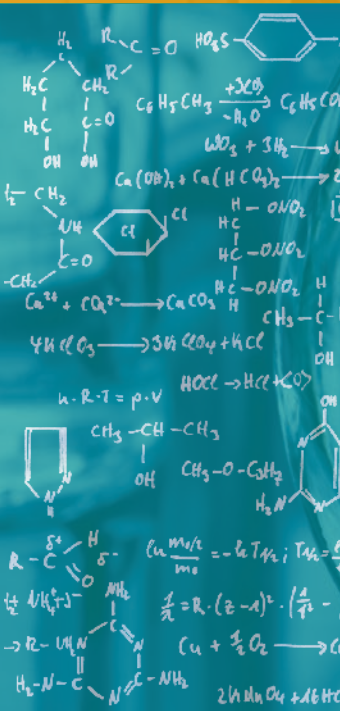


Massachusetts Institute of Technology

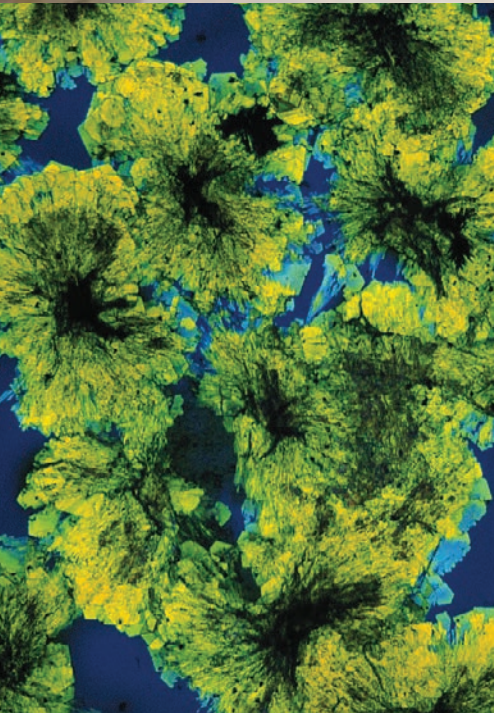
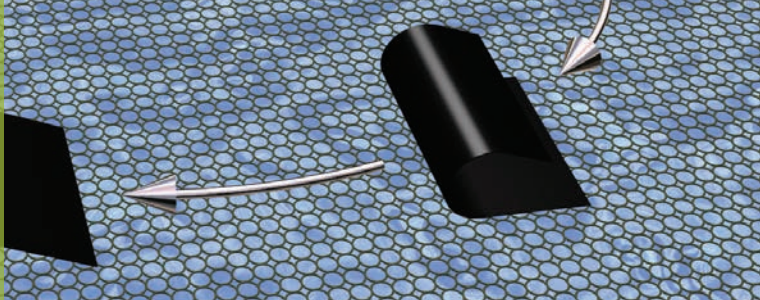
Department of Chemical Engineering

Graduate Studies



*“Chemical engineering prepares you for solving big picture problems while still being aware of what’s happening on the molecular scale.”*

Paula Hammond  
David H. Koch Professor in Engineering



# Why come to MIT ChemE?

The world today faces many challenges. Even when it comes to our most basic needs – from the foods we eat to the medicines we take, the clothes we wear, and the energy we use – the world is ready and waiting for new ideas.

And chemical engineers are uniquely prepared not only to come up with new ideas, but also to turn them into real solutions.

Chemical Engineers solve problems at the most fundamental levels. And at MIT, chemical engineers are solving a wide range of problems with great depth. As one of the largest chemical engineering departments in the country, MIT chemical engineering has 35 professors with expertise in energy and sustainability, materials, polymers, biotechnology and manufacturing. Each of our labs runs multiple well-funded research projects giving our graduate students incomparable opportunities to immerse themselves in the research programs they are most interested in.

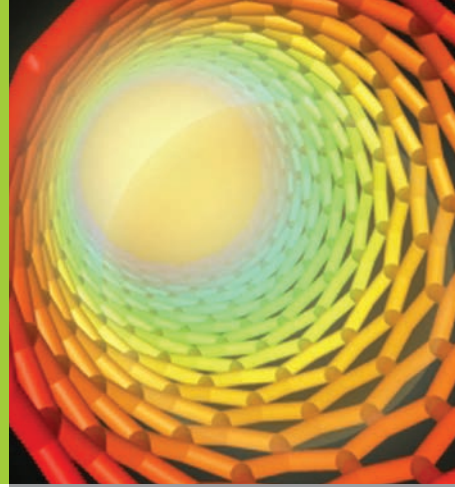
At MIT, you may end up with an advisor who is a legend. You may end up working with a young innovator. Or more likely, someone who is a little bit of both.

No matter which path you follow, MIT chemical engineering will give you ample time and the financial support to make the right choice. Whether your dream is to work in academia, industry or to create your own company, MIT chemical engineering has the people, the resources and the path to get you there.

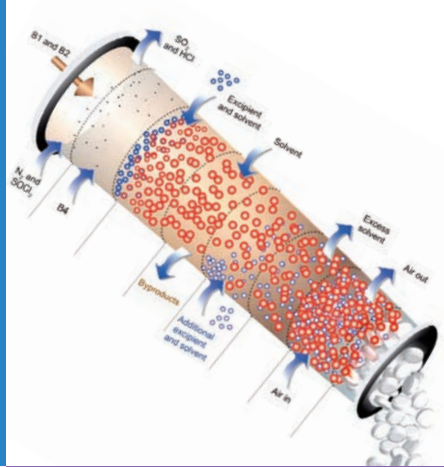
## Want to learn more?

Turn the pages and explore our world of chemical engineering.  
MIT Chemical Engineering. We put molecules to work.

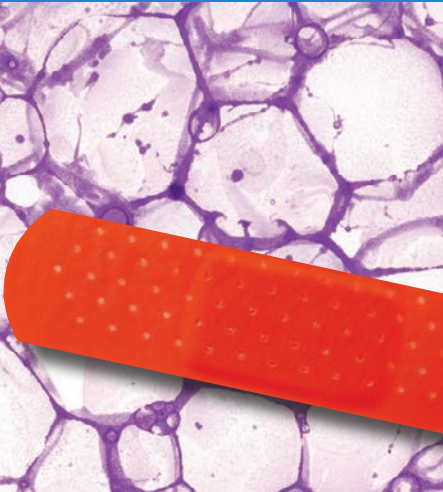
# Types of Research



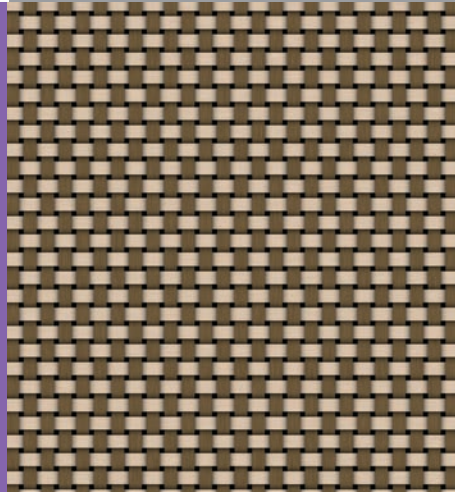
Go with the flow. The Novartis-MIT Center for Continuous Manufacturing is creating a continuous manufacturing process for pharmaceuticals. Key to the continuous system is the development of chemical reactions that can take place as the reactants flow through tubes, as opposed to the huge vats in which most pharmaceutical reactions now take place.



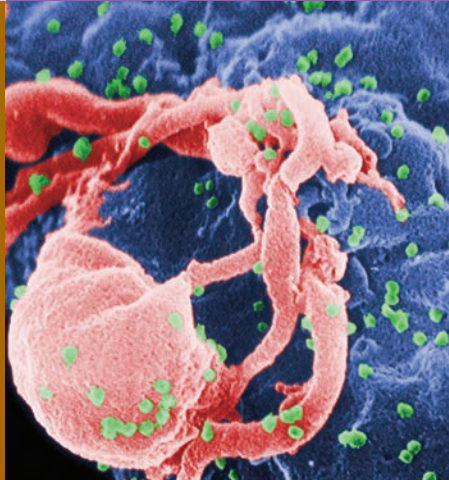
Live wire. Professor Michael Strano discovered a previously unknown phenomenon that can cause powerful waves of energy to shoot through minuscule wires known as carbon nanotubes. The discovery could lead to a new way of producing electricity.



Wound, heal thyself. Assistant professor Bradley Olsen is developing smart bandages that stop bleeding instantly and use bio-inspired materials that help the body heal itself.



Understanding HIV. MIT chemical engineers have made breakthroughs in the study of the HIV virus. Novel monitoring techniques for cell response to HIV and the new identification of some of the virus's vulnerabilities could help AIDS researchers develop new vaccines.



Nature's chemical factory. Associate professor Kristala Prather is turning single-celled organisms into miniature chemical plants by embedding multiple enzymatic pathways inside the bacteria cell walls.



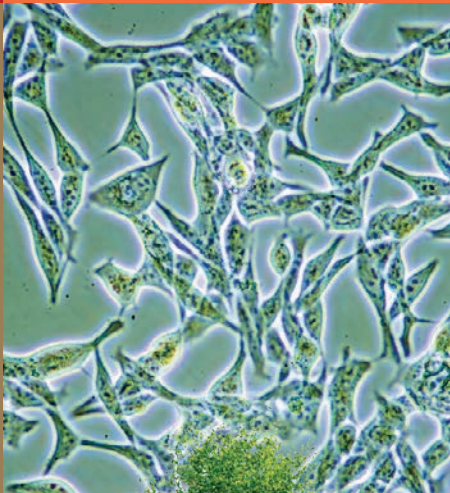
Plastics. Chemical engineers are finding ways to harvest biodegradable plastics from bacterial strains that store excess energy in the form of polymers instead of fats.



"The future is bright for chemical engineers. Think about the world today. We need to feed and clothe billions of people, we have to find new energy sources, and we want to help people live longer and healthier. These are all things chemical engineers are involved in. Molecular interactions are the root of everything. In chemical engineering, we teach our students to translate these molecular interactions into everyday – and not so everyday – products and processes. As a result, they go off in many directions, creating and improving pharmaceuticals, fuels, polymers, plastics, cosmetics, cereals and more."

**Klavs Jensen**, Department Head and Warren K. Lewis Professor of Chemical Engineering  
*On Being a Chemical Engineer*

Wear your Metabolism on Your Sleeve. MIT chemical engineering professors are developing tattoos made of fluorescent, glucose-detecting nanoparticles that may soon help diabetics monitor blood-sugar levels.



Cancer-seeking Missiles. Institute professor Robert Langer's lab helped create drug-carrying nanoparticles designed to specifically seek out prostate tumor cells and destroy them.

Wrap it Up. Novel plastic bags, envisioned by professor Paula Hammond, may help preserve the casava harvest in Africa by blocking out oxygen, a food spoiler, and consuming the oxygen already inside the bag.

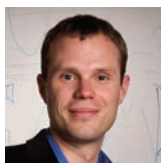


DIY Energy. Think like a chemical engineer and imagine a world with self-powered iPads, spray-on virus-based batteries, and self-healing solar cells.

# Cutting-Edge Research



## Bradley Olsen Associate Professor of Chemical Engineering Injectable Implants



The idea of an implant that slowly releases drugs only in tissues that need them used to be science fiction until chemical engineers – many of them at MIT – devised novel drug-releasing materials. Now, Bradley Olsen imagines turning these devices, which in many cases must be surgically implanted to reach the diseased tissues, into injectables. “Getting these implants would be like getting a shot instead of surgery,” says Olsen, which is not only safer for the patient, it saves in terms of medical costs. “It’s huge in terms of patient care.”

The key, says Olsen, is in how you make the implant. His research focuses on developing new hydrogels, gels that have a flexibility that resembles human tissues and that are already used in biomedical devices such as contact lenses and tissue engineering scaffolds. While hydrogels retain some of their key properties after injection, they don’t live up to clinical demands yet. “You have to be very careful about the hydrogel,” says Olsen. “The cool thing is that with new biotechnology tools, we are starting to make the gels out of the same components that people are made out of. So as the research advances, the injectable implant will behave more and more like natural tissue.”

## Yuriy Román Assistant Professor of Chemical Engineering Catalyzing Greener Products



With a changing climate and shifting fossil fuel economics, there’s a burning need to change the way the world makes and uses catalysts: the materials that induce or accelerate chemical reactions and are often the key to making chemical processes industrially viable. The drive to use plants rather than fossil fuels as feedstock means the catalytic materials used to process petrochemicals need to be adapted — or entirely new ones developed — to work with biomass.

Roman’s lab is working on the catalytic conversion of the inedible parts of plant matter, such as cellulose and lignin, into chemicals useful for making fuels and substances like plastics, adhesives, lubricants, detergents, fertilizer, and pharmaceuticals. Cutting-edge catalysis research requires tools and skills from a range of disciplines, including spectroscopy, materials design, and computational modeling. “Boundaries between the different fields are really fading, and I think this is something that’s really important to embrace,” says Román. “This is something that I feel is very specific to MIT, in that the barriers to interact with people from different departments are low,” he says. “As we start working at the interfaces of fields, we should begin to see new game-changing discoveries.”

*“In many ways MIT was the birthplace of the discipline of chemical engineering,” says Bernat Olle PhD ‘05, “And still today the department continues to set the standard for the discipline and lead the way in opening new research directions for the field.”*



## Areas of Focus:

- New energy technologies, including photovoltaics, fuel cells, biofuel refinement, and gas to liquid transformations.
- Biotechnology for therapeutics and biofuels.
- Biomedical devices and methods including cancer and AIDS research.
- New approaches to pharmaceutical manufacturing.
- Materials for electronic, optical, medical, and energy-conversion devices.
- Process design and control for chemical, energy-conversion and materials processes.

Sean Hunt, Current PhD Student

### Graduate Research: Making the Unsustainable Abundant



When one considers nonrenewable resources, the first to come to mind are fossil fuels: petroleum, coal, and natural gas. The rapid depletion of these unsustainable resources has sparked global research on renewable-energy technologies, such as fuel cells, electrolyzers, and lithium-air batteries.

Unfortunately there is a common unsustainable thread that links these burgeoning technologies: a dependence on platinum-group metals (PGMs): platinum, palladium, rhodium, iridium, ruthenium, and osmium. These are the most stable and active catalysts, but also the six least-abundant metals on the planet. Thus they're unsustainable resources that are currently needed to enable renewable energy technologies.

Sean Hunt got an idea: "Rather than finding new materials to replace PGMs in specific reactions, is it possible to modify [more abundant] metals to catalytically mimic the PGMs?"

Hunt has created a special ceramic coating method to synthesize nanoparticles with the same traits as the unsustainable PGMs. He is now working to make the process more efficient and less expensive, which could make the creation and use of renewable technologies much more feasible.

Siddarth Srinivasan, Current PhD Student

### Graduate Research: Chemical Engineering off a Duck's Back



Feathers have long been recognized as a classic example of efficient water-shedding — as in the well-known expression "like water off a duck's back." A combination of modeling and laboratory tests has now determined how both chemistry — the preening oil that birds use — and the microstructure of feathers, with their barbs and barbules, allow birds to stay dry even after emerging from amazingly deep dives.

Siddarth Srinivasan studies how cormorants and other diving birds are able to reach depths of some 30 meters without having water permanently wet their protective feathers. He and his research team have been able to separate chemical and structural effects to show why the combination of surface coating and shape is so effective.

The researchers took feathers from six different types of diving birds. They coated them with a layer that neutralized the effect of the preening oil, and then recoated them with hydrophobic material, preventing variations in oil composition from affecting the results. "This might lead to the design of artificial surfaces that do the same thing," Srinivasan says. "Let's say you make a hydrophobic surface so that even if it wets, by designing it the right way, just by shaking it the water might spontaneously dewet, and it would be dry again."

*"MIT offers two things that are hard to find anywhere else in the country. First, the faculty size is large and many of the faculty are running large groups. As a result, the range of research topics is very wide," says Kevin Dorfman PhD '01, "Second, the entrepreneurial spirit at MIT is astonishing."*

# Practice School



It started out a century ago, in 1916, when MIT chemical engineering alumnus Dr. Arthur D. Little and professor William Walker wanted to add a practical component to education in chemistry. They founded, with \$300 thousand of funding from George Eastman, of Eastman Kodak, the School of Chemical Engineering Practice. Just five sites participated at first – all in the Northeast, all traditional chemical industries working on dyes, abrasives, solvents and fuels. Today, Practice School students consult with companies all over the world to help them solve their toughest chemical engineering challenges, from food to pharmaceuticals to finance, in what is still the only academic program of its kind.

*“In this profession, more truly than any other, one needs to get into the water to learn to swim.”*

Arthur D. Little, Practice School Founder

## **Practice School Site: Corning, Inc., Corning, New York**

Station director Bob Hanlon found it a tremendous opportunity to engage with a Fortune 500 company focused on innovation. Corning’s selected projects provide a great mix of theory and experimentation, of fundamentals and applications, and of technologies and chemical engineering concepts, ranging, for example, from Corning® Gorilla® Glass and Celcor® substrates (used in catalytic converters) to mol-sieve drying, surface energy characterization, ion-exchange, and photo-catalysis. The students’ hosts also introduced them to Niagara Falls, a bus tour of the Finger Lakes Wine Region, and excursions to NYC’s Broadway and Chinatown.

## **Practice School Site: Novartis, Basel, Switzerland**

The Practice School has had stations at several Novartis locations, including France, California, Italy, and its headquarters in Switzerland. MIT students have helped the healthcare company on several projects, including optimizing existing processes, using near infrared spectroscopy for analysis and control, and dealing with the optimization of a ultrafiltration/diafiltration operation. Students also found time to take part in Basel’s “Fasnacht,” the city’s ancient three-day carnival, and see the countryside, including visits to Colmar and Strasbourg, in Alsace, France.





### Practice School Site:

#### General Mills, Minneapolis, Minnesota

One of the world's most iconic food companies, General Mills manages a myriad of top food brands. Our students have helped it keep its standing by applying their chemical engineering skills to real-world applications. Recently, students have focused on modeling product quality metrics in dough by describing the leavening reaction kinetics, thermodynamics, and constituent transport phenomena in the system. Another project focused on designing a process and corresponding control system to be used with new packaging for an existing product. And they still found time to catch a Red Sox-Twins game, hike, and sample several great restaurants in the area.

*“Practice school was obviously a once in a lifetime experience. You enter these companies and are exposed to people in very influential roles within those organizations. You work closely with them everyday, and make connections that will be invaluable throughout your career.”*

Christine Ensley '14, Practice School alumna



Christine Ensley MSCEP '14

### Sustainable Energy and Skills

When nearing the end of her undergraduate work, Christine Ensley knew she wanted to enter industry with “(a) the strongest foundation in ChemE fundamental principles possible and (b) the skills and confidence to apply this knowledge base to whatever my career could throw at me.” A Practice School degree was a perfect fit.

Ensley is now in Chicago working for *method*, a sustainable home and personal care products company. “There is no way I would have been given this opportunity without my MSCEP degree,” She says. “*method* is a very lean, fast-paced company that typically only recruits experienced candidates. My experience at Practice School helped give them the confidence to bring me in as a part of their Process Engineering team.”

# MIT and Cambridge/Boston



The Massachusetts Institute of Technology stands among the world's preeminent research universities and is home to one of the broadest and most advanced arrays of technical facilities anywhere in the world. We seek to develop in each member of the MIT community the ability and passion to work wisely, creatively, and effectively for the betterment of humankind.

■ 81 present and former members of the MIT community have won the Nobel Prize. Nine current faculty members are Nobel laureates.

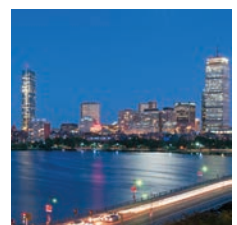
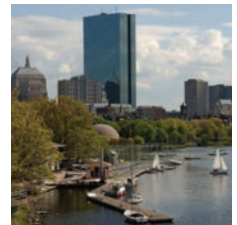
■ Coeducational and privately endowed, MIT includes over 1,000 faculty and approximately 4,500 undergraduate and 6,700 graduate students. The university's research sponsorship for fiscal year 2013 was \$675.3 million. The 154-acre campus stretches more than a mile along the leafy Cambridge banks of the Charles River, just a bridge away from the lively heart of Boston.

■ Boston, one of America's oldest cities, has evolved into a center for social and political change, the economic and cultural hub of New England, as well as a home to world-class shopping and exciting sports teams: the world champion Celtics, New England Patriots, Red Sox, and Bruins. Easily accessible from the city are opportunities to hike, bike, ski, sail, and rock-climb. From Cambridge and Boston, it is an easy drive to the mountains of Vermont, the woods of Maine, or the beaches of Cape Cod.

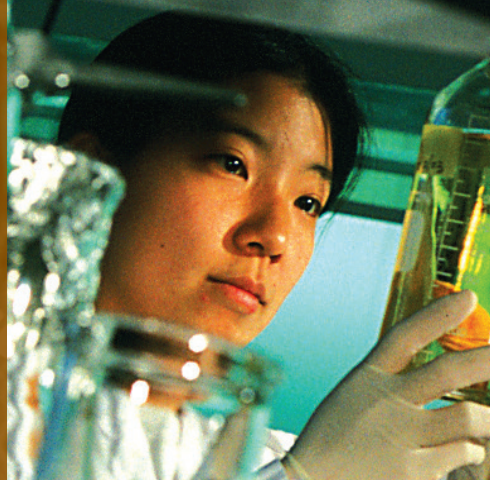
■ The MIT campus is just a short walk or T (subway) ride from downtown Boston. Transportation is available on foot or bicycle, on a city bus, or on an MIT SafeRide shuttle. Our students get free admission and discounts to places like the Museum of Science, the Museum of Fine Arts, the Boston Symphony Orchestra, and the Boston Ballet. Tickets for Bruins, Celtics, and Red Sox games are available, and a bus runs to Gillette Stadium, for those who want to attend Patriots games.

■ The MIT Campus also offers opportunities to relax, one being the Intramural (IM) Sports Program, a time-honored tradition of the Institute. Chemical Engineering graduate students have historically been strong participants in the IM program, from badminton to ice hockey to bowling to flag football.

**Be it academics, research, or IM dodgeball, you can find your path at MIT.**



# Degree Requirements/Options



Graduate study at MIT offers students the opportunity to do important, leading-edge research in any of a broad range of innovative areas and to work alongside our distinguished faculty, each a leader in his or her chosen specialty. Our students also take advantage of the extensive resources within the department, throughout MIT and in the intellectually and culturally rich Greater Boston area.

**MIT Chemical Engineering offers three distinct graduate programs:**

## PhD/ScD Degree

The Doctor of Philosophy and Doctor of Science degrees in Chemical Engineering are identical. Students may choose the appellation they prefer. This traditional, research-based doctoral degree program provides a thorough grounding in the fundamental principles of chemical engineering as well as an intensive research experience.

## PhDCEP Degree

Offered nowhere else but MIT, the Doctor of Philosophy in Chemical Engineering Practice degree program enhances a traditional doctoral program by leveraging the unique resources of MIT's David H. Koch School of Chemical Engineering Practice (Practice School) and the world-class leadership instruction of MIT's Sloan School of Management while still allowing students to complete the program in approximately 5 years. The PhDCEP program builds a solid foundation of industrial experience, research and business, preparing students for a quick launch into leadership.

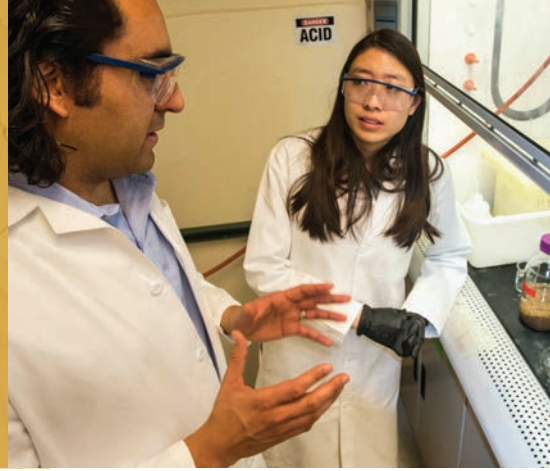
## MSCEP Degree

Also unique to MIT, the Master of Science in Chemical Engineering Practice degree program provides hands-on, real-world experience in industrial settings. Students complete two semesters of graduate-level courses at MIT (core plus electives), followed by one semester at industrial sites of the Practice School under the direction of resident MIT staff. Credit for the Practice School semester is accepted in lieu of a Master's thesis.

*"The reason I chose MIT was due in large part to the variety of research areas offered by the faculty and the rich tradition of preparing future faculty members as well as successful entrepreneurs. Given that I was uncertain about my desired research area and whether I would pursue a tenure track position or an entrepreneurial endeavor, I knew MIT had me covered."*

**Todd Zion PhD '04, president of 454, LLC, and founder of Smart-Cells, winner of MIT's \$50K Entrepreneurship Competition and now owned by Merck.**

# Where our PhDs go



## Matthew Stuber, PhD '13 Co-founder, WaterFX



Matthew Stuber says he chose MIT for graduate studies not just for its reputation, but for “the diversity in interesting problems that are studied and the opportunity to make a substantial impact on a global scale. The high concentration of brilliant minds at MIT fosters a very creative and motivating environment that I found invaluable for my personal and professional development.”

Stuber’s research at MIT was computational; and focused on robust simulation and design of novel process systems under uncertainty. Put simply, he worked on developing tools for designing and validating worst-case performance and safety of process systems to be deployed in extreme and hostile environments. The real-world impact is that safer and more robust systems may be engineered a priori as opposed to a posteriori following a disaster or failure.

Upon graduation, Stuber cofounded WaterFX, which focuses on desalinating diverse saltwater sources using renewable energy, specifically solar energy. “My time at MIT prepared me by not only giving me the tools and skills to synthesize, design, and optimize novel process systems but it prepared me to think creatively and critically as well as conduct independent high-quality research. The reputation of MIT also attracts many entrepreneurs and thinkers looking to start companies and consult on ideas that give many students, myself included, unique access to interesting non-traditional career and business opportunities.”

## **Entrepreneurs** Just some of the companies founded by graduates and faculty

Abcor Industries  
Acusphere  
Adimab  
Advanced Inhalation Research  
Alkermes  
Alnylam Pharmaceuticals  
Amgen  
Arsenal Medical  
Aspen Technologies  
BIND Biosciences  
Biogen Idec  
BioProcessors Corp.  
BioScale  
Echo Pharmaceuticals  
Enumeral Biomedical  
Focal  
Genzyme  
GVD Corp.  
Intelligen  
Ionics  
Living Proof  
MatTek Corp.  
MicroCHIPS, Inc.  
Mitra Biotech  
mNEMOSCIENCE GmbH  
Momenta  
Nano-C  
NewcoGen  
Optifood  
PerSpective Biosystems  
Pervasis  
Promethegen  
Pulmatrix Inc.  
PureTech Ventures  
Selecta Biosciences  
Semprus Biosciences  
Seventh Sense Biosystems  
T2 Biosystems  
Transform Pharmaceuticals



## Thought Leaders

**Just some of the universities where graduates teach and do research**

California Institute of Technology  
Colorado School of Mines  
Columbia University  
Cornell University  
Dartmouth College  
Duke University  
Emory University  
Georgia Institute of Technology  
Harvard University  
Hong Kong University of Science and Technology  
Imperial College London  
Johns Hopkins University  
KAIST  
Michigan State University  
National University of Singapore  
Princeton University  
Rensselaer Polytechnic Institute  
Seoul National University  
Stanford University  
Tsinghua University  
University of California at Davis  
University of California at Berkeley  
University of Colorado at Boulder  
University of Illinois at Urbana-Champaign  
University of Missouri  
University of Pennsylvania  
University of Texas at Austin  
University of Wisconsin at Madison

Lashanda Korley PhD '05

Associate Professor, Case Western Reserve University



“MIT is such a unique place and definitely a destination for graduate studies, especially Course 10. It’s a place to engage, explore, and tackle the world’s challenges, and a place to build and nurture lifelong relationships.”

For LaShanda Korley the choice to study chemical engineering came not as an epiphany, but through a process of elimination. “I was interested in how molecules work and I was good at math, chemistry and physics, so if you put it all together, it says ChemE,” she says. “But the reality is that I went to summer camp and knew I didn’t want to do electrical or mechanical engineering.” The remainder, chemical engineering, turned out to be a perfect fit.

Today, Korley runs her own lab at Case Western Reserve University. The lab, called “M-cubed” for mechanically-enhanced, multifunctional materials, focuses on materials inspired by natural substances, such as the titin protein or spider silk, that have special strength or toughness or responsiveness to heat or light. She applies her innovations to making protective fabrics, food packaging, scratch-resistant coatings, optical and mechanical sensors, and even drug-delivery and tissue engineering scaffolds.

While her work in Paula Hammond’s research group cemented her interest in the design of polymeric materials for high performance, MIT culture also played a big role in shaping Korley’s ideas. “On the campus, in the halls, at symposia, there was this vibrancy. Everybody was excited to talk about what they were doing,” she says. “It just opens your mind to start thinking about the next big thing.”

# Let Us Show You

You may have heard that Chemical Engineering at MIT has been ranked #1 by US News and World Report for over twenty years and counting, or that MIT chemical engineering is one of the largest chemical engineering departments in the country. No matter what you want to do in ChemE, they probably have someone here at MIT who is teaching it or researching it or, at the very least, wants to start it.

That's the great thing about MIT. It's filled with energy. A different kind of energy. MIT attracts bright people who have a passion for turning ideas into reality. MIT is a place where students and professors are also innovators and life-long learners. It is a place where people are more interested in moving forward together than being competitive separately. It's a place where people love to learn and discover.

And MIT is a place where people have a lot of fun.

Maybe it's chemistry. Maybe the place is engineered for innovation. In Course X, no doubt, it's a little bit of both.

[MIT Chemical Engineering. We put molecules to work.](#)

For more information visit: <http://mit.edu/cheme/>

