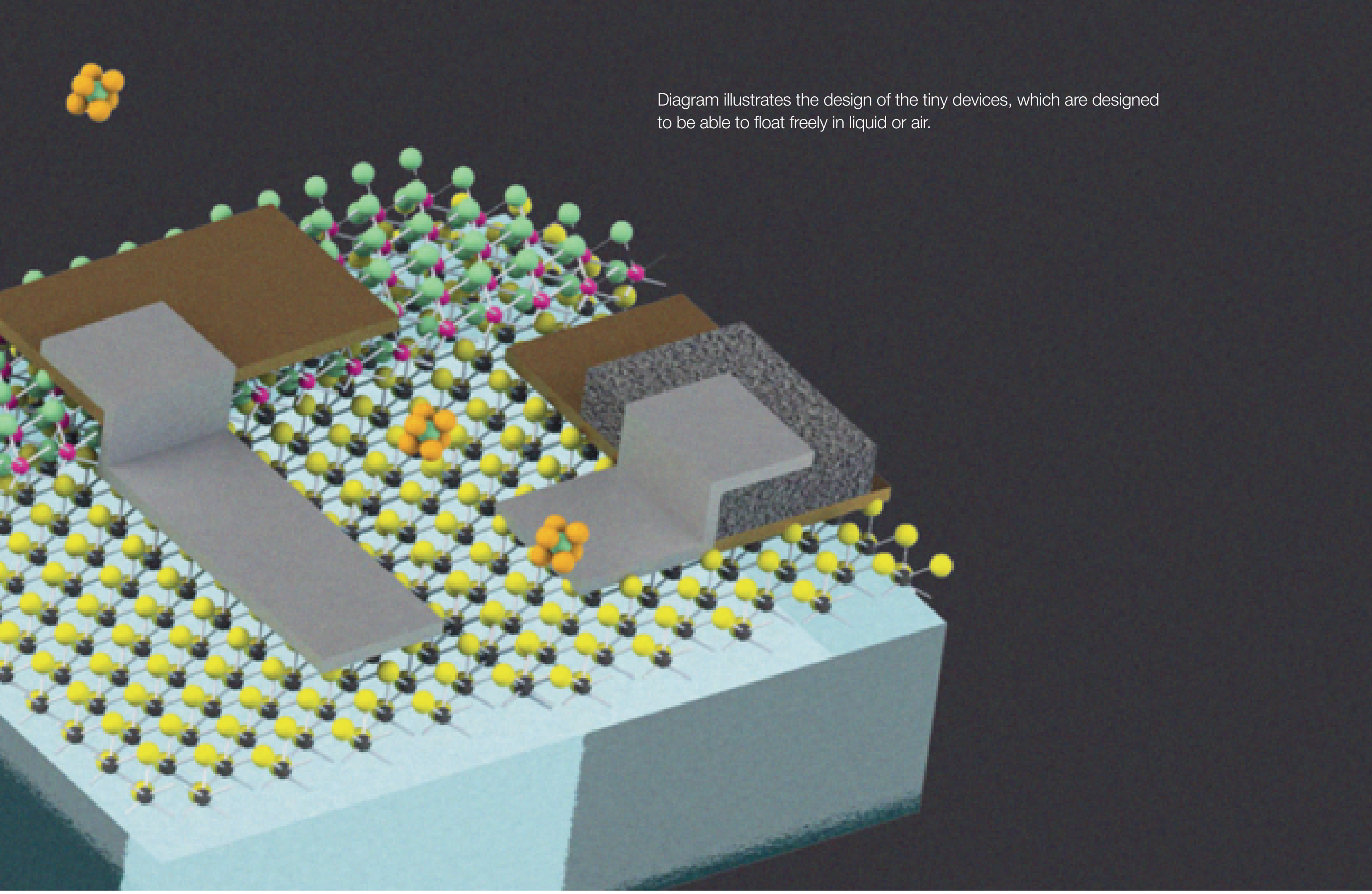
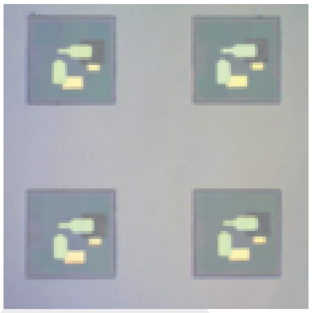


Diagram illustrates the design of the tiny devices, which are designed to be able to float freely in liquid or air.



Optical images show circuits made by the research team, attached to particles just a few hundred nanometers across.

end of the pipeline, carried along with the flow, and then removed at the other end, providing a record of the conditions they encountered along the way, including the presence of contaminants that could indicate the location of problem areas. The initial proof-of-concept devices didn't have a timing circuit that would indicate the location of particular data readings, but adding that is part of ongoing work.

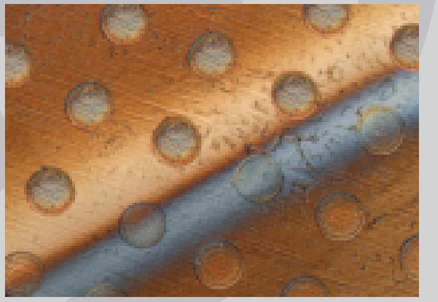
Similarly, such particles could potentially be used for diagnostic purposes in the body, for example to pass through the digestive tract searching for signs of inflammation or other disease indicators, the researchers say. X

For more information, go to news.mit.edu

How to mass produce cell-sized robots

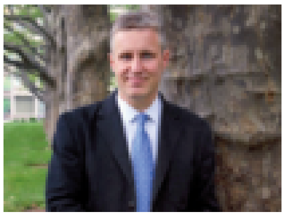
The key to making such tiny devices in large quantities lies in a method the team developed for controlling the natural fracturing process of atomically-thin, brittle materials, directing the fracture lines so that they produce miniscule pockets of a predictable size and shape. Embedded inside these pockets are electronic circuits and materials that can collect, record, and output data.

The novel process is called “autoperforation.” The system uses a two-dimensional form of carbon called graphene, which forms the outer structure of the tiny syncells. One layer of the material is laid down on a surface, then tiny dots of a polymer material, containing the electronics for the devices, are deposited by a sophisticated laboratory version of an inkjet printer. Then, a second layer of graphene is laid on top.



This photo shows circles on a graphene sheet where the sheet is draped over an array of round posts, creating stresses that will cause these discs to separate from the sheet. The gray bar across the sheet is liquid being used to lift the discs from the surface.

Faculty Highlights



Martin Bazant elected APS fellow, wins AIChE Acrivos Award

Martin Bazant has been elected as fellow of the American Physical Society (APS) for 2018. APS Fellowship recognizes members that have completed exceptional physics research, identified innovative applications of physics to science and technology, or furthered physics education. Nominated by the Division of Fluid Dynamics, Bazant was cited for “seminal contributions to electrokinetics and electrochemical physics, and their links to fluid dynamics, notably theories of diffuse-charge dynamics, induced-charge electro-osmosis, and electrochemical phase separation.”

In honor of one of the great fluid dynamacists of the 20th century, the American Institute of Chemical Engineers (AIChE) has renamed the Professional Progress Award, the Andreas Acrivos Award for Professional Progress in Chemical Engineering. Bazant received this award for his outstanding progress in the field of chemical engineering, having made a significant contribution to the science of chemical engineering through the development of a new principle, process or product in the chemical engineering field.

Richard Braatz elected to NAE, AIChE fellow

Election to the National Academy of Engineering (NAE) 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.” Braatz in recognized for contributions to diagnosis and control of large-scale and molecular processes for materials, microelectronics, and pharmaceuticals manufacturing.

Fellow is AIChE’s highest grade and is achieved only through election by the AIChE Board of Directors.

Fikile Brushett receives 2019 Supramaniam Srinivasan Young Investigator Award

The Electrochemical Society’s Energy Technology Division Supramaniam Srinivasan Young Investigator Award was established in 2011 to recognize and reward an outstanding young researcher in the field of energy technology. Such early recognition of highly qualified scientists is intended to encourage especially promising researchers to remain active in the field.

Heather Kulik wins 2019 NSF CAREER Award, DARPA Young Faculty Award, Mason Award

The CAREER program offers the foundation’s most prestigious awards in support of junior faculty who exemplify the role of teacher-scholars through outstanding research and education. Kulik’s project, “Enabling high-throughput computational discovery of stable and active single-site oxidation catalysts,” will advance computational tools to hasten the identification of efficient single-site catalysts that could provide the chemical and petroleum industries with new catalysts needed to maintain our nation’s competitiveness in the chemicals and energy sectors of the economy.

The objective of the Defense Advanced Research Projects Agency (DARPA) Young Faculty Award (YFA) program is to identify and engage rising stars in junior research positions, emphasizing those without prior DARPA funding, and expose them to Department of Defense (DoD) needs and DARPA’s program development process. The YFA program provides funding, mentoring and industry and DoD contacts to awardees early in their careers so they may develop their research ideas in the context of national security needs.

First awarded in 2015 and funded by the Marion Milligan Mason Fund, this American Association for the Advancement of Science (AAAS) Award is designed to kickstart the research efforts of early-career women researchers in the chemical sciences. The 2019 awardees have made extraordinary contributions through their research programs and demonstrate a commitment to move their fields forward. Kulik was recognized for her group’s work “harnessing first-principles electronic structure in transition-metal chemistry and large-scale enzymology to understand fundamental phenomena in chemical bonding for catalyst and materials design.”

Kristala Prather elected 2018 AAAS Fellow

Kristala Prather is among a group of 416 AAAS members elected by their peers in recognition of their scientifically or socially distinguished efforts to advance science. Prather's research focuses on designing new ways to engineer bacteria to synthesize useful chemical compounds such as drugs and biofuels. She has been recognized for her "distinguished contributions to the design and assembly of recombinant microorganisms for the production of small molecules using synthetic biology."

Yuriy Román receives ACS's inaugural Early Career Award, AIChE CRE Young Investigator Award, Rutherford Aris Award, and Bose grant

The Catalysis Science and Technology Division of the American Chemical Society (ACS)'s new award distinguishes individuals who have demonstrated pioneering research accomplishments in the design or synthesis of catalysts and/or chemical or mechanistic characterization of catalysts leading to recognized advancements in our understanding and application of catalysis. The Early Career Award recognizes and encourages accomplishments and innovation of unusual merit by an individual in early stages of their career, emphasizing independence and creativity.

The Rutherford Aris Award of the International Symposia on Chemical Reaction Engineering recognizes outstanding contributions in experimental and/or theoretical reaction engineering research of investigators in early stages of their career. Román was nominated "for innovative advances in heterogeneous catalysis and processes for renewable energy applications."

AIChE's Catalysis and Reaction Engineering Division (CRE) Young Investigator award recognizes individuals who have made significant contributions to the science and/or technology of catalysis and chemical reaction engineering through publications or practice. The candidate must have made important and specific technical contributions to the discovery, invention, characterization, modeling, development, design or implementation of products, catalysts or processes through ingenious and creative application of chemical reaction engineering and/or catalysis concepts.

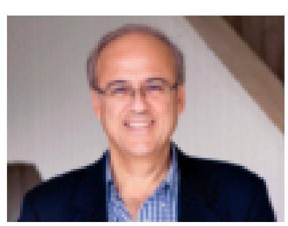
Román also received the 2018 Professor Amar G. Bose Research Grant, which supports work that is unorthodox, and potentially world-changing. "The Bose grant is itself like a catalyst," says Román, whose research centers on heterogeneous catalysis. With the support of the Bose research grant, he will embark on a new exploration: the potential of electric fields to impact molecular interactions on catalytic gas-solid surfaces.

Hadley Sikes receives 2018 ACS Best of BIOT Award

The Best of BIOT award recognizes the best presentations from the ACS's division of Biochemical Technology (BIOT) at the National Meeting. Award winners discuss their work in the Best of BIOT Webinar Series; Sikes presented her work on "Engineered binding proteins as replacements for antibodies in immunoassays" during the December 11, 2018, Biomolecular and Biophysical Processes webinar.

Zachary Smith receives DoE Early Career Award

The Department of Energy (DoE) has selected Zachary Smith to receive significant funding for research as part of the DOE Office of Science's Early Career Research Program. The effort, now in its ninth year, is designed to bolster the nation's scientific workforce by providing support to exceptional researchers during the crucial early career years, when many scientists do their most formative work. Smith was selected for his work on "Rational Sub-Nanometer Manipulation of Polymer Morphology for Efficient Chemical Separations."



Gregory Stephanopoulos receives ACS BIOT Gaden Award

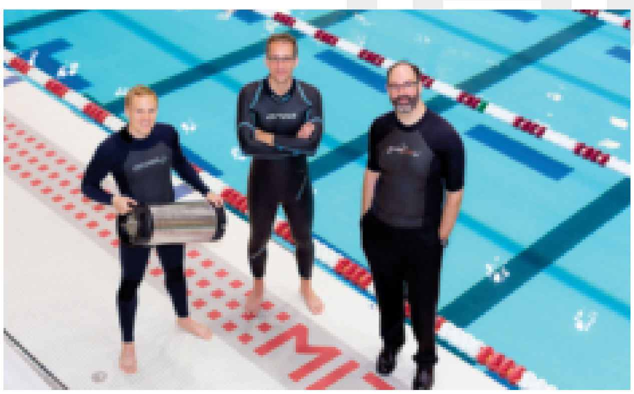
Greg Stephanopoulos has been given the 2019 B&B Elmer Gaden Award for Biotechnology and Bioengineering by ACS BIOT. As part of the award, he gave the annual Gaden Lecture at the annual ACS meeting on March 31, 2019. X

Research Highlights

"Artificial blubber" protects divers in frigid water

When Navy SEALs carry out dives in Arctic waters, or when rescue teams are diving under ice-covered rivers or ponds, the survival time even in the best wetsuits is very limited — as little as tens of minutes, and the experience can be extremely painful at best. Finding ways of extending that survival time without hampering mobility has been a priority for the U.S. Navy and research divers, as a pair of MIT engineering professors learned during a recent program that took them to a variety of naval facilities.

That visit led to a two-year collaboration that has now yielded a dramatic result: a simple treatment that can improve the survival time for a conventional wetsuit by a factor of three, the scientists say. The findings, which could be applied essentially immediately, are reported in the journal RSC Advances, in a paper by Michael Strano, the Carbon P. Dubbs Professor of Chemical Engineering; Jacopo Buongiorno, the TEPCO Professor and associate head of the Department of Nuclear Science and Engineering; and five others at MIT and George Mason University.

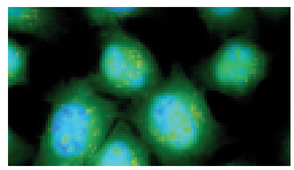


From left, graduate student Anton Cottrill, Professor Jacopo Buongiorno and Professor Michael Strano try out their neoprene wetsuits at a pool at MIT's athletic center. Cottrill is holding the pressure tank used to treat the wetsuits with xenon or krypton.

Engineers create an inhalable form of messenger RNA

Messenger RNA, which can induce cells to produce therapeutic proteins, holds great promise for treating a variety of diseases. The biggest obstacle to this approach so far has been finding safe and efficient ways to deliver mRNA molecules to the target cells. In an advance that could lead to new treatments for lung disease, MIT researchers have now designed an inhalable form of mRNA. This aerosol could be administered directly to the lungs to help treat diseases such as cystic fibrosis, the researchers say.

"We think the ability to deliver mRNA via inhalation could allow us to treat a range of different diseases of the lung," says Daniel Anderson, an associate professor in MIT's Department of Chemical Engineering, a member of MIT's Koch Institute for Integrative Cancer Research and Institute for Medical Engineering and Science (IMES), and the senior author of the study.



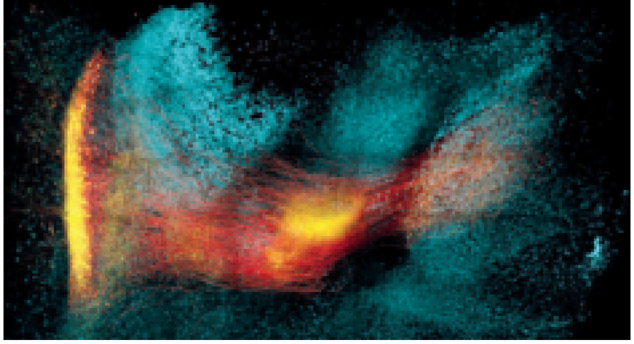
MIT researchers have designed inhalable particles that can deliver messenger RNA. These lung epithelial cells have taken up particles (yellow) that carry mRNA encoding green fluorescent protein.

Living drug factories" may one day replace injections

Patients with diabetes generally rely on constant injections of insulin to control their disease. But MIT spinout Sigilon Therapeutics is developing an implantable, insulin-producing device that may one day make injections obsolete. Sigilon recently partnered with pharmaceutical giant Eli Lilly and Company to develop "living drug factories," made of encapsulated, engineered cells that can be safely implanted in the body, and produce insulin over the course of months or even years. Down the road, cells may also be engineered to secrete other hormones, proteins, and antibodies.

"This allows us to have 'living drug factories' inside our bodies that can deliver therapeutics, at the right amount and in the right location, as needed," says co-founder and co-inventor Daniel G. Anderson, an associate professor in MIT's Department of Chemical Engineering, Institute for Medical Engineering and Science, and Koch Institute for Integrative Cancer Research. "The hope is that this living device can be placed in a patient, avoid the need for immune-suppression, and provide long-term therapy."

MIT spinout Sigilon Therapeutics has partnered with pharmaceutical giant Eli Lilly and Company to develop implantable medical devices that act like "living drug factories," encapsulating engineered cells that live in the body for months, or years, and produce insulin. Down the road, cells may also be engineered to secrete other hormones, proteins, and antibodies.



MIT researchers used their new tissue preservation technique to label and image neurons in a brain region called the globus pallidus externa. Neurons that express a protein called parvalbumin are labeled in red, and neurons labeled blue express a protein called GAD1.

Mapping the brain, cell by cell

MIT chemical engineers and neuroscientists have devised a new way to preserve biological tissue, allowing them to visualize proteins, DNA, and other molecules within cells, and to map the connections between neurons. The researchers showed that they could use this method, known as SHIELD, to trace the connections between neurons in a part of the brain that helps control movement and other neurons throughout the brain.

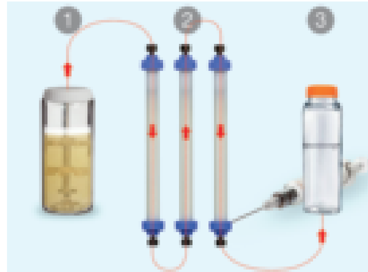
"Using our technique, for the first time, we were able to map the connectivity of these neurons at single-cell resolution," says Kwanghun Chung, an assistant professor of chemical engineering and a member of MIT's Institute for Medical Engineering and Science and Picower Institute for Learning and Memory. "We can get all this multiscale, multidimensional information from the same tissue in a fully integrated manner because with SHIELD we can protect all this information."

New pill can deliver insulin

An MIT-led research team has developed a drug capsule that could be used to deliver oral doses of insulin, potentially replacing the injections that people with type 1 diabetes have to give themselves every day. About the size of a blueberry, the capsule contains a small needle made of compressed insulin, which is injected after the capsule reaches the stomach. In tests in animals, the researchers showed that they could deliver enough insulin to lower blood sugar to levels comparable to those produced by injections given through skin. They also demonstrated that the device can be adapted to deliver other protein drugs.

"We are really hopeful that this new type of capsule could someday help diabetic patients and perhaps anyone who requires therapies that can now only be given by injection or infusion," says Robert Langer, one of the senior authors of the study.

An MIT-led research team has developed a drug capsule that could be used to deliver oral doses of insulin.



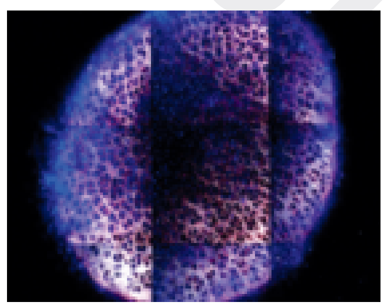
MIT chemical engineers have devised a new desktop machine that can be easily reconfigured to manufacture small amounts of different biopharmaceutical drugs.

A new way to manufacture small batches of biopharmaceuticals on demand

Biopharmaceuticals are increasingly important for "precision medicine" — drugs tailored toward the genetic or molecular profiles of particular groups of patients. Such drugs are normally manufactured at large facilities dedicated to a single product, using processes that are difficult to reconfigure.

To help make more of these drugs available, MIT researchers have developed a new way to rapidly manufacture biopharmaceuticals on demand. Their system can be easily reconfigured to produce different drugs, enabling flexible switching between products as they are needed.

"Traditional biomanufacturing relies on unique processes for each new molecule that is produced," says J. Christopher Love, a professor of chemical engineering at MIT and a member of MIT's Koch Institute for Integrative Cancer Research. "We've demonstrated a single hardware configuration that can produce different recombinant proteins in a fully automated, hands-free manner."



Six days after treatment with IGF-1 carried by dendrimer nanoparticles (blue), the particles have penetrated through the cartilage of the knee joint.

Potential arthritis treatment prevents cartilage breakdown

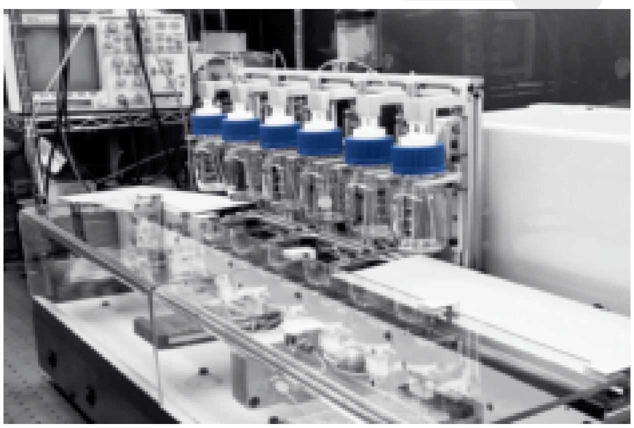
Some drug treatments can help alleviate the pain of osteoarthritis, but there are no treatments that can reverse or slow the cartilage breakdown associated with the disease. In an advance that could improve the treatment options available for osteoarthritis, MIT engineers have designed a new material that can administer drugs directly to the cartilage. The material can penetrate deep into the cartilage, delivering drugs that could potentially heal damaged tissue.

"This is a way to get directly to the cells that are experiencing the damage, and introduce different kinds of therapeutics that might change their behavior," says Paula Hammond, head of MIT's Department of Chemical Engineering, a member of MIT's Koch Institute for Integrative Cancer Research, and the senior author of the study.

Plug-and-play technology automates chemical synthesis

Designing a new chemical synthesis can be a laborious process with a fair amount of drudgery involved — mixing chemicals, measuring temperatures, analyzing the results, then starting over again if it doesn't work out. The Jensen lab, with Chemistry's Jamison lab, has now developed an automated chemical synthesis system that can take over many of the more tedious aspects of chemical experimentation, freeing up chemists to spend more time on the more analytical and creative aspects of their research. This system could cut the amount of time required to optimize a new reaction, from weeks or months down to a single day, the researchers say. They have patented the technology and hope that it will be widely used in both academic and industrial chemistry labs.

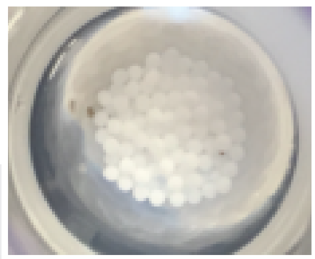
"When we set out to do this, we wanted it to be something that was generally usable in the lab and not too expensive," says Klavs F. Jensen, the Warren K. Lewis Professor of Chemical Engineering at MIT, "We wanted to develop technology that would make it much easier for chemists to develop new reactions."



MIT researchers have developed an automated chemical synthesis system that can take over many of the more tedious aspects of chemical experimentation, freeing up chemists to spend more time on the more analytical and creative aspects of their research.

Oxygen-tracking method could improve diabetes treatment

Transplanting pancreatic islet cells into patients with diabetes is a promising alternative to the daily insulin injections that many of these patients now require. These cells could act as a bioartificial pancreas, monitoring blood glucose levels and secreting insulin when needed. For this kind of transplantation to be successful, scientists need to make sure that the implanted cells receive enough oxygen, which they need in order to produce insulin and to remain viable. The Langer and Anderson labs have now devised a way to measure oxygen levels of these cells over long periods of time in living animals, which should help them predict which implants will be most effective.



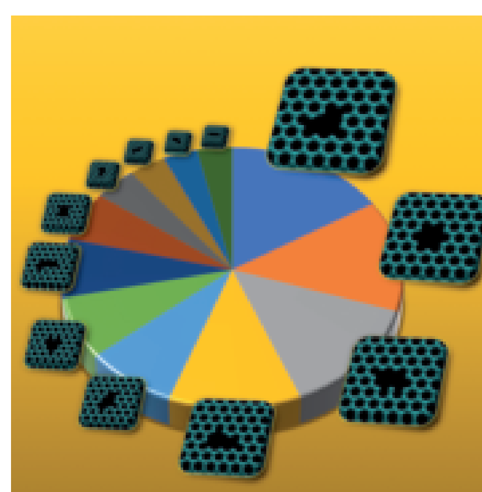
MIT researchers are testing encapsulated pancreatic islet cells as a possible treatment for diabetes. These 1.5 mm capsules are embedded with a fluorine-containing compound that allows the researchers to monitor their oxygen levels with MRI once implanted in the body.

Researchers catalog defects that give 2-D materials amazing properties

Amid the frenzy of worldwide research on atomically thin materials like graphene, there is one area that has eluded any systematic analysis — even though this information could be crucial to a host of potential applications, including desalination, DNA sequencing, and devices for quantum communications and computation systems. That missing information has to do with the kinds of minuscule defects, or "holes," that form in these 2-D sheets when some atoms are missing from the material's crystal lattice.

Now that problem has been solved by the Strano and Blankschtein labs, who have produced a catalog of the exact sizes and shapes of holes that would most likely be observed (as opposed to the many more that are theoretically possible) when a given number of atoms is removed from the atomic lattice.

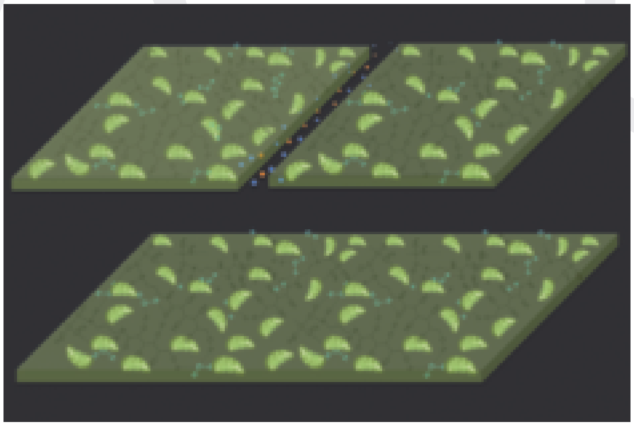
The twelve different forms that six-atom vacancy defects in graphene can have, as determined by the researchers, are shown in this illustration. The pie chart shows the relative abundances that are predicted for each of these different forms.



Self-healing material can build itself from carbon in the air

A material designed by MIT chemical engineers can react with carbon dioxide from the air, to grow, strengthen, and even repair itself. The polymer, which might someday be used as construction or repair material or for protective coatings, continuously converts the greenhouse gas into a carbon-based material that reinforces itself. The current version of the new material is a synthetic gel-like substance that performs a chemical process similar to the way plants incorporate carbon dioxide from the air into their growing tissues.

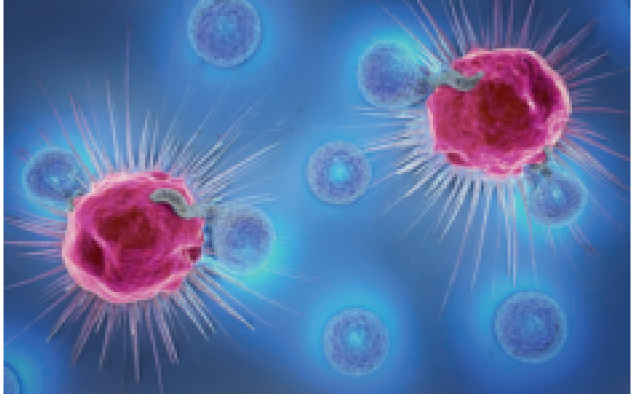
"This is a completely new concept in materials science," says Strano, the Carbon C. Dubbs Professor of Chemical Engineering. "What we call carbon-fixing materials don't exist yet today" outside of the biological realm, he says, describing materials that can transform carbon dioxide in the ambient air into a solid, stable form, using only the power of sunlight, just as plants do.



Diagrams illustrate the self-healing properties of the new material. At top, a crack is created in the material, which is composed of a hydrogel (dark green) with plant-derived chloroplasts (light green) embedded in it. At bottom, in the presence of light, the material reacts with carbon dioxide in the air to expand and fill the gap, repairing the damage.

Sensor could help doctors select effective cancer therapy

MIT chemical engineers have developed a new sensor that lets them see inside cancer cells and determine whether the cells are responding to a particular type of chemotherapy drug. The sensors, which detect hydrogen peroxide inside human cells, could help researchers identify new cancer drugs that boost levels of hydrogen peroxide, which induces programmed cell death. The sensors could also be adapted



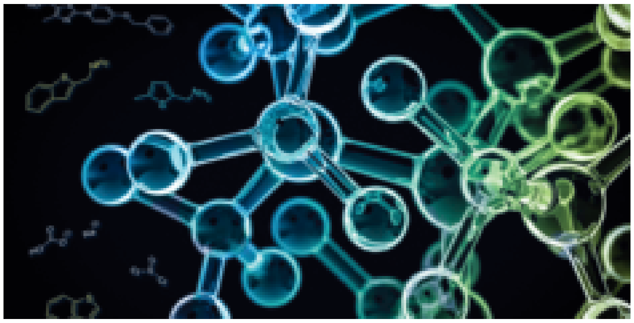
to screen individual patients' tumors to predict whether such drugs would be effective against them.

"The same therapy isn't going to work against all tumors," says Hadley Sikes, an associate professor of chemical engineering at MIT. "Currently there's a real dearth of quantitative, chemically specific tools to be able to measure the changes that occur in tumor cells versus normal cells in response to drug treatment."

Computer system predicts products of chemical reactions

When organic chemists identify a useful chemical compound — a new drug, for instance — it's up to chemical engineers to determine how to mass-produce it. There could be 100 different sequences of reactions that yield the same end product. Historically, determining the most efficient and cost-effective way to produce a given molecule has been as much art as science. But MIT researchers are trying to put this process on a more secure empirical footing, with a computer system that's trained on thousands of examples of experimental reactions and that learns to predict what a reaction's major products will be. In tests, the system was able to predict a reaction's major product 72 percent of the time; 87 percent of the time, it ranked the major product among its three most likely results.

"There's clearly a lot understood about reactions today," says Klavs Jensen, the Warren K. Lewis Professor of Chemical Engineering, "but it's a highly evolved, acquired skill to look at a molecule and decide how you're going to synthesize it from starting materials." X



A new computer system predicts the products of chemical reactions. "The vision is that you'll be able to walk up to a system and say, 'I want to make this molecule.' The software will tell you the route you should make it from, and the machine will make it," says professor Klavs Jensen.

For more information, go to news.mit.edu

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

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Alumni Highlights

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

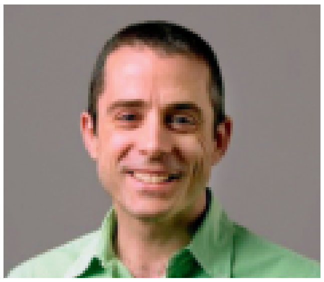
Institute Professor Emeritus **John M. Deutch '61, PhD '65** has made a generous endowment gift to name an MIT Institute Professorship. This appointment — the highest honor awarded by MIT's faculty and administration — recognizes faculty members who have "demonstrated exceptional distinction by a combination of leadership, accomplishment, and service in the scholarly, educational, and general intellectual life of the Institute or wider academic community." Deutch says his motivation for making the gift was his "great respect for MIT and for the tremendous professional and personal satisfaction I have enjoyed as a member of the MIT community for over 59 years."

Mark Manary '77 is waging a successful fight against childhood malnutrition. From 1985 to 2000, Manary pursued potential treatments as he divided his time between frontline medical work in Africa and New Guinea, work in the US Public Health Service, and a faculty position at Washington University, where he had earned his MD. Manary and his colleague André Briend developed a combination of roasted ground peanuts, powdered milk, vegetable oil, sugar, and vitamins that improved on products known as ready-to-use therapeutic food (RUTF). In 2007, home-based RUTF therapy was internationally recognized as the standard of care for severe malnutrition, and Manary was honored with the World of Children Health Award and chosen as Academic Humanitarian Physician of the Year by the American Association of Medical Colleges.

Gareth McKinley PhD '91 has been elected to the National Academy of Engineering. McKinley, the School of Engineering Professor of Teaching Innovation in MIT's Department of Mechanical Engineering, was recognized for contributions in rheology, understanding of complex fluid dynamical instabilities, and interfacial engineering of super-repellent textured surfaces.

Venkat Ganesan PhD '99 has been named a Fellow of the American Association for the Advancement of Science. Ganesan is the Kenneth A. Kobe Professor in Chemical Engineering at the University of Texas at Austin. He is a recipient of a NSF Career Award, an Alfred P. Sloan Foundation Fellowship and most recently the Dillon Medal awarded by the American Physical Society. Ganesan's research efforts focus on developing coarse-grained models and simulations for the prediction of phase behavior of protein-polymer mixtures, protein-polysaccharides, modeling the physics of protein resistant surfaces, structure and phase behavior of random copolymers which mimic biological systems.

Hal Alper PhD '06 has been named the 2018 recipient of AIChE's Allan P. Colburn Award for Excellence in Publications by a Young Member of the Institute. Alper was nominated and selected for his seminal contributions in the field of biochemical engineering, which includes rewiring microbial systems to produce renewable chemicals, fuels, and materials. Alper's research focusses on developing new ways to control the metabolism of cellular systems through efforts of metabolic engineering and synthetic biology.



Bernat Olle PhD ’07 has been named one of the Boston Business Journal’s 2018 40 Under 40 honorees. 40 Under 40 honors a group of people who have climbed the professional ranks at a young age while still finding time in their busy schedules to volunteer in their communities. Olle is a co-founder and Chief Executive Officer of Vedanta Biosciences. In 2013 Dr. Olle was named “Innovator of the Year” in MIT Technology Review Spain’s “Innovators under 35” awards, and in 2015 he was awarded the Princess of Girona business award by the King of Spain.

In Memoriam

Gay V. Land ’44
1924-2019

Gay V. Land died Jan 21 at his home in Atlanta. He was 94. Land graduated from MIT in 1944 with a BS in chemical engineering and later received his MBA from the Wharton School of Business at the University of Pennsylvania.

He married Elizabeth Cooper of New York City in 1945. After serving in Oak Ridge, Tennessee with the U.S. Army, he settled in Westport to raise his family. After a long career in corporate development, he retired from the Celanese Corporation and founded Vale Petroleum, an oil and gas exploration company.

Land was involved in many community groups and was an avid sailor. He raced both one-design and cruising boats, often with his family as crew. He also loved to play golf and served as the president of the Country Club of Darien. He was a longtime member of the United Methodist Church of Westport and Weston, CT, serving on the building committee when the church moved its location to Rabbit Hill.

Wayne Douglas Erickson SM ’58 ScD ’62

Dr. Wayne Douglas Erickson died November 30, 2018, after an extended illness. He died peacefully at home, which was as he wished. He was pre-deceased by his parents, Claud R. and M. Helen Erickson, and his sister Shirley Young. He is survived by Alice, his wife of almost sixty years, his son John, daughter-in-law Carole, granddaughter Lydia and sisters Edith Davies [John] and Dawn Tyler.

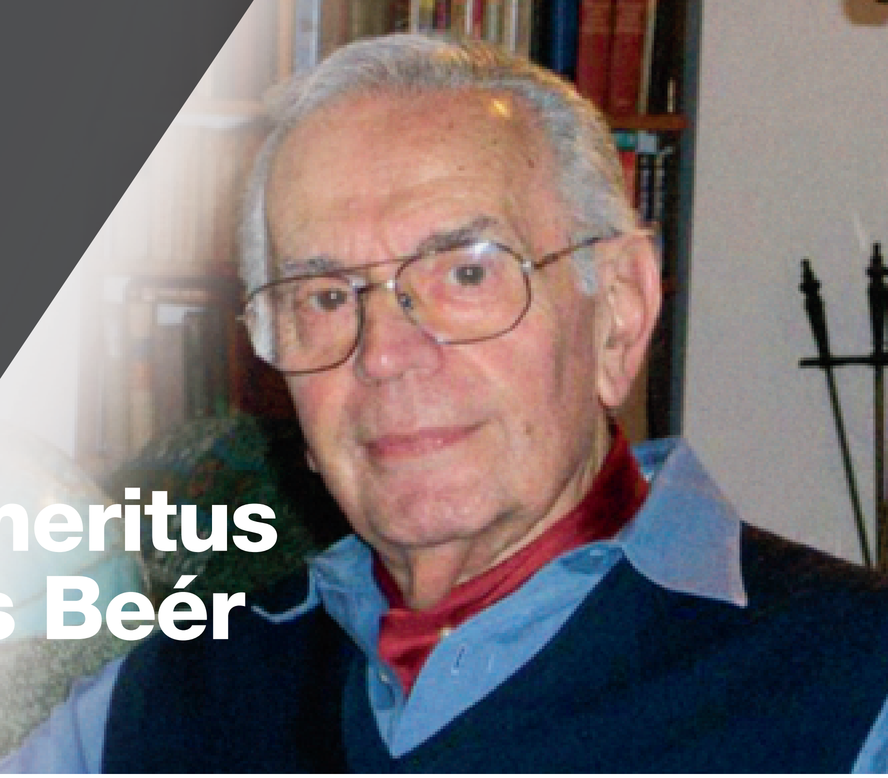
He grew up in Lansing, MI, the fourth child and only boy in the family. Every year he and his sisters spent the summers on their grandfather’s farm in Reed City, MI, where Erickson learned to drive a tractor at age nine. He earned four degrees in chemical engineering; BS and MS degrees from Michigan State University, and SM and ScD degrees from MIT.

In 1955, Erickson was a Second Lieutenant in the US Air Force assigned to the National Advisory Committee for Aeronautics (NACA) at Langley Aeronautical Laboratory. After graduate work in Massachusetts, he returned to his hometown in June 1958 and met Alice at a Fourth of July church picnic. They were married in March of the following year.

Erickson worked at NACA/NASA Langley as a research engineer, a supervisor of various research sections and branches, Senior Scientist for Langley Research Center and as Chief Scientist of various Divisions and Offices until 1995. In 1970 Wayne and the family went to Cambridge University, England, for his research at the Physical Chemistry Laboratory. At the completion of the research Wayne was asked to give a report to The Royal Society, which was an experience of a lifetime. Other special projects included the Apollo 13 Accident Review Board, teaching at MIT and NC State, and the US Air Force Scientific Advisory Board.

In Memoriam

Professor Emeritus János Miklós Beér



Professor Emeritus János Miklós Beér helped Swedish diplomat Raoul Wallenberg rescue Jews in Budapest.

Passionate advocate for cleaner combustion and refugee who helped Raoul Wallenberg rescue Jews in Nazi-occupied Hungary.

János Miklós Beér, professor emeritus of chemical and fuel engineering and a pathbreaking researcher in the field of flames, combustion, and cleaner-burning fossil fuels, died peacefully on Dec. 8, in Winchester at the age of 95.

Beér served on the MIT faculty from 1976 to 1993, helping to launch the Combustion Research Facility as part of the Institute's Energy Laboratory. In 2003, U.S. Energy Secretary Spencer Abraham awarded him the Homer H. Lowry Award, the department's highest honor, for his work leading to commercial burners that achieved high efficiencies while minimizing noxious emissions such as nitrogen oxides.

"Dr. Beér has made pioneering research and development contributions for 45 years to combustion science and technology of coal, oil, and gaseous flames," Abraham said at the award ceremony. "He has also been a major influence on industry through his publications and lectures to professionals at national and international meetings, his leadership with students on university campuses, and his service as a consultant to many power and utility companies both in the U.S. and abroad."

Beér's early years in Central Europe unfolded against a backdrop of the 20th century's most tumultuous and violent episodes. Born on Feb. 27, 1923, in Budapest, Hungary, an only child to Jewish parents, he attended that city's University of Technical and Economic Sciences. But in April 1944, Beér was conscripted into the Hungarian army's labor battalion, and with the fascist Arrow Cross Party ascendant, he found himself in danger of deportation to Germany.

Then fate intervened: A friend of Beér's introduced him to the Swedish diplomat Raoul Wallenberg, who had arrived in Budapest with a plan to rescue Jews. Beér eagerly joined the effort, distributing Swedish passes to Jewish prisoners in railway cattle cars before they could be shipped to concentration camps, and then helping to ferry these people to safety in diplomatically protected houses. In testimony he left to the U.S. Holocaust Museum, Beér said: "Wallenberg was very brave, but not reckless … and there was much solidarity in our group."

Beér remained with the Swedish legation until the end of the war, when he was able to reunite with his wife, Marta Gabriella Csato, whom he had married in October 1944. They remained married until her death in 2017. Resuming his education, he received a first class honors degree from József Nádor University of Technology in 1950, and became a research engineer at Budapest's Heat Research Institute, as well as a lecturer at Budapest Technical University.

Beér did not have long to enjoy his newly established professional life, however. When Soviet tanks rolled into Budapest in 1956 to put down the popular uprising against the Communist regime, he and his wife fled from the mass arrests. They landed as refugees in Scotland, where Beér found employment with Babcock and Wilcox Ltd. In 1957, the couple moved to England, and soon Beér was completing his doctorate at the University of Sheffield. After receiving his PhD in 1960, Beér took a position with the International Flame Research Foundation (IFRF) in Ijmuiden, the Netherlands.

As head of station at the IFRF, a global research hub for the industrial combustion community, "János performed with distinction," noted Philip Sharman, current IFRF director. He led a team of investigators "in a great deal of pioneering research on the aerodynamics and mixing in isothermal jet flames. …

In 1963, Beér left to become a professor of fuel science at Penn State University. He then returned to the University of Sheffield, where he served on the faculty and later as head of the school's department of chemical engineering and fuel technology. He was awarded a doctorate of science there in 1968, and also served as dean of engineering from 1973 to 1976, when he was recruited to MIT as professor of chemical and fuel engineering.

Throughout his career, Beér focused on improving electric power generation from fossil fuels, hoping to gain efficiency, lower costs, and reduce emissions. Even after his retirement from MIT, he pursued these goals, publishing in journals well into his 80s. During his career, Beér authored more than 300 articles, co-authored "Combustion Aerodynamics" (Applied Science Publishers, 1972), a foundational textbook of the era that characterized flow patterns in flames and furnaces.

Amongst his numerous honors, Beér received the Knight's Cross of the Order of Merit of the Hungarian Republic for his support of Hungarian higher education and research. In 2012, Beér received the Worcester Reed Warner Medal from the American Society of Mechanical Engineers for his achievements, including such firsts as using water model studies as an analogy for describing combustion systems; detailing scaling laws for use in combustors and furnaces; studying single droplet combustion; and developing processes for reducing NOx emissions from a range of combustion sources.

Hungarian President's Award by the president of the Hungarian Academy of Sciences, Szilveszter Vizi, at the March 17, 2008, ceremony at the academy in Budapest, Hungary.

"Beér was a giant in his field of combustion," said Gregory Stephanopoulos, the Willard Henry Dow Professor in the Department of Chemical Engineering. But he was not just an accomplished researcher. Colleagues recall a friend distinguished by a certain old-world charm.

Paula Hammond, the David H. Koch Professor of Engineering and head of the MIT chemical engineering department, recalls: "I knew János personally as he was my next door office suitemate when I started as a faculty member. He was the ultimate gentleman, warm, kind and ever thoughtful — asking me about my work and offering his support for me as a new junior faculty member.

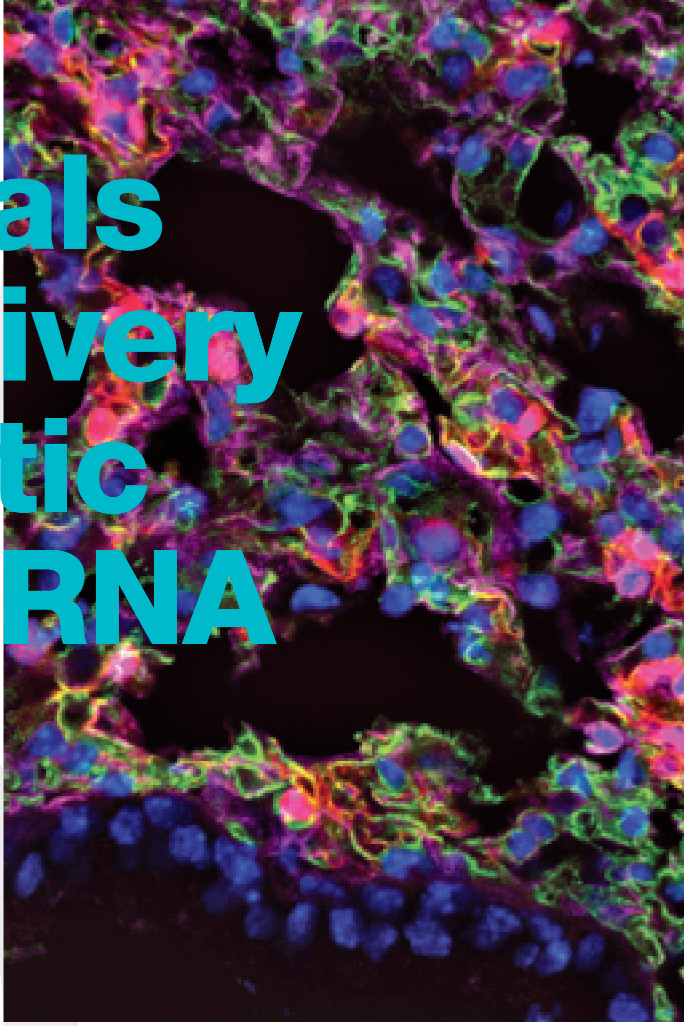
"Although Janos will always be known for his many outstanding achievements in establishing and expanding the area of combustion engineering, his lasting contributions are his many past students, who were inspired and influenced by his mentorship," Hammond says.

Yiannis A. Levendis, distinguished professor of mechanical and industrial engineering at Northeastern University remembers Beér's arrival for a PhD student's thesis defense, when Beér carefully fastened a pin on his ascot. "The occasion of such an important event in a student's life called for respectful formality," Beér told Levendis.

Adds Stephanopoulos: "As a true Hungarian, he appreciated good coffee and had mastered the full art of brewing temperature, duration, and amount of coffee to get a perfect cup."

"At the age of 95, I have known a lot of professors," says Edward W. Merrill, the C.P. Dubbs Professor of Chemical Engineering, emeritus. "János was a delightful, warm person — a great gentleman as well as teacher."

There will be a tribute to Professor János Miklós Beér at the 2019 Clearwater Clean Energy Conference in June in Clearwater Beach, Florida. For more information, go to www.ClearwaterCleanEnergyConference.com. X



New materials improve delivery of therapeutic messenger RNA

Polymeric nanoparticles can efficiently administer mRNA to cells of the lungs, liver, and other organs.

Anne Trafton, MIT News Office

In an advance that could lead to new treatments for a variety of diseases, MIT researchers have devised a new way to deliver messenger RNA (mRNA) into cells.

Messenger RNA, a large nucleic acid that encodes genetic information, can direct cells to produce specific proteins. Unlike DNA, mRNA is not permanently inserted into a cell's genome, so it could be used to produce a therapeutic protein that is only needed temporarily. It can also be used to produce gene-editing proteins that alter a cell's genome and then disappear, minimizing the risk of off-target effects.

Because mRNA molecules are so large, researchers have had difficulty designing ways to efficiently get them inside cells. It has also been a challenge to deliver mRNA to specific organs in the body. The new MIT approach, which involves packaging mRNA into polymers called amino-polyesters, addresses both of those obstacles.

“We are excited by the potential of these formulations to deliver mRNA in a safe and effective manner,” says Daniel Anderson, an associate professor in MIT's Department of Chemical Engineering and a member of MIT's Koch Institute for Integrative Cancer Research and Institute for Medical Engineering and Science (IMES).

Anderson is the senior author of the paper, which appears in the journal Advanced Materials. The paper's lead authors are MIT postdoc Piotr Kowalski and former visiting graduate student Umberto Capasso Palmiero of Politecnico di Milano. Other authors are research associate Yuxuan Huang, postdoc Arnab Rudra, and David H. Koch Institute Professor Robert Langer.

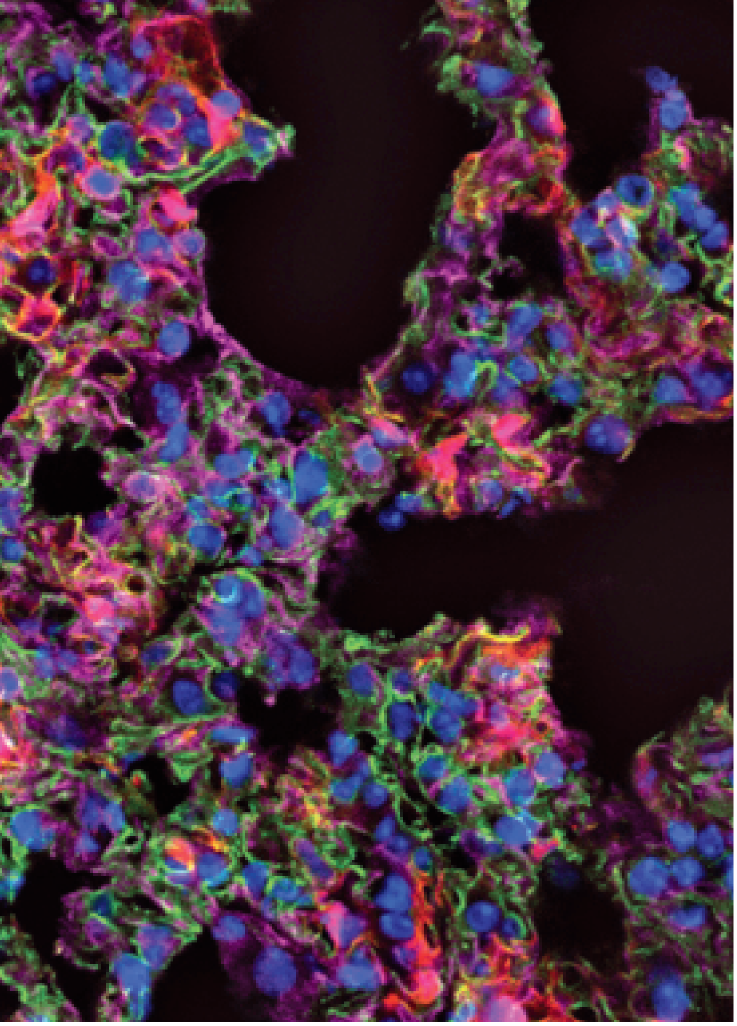
Polymer control

Cells use mRNA to carry protein-building instructions from DNA to ribosomes, where proteins are assembled. By delivering synthetic mRNA to cells, researchers hope to be able to stimulate cells to produce proteins that could be used to treat disease. Scientists have developed some effective methods for delivering smaller RNA molecules, and a number of these materials have shown potential in clinical trials.

The MIT team decided to package mRNA into new polymers called amino-polyesters. These polymers are biodegradable, and unlike many other delivery polymers, they do not have a strong positive charge, which may make them less likely to damage cells.

To create the polymers, the researchers used an approach that allows them to control the properties of the polymer, such as its molecular weight. This means that the quality of the polymers produced will be the similar in each batch, which is important for clinical transition and often not the case with other polymer synthesis methods.

“Being able to control the molecular weight and the properties of your material helps to be able to reproducibly make nanoparticles with similar qualities, and to produce carriers starting from building blocks that are biocompatible could reduce their toxicity,” Capasso Palmiero says.



MIT researchers have designed nanoparticles that can deliver messenger RNA to specific organs. In this image, lung cells expressing the synthetic mRNA show up as red.

"It makes clinical translation much harder if you don't have control over the reproducibility of the delivery system and the released degradation products, which is a challenge for polymer-based nucleic acid delivery," Kowalski says.

For this study, the researchers created a diverse library of polymers that varied in the composition of amino-alcohol core and the lactone monomers. The researchers also varied the length of polymer chains and the presence of carbon atom side chains in the lactone subunits.

After creating about three dozen different polymers, the researchers combined them with lipids, which help stabilize the particles, and encapsulated mRNA within the nanoparticles.

In tests in mice, the researchers identified several particles that could effectively deliver mRNA to cells and induce the cells to synthesize the protein encoded by the mRNA. To their surprise, they also found that several of the nanoparticles appeared to preferentially accumulate in certain organs, including the liver, lungs, heart, and spleen. This kind of selectivity may allow researchers to deliver specific therapies to certain locations in the body.

"It is challenging to achieve tissue-specific mRNA delivery," says Yizhou Dong, an associate professor of pharmaceutics and pharmaceutical chemistry at Ohio State University, who was not involved in the research. "The findings in this report are very exciting and provide new insights on chemical features of polymers and their interactions with different tissues in vivo. These novel polymeric nanomaterials will facilitate systemic delivery of mRNA for therapeutic applications."

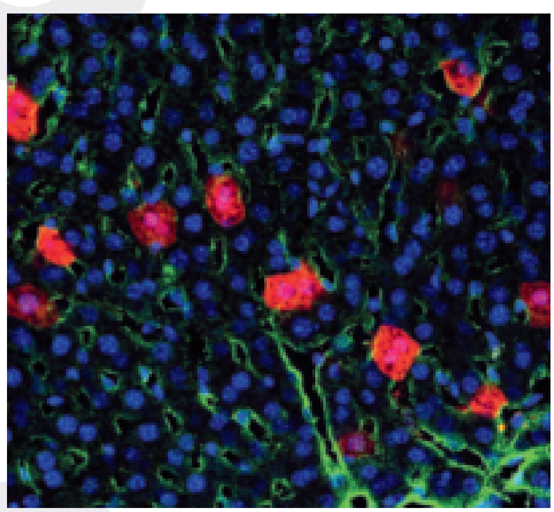
Targeting disease

The researchers did not investigate what makes different nanoparticles go to different organs, but they hope to further study that question. Particles that specifically target different organs could be very useful for treating lung diseases such as pulmonary hypertension, or for delivering vaccines to immune cells in the spleen, Kowalski says. Another possible application is using the particles to deliver mRNA encoding the proteins required for the genome-editing technique known as CRISPR-Cas9, which can make permanent additions or deletions to a cell's genome.

Anderson's lab is now working in collaboration with researchers at the Polytechnic University of Milan on the next generation of these polymers in hopes of improving the efficiency of RNA delivery and enhancing the particles' ability to target specific organs.

"There is definitely a potential to increase the efficacy of these materials by further modifications, and also there is potential to hopefully find particles with different organ-specificity by extending the library," Kowalski says.

The research was funded by the U.S. Defense Advanced Research Projects Agency and the Progetto Roberto Rocca. **X**



MIT researchers have designed nanoparticles that can deliver messenger RNA to specific organs, in this case, the liver. Cells expressing the synthetic mRNA show up as red.

Squeezing cells to cure diseases

Startup SQZ Biotech aims to open a new path in immunotherapy with its cell-compressing technique.

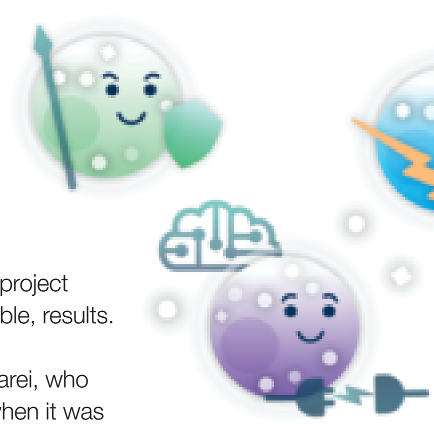
Zach Winn, MIT News Office

Cell-based immunotherapies, which often involve engineering cells to activate or suppress the immune system, have delivered some dramatic results to cancer patients with few other options. But the complex process of developing these therapies has limited a field that many believe could be a powerful new frontier in medicine.

SQZ co-founder and CEO Armon Sharei SM '13 PhD '13 says his company leverages a simple process — squeezing cells so they can be penetrated by specific molecules — to engineer a broader suite of cell functions than has been possible with the gene therapy approaches that have attracted the bulk of the investments in the field.

The technology behind SQZ was discovered out of exasperation as much as innovation. It began as a research project in the lab of Klavs Jensen, the Warren K. Lewis Professor of Chemical Engineering.

For over three years, researchers on the project attempted to shoot materials into cells using a microfluidic device and a jet. The cells proved to be difficult to penetrate, often deflecting away from the jet's stream, so the team started forcing the cells toward the jet by constricting the cells through smaller channels within the chip. Eventually the project started to yield limited, often uncontrollable, results.



"It was a rough project," remembers Sharei, who joined the project as a PhD candidate when it was roughly two years old, while being co-advised by Jensen and Robert Langer, the David H. Koch Institute Professor. "There was quite a while when nothing was happening. We kept banging our head against the wall with the jet technique."

One day the team decided to run the cells through the system without the jet and found that biomaterials in the fluid still entered the cells. That's when they realized that constricting, or squeezing, the cell was opening up holes in the cell membranes.

The discovery set off a string of experiments to improve the process. In 2013, Sharei, Jensen, and Langer founded SQZ Biotech to share the cell squeezing technology with other research groups. But those collaborations didn't produce the kind of groundbreaking experiments Sharei and his team were hoping for.

So SQZ pivoted from providing a lab tool to developing new therapies. Sharei, whose undergraduate work in organic electronics had made him an unlikely participant in the original research project to begin with, found himself with his first full-time job running a company with a unique strategy.

"At the time, the cell therapy industry was very focused on CAR T-cell therapy and gene editing," Sharei says. "We thought there were much more powerful and simple concepts to implement [with SQZ], and you could hit a lot more diseases. This was an initially difficult message to convey to the field."

But the broader perception of SQZ changed overnight when the startup signed a partnership with Roche toward the end of 2015, which marked Roche's first investment in cell-based immunotherapies. "The long-term vision is a company that's creating many different cell-based therapeutics that have an impact across different disease areas," Sharei says. X

Connor Coley, “Machine-Learning Maestro”

Graduate student Connor Coley has been named one of Forbes’s 30 Under 30 for 2019. The magazine calls its 2019 30 Under 30 honorees “a collection of bold risk-takers who are putting a new twist on the old tools of the trade.” Coley was recognized in the “Healthcare” category; his citation explains that “only one in ten experimental drugs tested in patients reaches the market. Connor Coley has racked up 11 peer-reviewed papers trying to remove a bottleneck: the synthesis of candidate drug molecules, using data science and machine learning to reduce subjectivity and make the job easier.”

Coley was also selected as one of 2018’s “Talented Twelve” by Chemical and Engineering News (C&EN). He was nicknamed the “machine learning maestro” and recognized for his work in “reprogramming the way chemists design drugs.”

Currently a member of the Klavs Jensen and William Green research groups, Coley is focused on improving automation and computer assistance in synthesis planning and reaction optimization with medicinal chemistry applications. He is more broadly interested in the design and construction of automated microfluidic platforms for analytics (e.g. kinetic or process understanding) and on-demand synthesis.

The goal of many synthetic efforts, particularly in early stage drug discovery, is to produce a target small molecule of interest. At MIT, Coley’s early graduate research focused on streamlining organic synthesis from an experimental perspective: screening and optimizing chemical reactions in a microfluidic platform using as little material as possible.

But even with an automated platform to do just that, researchers need to know exactly what reaction to run. They must first figure out the best synthetic route to make the target compound and then turn to the chemical literature to define a suitable parameter space to operate within. As part of the DARPA Make-It program, Coley and his colleagues started working toward a much more ambitious goal. Instead of automating only the execution of reactions, could a researcher automate the entire workflow of route identification, process development, and experimental execution?

Coley’s recent research has focused on various aspects of computer-aided synthesis planning to help make a fully autonomous synthetic chemistry platform, leveraging techniques in machine learning to meaningfully generalize historical reaction data. This includes questions of how best to propose novel retrosynthetic pathways and validate those suggestions in silico before carrying them out in the laboratory. The overall goal of his work is to develop models and computational approaches that — in combination with more traditional automation techniques — will improve the efficiency of small molecule discovery.

As described in C&EN, “Machine learning aims to create artificial intelligence systems that make decisions with little intervention from people. Coley’s efforts in this arena have blossomed into a collaboration between MIT and eight drug industry partners, known as the Machine Learning for Pharmaceutical Discovery and Synthesis Consortium. While most other chemists working in the field of machine learning and chemical synthesis use rules devised by experts to guide their systems, Coley relies on reactions in databases, such as those in U.S. patent filings, to teach the computer what transformations will and won’t take place without being influenced by human bias.”

Earlier this year, Coley was also named a 2018 “Riser” by the U.S. Defense Advanced Research Projects Agency (DARPA). X

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Current alumni are invited to celebrate our newest round of graduates at the Course X Commencement Reception

Monday, November 11, 2019:
MIT Reception at the Annual AIChE Meeting in Orlando, FL

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