Spring/Summer 2018
Massachusetts Institute of Technology
Course X News
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MIT Chemical Engineering Alumni News

X Currents

Course X Undergrads Solve Real-World Problems

Teams win awards for work addressing today's energy, material, and biological problems.

Massachusetts
Institute of
Technology

XCurrents

MIT Chemical Engineering Alumni News

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.

Table of Contents

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Acknowledgments

From the Department Head

It is a pleasure to share with you the current issue of XCurrents. So far, 2018 has been a year of exciting research developments, faculty honors, and advances in our continuing efforts to inspire and challenge the next generation of chemical engineers.

The cover of this edition highlights one of the ways our students are working to solve today's problems through our undergraduate research laboratory. In our 10.26/28/29 classes, student teams work with industry and research sponsors to address challenges that are happening right now. This year's projects included demonstrating an oil/aluminum suspension with good shelf life and fuel performance, optimizing voltage on a sticker that can harvest energy from human sweat, and evaluating and improving the performance of perovskite nanocrystals for use in high-efficiency lighting and displays, among others. This undergraduate class truly reflects real-world conditions: not only do the students conduct research, they learn teamwork, proposal writing, and presentation skills. This year, for the first time, the department hosted a final presentation competition among the student teams, which was open to the community and had MIT ChemE faculty as the judges. It was a fun and engaging afternoon of presentations, and I was personally inspired by the work of these budding chemical engineers. Read for yourself the innovative projects and winners on page 15.

Another way the department is working to inspire students is through the creation of a Biomaker Space. Although there are more than 130,000 square feet of maker spaces at MIT, there is no place for students to independently explore and innovate within the bio-molecular engineering disciplines, most significantly chemical engineering and biological engineering. In fact, there are few examples of molecular maker spaces in academia. We are collaborating with the Department of Biological Engineering to create such a space, which would once again position MIT as the global leader in defining best practices for hands-on, student-directed exploration of bio-molecular engineering.

Our students have shown a strong desire to undertake projects on their own initiative – often hoping to make, refine, and bring their designs from the bench to the marketplace. This new space will foster creativity and innovation within these disciplines and encourage translational research. Such a space would also allow our students a greater ability to participate in MIT's existing entrepreneurial and innovation ecosystem, for example the Sandbox Program and StartMIT among others. If you'd like to learn more about this space and how you can support or be a part of it, please contact our Development Officer, Heather Upshaw (hupshaw@mit.edu).

This past year, we had two professors retire from the department: George Stephanopoulos and Preetinder Virk. George's title will be Professor Post-Tenure; we will be fortunate enough to still have him on campus as he continues to teach an undergraduate process design module. Preetinder will be emeritus. We are very thankful to both of these men for their work in the department and contributions to the chemical engineering field in general.

I also would like to share with you some sad news regarding the passing of our former Department Head, Ray Baddour, last December. Ray was a legend. Not only was he a visionary in education and entrepreneurship, but also in the future of MIT Chemical Engineering. Ray was the mastermind behind the construction of Building 66. We are currently working with the family on a plan for a memorial service in the future and will be sure to let our alumni and friends know when an event is scheduled.

I would love to hear your thoughts on our current happenings around the department and hope to see you on campus. We hope you enjoy this edition of XCurrents and I sincerely thank you for your continued support and friendship.

Sincerely,

Paula T. Hammond

Paula T. Hammond
Department Head

Greetings from the MIT Practice School

Now celebrating its 102nd year of operation, the David H. Koch School of Chemical Engineering Practice continues its legacy of promoting real-world problem solving and project management skills amongst Course X students. Although the products and industries of the 2017 stations varied, the core challenges were similar and enabled the students to connect their classroom lessons to very real industrial issues. The following details are from our station directors, who worked closely with students and industry hosts at each location.

SUMMER 2017 STATIONS

Corning Inc., Corning, New York
Directed by Douglas Harrison
Corning has a large research program in materials science, including glass science, ceramic science, and optical physics as well as significant expertise in engineering and manufacturing. Our four projects this term involved the production of new advanced glass products, the development of a methodology for the evaluation of improvements in the manufacturing process of one of Corning's flagship products, and a persistent and serious problem in one of the manufacturing processes for a Corning product.

GSK (Glaxo Smith Kline) Pharmaceuticals, Stevenage, England
Directed by Thomas Blacklock
At GSK, our teams were assigned the tasks of advancing two programs that GSK have been developing: predictive scaling methodologies for crystallizations, and algorithms to predict physical chemical properties of drug candidates, such as solubility, based on first principles. Successful applications of these tools promise enormous savings in time and resources.

Students from the EGA Dubai station pose in front of the Emirates Palace.

FALL 2017 STATIONS

Emirates Global Aluminium, Dubai, UAE
Directed by Brian Stutts
A progressive company, Emirates Global Aluminium (EGA) puts a particular focus on continuous improvement throughout the aluminum production process and, in particular, energy efficiency at their plant. We contributed to heat integration opportunities in not-yet-deployed processes for the new Al Taweelah refinery and process modeling to better understand opportunities to reduce emissions from EGA processes. In addition, real time improvements were identified to reduce downtime, improve process operation, and improve process control in a variety of operations throughout the smelting process.

Shell Technology Center, Houston, Texas
Directed by Robert Fisher
At the Shell Technology Center Houston (STCH), we have been enlightened as to the breadth of Shell's involvement in various aspects of the energy field and environmental concerns. Our projects focused on developing a more thorough understanding of conversion to a hydrogen economy; a proof-of-concept investigation into the ability to retrofit a chemical process plant and subsequently the design of a grassroots plant to eliminate the carbon footprint of that process; an electro-chemical analysis to validate potential performance enhancements of novel alternative solar energy collection systems; and a proof-of-concept investigation of how to improve a high-pressure hydrogen delivery system for transportation vehicles.

As you can see, our Practice School students continue to represent MIT ChemE well around the world as they demonstrate their versatility by making an immediate impact in a number of different industries. I look forward to continuing to share with you the ongoing experiences of the students and their projects in future newsletters.

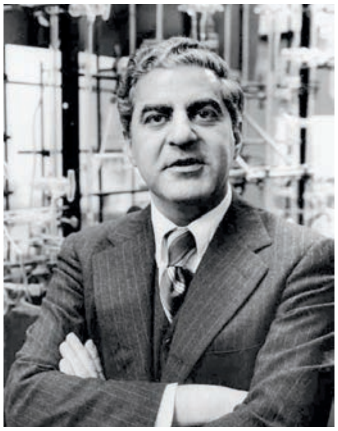
Best regards,

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

Remembering Raymond F. Baddour, professor emeritus of chemical engineering

A visionary educator and entrepreneur, Baddour was a pioneer in biotechnology and pharmaceutical research, and spearheaded the creation of Building 66.

Anne Trafton, MIT News Office



Baddour during his tenure as head of the Department of Chemical Engineering.

Raymond F. Baddour, the Lammot du Pont Professor Emeritus of Chemical Engineering at MIT, died peacefully at his home Dec. 15, 2017, surrounded by his family.

Baddour received a BS in chemical engineering from the University of Notre Dame. He received his SM in chemical engineering practice at MIT in 1949 and, upon earning his ScD from MIT in 1951, became an assistant professor in the department. He became a full professor in 1963 and founded MIT's Environmental Laboratory in 1970, becoming its first director. Baddour was head of the Department of Chemical Engineering from 1969 to 1976 and was awarded the Lammot du Pont Professorship in 1969.

While department head, Baddour put together and executed a visionary plan to expand the department's programs in energy and environmental engineering, bioengineering, and applied chemistry. He launched a bold and aggressive hiring initiative that broke with longstanding departmental traditions; now, 30 years later, Course 10 continues to see the positive impact of his vision.

The current home of the Department of Chemical Engineering is a physical example of Baddour's impact: In order to revitalize and address space concerns for new faculty and research programs, Baddour conceived of the plan to create the Ralph Landau Building (Building 66). He also raised funds for the building completely through private sources, an act that has not been duplicated at the Institute since.

"Professor Baddour has left a great legacy in the department that has touched on almost every aspect of the department's history and success," says Paula Hammond, the David H. Koch Professor in Engineering and current department head. "Ray was an institution and a real driver at the biotechnology and pharmaceutical interface when it was still very new in the field of chemical engineering. As a teacher, he will be remembered as an inspirational educator who imbued a generation of students with a passion for chemical engineering."

In 2014, Baddour made a generous gift to endow the Raymond F. Baddour (1949) Professorship in Chemical Engineering, established to support a distinguished faculty member in the department. Bernhardt Trout is the first and current recipient of the Baddour Professorship.

Baddour was also a role model for entrepreneurship: He started his first company in 1962, and in 1980 co-founded the biopharmaceutical company Amgen, serving as director until 1987. In addition, he was a co-founder of Ascent Pediatrics, MatTek Corp., BREH Partners, BREHK Inc., BLW Corp., Enterprise Management Corp., SKB Inc., Energy Resource Co., Abcor Inc., and Amicon Corp.

Baddour served as director at ActivBiotics Inc., Scully Signal Co., Hyseq Inc., Lam Research Corp., and the Raychem Corp. He was chairman of ERCO, AG. Baddour was a consultant to Oxbow Corp., Mobil Chemical Co., Freeport Minerals Co., Allied Chemical Co., Roger Milliken and Co., Loeb, Rhodes, and Co., LFE Corp., Stauffer Chemical Co., Hooker Chemicals Corp., Avco Research and Advanced Development, Celanese Corp., and Stone and Webster Engineering Corp.

Baddour leaves his wife of 62 years, Anne; daughter, Cynthia Baddour (Christopher Ryan) of Harvard, Massachusetts; son, Frederick Baddour of Palmetto Bay, Florida; daughter, Jean Nardi (Edward) of Concord, Massachusetts; and five grandchildren. X

Engineers create plants that glow

Illumination from nanobionic plants might one day replace some electrical lighting.

Anne Trafton, MIT News Office

Imagine that instead of switching on a lamp when it gets dark, you could read by the light of a glowing plant on your desk.

MIT engineers have taken a critical first step toward making that vision a reality. By embedding specialized nanoparticles into the leaves of a watercress plant, they induced the plants to give off dim light for nearly four hours. They believe that, with further optimization, such plants will one day be bright enough to illuminate a workspace.

"The vision is to make a plant that will function as a desk lamp — a lamp that you don't have to plug in. The light is ultimately powered by the energy metabolism of the plant itself," says Michael Strano, the Carbon P. Dubbs Professor of Chemical Engineering at MIT and the senior author of the study.

This technology could also be used to provide low-intensity indoor lighting, or to transform trees into self-powered streetlights, the researchers say.

MIT postdoc Seon-Yeong Kwak is the lead author of the study, which appears in the journal Nano Letters.

Nanobionic plants

Plant nanobionics, a new research area pioneered by Strano's lab, aims to give plants novel features by embedding them with different types of nanoparticles. The group's goal is to engineer plants to take over many of the functions now performed by electrical devices. The researchers have previously designed plants that can detect explosives and communicate that information to a smartphone, as well as plants that can monitor drought conditions.

Lighting, which accounts for about 20 percent of worldwide energy consumption, seemed like a logical next target. "Plants can self-repair, they have their own energy, and they are already adapted to the outdoor environment," Strano says. "We think this is an idea whose time has come. It's a perfect problem for plant nanobionics."

To create their glowing plants, the MIT team turned to luciferase, the enzyme that gives fireflies their glow. Luciferase acts on a molecule called luciferin, causing it to emit light.

Illumination of a book ("Paradise Lost," by John Milton) with the nanobionic light-emitting plants (two 3.5-week-old watercress plants). The book and the light-emitting watercress plants were placed in front of a reflective paper to increase the influence from the light emitting plants to the book pages. Image: Seon-Yeong Kwak

Another molecule called co-enzyme A helps the process along by removing a reaction byproduct that can inhibit luciferase activity.

The MIT team packaged each of these three components into a different type of nanoparticle carrier. The nanoparticles, which are all made of materials that the U.S. Food and Drug Administration classifies as "generally regarded as safe," help each component get to the right part of the plant. They also prevent the components from reaching concentrations that could be toxic to the plants.

The researchers used silica nanoparticles about 10 nanometers in diameter to carry luciferase, and they used slightly larger particles of the polymers PLGA and chitosan to carry luciferin and coenzyme A, respectively. To get the particles into plant leaves, the researchers first suspended the particles in a solution. Plants were immersed in the solution and then exposed to high pressure, allowing the particles to enter the leaves through tiny pores called stomata.

Particles releasing luciferin and coenzyme A were designed to accumulate in the extracellular space of the mesophyll, an inner layer of the leaf, while the smaller particles carrying luciferase enter the cells that make up the mesophyll. The PLGA particles gradually release luciferin, which then enters the plant cells, where luciferase performs the chemical reaction that makes luciferin glow.

The researchers' early efforts at the start of the project yielded plants that could glow for about 45 minutes, which they have since improved to 3.5 hours. The light generated by one 10-centimeter watercress seedling is currently about one-thousandth of the amount needed to read by, but the researchers believe they can boost the light emitted, as well as the duration of light, by further optimizing the concentration and release rates of the components. X

For more information, go to news.mit.edu

Faculty Highlights

Karthish Manthiram named one of Forbes 30 under 30 - Science
The annual list of up-and-coming innovators recognized Professor Karthish Manthiram for his research, which is "focused on providing farmers with fertilizer by manufacturing it out of thin air 'literally' by using air, water and solar power. Manthiram is also working to mitigate climate change by turning carbon dioxide into fuel and creating polymers that can capture carbon dioxide from the atmosphere."

Zachary Smith named ACS Petroleum Research Fund Doctoral New Investigator
The American Chemical Society's Doctoral New Investigator (DNI) grants provide start-up funding for scientists and engineers in the United States who are within the first three years of their first academic appointment at the level of Assistant Professor or the equivalent. The DNI grants are to be used to illustrate proof of principle or concept, to test a hypothesis, or to demonstrate feasibility of an approach. Smith's research focuses on the rational design, synthesis, and characterization of polymers and porous materials for clean technology applications related to energy-efficient separations.

János Beér and Bill Green named inaugural fellows of The Combustion Institute
Members of the international combustion community recognized by their peers as distinguished for outstanding contributions to combustion, whether it be in research or in applications, may be designated Fellows of The Combustion Institute. Fellows are active participants in The Combustion Institute, as evidenced by the publishing of papers in CI affiliated journals, attendance at the International Symposia on Combustion, and/or attendance at CI Section meetings. Beér and Green join the inaugural 2018 class of fellows.

Bob Langer tops Medicine Maker's 2018 Power List
Topping the "Masters of the Bench" category, Langer earned his place on the list for his contributions "to the life-changing, and often life-saving, work carried out by the biopharmaceutical industry."

Martin Bazant named a Fellow of the Royal Society of Chemistry
Achieving Fellow status in the chemical profession denotes to the wider community a high level of accomplishment as a professional chemist. Eligibility for Fellow status applies to applicants who must have made an outstanding contribution to the advancement of the chemical sciences; or to the advancement of the chemical sciences as a profession; or have been distinguished in the management of a chemical sciences organization.

Yuriy Román wins 2018 Robert Augustine Award
The Organics Reactions Catalysis Society has named Yuriy Román as the recipient of the 2018 Robert Augustine Award for his significant early career contributions to catalysis of organic reactions of industrial importance. Professor Román has been at MIT since 2010, and he has already made an impact in multiple areas of catalysis and analysis to better understand reaction mechanisms and characterize heterogeneous catalysts.

Klavs Jensen receives 2018 Corning International Prize for Outstanding Work in Continuous Flow Reactors
Professor Klavs Jensen has been awarded the inaugural Corning International Prize for Outstanding Work in Continuous-Flow Reactors and Chemistry for

a Greener and Safer World. Corning presented the award to Jensen at the eighth annual Corning Reactor Technology Conference in Changzhou, China on March 29.

"No laboratory in the world has done as much to understand and progress advanced-flow reactor (AFR) technology for chemical transformation than the Jensen lab at MIT," said Yi Jiang, business director, Global Advanced-Flow Reactors, and innovation officer, Corning Greater China. "Professor Jensen and team's original engineering research on continuous-flow reactors and flow chemistry has provided critical direction to the entire global field. In the process, they introduced a new generation of researchers and scientists to this disruptive technology."

Klavs Jensen wins 2018 John Prausnitz AIChE Institute Lecturer Award

Each year, AIChE invites a distinguished member of AIChE to present the John Prausnitz Institute Lecture, a comprehensive authoritative review of the chemical engineering science in his or her field of specialization. Jensen has been recognized with this honor for the 2018 Annual Meeting. Prior to 2016 the John M. Prausnitz AIChE Institute Lecturer Award was named the Institute Lecturer Award.

Arup Chakraborty awarded Guggenheim Fellowship

Appointed on the basis of prior achievement and exceptional promise, the successful candidates were chosen from a group of almost 3,000 applicants in the Foundation's ninety-fourth competition. Chakraborty was chosen based on his "work that brings together approaches from different disciplines to understand diverse basic phenomena and harnessing that knowledge toward practical ends." Since 2000, Chakraborty's work has focused on bringing together immunology and the physical and engineering sciences; more specifically, the intersection of statistical mechanics and immunology. His interests span T cell signaling, T cell development and repertoire, and a mechanistic understanding of HIV evolution, antibody evolution, and vaccine design.

Heather Kulik receives 2018 ONR Young Investigator Award

The Office of Naval Research (ONR) Young Investigator Award identifies and supports academic scientists and engineers who are in their first or second full-time tenure-track or tenure-track-equivalent academic appointment and who show exceptional promise for doing creative research. The program's objectives are to attract outstanding faculty members of Institutions of Higher Education (hereafter also called "universities") to the Department of Navy's (DoN's) research program, to support their research, and to encourage their teaching and research careers. Kulik's research, "Adaptive-Resolution Chemical Discovery Strategies for Precise and Fast Computer-Aided Transition Metal Complex Design," was one of the projects chosen for 2018.

Heather Kulik earns ACS OpenEye Outstanding Junior Faculty Award

The American Chemical Society Division of Computers in Chemistry has named Heather Kulik as a winner of the Spring 2018 OpenEye Outstanding Junior Faculty Award in Computational Chemistry. This award goes to outstanding tenure-track junior faculty members to present their work in the COMP poster session at the ACS National Meeting. The Awards are designed to assist new faculty members in gaining visibility within the COMP community. Selection criteria includes the novelty and importance of the work to be presented, CV of the applicant, as well as the level of departmental support as indicated by the applicant's department chair. X

Research Highlights

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

Hammond's nanoparticles can shrink glioblastoma tumors

Glioblastoma multiforme, a type of brain tumor, is one of the most difficult-to-treat cancers. Only a handful of drugs are approved to treat glioblastoma, and the median life expectancy for patients diagnosed with the disease is less than 15 months. MIT researchers have now devised a new drug-delivering nanoparticle that could offer a better way to treat glioblastoma. The particles, which carry two different drugs, are designed so that they can easily cross the blood-brain barrier and bind directly to tumor cells. One drug damages tumor cells' DNA, while the other interferes with the systems cells normally used to repair such damage.

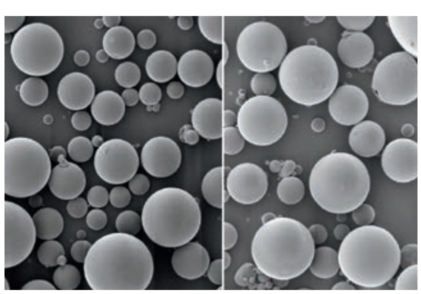
"What is unique here is we are not only able to use this mechanism to get across the blood-brain barrier and target tumors very effectively, we are using it to deliver this unique drug combination," says Paula Hammond, a David H. Koch Professor in Engineering, the head of MIT's Department of Chemical Engineering, and a member of MIT's Koch Institute for Integrative Cancer Research.

MIT researchers have designed brain-tumor-targeting nanoparticles that can carry two different drugs, one in the core and one in the outer shell.

Langer Lab develops single-injection vaccine for the polio virus

A new nanoparticle vaccine developed by MIT researchers could assist efforts to eradicate polio worldwide. The vaccine, which delivers multiple doses in just one injection, could make it easier to immunize children in remote regions of Pakistan and other countries where the disease is still found. While the number of reported cases of polio dropped by 99 percent worldwide between 1988 and 2013, according to the Centers for Disease Control, the disease has not been completely eradicated, in part because of the difficulty in reaching children in remote areas to give them the two to four polio vaccine injections required to build up immunity.

"We are very excited about the approaches and results in this paper, which I hope will someday lead to better vaccines for patients around the world," Langer says.

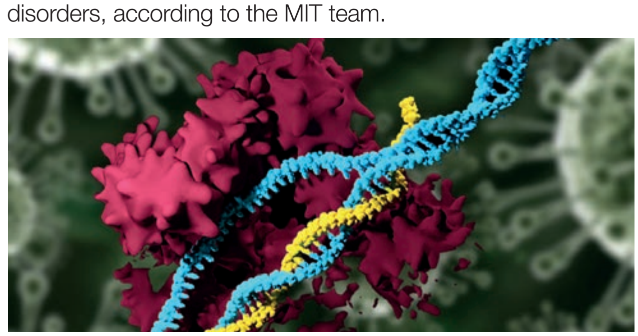


MIT researchers developed these polymer microspheres containing polio vaccine that can be released in two separate bursts.

The Anderson Lab's CRISPR-carrying nanoparticles edit the genome

In a new study, MIT researchers have developed nanoparticles that can deliver the CRISPR genome-editing system and specifically modify genes in mice. The team used nanoparticles to carry the CRISPR components, eliminating the need to use viruses for delivery. Using the new delivery technique, the researchers were able to cut out certain genes in about 80 percent of liver cells, the best success rate ever achieved with CRISPR in adult animals.

"What's really exciting here is that we've shown you can make a nanoparticle that can be used to permanently and specifically edit the DNA in the liver of an adult animal," says Anderson. One of the genes targeted in this study, known as Pcsk9, regulates cholesterol levels. Mutations in the human version of the gene are associated with a rare disorder called dominant familial hypercholesterolemia, and the FDA recently approved two antibody drugs that inhibit Pcsk9. However these antibodies need to be taken regularly, and for the rest of the patient's life, to provide therapy. The new nanoparticles permanently edit the gene following a single treatment, and the technique also offers promise for treating other liver disorders, according to the MIT team.



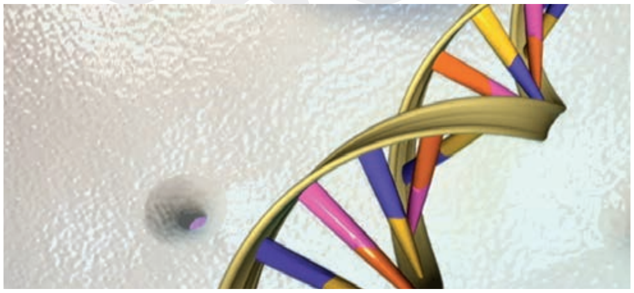
In a new study, MIT researchers have developed nanoparticles that can deliver the CRISPR genome-editing system and specifically modify genes, eliminating the need to use viruses for delivery.

The Doyle Lab discovers how to control knots that form in DNA molecules

Just like any long polymer chain, DNA tends to form knots. Using technology that allows them to stretch DNA molecules and image the behavior of these knots, MIT researchers have discovered, for the first time, the factors that determine whether a knot moves along the strand or “jams” in place.

“People who study polymer physics have suggested that knots might be able to jam, but there haven’t been good model systems to test it,” says Doyle, “We showed the same knot could go from being jammed to being mobile along the same molecule. You change conditions and it suddenly stops, and then change them again and it suddenly moves.”

The findings could help researchers develop ways to untie DNA knots, which would help improve the accuracy of some genome sequencing technologies, or to promote knot formation. Inducing knot formation could enhance some types of sequencing by slowing down the DNA molecules’ passage through the system, the researchers say.



MIT researchers developed these polymer microspheres containing polio vaccine that can be released in two separate bursts.

Strano Lab technology can harness external temperature to produce electricity

Thermoelectric devices, which can generate power when one side of the device is a different temperature from the other, have been the subject of much research in recent years. Now, a team at MIT has come up with a novel way to convert temperature fluctuations into electrical power. Instead of requiring two different temperature inputs at the same time, the new system takes advantage of the swings in ambient temperature that occur during the day-night cycle.

The new system, called a thermal resonator, could enable continuous, years-long operation of remote sensing systems, for example, without requiring other power sources or batteries, the researchers say. The findings are being reported in the journal Nature Communications, in a paper by graduate student Anton Cottrill, Carbon P. Dubbs Professor of Chemical Engineering Michael Strano, and seven others in MIT’s Department of Chemical Engineering.

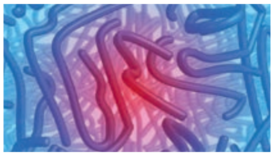
“We basically invented this concept out of whole cloth,” Strano says. “We’ve built the first thermal resonator. It’s something that can sit on a desk and generate energy out of what seems like nothing. We are surrounded by temperature fluctuations of all different frequencies all of the time. These are an untapped source of energy.”

The team’s test device, which has been deployed on the roof of an MIT building for several months, was used to prove the principle behind their new energy-harvesting concept. The test device is the black box at right, behind a weather-monitoring system (white) and a set of test equipment to monitor the device’s performance (larger black case at left).

Karen Gleason and colleagues turn plastic insulator into heat conductor

Plastics are excellent insulators, meaning they can efficiently trap heat — a quality that can be an advantage in something like a coffee cup sleeve. But this insulating property is less desirable in products such as plastic casings for laptops and mobile phones, which can overheat, in part because the coverings trap the heat that the devices produce.

Now a team of engineers at MIT has developed a polymer thermal conductor — a plastic material that, however counterintuitively, works as a heat conductor, dissipating heat rather than insulating it. The new polymers, which are lightweight and flexible, can conduct 10 times as much heat as most commercially used polymers. X



Engineers at MIT have developed a polymer thermal conductor — a plastic material that, however counterintuitively, works as a heat conductor, dissipating heat rather than insulating it.

The MIT team developed tiny devices that can be implanted into the brain to deliver drugs. They can be used to deliver tiny doses of one or more drugs

Ultrathin needle can deliver drugs directly to the brain

Anne Trafton, MIT News Office

MIT researchers have devised a miniaturized system that can deliver tiny quantities of medicine to brain regions as small as 1 cubic millimeter. This type of targeted dosing could make it possible to treat diseases that affect very specific brain circuits, without interfering with the normal function of the rest of the brain, the researchers say.

Using this device, which consists of several tubes contained within a needle about as thin as a human hair, the researchers can deliver one or more drugs deep within the brain, with very precise control over how much drug is given and where it goes. In a study of rats, they found that they could deliver targeted doses of a drug that affects the animals' motor function.

"We can infuse very small amounts of multiple drugs compared to what we can do intravenously or orally, and also manipulate behavioral changes through drug infusion," says Canan Dagdeviren, the LG Electronics Career Development Assistant Professor of Media Arts and Sciences and the lead author of the paper, which appears in the Jan. 24 issue of Science Translational Medicine.

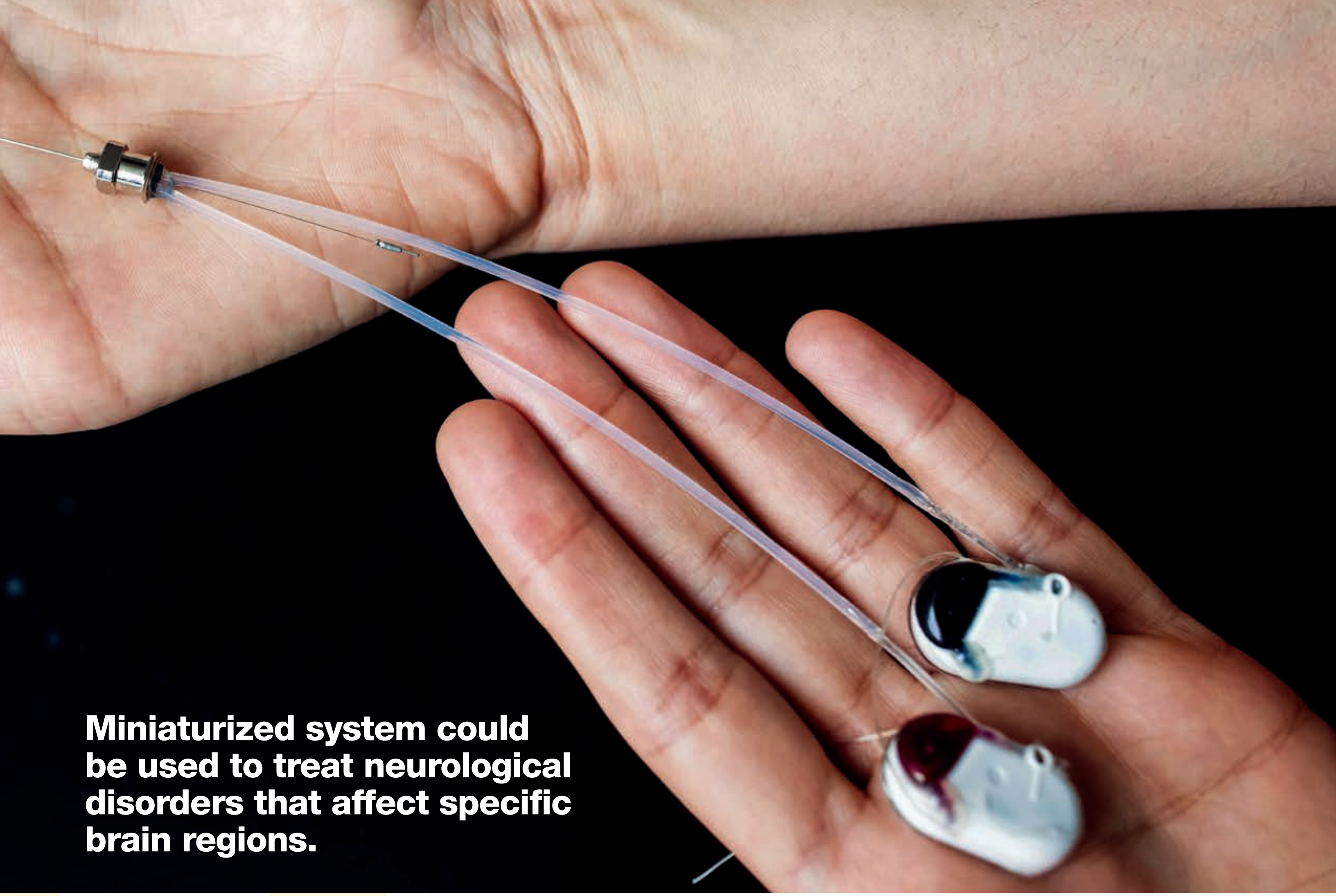
"We believe this tiny microfabricated device could have tremendous impact in understanding brain diseases, as well as providing new ways of delivering biopharmaceuticals and performing biosensing in the brain," says Robert Langer, the David H. Koch Institute Professor at MIT and one of the paper's senior authors.

Michael Cima, the David H. Koch Professor of Engineering in the Department of Materials Science and Engineering and a member of MIT's Koch Institute for Integrative Cancer Research, is also a senior author of the paper.

Targeted action

Drugs used to treat brain disorders often interact with brain chemicals called neurotransmitters or the cell receptors that interact with neurotransmitters. Examples include l-dopa, a dopamine precursor used to treat Parkinson's disease, and Prozac, used to boost serotonin levels in patients with depression. However, these drugs can have side effects because they act throughout the brain.

"One of the problems with central nervous system drugs is that they're not specific, and if you're taking them orally they go everywhere. The only way we can limit the exposure is to just deliver to a cubic millimeter of the brain, and in order to do that, you have to have extremely small cannulas," Cima says.



Miniaturized system could be used to treat neurological disorders that affect specific brain regions.

The MIT team set out to develop a miniaturized cannula (a thin tube used to deliver medicine) that could target very small areas. Using microfabrication techniques, the researchers constructed tubes with diameters of about 30 micrometers and lengths up to 10 centimeters. These tubes are contained within a stainless steel needle with a diameter of about 150 microns. "The device is very stable and robust, and you can place it anywhere that you are interested," Dagdeviren says.

The researchers connected the cannulas to small pumps that can be implanted under the skin. Using these pumps, the researchers showed that they could deliver tiny doses (hundreds of nanoliters) into the brains of rats. In one experiment, they delivered a drug called muscimol to a brain region called the substantia nigra, which is located deep within the brain and helps to control movement.

Previous studies have shown that muscimol induces symptoms similar to those seen in Parkinson's disease. The researchers were able to generate those effects, which include stimulating the rats to continually turn in a clockwise direction, using their miniaturized delivery needle. They also showed that they could halt the Parkinsonian behavior by delivering a dose of saline through a different channel, to wash the drug away.

"Since the device can be customizable, in the future we can have different channels for different chemicals, or for light, to target tumors or neurological disorders such as Parkinson's disease or Alzheimer's," Dagdeviren says.

This device could also make it easier to deliver potential new treatments for behavioral neurological disorders such as addiction or obsessive compulsive disorder, which may be caused by specific disruptions in how different parts of the brain communicate with each other.

"Even if scientists and clinicians can identify a therapeutic molecule to treat neural disorders, there remains the formidable problem of how to deliver the therapy to the right cells — those most affected in the disorder. Because the brain is so structurally complex, new accurate ways to deliver drugs or related therapeutic agents locally are urgently needed," says Ann Graybiel, an MIT Institute Professor and a member of MIT's McGovern Institute for Brain Research, who is also an author of the paper. X

For more information, go to
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A Correction and Special Thank You for Your Support

Each fall/winter edition of XCurrents includes an honor roll of individuals who have given over $100 to the Department during the previous academic year. Due to a data collection error, some of our supporters for the 2016-2017 year were not included in the most recent XCurrents edition.

We have included the names of those inadvertently omitted from the previous list. We are deeply grateful for every gift, which directly supports our mission to provide the best research and academic resources for our students and faculty. A full correct version of our honor roll is online at https://cheme.mit.edu/thank-you-for-your-support/.

The fall/winter 2018 XCurrents will include an honor roll of supporters from the 2017-2018 academic year. Thank you to everyone who has supported us throughout the year!

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Chemical Engineering Undergraduates' Prize-Winning Work Also Helps Solve Real-World Problems

On May, 15, 2018, Course X undergraduates gathered to take part in the first annual 10.26/27/29 student competition, a culmination of semester-long project work that addressed real problems.

The projects included continuous flow optimization, improving the efficiency of aluminum-based fuel, working to create an electronic sticker that can harvest energy from human sweat, the stability of the next generation of LEDS, enhancing lithium ion batteries, and a better way to clean up oil spills.

The 10.26/27/29 experience is truly hands-on, and encompasses the full industry experience. Divided into teams of three or four, the students not only addressed these real-world challenges through their own experiments, but engaged in proposal writing, group work and presentations, and defenses of their findings.

The final competition was a lively debate among the students, faculty, and sponsors. Faculty members judged the final presentations, and the full winners are listed below.

1st place:
Team 1: Corning Advanced Flow Laboratory Molecule Maker: Continuous Flow Optimization
Students: John Deely, Isabel Kaspriskie, Rafid Mollah
Advisor: Klavs Jensen
TA: Arie Havasov

2nd place:
Team 7: Thermal Transport in Lithium Ion Battery Electrodes
Students: Stephon Henry-Rerrie, Ethan McGarrigle, Andy Rodriguez
Advisor: Will Tisdale
TA: SK Ha

3rd place:
Team 5: The Electronic Sticker: Skin-Conformable 2D Material Electrical Power Generator for Energy Harvesting from Human Sweat
Students: Allison Shepard, Nancy Wang, Geneva Werner
Advisor: Michael Strano
TA: Bridget Derksen

Alumni Highlights

Gerald Lessells ’50 has boosted AIChE’s **Henry Brown SM ’56** Scholarship endowment with a major gift. To build the endowment for the Henry T. Brown Endowment for the Education of Under-Represented Minority Chemical Engineers, Lessells, who collaborated with Brown on AIChE’s earliest minority outreach activities, has made a challenge gift and will match others’ donations to the fund up to $50,000.

Beginning in the 1960s, Brown and Lessells worked together to raise the profile of minority engineers in the Institute and the chemical engineering profession. Lessells is a past director and 65-year member of AIChE. His career in the chemical process industries included many years as Technical Director for the Printing Ink Div. of J. M. Huber Corp. He is a life member of the NAACP, and has held officer positions in AIChE’s Central Illinois and New Jersey local sections. He has also received AIChE’s Service to Society Award and Van Antwerpen Award for Service to the Institute.

Leslye Miller Fraser ’78 SM ’80 has been elected to the MIT Corporation, effective July 1, 2018. Fraser, a retired environmental appeals judge for the U.S. Environmental Protection Agency, earned her bachelor’s and master’s degrees in chemical engineering from MIT and a JD from the University of California at Los Angeles School of Law in 1992. Upon graduating, she worked nine years at an aerospace company before attending law school. She joined the Environmental Protection Agency in 1995 as a staff attorney and in 2011 was promoted to associate director for regulations at the U.S. Food and Drug Administration, where she worked in many positions over the years. Currently, she serves as national president for the African American Federal Executive Association, a nonprofit organization dedicated to advancing African Americans into senior roles of the U.S. government, and serves as national co-chair of the STEM Committee for The Links, a non-profit women’s community service organization. She is also a charter member of the National Society of Black Engineers (1975) and Alpha Kappa Alpha Sorority (1977), the first sorority at MIT.

Joe F. Moore ’52 has been named to the Chickasaw Nation Hall of Fame, a high honor bestowed upon Chickasaw citizens who have distinguished themselves through outstanding contributions to the Chickasaw Nation and their communities. Moore had a long career in the oil, gas and computing business that began as a consulting company and grew into a worldwide enterprise. Moore’s company improved efficiency and computer modeling of oil refining operations, marking a significant achievement. He was a founding member of the President’s Circle of the National Academies of Science, Engineering and Medicine. Throughout his life, Moore contributed his time and service to his church by working in various roles and leadership positions. He continues to serve today. He has been an active citizen in the local community, serving on various management boards.

Winnette McIntosh Ambrose ’98 has become a double Food Network champion. Only 10 weeks into opening a high-end bakery in 2011, McIntosh Ambrose entered and won Cupcake Wars. In January 2018, she returned to the Food Network to show her skills on Chopped, the show that requires chefs to make a three-course meal using unexpected and often bizarre mystery ingredients—like goat brains or mashed potato candy. McIntosh Ambrose won the baking round of the Chopped Gold Medal Games on Jan. 23 and competed in the grand finals, making it to the second round. “Chopped is everything that it appears to be on TV and then some,” says McIntosh Ambrose. “It is high stress, super intense, the time limitations are just crazy, and you will be pushed to work with some really wild things. The competition is real—I mean you go up against people with some real culinary chops. It is not something to be underestimated.”

Louis Fouché ’07 is a musician and saxophonist for The Late Show with Stephen Colbert. He joined the show in 2017 and has a solo album that has reached number one in jazz on Amazon. Fouché credits MIT with helping push him toward success. “Working at the show is electrifying—it’s amazing to watch the mastery of Stephen Colbert,” Fouché says. “And I’m thankful for MIT. My mind works differently than it would had I gone anywhere else.”

Kyra Sedransk Campbell ’08 has won IChem’s Nicklin Medal. The Nicklin Medal is an early careers award designed to recognize talented chemical engineering researchers. It is named after Don Nicklin, long-standing Head of Chemical Engineering at Queensland University who was renowned for supporting up-and-coming researchers. Sedransk Campbell received the medal for being an “outstanding young researcher and role model who would bring great credit and profile to the Nicklin Medal.” Sedransk Campbell is currently a Royal Society - EPSRC Dorothy Hodgkin Research Fellow at Imperial College London. She received her PhD from the University of Cambridge under the supervision of Professor Geoff Moggridge and was sponsored by the National Science Foundation (USA) Graduate Research Fellowship.

Steven Little PhD ’05 has won the Controlled Release Society 2018 Young Investigator Award. The honor annually recognizes one individual in the world, 40 years of age or younger, for outstanding contributions in the science of controlled release. Little is the William Kepler Whiteford Endowed Professor and Chair of the Department of Chemical and Petroleum Engineering at Pitt’s Swanson School of Engineering. Little focuses on novel drug delivery systems that mimic the body’s own mechanisms of healing and resolving inflammation. This allows for dosages that are millions of times smaller than current medicine, and his next-generation treatments have shown promise for addressing a number of conditions including glaucoma, periodontal disease, wound healing, cancer, skin allergic dermatitis, and even transplantation of tissues and limbs.

June Park ’16 has been named a 2018 Gates Cambridge Scholar. She will pursue an advanced degree in engineering in the fall at Cambridge University in the U.K. She is currently an associate consultant at Putnam Associates, where she helps generate and deliver strategic recommendations for global biopharmaceutical and biotechnology companies. Park will attend Cambridge University to earn a PhD in bioengineering, and will be working to develop a biomimetic, 3-D-printable scaffold for the development of lung stem cell-derived artificial trachea and organoids. The successful development of an artificial trachea using the synthetic scaffold and patient stem cells may transform the treatment of tracheal injuries and diseases, significantly improving the survival and post-treatment quality of life for millions of patients.

In Memoriam
John D. Helferich ’79 SM ’11
1957-2018

Mr. John D. Helferich, a longtime resident of Rockport, Mass., and beloved husband of Lynn M. (Furey) Helferich, passed away in Washington, D.C., on Friday, April 27, 2018. He was 61 years old.

Born in Cincinnati, Ohio, on February 15, 1957, he was the beloved son of the late Howard E. and Virginia F. (Jones) Helferich. Mr. Helferich earned both his undergraduate and master’s degrees from MIT, and was near completion of his Ph.D. from MIT. John worked for many years in research and technology at Procter & Gamble Corporation, Ocean Spray Cranberries, and Mars, Inc. He had recently been employed as a consultant and was co-founder and co-proprietor of the recently opened Oak & Iron Brewery in Andover, Mass.

Throughout his lifetime, Mr. Helferich was committed to pursuing further education for himself, and enabling many others the same opportunity. He was extremely outgoing and his exuberant and affable nature was enjoyed by everyone he knew. A generous spirit, Mr. Helferich freely shared both time and resources with family, fellow students, veterans of the military, and many departments at MIT. He was a brilliant man who continually explored interests as diverse as food safety, history, theater, genealogy and woodworking. He infused fun and spontaneity into all his efforts, and his warm humor and open heart will be dearly missed. X

Blast from the Past

Party Time! The TG is a time-honored tradition for the Course X graduate community. Do you see yourself in these photos from the 90s?

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

In Memoriam

P.L. Thibaut Brian 1930-2018

Pierre Leonc Thibaut Brian, professor emeritus in the Department of Chemical Engineering, died on April 2 at age 87.

Born in New Orleans, Louisiana, on July 8, 1930, Brian received a BS in chemical engineering from Louisiana State University in 1951. He earned his ScD in chemical engineering from MIT in 1956, supervised by Professor Edwin R. Gilliland. Upon graduation, he immediately joined the faculty of the Department of Chemical Engineering as director of the Bangor Station of the Chemical Engineering Practice School. As a professor, Brian's research focused largely on mass and heat transfer with simultaneous chemical reaction. He was an early adopter of computers in chemical engineering and contributed to the associated opportunities in process control and numerical analysis.

"Thibaut was well known for many qualities but two may head the list: high energy and quickness of insight. He projected enormous energy and worked extremely hard — and this made him a captivating teacher," says Ken Smith, the Gilliland Professor Emeritus of Chemical Engineering. "When Thibaut was presented with a complex, ill-defined problem, he would almost instantly understand what the essential elements really were and how one should go about attacking it."

In 1972, Brian retired from MIT and joined Air Products as vice president of engineering, where he remained until 1994. Brian's early contributions at Air Products were mainly of a technical sort, largely in the context of air separation. Later, he became a very effective advocate for enhanced safety in the chemical process industry and particularly for sophisticated quantitative hazard analyses as a means of assessing risks. As a result of his efforts, Air Products' safety record became one of the best in the industry and other companies emulated their procedures.

Brian was an active member and director of the American Institute of Chemical Engineers; he received its Professional Progress in Chemical Engineering Award in 1973 and its R.L. Jacks Award (now re-named the Management Award) in 1989. Churchill College of Cambridge in the United Kingdom elected him to the position of Overseas Fellow, and hosted him for a sabbatical year. Brian was a member of the Chemical Industry Institute of Toxicology and the American Industrial Health Council. He was elected to the National Academy of Engineering in 1975 for his "contributions to both theory and engineering practice of desalination, mass transfer in chemically reactive systems, and the technology of liquefied gases." Brian was elected to foreign membership in the Royal Academy of Engineering (UK) in 1991. In 1972, he authored the book, "Staged Cascades in Chemical Processing."

Predeceased in 2016 by his wife of 64 years, Geraldine 'Gerry,' he is survived by his son Richard and daughter-in-law Susan; his son James and daughter-in-law Sheryl; his daughter, Evelyn 'Evie'; his grandchildren, Richard Christopher Brian and Lauren Brian Spears; and by his great grandson, Olin Thomas Spears. Condolences may be made to brownandsonsfuneral.com. X

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We hope to see you this fall!
Save the date:

Friday, October 26, 2018: 33rd Annual Hoyt C. Hottel Lecture – Steven Chu, William R. Kenan Jr. Professor and Professor of Molecular and Cellular Physiology, Stanford University

Friday, December 7, 2018: 16th Annual Daniel I.C. Wang Lecture on the Frontiers of Biotechnology – David Mooney, Robert P. Pinkas Family Professor of Bioengineering, Harvard University

Monday, October 29, 2018: MIT Reception at the Annual AIChE Meeting in Pittsburgh, PA

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