

Engineering Entrepreneurs



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In May, MIT celebrated its first in-person Commencement in three years. MIT's Department of Mechanical Engineering hosted its annual "MechE Tent" event to celebrate the Class of 2022. Recent alumni from the Class of 2020 and Class of 2021 were also invited to a special ceremony celebrating their degrees. Here, current and former members of the MIT Gear Lab, led by Professor Amos Winter (fifth from left) join the celebrations. Credit: Tony Pulsone



About MechE

The Department of Mechanical Engineering – MechE – embodies the Massachusetts Institute of Technology's motto *mens et manus*, "mind and hand," as well as "heart" by combining analysis and hands-on discovery with a commitment to making the world a better place. By leveraging our strengths, we aspire to solve some of the biggest challenges facing our world – and train the next generation of mechanical engineers to develop creative products and solutions.

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Part of MIT MechE's mission is to foster an innovative and entrepreneurial spirit that permeates our classrooms and laboratories. As a result, our alumni, faculty, students, and staff have founded hundreds of startups and companies that develop solutions for problems in nearly every industry. Pictured, students in class 2.009, Product Engineering Processes, present a product prototype they developed in front of a sold-out Kresge Auditorium. Learn more about startups that have spun out of 2.009 on page 22.

Credit: 2.009 Team

Have updates or news to share with the MechE community? Have ideas for future issues of MechE Connects?

Email us at mecomms@mit.edu



Dear Alumni, Students, Faculty, Staff, and Friends,

Few places do entrepreneurship quite like MIT. There is an entire ecosystem at the Institute designed to encourage and support entrepreneurs in any field. The Martin Trust Center for MIT Entrepreneurship, the MIT Startup Exchange, the Deshpande Center for Technological Innovation, the Legatum Center for Development and Entrepreneurship – the list of programs available to help members of the MIT community refine ideas, conduct market analysis, and launch new startups goes on-and-on.

To say the mechanical engineering community at MIT has taken advantage of these resources is an understatement. Over the decades, MIT MechE faculty, students, and alumni have launched hundreds of startups and companies. These include companies that have become household names, like ThermoFisher Scientific and iRobot.

We often hear from our undergraduate students that one of the main reasons they declared Course 2 was the flexibility mechanical engineering offers. Our curriculum prepares them for careers in almost any industry – and the diversity of startups and companies founded by members of our community confirms it. There has been a startup founded by a member of the MechE community in nearly every industry – from robotic restaurants (Spyce) to electric vehicles (Rivian), and hydrogel bandages (SanaHeal).

There has been a startup founded by a member of the MechE community in nearly every industry.

Entrepreneurship is also baked into our pedagogy. Alongside our rigorous and comprehensive curriculum, our faculty and teaching staff encourage students to think outside the box and foster an entrepreneurial spirit. Projects in classes like 2.009: Product Design Processes, 2.75: Medical Device Design, and 2.014/2.734: Engineering Systems Design and Development II, prompt students to work in teams, ideate, pitch products, and build prototypes just as they would at a startup.

In this issue of MechE Connects, we highlight just a few of the many startups and companies that had their origins in our department. We look at four companies that offer solutions for clean manufacturing, learn about how a student plans to protect machine learning teams' datasets, and how an alum is on a mission to make menopause more manageable. We also highlight trends in medtech startups, feature a few startups that spun out of 2.009, and have a discussion with Professor Cullen Buie about his cell engineering startup Kytopen. Finally, we take a moment to reflect on the amazing and impactful career of our academic administrator Leslie Regan, who retired from MIT after forty-seven years.

Sincerely,

Evelyn Wang
Ford Professor of Engineering



Manufacturing a cleaner future

By Mary Beth Gallagher

Startups founded by mechanical engineers are at the forefront of developing solutions to mitigate the environmental impact of manufacturing.

Manufacturing had a big summer. The CHIPS and Science Act, signed into law in August, represents a massive investment in US domestic manufacturing. The Act aims to drastically expand the US semiconductor industry, strengthen supply chains, and invest in R&D for new technological breakthroughs.

According to John Hart, professor of mechanical engineering and director of the Laboratory for Manufacturing and Productivity at MIT, the CHIPS Act is just the latest example of significantly increased interest in manufacturing in recent years.

Founded by MIT MechE alumni Anurag Bajpayee and Prakash Govindan, Gradiant develops cleantech water solutions with applications across a broad range of industries.
Credit: Gradiant

“You have multiple forces working together: reflections from the pandemic’s impact on supply chains, the geopolitical situation around the world, and the urgency and importance of sustainability,” says Hart. “This has now aligned incentives among government, industry, and the investment community to accelerate innovation in manufacturing and industrial technology.”

Hand in hand with this increased focus on manufacturing is a need to prioritize sustainability.

Roughly one-quarter of greenhouse gas emissions came from industry and manufacturing in 2020. Factories and plants can also deplete local water reserves and generate vast amounts of waste, some of which can be toxic.

To address these issues and drive the transition to a low-carbon economy, new products and industrial processes must be developed alongside sustainable manufacturing technologies. Hart sees mechanical engineers as playing a crucial role in this transition.

“Mechanical engineers can uniquely solve critical problems that require next generation hardware technologies, and know how to bring their solutions to scale,” says Hart.

Several fast-growing companies founded by faculty and alumni from MIT’s Department of Mechanical Engineering offer solutions for manufacturing’s

environmental problem, paving the path for a more sustainable future.

Gradiant: Cleantech water solutions

Manufacturing requires water, and lots of it. A medium-sized semiconductor fabrication plant uses upwards of 10 million gallons of water a day. In a world increasingly plagued by droughts, this dependence on water poses a major challenge.

Gradiant offers a solution to this water problem. Co-founded by Anurag Bajpayee SM '08 PhD '12 and Prakash Govindan PhD '12, the company is a pioneer in sustainable – or “cleantech” – water projects.

As doctoral students in the Rohsenow Kendall Heat Transfer Laboratory, Bajpayee and Govindan shared a pragmatism and penchant for action. They both worked

Customers look at us as their water partner. We can take care of their water problem end-to-end so they can focus on their core business.

With over 500 employees, Gradiant has built 450 water and wastewater treatment plants around the globe. Clients include Pfizer, Coca-Cola, and Intel. Credit: Gradiant



on desalination research – Bajpayee with Professor Gang Chen and Govindan with Professor John Lienhard.

Inspired by a childhood spent during a severe drought in Chennai, India, Govindan developed a humidification dehumidification technology that mimicked natural rainfall cycles for his PhD. It was with this piece of technology, which they named Carrier Gas Extraction (CGE), that the duo founded Gradiant in 2013.

The key to CGE lies in a proprietary algorithm that accounts for variability in the quality and quantity in wastewater feed. At the heart of the algorithm is a non-dimensional number, which Govindan proposes one day be called the “Lienhard Number,” after his doctoral advisor.

“When the water quality varies in the system, our technology automatically sends a signal to motors within the plant to adjust the flow rates to bring back the non-dimensional number to a value of one. Once it’s brought back to a value of one, you’re running in optimal condition,” explains Govindan, who serves as CTO of Gradiant.

This system can treat and clean the wastewater produced by a manufacturing plant for reuse, ultimately conserving millions of gallons of water each year.

As the company has grown, the Gradiant team has added new technologies to their arsenal, including Selective Contaminant Extraction, a cost-efficient method that removes only specific contaminants, and a brine-concentration method called Counter-Flow Reverse Osmosis. They now offer a full technology stack of water and wastewater treatment solutions to clients in industries including pharmaceuticals, energy, mining, food and beverage, and the ever-growing semiconductor industry.

“We are an end-to-end water solutions provider. We have a portfolio of proprietary technologies and will pick and choose from our ‘quiver’ depending on a customer’s needs,” says Bajpayee, who serves as CEO of Gradiant. “Customers look at us as their water partner. We can take care of their water problem end-to-end so they can focus on their core business.”

Gradiant has seen explosive growth over the past decade. With 450 water and wastewater treatment plants built

to date, they treat the equivalent of 5 million households’ worth of water each day. Recent acquisitions saw their total employees rise to above 500.

The diversity of Gradiant’s solutions is reflected in their clients, who include Pfizer, AB InBev, and Coca-Cola. They also count semiconductor giants like Micron Technology, GlobalFoundries, Intel, and TSMC among their customers.

“Over the last few years, we have really developed our capabilities and reputation serving semiconductor wastewater and semiconductor ultra-pure water,” says Bajpayee.

Semiconductor manufacturers require ultra-pure water for fabrication. Unlike drinking water, which has a total dissolved solids range in the parts per million, water used to manufacture microchips has a range in the parts per billion or quadrillion.

Currently, the average recycling rate at semiconductor fabrication plants – or fabs – in Singapore is only 43%. Using Gradiant’s technologies, these fabs can recycle 98-to-99% of the 10 million gallons of water they require daily. This reused

water is pure enough to be put back into the manufacturing process.

“What we’ve done is eliminated the discharge of this contaminated water and nearly eliminated the dependence of the semiconductor fab on the public water supply,” adds Bajpayee.

With new regulations being introduced, pressure is increasing for fabs to improve their water use, making sustainability even more important to brand owners and their stakeholders.

As the domestic semiconductor industry expands in light of the CHIPS and Science Act, Gradiant sees an opportunity to bring

their semiconductor water treatment technologies to more factories in the US.

Via Separations: Efficient chemical filtration

Like Bajpayee and Govindan, Shreya Dave '09 SM '12 PhD '16 focused on desalination for her doctoral thesis. Under the guidance of her advisor Jeffrey Grossman, professor of materials science and engineering, Dave built a membrane that could enable more efficient and cheaper desalination.

A thorough cost and market analysis brought Dave to the conclusion that the

desalination membrane she developed would not make it to commercialization.

“The current technologies are just really good at what they do. They’re low cost, mass produced, and they worked. There was no room in the market for our technology,” says Dave.

Shortly after defending her thesis, she read a commentary article in the journal *Nature* that changed everything. The article outlined a problem. Chemical separations that are central to many manufacturing processes require a huge amount of energy. Industry needed more efficient and cheaper membranes. Dave thought she might have a solution.

Co-founded by Professor Jeff Grossman (left), Shreya Dave '09 SM '12 PhD '16 (center), and Brent Keller PhD '16, Via Separations has developed a technology that can eliminate 90% of the energy used in thermal separations. Credit: The Engine



After determining there was an economic opportunity, Dave, Grossman, and Brent Keller PhD '16 founded Via Separations in 2017. Shortly thereafter, they were chosen as one of the first companies to receive funding from MIT’s venture firm, The Engine.

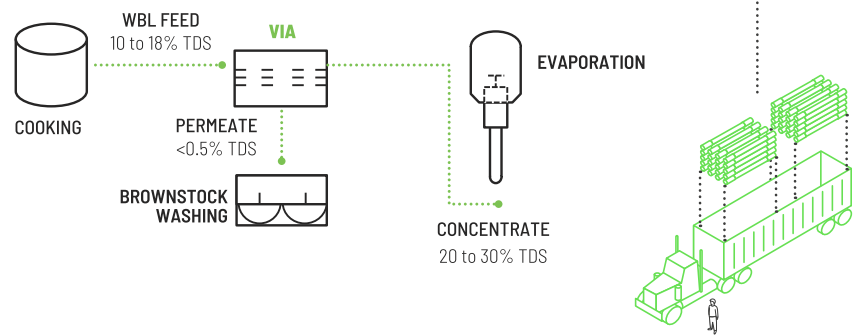
Currently, industrial filtration is done by heating chemicals at very high temperatures to separate compounds. Dave likens it to making pasta by boiling all of the water off until it evaporates and all you are left with is the pasta noodles. In manufacturing, this method of chemical separation is extremely energy intensive and inefficient.

Via Separations has created the chemical equivalent of a “pasta strainer.” Rather than using heat to separate, their membranes “strain” chemical compounds. This method of chemical filtration uses 90% less energy than standard methods.

While most membranes are made of polymers, Via Separations' membranes are made with graphene-oxide, which can withstand high temperatures and harsh conditions. The membrane is calibrated to the customer's needs by altering the pore size and tuning the surface chemistry.

Currently, Dave and her team are focusing on the pulp and paper industry as their beachhead market. They have developed a system that makes the recovery of a substance known as "black liquor" more energy efficient.

"When tree becomes paper, only one third of the biomass is used for the paper. Currently the most valuable use for the remaining two thirds not needed for paper is to take it from a pretty dilute stream to a pretty concentrated stream using evaporators by boiling off the water," says Dave.



This diagram shows the Via Separations Black Liquor Concentration System, which removes water directly from weak black liquor, a byproduct of the paper manufacturing process. Credit: Via Separations

This black liquor is then burned. Most of the resulting energy is used to power the filtration process.

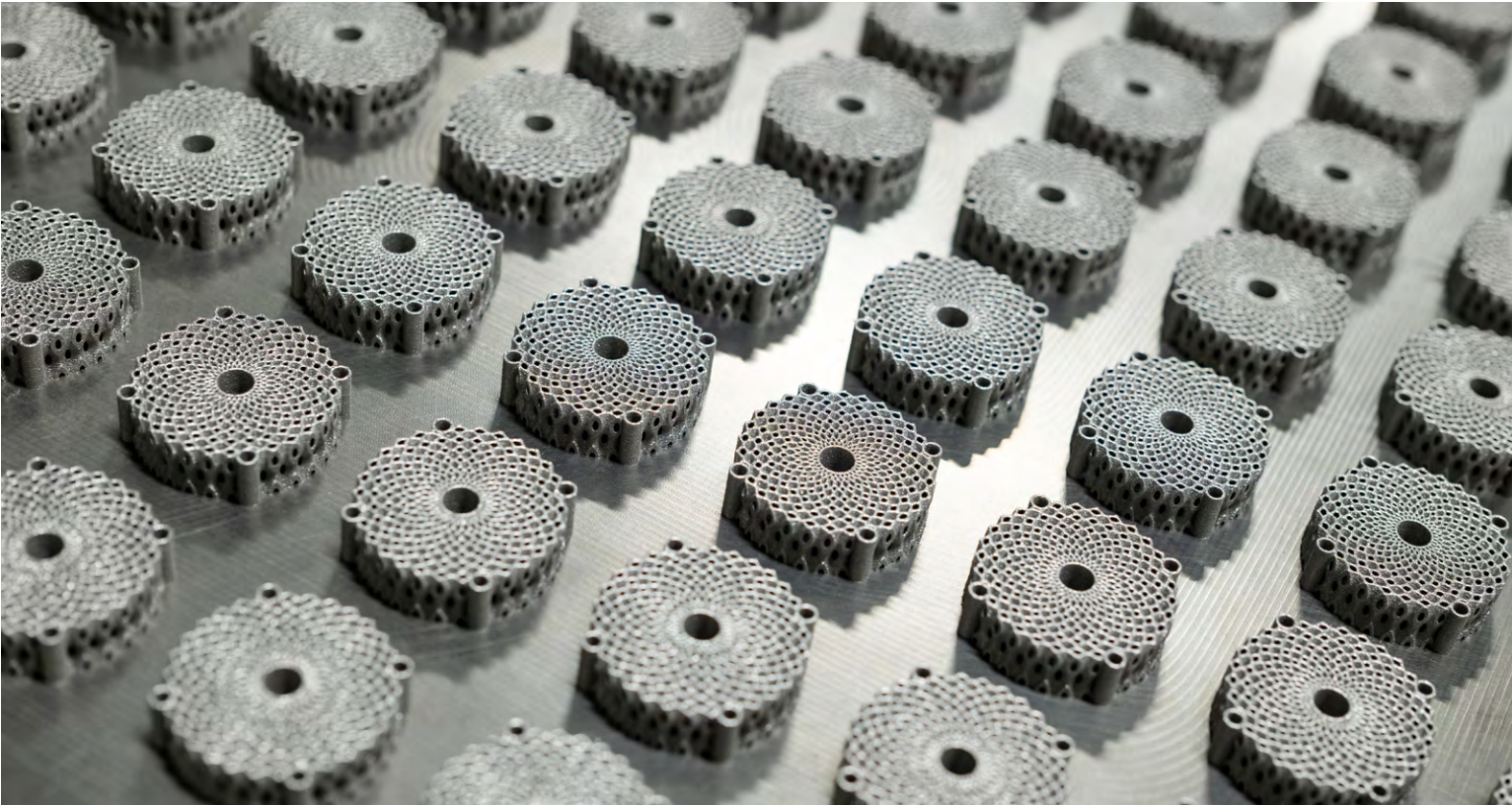
"This closed loop system accounts for an enormous amount of energy consumption in the US. We can make that process 84% more efficient by putting the 'pasta strainer' in front of the boiler," adds Dave.

VulcanForms: Additive manufacturing at industrial scale

The first semester John Hart taught at MIT was a fruitful one. He taught a course on 3D printing, broadly known as additive manufacturing (AM). While it wasn't his main research focus at the time, he found the topic fascinating. So did many of the

Professor John Hart sits in the frame of a 3D printer at a VulcanForms production factory. Credit: Joseph Seif





VulcanForms can 3D print metal parts with unparalleled precision, which can ultimately lead to materials savings. Credit: Joseph Seif

students in the class, including Martin Feldmann MEng '14.

After graduating with his MEng in Advanced Manufacturing, Feldmann joined Hart's research group full time. There, they bonded over their shared interest in AM. They saw an opportunity to innovate with an established metal AM technology, known as laser powder bed fusion, and came up with a concept to realize metal AM at an industrial scale.

The pair co-founded VulcanForms in 2015.

"We have developed a machine architecture for metal AM that can build parts with exceptional quality and productivity," says Hart. "And, we have integrated our machines in a fully digital production system, combining AM, post-processing, and precision machining."

Unlike other companies that sell 3D printers for others to produce parts,

VulcanForms makes and sells parts for their customers using their fleet of industrial machines. VulcanForms has grown to nearly 400 employees. Last year, the team opened their first production factory, known as "VulcanOne," in Devens, Massachusetts.

The quality and precision with which VulcanForms produces parts is critical for products like medical implants, heat exchangers, and aircraft engines. Their machines can print layers of metal thinner than a human hair.

"We're producing components that are difficult, or in some cases impossible to manufacture otherwise," adds Hart, who sits on the company's board of directors.

The technologies developed at VulcanForms may help lead to a more sustainable way to manufacture parts and products, both directly through the additive process and indirectly through more efficient, agile supply chains.

One way that VulcanForms, and AM in general, promotes sustainability is through material savings.

Many of the materials VulcanForms uses, such as titanium alloys, require a great deal of energy to produce. When titanium parts are 3D printed, substantially less of the material is used than in a traditional machining process. This material efficiency is where Hart sees AM making a large impact in terms of energy savings.

Hart also points out that AM can accelerate innovation in clean energy technologies, ranging from more efficient jet engines to future fusion reactors.

"Companies seeking to de-risk and scale clean energy technologies require know-how and access to advanced manufacturing capability, and industrial additive manufacturing is transformative in this regard," Hart adds.

LiquiGlide: Reducing waste by removing friction

There is an unlikely culprit when it comes to waste in manufacturing and consumer products: friction. Kripa Varanasi, professor of mechanical engineering, and the team at LiquiGlide are on a mission to create a frictionless future, and substantially reduce waste in the process.

Founded in 2012 by Varanasi and alum David Smith SM '11, LiquiGlide designs custom coatings that enable liquids to “glide” on surfaces. Every last drop of a product can be used, whether it’s being squeezed out of a tube of toothpaste or drained from a 500 liter tank at a manufacturing plant. Making containers frictionless substantially minimizes wasted product, and eliminates the need to clean a container before recycling or reusing.

Since launching, the company has found great success in consumer products. Customer Colgate utilized LiquiGlide’s technologies in the design of the Colgate Elixir toothpaste bottle, which has been honored with several industry awards for design. In a collaboration with world-renown designer Yves Béhar, LiquiGlide is applying their technology to beauty and personal care product packaging. Meanwhile, the FDA has granted them a Device Master Filing, opening up opportunities for the technology to be used in medical devices, drug delivery, and biopharmaceuticals.

In 2016, the company developed a system to make manufacturing containers frictionless. Called CleanTanX, the technology is used to treat the surfaces of



By utilizing LiquiGlide’s technologies, the Colgate Elixir bottle enables customers to use every drop of toothpaste, minimizing wasted product. Credit: Colgate

tanks, funnels, and hoppers, preventing materials from sticking to the side. The system can reduce material waste by up to 99%.

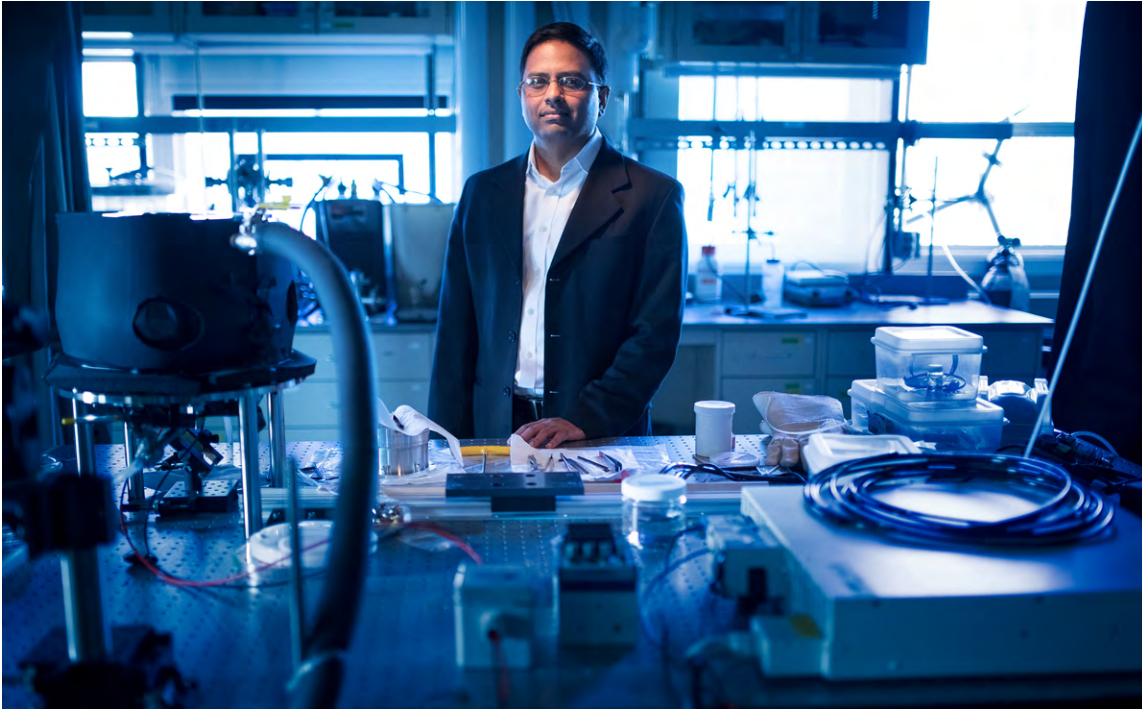
“This could really change the game. It saves wasted product, reduces wastewater generated from cleaning tanks, and can help make the manufacturing process zero waste,” says Varanasi, who serves as chairman at LiquiGlide.

LiquiGlide works by creating a coating made of a textured solid and liquid lubricant on the container surface. When applied to a container, the lubricant remains infused within the texture. Capillary forces stabilize and allow the liquid to spread on the surface, creating a continuously lubricated surface that any viscous material can slide right down. The company uses a thermodynamic algorithm to determine the combinations of safe solids and liquids depending on the product, whether it’s toothpaste or paint.

The company has built a robotic spraying system that can treat large vats and tanks at manufacturing plants on site. In addition to saving companies millions of dollars in wasted product, LiquiGlide drastically reduces the amount of water needed to regularly clean these containers, which normally have product stuck to the sides.

“Normally when you empty everything out of a tank, you still have residue that needs to be cleaned with a tremendous amount of water. In agrochemicals for example, there are strict regulations about how to deal with the resulting wastewater, which is toxic. All of that can be eliminated with LiquiGlide,” says Varanasi.

Professor Kripa Varanasi and the team at LiquiGlide are on a mission to create a frictionless future, and substantially reduce waste in the process. Credit: Bryce Vickmark



This could really change the game. It saves wasted product, reduces wastewater generated from cleaning tanks, and can help make the manufacturing process zero waste.

While the closure of many manufacturing facilities early in the pandemic slowed down the roll out of CleanTanX pilots at plants, things have picked up in recent months. As manufacturing ramps up both globally and domestically, Varanasi sees a growing need for LiquiGlide's technologies, especially for liquids like semi-conductor slurry.

Companies like Gradiant, Via Separations, VulcanForms, and LiquiGlide demonstrate that an expansion in manufacturing industries does not need to come at a steep environmental cost. It is possible

for manufacturing to be scaled up in a sustainable way.

"Manufacturing has always been the backbone of what we do as mechanical engineers. At MIT in particular, there is always a drive to make manufacturing sustainable," says Evelyn Wang, Ford Professor Engineering and department head. "It's amazing to see how startups that have an origin in our department are looking at every aspect of the manufacturing process and figuring out how to improve it for the health of our planet."

As legislation like the CHIPS and Science Act fuels growth in manufacturing, there will be an increased need for startups and companies that develop solutions to mitigate the environmental impact, bringing us closer to a more sustainable future. 

Student Spotlight:

Bernardo Aceituno SM '20

Protecting machine learning datasets

Bernardo Aceituno has always been fascinated by machine learning. As an undergraduate student in his hometown of Caracas, Venezuela, he spent most of his free time working on projects that involved artificial intelligence and robotics.

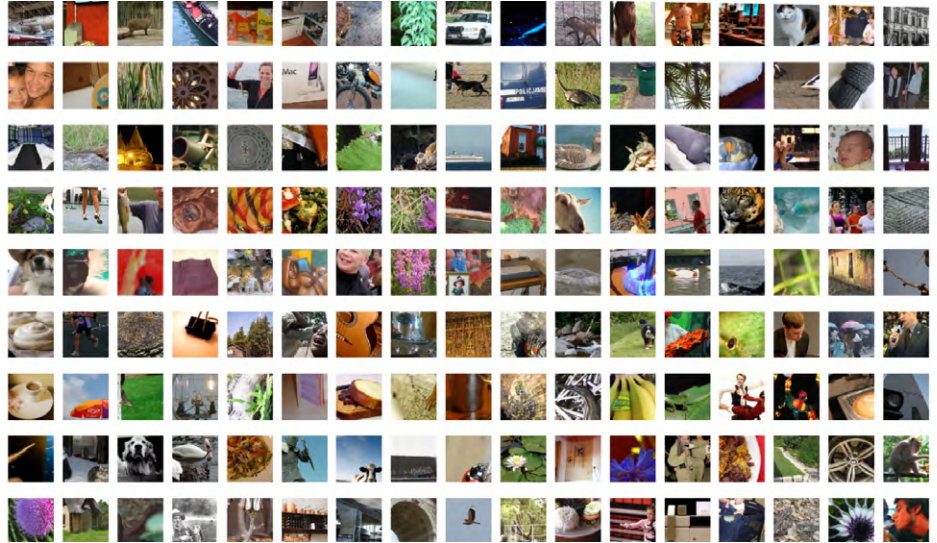
“I always felt very passionate about exploring the frontier of machine learning technology, so I started looking at how mathematical models could be used to embed logic into robotics,” says Aceituno.

This passion brought Aceituno to graduate school at MIT’s Department of Mechanical Engineering, where he joined Associate Professor Alberto Rodriguez’s team at the MCube Lab. There, he worked on developing model-based methods for robotic manipulation. These methods could help a robot touch, grasp, or move an object.

“It seems like such an easy problem, pushing or flipping a cube. But robots struggle to solve problems that are so intuitive for us humans,” he adds.

After graduating with his master’s degree, Aceituno spent a summer interning for Meta’s Facebook AI Research group. He developed a machine-learning pipeline that aimed to teach robots how to move and manipulate objects on their own, a project he built upon for his PhD thesis.

During his doctoral studies, Aceituno has been building a mathematical framework



Startup Stack provides machine learning teams with a developer tool that can manage and control the thousands of datapoints and images used to train their models. Credit: Stack

for robotic manipulation that accounts for uncertainty. While working on his thesis, he started to feel a pull toward entrepreneurship.

“Bernardo has always had an itch to do things differently and try new things,” says Rodriguez, who serves as Aceituno’s advisor. “Every time that we chat, he brings a new idea or a new story to the table.”

Aceituno and his friend, Antoni Rosinol SM '18, a graduate student in MIT AeroAstro, started brainstorming ideas that solved practical problems outside of the lab. They joined MIT Fuse, a micro-accelerator program organized by the Martin Trust Center for MIT Entrepreneurship.

At MIT Fuse, Aceituno and Rosinol met Melissa McAneny MBA '22, then a student

at the MIT Sloan School of Management and a former SpaceX engineer. The trio originally set out to develop an automated warehouse system that enabled smaller e-commerce companies to fulfill same-day delivery orders, similar to Amazon. The team named their startup Stack, and were accepted into the Martin Trust’s 2021 “delta v” program.

While visiting warehouses and potential customers, Aceituno and his team realized there wasn’t a viable market for their automated warehouse solution. Instead, they pivoted to another problem that was becoming ubiquitous in industry: managing and protecting datasets for machine learning.

The machine learning model the team developed for their original warehouse

solution was built using thousands upon thousands of images and datapoints. Aceituno, Rosinol, and McAneny stored this data on platforms like Google Drive and DropBox. These platforms, which are used by many machine learning teams, fail to track changes to data and user access. There was no elegant solution for keeping track of data and user changes, so the team decided to develop one.

Stack was reimagined as a developer tool that helps machine learning teams manage and control the data that will be used to train their models. It gives these teams the complete history of their datasets.

“Risking your datasets is risking your business. Teams frequently change, overwrite, and reformat their data, and currently, they resort to email and backups to troubleshoot their datasets. This process risks hundreds of thousands of work

hours and revenue every year,” explains McAneny, who serves as Stack’s Chief Operating Officer.

Stack is a storage agnostic platform that provides machine learning teams with a central list of datasets, a map of where each dataset is located, and information on any changes to the data.

According to Paul Cheek, Executive Director of the Martin Trust Center at MIT, the pivot from warehouse automation to dataset management company saved the Stack team two of the most valuable resources for entrepreneurs: time and money.

“In identifying a new market opportunity, the Stack team improved their odds of success by narrowing their focus on one potential beachhead market, rather than splitting their time and attention across multiple potential markets,” adds Cheek.

Having spent his entire academic career focused on machine learning, Aceituno has a ground truth in the needs of Stack’s customers.

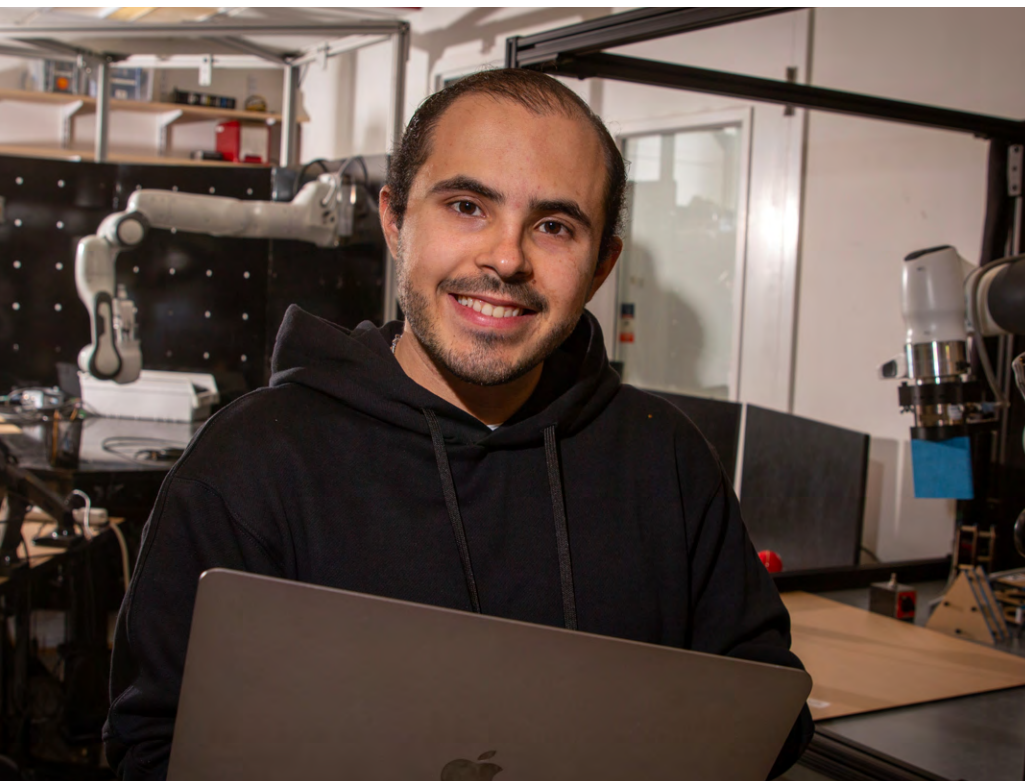
“We understand the market really well, because we are the market,” says Aceituno.

The team has done extensive market research. As they prepare to launch a beta version of their platform, they are targeting medium-sized machine learning teams at startups in life science and computer vision fields.

Launching Stack in beta isn’t the only milestone Aceituno is preparing for this fall. He is gearing up to defend his doctoral thesis. After graduating, he will serve as Stack’s CEO full time, working to get it to market.

With his time at MIT coming to a close, Aceituno has been reflecting on the community he found here. As a former president of GAME – the Graduate Association of Mechanical Engineers – and an active member of MIT’s Latin Graduate Student Association and MIT Hillel, a community of Jewish students, Aceituno has surrounded himself with a network of peers who cheered him on throughout graduate school.

“This was my first time living in the U.S. and MIT has been such a welcoming community,” he says. “It is an amazing place to take everything you’ve learned and put it into practice. Whether you want to start the next big research project or launch a startup, there are resources for you to do it and like-minded people who can join you.”



PhD Candidate Bernardo Aceituno
Credit: Tony Pulsoni

Alumni Profile: Loewen Cavill '20

Hot flash relief during menopause

Amira's bracelet connects with an app that tracks hot flash data, providing users with an overview of their hot flash trends.



Despite the fact that half of the world's population will experience menopause, it is often considered a taboo topic. As a result, there are very few evidence-based methods or products that alleviate one of menopause's most disruptive symptoms: hot flashes. Loewen Cavill '20 hopes to shatter the taboo, and provide menopausal individuals with much-needed relief in the process.

"Four out of five women will lose sleep due to hot flashes. Women with severe hot flashes can have them last ten years," says Cavill.

Cavill is co-founder and CEO of Amira, a startup formerly known as AuraBlue that has developed the first wearable device to predict hot flashes.

Users of Amira wear a bracelet embedded with novel sensing technologies. Based on biological data taken from the bracelet, an algorithm can predict when a hot flash is about to occur. The bracelet communicates this information to a cooling mattress pad underneath the bedsheet. The pad automatically cools down, helping the user regulate their body temperature and preventing the hot flash from starting.

"What's magical about predicting a hot flash is you can actually mitigate the hot flash experience altogether by cooling women down in advance. This helps keep women asleep through the night," Cavill adds.

As a student at MIT, Cavill was drawn to the flexibility a degree in mechanical engineering offered. Her experience in the Course 2 capstone class 2.009, Product Engineering Processes, led her down the path of entrepreneurship. In December 2019, she and her teammates presented their product, "Uplift," in front of a sold-out crowd in MIT's Kresge Auditorium.

Uplift was a portable ramp developed to help airport workers as they load and remove luggage from a plane's cargo bay. After their presentation, Cavill and her team joined the "delta v" program at the Martin Trust Center for MIT Entrepreneurship. The team had meetings with major airlines like United and Alaskan Airlines.

Then, in March 2020, the pandemic effectively grounded all flights worldwide. Cavill and her team knew it was not the right time to launch a product targeting the airline industry. They made the gut-wrenching decision to drop the company.

It was then that Cavill revisited an idea she had previously hatched with her Uplift teammate Claire Traweek '20. The pair had participated in MEMSI, the MIT Entrepreneurship and Maker Skills Integrator, a hackathon-style event that takes place in Hong Kong each year.

At MEMSI, Cavill and Traweek developed the first iteration of what would later

become Amira. Cavill drew inspiration from her aunt. A longtime sufferer of hot flashes, Cavill's aunt was desperate for relief and had spent over \$10,000 on unregulated products. One such product resulted in a hospital stay.

Following their pitch at MEMSI, Cavill and Traweek were flooded with emails from people asking for more information about the hot flash relief product. The pair realized there was a massive opportunity to regroup the Uplift team and focus on a new product.

"Our pivot was a response to uncertainty at the beginning of Covid, but ultimately it forced us to reconsider our priorities and our product's effectiveness at making life-changing impacts. Our company post-pivot was definitely far better for it," says Traweek, Chief Product Officer at Amira.

Cavill's Amira co-founders, which include Traweek, Emilio Sison '20, and Felipe Radovitzky '20, threw themselves into market research.

"Their team thrived together in this transition, which reinforces the value of a strong team over a strong idea," says Paul Cheek, Executive Director of the Martin Trust Center at MIT and one of Amira's delta-v mentors.

The team's dedication to developing their product was unparalleled. Sison, who serves as Chief Technology Officer, set an alarm for 4:00am every day to eat a

bowl of ghost peppers, inducing a similar physiological response as a menopausal hot flash.

Cavill credits this commitment, and the close bond the team formed during 2.009, with their ability to quickly refocus and develop a new product.

“Building a startup is hard. You see the ugliest sides of people. But after pulling all-

nights during 2.009, several hackathons, and pivoting from the Uplift product, we really got to know how each other works and could thrive as a team,” says Cavill.

User testing and customer feedback has been instrumental in the development of Amira. Cavill and her team have spoken with 350 menopausal individuals and have conducted user testing with thirty-five people. The feedback they have received


has been overwhelmingly positive, with one hundred people already on the waitlist for when the product hits the market.

“Before building all of their new sleep technology, Loewen and her team at Amira leaned into the commercialization of their new technology and leveraged market-testing tactics to ensure that a market didn’t just exist, but was activated and would in fact pay for their product,” adds Cheek.

With data from over 300 nights of sleep, Amira has already compiled the world’s largest dataset of hot flashes. As the product goes to market, Cavill sees an opportunity to grow this database, leading to the largest set of health data about women, a demographic that controls 80% of healthcare spend. This could make Amira pioneers in predictive healthcare.

Cavill hopes to bring Amira to market in 2023. The product will be available online, direct to consumer. Longer term, they hope to make the product available through insurance providers and employee benefit programs.

In June 2022, Cavill presented Amira at the first annual MIT Female Founders Pitch in New York. She was awarded the Audience Choice Award.

The positive reaction to the product is perhaps not surprising given the ubiquity of hot flashes. “Women already know they want this problem solved. There is no education needed,” says Cavill. 

Loewen Cavill '20, co-founder
and CEO of Amira
Credit: Scott Strazzante



Research Focus: Medtech

Mechanical engineer-led startups offer healthcare solutions

Healthcare has always been ripe for innovation. Whether it's increasing safety in operating rooms, developing systems to reduce patient wait times, or improving drug delivery, there are endless opportunities to improve the efficacy and efficiency of healthcare. The Covid-19 pandemic made the need for these solutions all the more pressing.

"There were a number of startups from MIT that addressed problems related to the pandemic. One company, Biobot, developed a technology to monitor disease spread by looking at wastewater in sewers. In a case of unbelievable serendipity, they developed this right as Covid was starting to spread," says Dr. George Whitfield, Entrepreneur in Residence at the Martin Trust Center for MIT Entrepreneurship.

Another startup inspired by the Covid-19 pandemic, Teal Bio, developed a comfortable, reusable, and transparent respirator that can be worn by healthcare professionals on long shifts. The company has identified a number of benefits to their design, including lower costs, decreased waste, and an improved ability to identify emotions. Teal Bio was co-founded by MechE LGO alum Jason Troutner MBA '19 SM '19 and Giovanni Traverso, assistant professor of mechanical engineering at MIT.

Traverso is no stranger to startups. He has co-founded seven of them. An MD-PhD, Traverso is both an assistant professor at MIT and a physician at Brigham and



Women's Hospital.

His companies range in size from one employee to 140 employees. With the exception of Teal Bio, the thread that connects his companies is gastroenterology.

"These companies are launching systems that make it easier for patients to receive medication one way or another, particularly through the GI tract," says Traverso.

One of the companies that Traverso co-founded, Lyndra Therapeutics, hopes to revolutionize how patients take medications. They have developed an oral drug-delivery platform called LYNX™, which consistently delivers one, two, or four weeks of medication in one capsule that releases the medication over a specific time period. The capsule dissolves in the stomach and a star-shaped drug delivery system emerges.

The arms of the "star" are made of a polymer that holds the medication and are connected to a central core through degradable linkers. Once the dosing period is complete, the linkers disintegrate, the arms separate, and the entire system safely moves from the stomach into the small intestines, where it passes through the GI tract. The platform is being studied with a variety of drugs, including an oral memantine for Alzheimer's

disease treatment and once-a-month oral contraceptives.

"Many patients need a loved one or caretaker to help them take oral medication daily, so giving them the ability to take a pill once a week or once a month would positively affect adherence and be hugely impactful on their quality of life," says Traverso.

Lyndra has raised \$240 million to date. One of the therapies they developed to deliver drugs used to treat schizophrenia has advanced to phase-two clinical trials.

Clinical trials are one example of the unique hurdles that medtech startups like Lyndra face on the path to commercialization. Bodies like the FDA and the National Institute for Occupational Safety and Health require strict regulations that need to be met before any medical device, drug, or healthcare platform can be sold to end users.

"Having an understanding of the regulatory, manufacturing, and business challenges that need to be met to launch a successful product is really crucial. It speaks to the

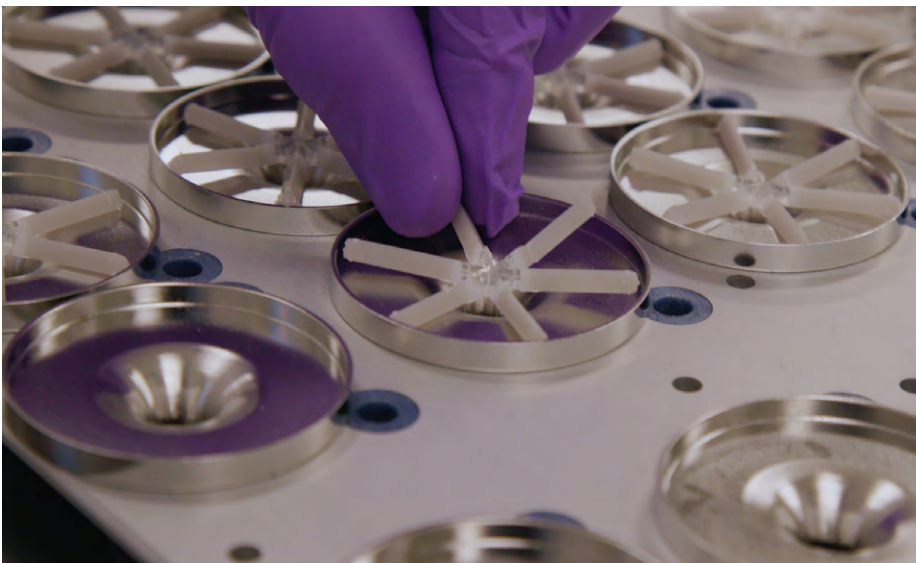
resources that are required to actually be able to execute on these regulations,” adds Traverso. In his first year on MIT’s faculty, Traverso introduced a new class called Translational Engineering (2.s988), which aims to introduce these critical elements to students.

Ellen Roche, associate professor of mechanical engineering, is currently trying to determine the regulatory needs for her own startup. In May, she won the grand prize at the inaugural MIT Future Founders Initiative Prize Competition for her pitch.

Roche has developed a minimally invasive technology that occludes the left atrial appendage in patients with atrial fibrillation. The technology, which she developed alongside Professor Jennifer Lewis at Harvard University, decreases the likelihood that blood clots will dislodge, thereby preventing stroke.

“The Future Founders program was invaluable for refining the vision for our company and identifying the correct regulatory and commercialization path to move forward,” says Roche. “Creating a pitch deck forced us to really think through aspects such as our beachhead market, our clinical target population, our funding and IP strategy, all the while having access to a network of experts.”

Lyndra Therapeutics developed an oral drug-delivery platform called LYNX™, which consistently delivers one, two, or four weeks of medication in one capsule. The capsule dissolves in the stomach and a star-shaped drug delivery system emerges. Credit: Lyndra Therapeutics



In September, Roche and her team also won the LabCentral Ignite Golden Ticket to support startup founders from traditionally underrepresented groups in the biotech industry.

Both Traverso and Roche have served as instructors for mechanical engineering class 2.75, Medical Device Design, alongside Professor Alexander Slocum and Dr. Nevan Hanumara. The class culminates in a project in which students work with clinicians from Boston-area hospitals and representatives from industry on designing medical devices that address a particular problem. Throughout the class, regulatory experts introduce students to the unique challenges of starting a company or launching a product in the healthcare space.

One former student of 2.75, Adam Sachs ’13, co-founded the startup Vicarious Surgical. The company has developed a robotic system that enables minimally invasive surgery. A camera and two robotic instruments enter the abdomen via an incision smaller than the size of a dime. The surgeon can then operate with 360-degree visibility inside a patient’s body.

“Course 2.75 gave me a deep understanding of the entire medical device design process, which was incredibly valuable when we




Assistant Professor Giovanni Traverso has co-founded seven startups. Credit: Tony Pulsone

founded Vicarious Surgical. It helped me understand the needs of a user, showed me how to deliver on a product, and allowed me to dip my toes into the process of developing a device from start to finish – much of which I still reference as the company grows and we continue to develop our system,” says Sachs.

Vicarious Surgical, which is based in Waltham and currently has just over 200 full-time employees, is in the development process. They have received positive feedback from surgeons regarding their Beta 2 prototypes. After securing the appropriate approvals from the FDA, Sachs and his team plan to bring their product to market for use in hernia and other general surgery procedures.

Traverso sees mechanical engineers, like himself, Roche, and Sachs, as being particularly well suited to launch medtech startups.

“A huge part of our program is hands-on experience, which we introduce and nurture through many of our course offerings. I think that’s so valuable when you’re developing a device that will be engaging with another human being,” he says. 

Class Close-Up:

2.009, Product Engineering Processes



Mechanical engineering students present product prototypes at the 2.009 final presentations in Kresge Auditorium each December. Dozens of these products have inspired the launch of startups. Credit: 2.009 Team

Startups take root in senior capstone class

On a Monday evening early each December, Kresge Auditorium transforms into something resembling a pep rally. The sold-out crowd cheers loudly, waving colorful pom poms in the air as confetti rains from the ceiling. Eight teams of mechanical engineering students in class 2.009,

Product Engineering Processes, take to the stage, demonstrating the product prototype they spent the semester working on in a presentation that would be welcome in any boardroom.

For many students, these presentations represent the finish line after months of hard work. But for others, it is when the work really begins. Over the years, dozens of 2.009 team products have inspired startups.

The curriculum of the class, which is typically taken in the fall semester of senior year, has been carefully designed to mimic the product design process at a typical product development firm. Students work on large teams of roughly twenty. The class walks students through the early phases of product development – from opportunity identification to market analysis and alpha-prototype production.

Students are asked to develop a product based on a central theme that improves the

quality of life for its end users. Alongside the basics of developing a business model, students receive mentorship from successful entrepreneurs and are given resources to file a patent if relevant.

“The focus in the class is to help motivate and set the foundation for students to be successful technical innovators and positive contributors throughout their entire careers, whether that be through the continuation of a product from the class, or in other pursuits,” says David Wallace, professor of mechanical engineering and long-time instructor of 2.009.

While founding companies is not necessarily the class’ intended goal, according to Wallace it is no surprise that so many startups have spun out from its projects. “This outcome is a natural extension of being immersed in a product development process focused on providing benefits to real people,” he says.

Perhaps the most useful takeaway for students interested in founding a company, according to Associate Professor Ellen Roche, is how to work on teams. “These projects provide students with an opportunity to work on larger teams, divide out roles and responsibilities, and experience team dynamics for the first time in a product development setting,” she says.

This fall, Roche has served as course instructor alongside Josh Wiesman, a visiting professor of entrepreneurship from Tufts University, while Wallace has been on sabbatical.

Among the many startups that have originated in the class and continue to grow and develop toward commercialization are Encora Therapeutics, Avive, and Floe.



The wearable device developed by Encora Therapeutics uses vibrations to send signals to the brain that can help relieve tremors of the hand. Credit: 2.009 Team

Encora Therapeutics: A device to relieve tremors

When Michael took to the stage in Kresge Auditorium, you could hear a pin drop. Michael, who lives with Parkinson’s Disease, suffers severe tremors in his right hand. Using a marker, he traced a spiral on a piece of paper. His tremor prevented him from tracing the spiral in a clear line.



Michael, who lives with Parkinson’s Disease, demonstrated the device by tracing a spiral live on stage during the 2.009 final presentations. Credit: 2.009 Team

Michael then turned on a device on his wrist. With the device on, he was able to trace the spiral perfectly. The audience erupted with applause.

The device Michael used was the product prototype developed by the “Purple Team” in the fall of 2017. Then called Animo, the wearable device used vibration therapy to reduce tremors in patients with neurological movement disorders.

“When Michael traced his second spiral, the first thing I felt was relief, followed by overwhelming emotion and gratitude toward Michael and his family for trusting us and allowing us to show his Parkinson’s Disease in such a public way,” says Allison Davanzo ’18, one of the Purple Team members. “Seeing their emotional response is what made me realize I wanted to bring that feeling to others like Michael around the world.”

Davanzo and some of her fellow teammates decided to explore opportunities for launching a business with their device. They utilized entrepreneurship resources at MIT like the MIT Sandbox Innovation Fund Program, the Martin Trust Center for MIT Entrepreneurship “delta v” accelerator, the MIT \$100k Entrepreneurship Competition,

and the PKG IDEAS Social Innovation Challenge, to a name a few.

With the help of these programs and resources, Davanzo honed the idea started in 2.009 and co-founded Encora Therapeutics with fellow Purple Team members Daniel Carballo '18 and Kyle Pina '18.

The latest version of the device the team has built uses sensors to assess the severity of a tremor. Depending on the tremor severity, the device will tune the frequency and strength of the vibration it produces. This customized vibration stimulates nerves in the wrist. These nerves send a signal to the brain to indicate the wrist is already trembling. As a result, the brain sends fewer tremor signals back to the wrist.

The Encora team was granted an FDA Breakthrough Designation in 2021 and is planning a pivotal study before submitting for regulatory clearance to market the device to consumers.

Pina credits 2.009 for giving him, Carballo, and Davanzo the tools needed to found a startup.

"2.009 taught us to how to balance the many aspects of starting a company, wearing different hats when needed. That has been a crucial skill, since not only have we dealt with product and business development, but our roles have also expanded to include regulatory and clinical studies," says Pina.

Avive: Connecting AEDs to those who need them

After his 2.009 team presented their product Revive, a portable Automated External Defibrillator – or AED – that could be charged using a cell phone battery, Rory

Beyer '17 was invited to speak at the annual Parent Heart Watch Conference in January 2017. The event was dedicated to preventing cardiac arrest in youths.

Beyer did a live demo of Revive in front of an audience of several hundred people. He received a standing ovation.

"At MIT you're in this bubble, so having validation from groups dedicated to this cause, ranging from legislators to medical professionals to parents who had lost children to cardiac arrest, was a really pivotal moment," says Beyer.



At the conference, Beyer and his 2.009 teammate Moseley Andrews '17 met Sameer Jafri, then a student at UCLA. Together, the trio co-founded a startup, now called Avive. The company has built a user-friendly AED that is fully connected with Wi-Fi, cellular data, GPS, and Bluetooth capabilities.

When someone calls 911 to report a sudden cardiac arrest, the 911 dispatchers can launch an "Avive" button. Avive AEDs near the person experiencing the medical emergency will light up and display a map, leading a user to the patient. Additionally,

any Avive app user nearby will get an alert that navigates them to the nearest Avive AED, and then to the patient. This connectivity could save countless lives.

Beyer and his co-founders plan to target customers like gyms, office buildings, and schools, some of whom are legally required to have an AED on site. They also plan to work with cities on putting enough Avive AEDs in place that a device is never more than four minutes away from a person experiencing cardiac arrest. Eventually, they hope to get their AEDs in the houses of individuals who are particularly susceptible to cardiac arrest.

Avive, which received FDA Approval in October, is the first new company in twenty years to have a defibrillator approved on the market. Beyer, who serves as Avive's COO and President, reflects on his time in 2.009 as crucial in helping them refine their product offering.

"The class gives you a structure and a framework to run a development process. And that's invaluable when you're starting a company that is so technology focused, because your company is based on the product that you're building," he adds.

Floe: A new way to prevent ice dams

For their 2.009 project, David Dellal '17 and his fellow members of the Silver Team developed a solution to address a practical problem that many home and business owners face each year: ice dams.

Ice dams form when heat from a building melts snow on a roof, forming ice. The water that pools behind the ice dam can leak into a house or office, causing damage that can be catastrophic. For their project, the Silver Team designed Floe, a

cost-effective, smart system that combines drip irrigation with deicing fluids.

“Traditionally, heating cables have been used to melt ice and snow on a roof. This is actually really dangerous and expensive. So, we started to explore mechanical and chemical approaches,” says Dellal. “We had a Eureka moment where we realized that we could solve the water issue by irrigating a small amount of deicing fluid in certain locations.”

The Floe system is embedded with temperature and water sensors that sense when conditions could lead to ice dam formation. In the original design, a mixer combines deicing fluid with a building’s water supply. The fluid then travels to tubing with drip emitters on the roof. This creates channels that drain the water behind ice dams, preventing damage.

After the final presentation in 2.009, three members of the Silver Team, including Dellal, decided to explore founding a company with Floe’s technologies. They received funding from MIT Sandbox, MIT delta v, the MIT Water Innovation Prize, and the MIT \$100K Competition, as well as mentorship via MIT’s Venture Mentoring Service.


A year and a half later, Dellal, who serves as Floe’s CEO, connected with his fraternity brother Hector Castillo ’20 and asked him to join the Floe team. Then a senior studying mechanical engineering, Hector was working on his own 2.009 team project at the time. According to Castillo, the experience prepared him for his current role of CTO.

“One of the big things for me about 2.009 is you aren’t just working on a P-set by yourself. You have to learn how to manage

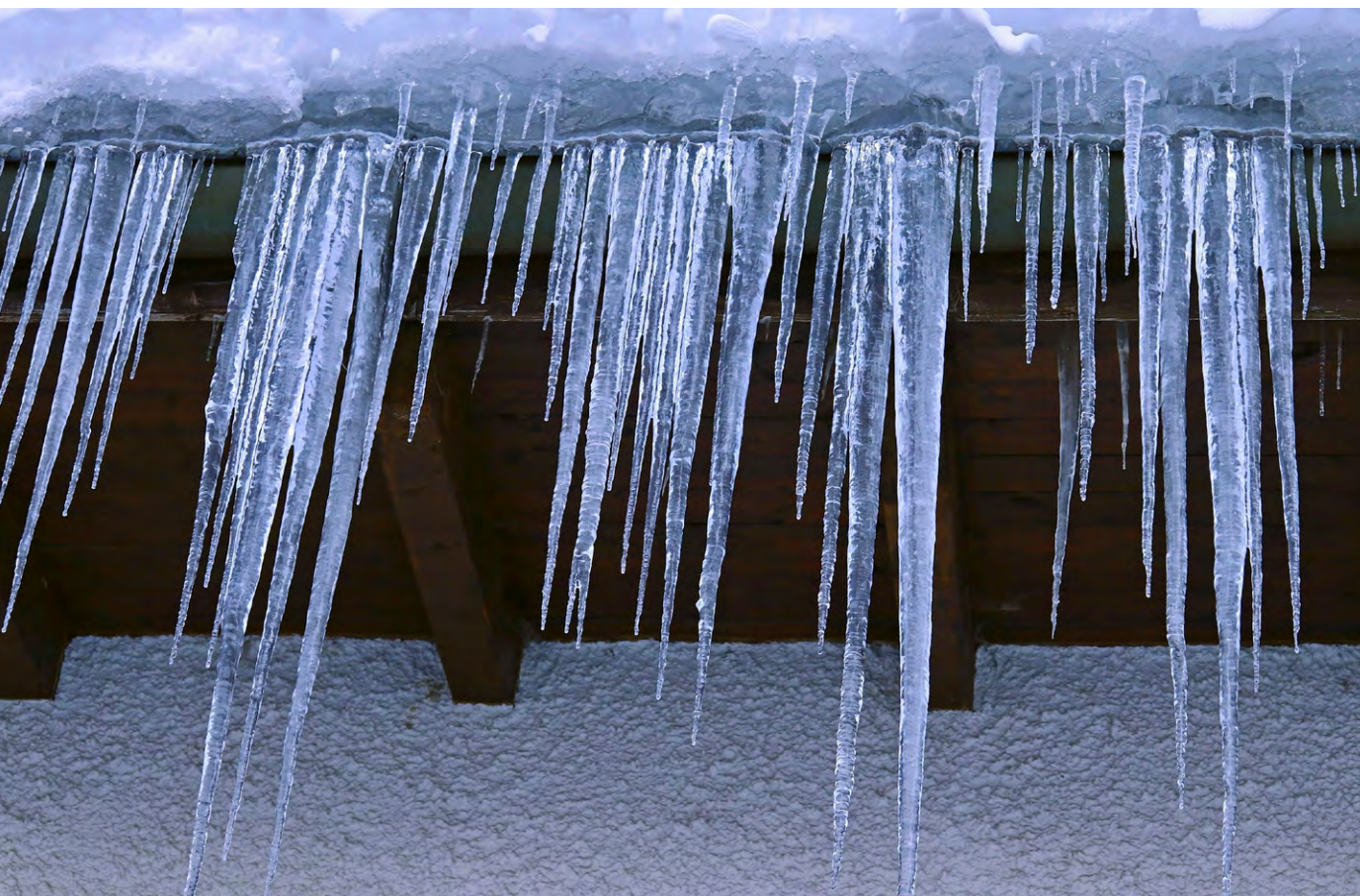
a team of people and stakeholders. That’s especially important for me as CTO since I manage the product development side of things,” Castillo adds.

In the winter of 2021, the Floe team conducted a pilot on roofs, including buildings in Maine, ski resorts in Colorado, and MIT’s very own Building 24. The team is in the process of finalizing product development so they can do a full-scale launch.

Castillo says the team continues to draw from their 2.009 experiences.

“The class definitely pushed me beyond hacking a project in my dorm room. It rounds out your engineering education by pulling it into the real world, where nearly all engineering projects have customer and business components to them,” he says. 

The Floe system is embedded with temperature and water sensors that detect when conditions could lead to ice dam formation.



MechE Startups & Companies

Over the decades, members of the MIT MechE community have launched hundreds of startups and companies in nearly every industry. Here are some highlights.



Thermo Fisher Scientific (formerly Thermo Electron)

Founded in: 1956
Founder: Professor George Hatsopoulos
Description: Scientific and laboratory instrumentation, software, and services



CubicPV (formerly 1366 Technologies)

Founded in: 2008
Founders: Professor Emanuel Sachs, Frank van Mierlo '82
Description: Innovations in solar manufacturing and materials



iRobot

Founded in: 1990
Founders: Helen Greiner '89 SM '90, Colin Angle, Rodney Brooks
Description: Consumer robots, including the Roomba vacuum



Rivian Automotive

Founded in: 2009
Founder: RJ Scaringe '07 PhD '09
Description: Automaker of electric adventure and sports vehicles



Cambridge Polymer Group

Founded in: 1996
Founder: Professor Gareth McKinley PhD '91
Description: Contract research lab specializing in materials and products



LiquiGlide

Founded in: 2012
Founders: Professor Kripa Varanasi, J. David Smith SM '11
Description: Removes friction in consumer products, manufacturing, and biomedicine



Amazon Robotics (formerly Kiva Systems)

Founded in: 2003
Founders: Mick Mountz '87, Peter Wurman '87, Raffaeallo D'Andrea
Description: Robotic automation fulfillment systems for warehouses



Akselos

Founded in: 2012
Founders: David Knezevic PD '11, Thomas Leurent SM '01, Phuong Huynh PD '09
Description: Advanced engineering simulation technology



Loci Controls

Founded in: 2012

Founders: Andrew Campanella '05 SM '13,
Melinda Hale SM '09 PhD '13

Description: Automated landfill gas collection



Desktop Metal

Founded in: 2015

Founders: Professor A. John Hart,
Professor Emanuel Sachs,
Ric Fulop MBA '06,
Jonah Myerberg, Rick Chen,
Professor Yet-Ming Chiang '80 SCD '85, Chris Schuh

Description: Metal 3D printing systems



Aurora Driver

Founded in: 2017

Founder: Sterling Anderson SM '09
PhD '13

Description: Software, hardware, and data services for self-driving cars and trucks



Gradient

Founded in: 2013

Founders: Anurag Bajpayee SM '08
PhD '12,
Prakash Govindan PhD '12

Description: Cleantech water solutions for industry



VulcanForms

Founded in: 2015

Founders: Professor A. John Hart,
Martin Feldmann MEng '14

Description: Digital manufacturing at industrial scale



InkBit

Founded in: 2017

Founders: Davide Marini PhD '03,
Javier Ramos '12 SM '14,
Wojciech Matusik SM '01
PhD '03

Description: Multi-material additive manufacturing



Vicarious Surgical

Founded in: 2014

Founders: Adam Sachs '13,
Sammy Khalifa '12,
Dr. Barry Greene

Description: Revolutionizing robotic surgery



Spyce

(Acquired by Sweetgreen)

Founded in: 2015

Founders: Brady Knight '16,
Michael Farid '16,
Kale Rogers '16,
Luke Schlueter '16

Description: Robotic-powered restaurant



Infinite Cooling

Founded in: 2017

Founders: Professor Kripa Varanasi,
Maher Damak SM '15 PhD '18,
Karim Khalil SM '14 PhD '18

Description: Capture water from plant cooling towers



Keystone Tower Systems

Founded in: 2015

Founders: Eric Smith '01 SM '07,
Rosalind Takata '01 SM '06

Description: Low-cost wind energy solution



Multiply Labs

Founded in: 2016

Founders: Fred Parietti PhD '16,
Alice Melocchi

Description: Robotic manufacturing for precision medicine



NuTonomy

(acquired by Aptiv then Motional)

Founded in: 2022

Founder: Karl Iagnemma SM '97
PhD '01

Description: Driverless technology and autonomous vehicles

Talking Shop:

Professor Cullen Buie

A new era for cell therapies

Genetic engineering and personalized cell therapies could transform healthcare. In recent years, stem cells and gene-editing tools like CRISPR have been making headlines for the possibilities they offer to treat diseases, including cancer. But engineering cells is a slow, labor-intensive process, making it difficult to produce personalized therapies at scale.

The startup Kytopen, co-founded by Professor Cullen Buie and Dr. Paolo Garcia, offers a solution that could lead to the mass production of genetically engineered cells. MechE Connects spoke with Buie to discuss how Kytopen has grown since its founding.

How did you and Dr. Garcia come up with the original idea for Kytopen?

In many ways, the genesis of Kytopen started in 2013. After attending a conference on synthetic biology, I received a DARPA Young Faculty Award to look at the problem of getting genetic material into bacterial cells. That funding allowed me to hire Paulo Garcia as a postdoc. Two years later, we participated in the NSF Innovation Corps program, which helps researchers translate their technologies to applications beyond the lab. Through that program, we interviewed over 100 people in industry and uncovered a huge problem in genetic engineering: the delivery of genetic material to cells was too slow, too manual, and low throughput.

Flowfect[®] allows us to process billions of cells per minute. This is crucial for many of the therapies being developed.

I remember we visited one synthetic biology company that was trying to automate the process. Everything was automated except the actual gene delivery step. For that part, two staff scientists would take ninety-six well plates off the line and manually pipette material into the cell samples, one-by-one, then perform electroporation. We immediately identified this as the problem area we wanted to solve and raised more research funding to develop a new technology that ultimately led to Kytopen.

Kytopen pivoted from focusing on bacterial cells to human cells. What inspired that change?

When we founded the company in 2017 and were conducting market research, researchers at companies would repeatedly ask, “Hey, have you ever thought about

using this on mammalian cells or T cells or stem cells?” When you hear that once or twice, you take note. We probably heard it thirty times. We recognized there was a lot more value to be made in that space. There’s a whole industry that is growing and being developed in which clinicians would like to take your cells and re-engineer them to fight your disease. They require similar technologies as what we were developing for bacteria – they also needed them to be high throughput and produced at large volumes.

Around the same time, we received seed funding from The Engine. That gave us the resources needed to explore this space. Once we found this potential application in human immune cells, we hired several immunologists to help us adapt the technology from working on bacteria to working on human cells.



Professor Cullen Buie
Credit: The Engine

Can you explain how Kytopen's technology actually works?

The technology we invented at Kytopen, called Flowfect[®], uses electric fields and a continuous fluid flow at the same time to open pores in cells and deliver genetic materials, like mRNA and DNA. Using microfluidic devices, we're applying an electric field while flowing at very high flow rates. The high flow rates impose shear stress on the cells that, coupled with the electric field, allows you to open pores. We use much less electrical energy than you typically would need for electroporation thanks to this mechanical aspect. As it turns out for many different cell types, this leads to better physical outcomes for the cells. They respond better to this combination of mechanical and electrical stress, because we don't have to shock them as much as traditional electroporation.

Because we're using these very fast flows to induce mechanical strain on the cell, the process is high throughput. We're flowing at very high flow rates, which means we can process a lot of cells. Flowfect[®] allows us to process billions of cells per minute. This is crucial for many of the therapies being developed, which need around a million cells per kilogram of the patient. This opens up a world of possibilities for safe immunotherapies, including immunoncology and gene-editing applications.

Can you combine the technology developed by Kytopen with gene-editing tools like CRISPR?

Currently, the clinically approved way to deliver material into a cell is to use viruses. A virus will invade the cell and integrate its payload into the genome. This is really expensive. It takes a lot of engineering and

development to create a virus that can do this. There are also safety concerns about how the virus can integrate into a patient's cells in a way that may result in negative health outcomes. As a result, there's been a move to non-viral vectors, like CRISPR.

Kytopen is essentially a technology that can enable CRISPR-based gene editing for personalized therapies. There are other gene-editing methodologies, but CRISPR is known as one of the easiest and is being explored the broadest. However, you need to find a way to get CRISPR reagents into the cell, and that's where Kytopen and Flowfect[®] come in. We provide customers and their manufacturing partners with our device so they can integrate it into their manufacturing process and transform the way they conduct cell engineering. 

Staff Spotlight: Leslie Regan

Leslie's legacy

After forty-seven years in MIT's Department of Mechanical Engineering, Leslie Regan retired, leaving a legacy of care and compassion for generations of graduate alumni.

If you mention Leslie Regan's name to any alum of MIT's mechanical engineering graduate program, their face will break into a smile. For nearly five decades, Regan's kind, caring presence was a mainstay for thousands of mechanical engineering students.

Regan joined MIT's staff in September 1974. She started as an administrative assistant supporting three faculty members, including Professor David Wormley. It was in that role that Regan first discovered her love of working with students.

After Wormley became department head in 1982, Regan joined him in MechE headquarters. She spent four years working alongside Wormley, learning the ins-and-outs of the Institute's policies and procedures.

In 1986, there was an opening for the academic administrator in the graduate office and Regan seized an opportunity to get back to where she felt she belonged: working with students.

"My heart was with the students. To me it was never really a job, it was a lifetime mission. I really loved seeing them grow and helping them if they had issues," says Regan.

As academic administrator, Regan helped countless graduate students navigate the often tumultuous experiences of securing funding, passing qualifying exams, and finishing their theses. For many students, especially international students, she was a safe harbor far from home.

Leslie Regan with grad student Andrea Lehn SM '19 at a party celebrating her MIT Excellence Award in 2020. Credit: Tony Pulsone



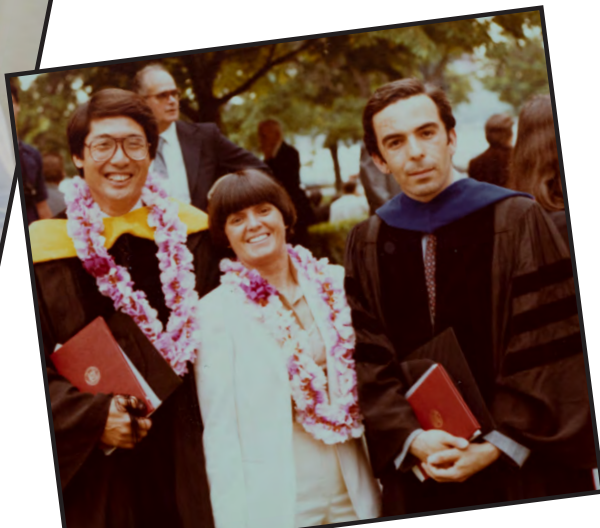
One such student was Shangzhi Wu SM '81 MBA '84 PhD '85. Wu was the first student from mainland China accepted into MIT after the Cultural Revolution. The week he

To me it was never really a job, it was a lifetime mission.

was set to leave for Cambridge, Wu and his wife quickly got married in Beijing since there was so much uncertainty about their visas. The wedding took place in a civil office without a ceremony or reception. Two days later, Wu boarded a flight to Boston.

Over the next two years, Wu developed a close friendship with Regan. When his wife finally joined him in Cambridge, Regan organized the wedding party they never had.

"When Leslie learned that we never had an official wedding ceremony, she organized





a party with many friends at her house,” says Wu. “We really appreciated Leslie’s friendship and kindness to organize that in her house.”

From Regan’s perspective, she gained just as much from her relationships with international students as they did from her.

“I just feel like we can make an impact no matter where we are.

People would always ask me ‘Do you travel?’ And I say that I do. I travel all over the country and all over the world through the eyes of our students,” Regan says. “There’s no place I haven’t been. They come into MIT and I get to know their culture.”

As the years went on, Leslie became an institution within MechE. She ushered the graduate program from a time when master’s and doctoral theses were written on typewriters and copied on mimeographs, through to the digital age and the pandemic, which saw students defending their PhD theses on Zoom.

Over the years, her office on the first floor of MIT’s Building 3 became a shrine to the many students she cared for, helped, and mentored over the years. The walls were decorated with mementos sent from every corner of the world, and even beyond.

On one of his trips to the International Space Station, alum and former NASA astronaut Mike Massimino SM ’88 PhD ’92 had the opportunity to bring an item to space as a gift when he returned to Earth. He chose a t-shirt with MechE’s name on

it in honor of the department’s – and by extension Leslie’s – impact on his life.

“Leslie made every one of us feel like family. I wanted to fly something for the department specifically, and Leslie had a lot to do with that because the department took care of me. They educated me and gave me these great opportunities,” says Massimino. “A lot of people come in-and-out of your life to make these things possible, and Leslie was one of them.”

After decades of keeping the graduate office running, Regan is adjusting to the slower pace of retirement. She has been cleaning and organizing boxes and boxes of keepsakes, including dozens of cherished letters and emails from alumni. She also is very active in her church community and keeps busy with volunteering.

When she reflects on her career at MIT, Regan only has positive things to say about each student she worked with.

“I never felt like this was a job. I felt this is really the place I should be and I loved every minute of it,” says Regan. “Some people would say to me, ‘There must be one student you didn’t like.’ And I would say never, not one. Sure, their needs are different, but I cared for every single student who went through our program.”



News & Awards

Departmental News

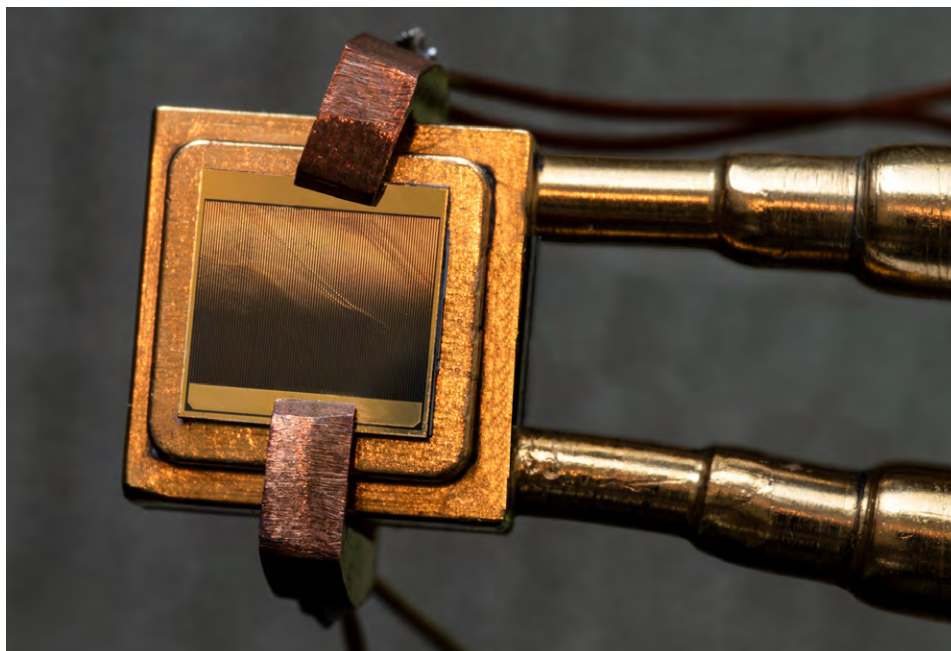
- In their annual university rankings, *US News & World Report* named MIT's Department of Mechanical Engineering the number one undergraduate program in mechanical engineering for 2023 and the number one graduate program in mechanical engineering for 2023.
- In April, QS World University Rankings honored MIT with a number one ranking in the subject area of Mechanical, Aeronautical, and Manufacturing Engineering for 2022.

Research News

- In a *Science Advances* study on deep-sea mining, a team led by Professor Thomas Peacock was the first to examine the cloud of sediment that a collector vehicle stirs up as it picks up polymetallic nodules from the seafloor.
- A team including Associate Professor Jeehwan Kim devised a new kind of wearable sensor that communicates wirelessly without requiring onboard chips or batteries. Their research was published in the journal *Science*.
- Researchers led by Professor Asegun Henry and Professor Evelyn Wang have developed a thermophotovoltaic cell that converts heat to electricity with over 40 percent efficiency – a performance better than that of traditional steam turbines. Their work was published in *Nature*.
- Using machine learning along with data from wave tank experiments, MIT engineers led by Professor Themistoklis Sapsis have found a way to model how waves break in a *Nature Communications* study.

A field study conducted by Professor Thomas Peacock reveals a previously unobserved fluid dynamic process that is key to assessing the impact of deep-sea mining operations. Credit: Global Sea Mineral Resources





Associate Professor Asegun Henry and Professor Evelyn Wang have designed a new heat engine with no moving parts that is as efficient as a steam turbine. Credit: Felice Frankel

- In a groundbreaking *Science* study, a team led by Professor Gang Chen determined that the material known as cubic boron arsenide overcomes the limitations of silicon and is the best semiconductor material ever found.
- Associate Professor Jeehwan Kim has been granted tenure. Kim has made pioneering contributions to the growth of non-silicon semiconductors for next generation electronic and photonic devices.
- Themistoklis Sapsis was promoted to Full Professor. Sapsis is an international pioneer in the field of stochastic nonlinear dynamical system.
- A *PNAS* study by Professor Anette “Peko” Hosoi focused on how masking and distancing at NFL stadiums may inform decisions on holding large outdoor gatherings amid future public health crises.
- Associate Professor Mathias Kolle has received tenure. Kolle has become a leader in the field of biological and bio-inspired optics.
- Dr. Tian Tian has been promoted to Senior Research Engineer. He is a recognized world leader in engine tribology.

Faculty & Research Staff Promotions

- Irmgard Bischofberger was promoted to Associate Professor without Tenure. She is a rising star in the area of pattern formation in fluids and soft materials.
- Associate Professor Ming Guo received tenure. Guo is a recognized leader at the intersection of cell mechanics and soft matter physics.
- Kenneth Kamrin has been promoted to Full Professor. He is an international leader in the modeling of large-scale granular flows and particulate media.



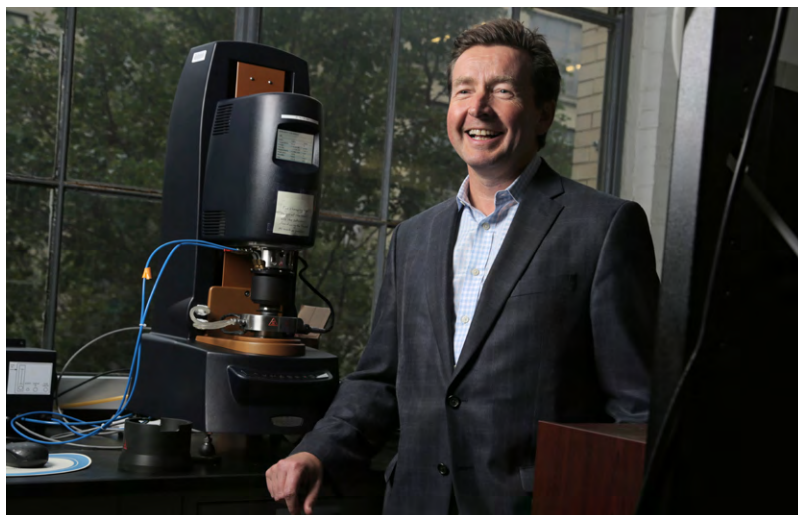
Irmgard Bischofberger has been promoted to Associate Professor. Credit: Lillie Paquette



A health worker in rural Rwanda takes an image of a new mother's Cesarean section wound using the mobile health app developed by an interdisciplinary team, including Dr. Richard Fletcher. Credit: Partners in Health

Awards

- An interdisciplinary team, including research scientist Dr. Richard Fletcher, received the \$500,000 first-place prize in the NIH Technology Accelerator Challenge for Maternal Health for their mobile health platform that uses AI to detect infection in Cesarean section wounds for use in rural Rwanda.
- Professor Daniel Frey has won the Teaching with Digital Technology Award. This student-nominated, student-judged award recognizes faculty who use digital technology to make learning more engaging and effective.
- Professor Ian Hunter and Professor Evelyn Wang were both elected as 2021 AAAS Fellows in recognition of their scientifically and socially distinguished achievements.
- Professor John Lienhard was given the Donald Q. Kern Award by the American Institute of Chemical Engineers in recognition of expertise in a given field of heat transfer, transport phenomena, and energy processes.
- Professor Gareth McKinley has been selected for the 2022 Society of Engineering Science G.I. Taylor Medal for his seminal contributions to the development of viscoelastic fluid mechanics through a unique combination of experiments and theory.



Professor Gareth McKinley won the 2022 Society of Engineering Science's G.I. Taylor Medal. Credit: John Freidah

- Associate Professor Stefanie Mueller has been named to the *MIT Technology Review* 35 Innovators Under 35 list. Mueller is developing a way to reprogram the appearance of objects using photochromic dyes with fine control over each color channel.

- Assistant Professor Carlos Portela has been named one of the 35 Innovators Under 35 by the *MIT Technology Review*. Portela has developed a process that allows him to create 3D nanomaterials you can hold in your hand.

- Professor Ellen Roche received the grand prize at the MIT Future Founders Initiative Prize Competition, which encourages women to pursue entrepreneurship in biotech.

- Associate Professor Irmgard Bischofberger received the MIT School of Engineering Junior Bose Award, given annually to an outstanding contributor to education.



MIT Technology Review named Assistant Professor Carlos Portela one of the 35 Innovators Under 35. Credit: Tony Pulsone



- MechE producer John Freidah was awarded a New England Emmy Award for his video, “Understanding the Arctic,” which chronicles a team of MIT engineers as they test a method for autonomous vehicles to accurately navigate the Arctic Ocean without GPS.

- Dr. Barbara Hughey has been awarded the School of Engineering Distinguished Educator Award for her sustained contributions to 2.671, Measurement and Instrumentation, spanning nearly two decades.


- Dr. Dawn Wendell was honored with the Mechanical Engineering Exceptional Educator Award for her sustained and diverse contributions to MechE’s curriculum, spanning classes such as 2.007, 2.671, 2.008, and 2.810.

Alumni News

- Yoonho Kim SM '18 PhD '22 was named to *MIT Technology Review*'s list of 35 Innovators Under 35. Kim, who is currently a postdoctoral associate in Professor Xuanhe Zhao’s lab, developed a teleoperated robotic system that can wind its way through the brain’s vascular network.

- Trang Luu '18 SM '20 has been awarded a 2022 Paul & Daisy Soros Fellowship for New Americans. Luu, who developed assistive technologies and evaporative cooling devices for off-grid farmers at MIT, will pursue an MBA at Harvard Business School.

- Hyunwoo Yuk SM '18 PhD '22 has been named to *MIT Technology Review*'s list of 35 Innovators Under 35. Yuk has developed bioadhesives that allow for near-instant repair of tissues and organs.

- Spyce, the innovative restaurant where robots assemble and serve healthy meals, has been acquired by Sweetgreen. The Boston-based restaurant was co-founded by MechE alumni Kale Rogers '16, Luke Schlueter '16, Michael Farid '14 SM '16, and Brady Knight '16. 



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