



SPRING 2018

# DARTMOUTH Engineer

THAYER SCHOOL OF ENGINEERING

inside

FORMULA HYBRID

ERASING BOUNDARIES

THE POWER OF DESIGN THINKING

## THE QUEST FOR NEW FUELS

PROFESSOR LEE R. LYND TH'84 TH'87 IS DRIVEN BY THE CHALLENGES AND THE PROMISE OF CELLULOSIC BIOFUELS.

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# Dartmouth's Next Provost



## FOLLOWING A NATIONAL SEARCH, DEAN JOSEPH

J. Helble has been appointed Dartmouth's next provost by President Phil Hanlon '77. Helble will take up his new position at the end of October. The search for Thayer's next dean will begin this summer, and an interim dean will be appointed before the start of fall term.

During his four terms and nearly 13 years at Thayer's helm, Helble has been a tireless advocate for the liberal arts as an essential element of an engineer's education. As he says, "A grounding in the liberal arts creates the context for understanding engineering problems and helps students learn to ask broader questions and develop deeper critical thinking skills."

Under Helble's leadership, Thayer enrollments have nearly doubled, the faculty has grown, funding has risen to record levels, and Thayer has achieved two national firsts: graduating a majority female engineering class and launching a PhD Innovation Program that augments doctoral research with entrepreneurial training. Thayer established new exchange programs in Asia and Denmark, a modified major with public policy for those interested in careers in public service, summer design programs for middle and high school students interested in exploring engineering, short courses taught over winter break for Dartmouth and Thayer students interested in exploring a technology-focused topic, and a biomedical engineering sciences major for engineering students interested in attending medical school. And, as 70 percent of Dartmouth students take at least one engineering or computer science course, Helble has helped spearhead an ambitious growth plan that includes an additional building at Thayer that will house an expanded engineering faculty, the Department of Computer Science, the Magnuson Family Center for Entrepreneurship, and state-of-the-art classrooms and design spaces that will facilitate active learning (see page 8), which he will continue to shepherd in his new position.

"As an educational trailblazer, Joe Helble is eminently suited to help shape Dartmouth's future at this time of dynamic change and opportunity," says Hanlon. "He is a visionary and skilled leader who will bring a track record of accomplishment to his new role."

As provost, Helble will be Dartmouth's second-ranking officer and the chief academic officer. In consultation with the academic deans, he will be charged with advancing the teaching and scholarship of the Faculty of Arts and Sciences, the Geisel School of Medicine, the Guarini School of Graduate and Advanced Studies, the Tuck School of Business, and Thayer. Working with the academic deans, dean of the College, and vice provost for enrollment management, Helble will be responsible for supporting and advancing all student-related programs, including leadership for all aspects of enrollment management, admissions, and financial aid, and will have significant financial oversight, working closely with the executive vice president to manage the academic budget.

"I am honored to be taking on this important role at this momentous time for Dartmouth, and I look forward to working closely with President Hanlon and the extraordinary people at Dartmouth—our talented faculty, gifted students, and committed staff," Helble says.

The dean makes clear that he isn't leaving Thayer behind. Addressing the Thayer community, he says, "One of the true privileges of my time at Thayer has been the opportunity to work with such dedicated faculty, staff, and alumni at Thayer, fully committed to supporting the education and research of incredible students. Since I am only walking across campus to a new office and will still be engaged at Thayer, including with our building project, I look forward to further collaborations with all of you."



# Contents

8

## Erasing Boundaries

As the physical and digital worlds converge, engineering and computer science build an integrated future.

BY KRISTEN SENZ AND KAREN ENDICOTT

12

## The Grand Challenge of Cellulosic Biofuels

Why cellulosic biofuels have fallen short of expectations and what we can do about it.

BY PROFESSOR LEE R. LYND TH'84 TH'87

18

## The Power of Design Thinking

Thayer's growing design offerings ground engineers—and other students—in what matters most.

BY KRISTEN SENZ

### IN DEMAND

70 percent of Dartmouth undergraduates take at least one engineering or computer science course, such as Professor Jeremy Faludi's ENGS 75: Product Design. Page 8

### DEPARTMENTS

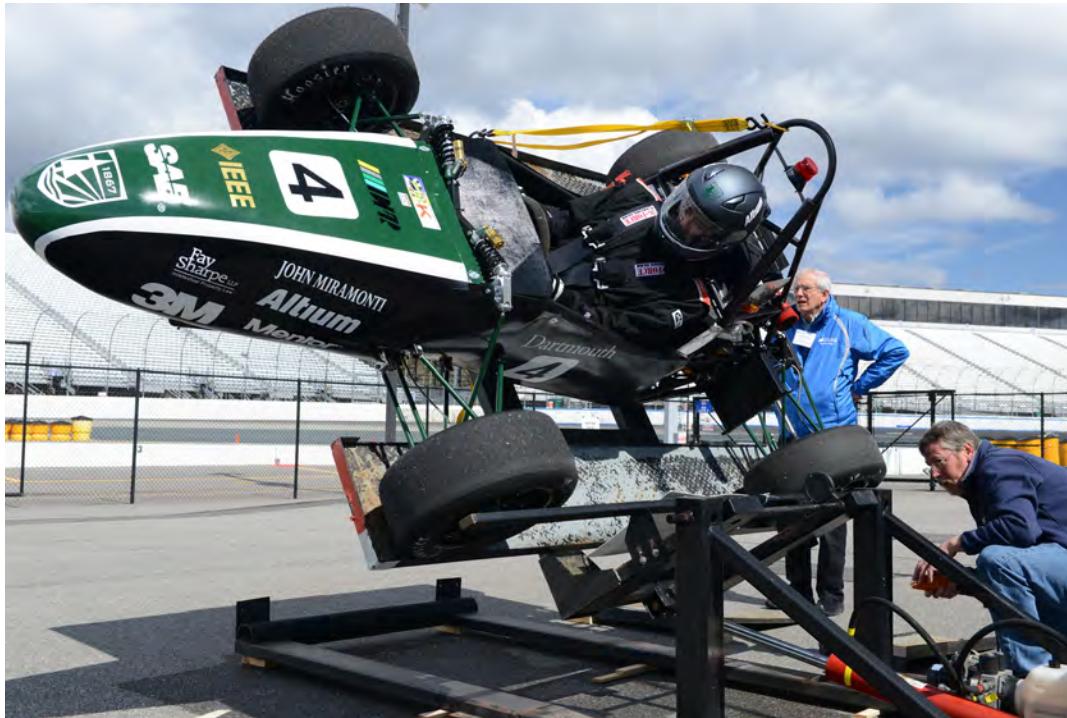
- 2 The Great Hall
- 24 Alumni News
- 32 Inventions
- 33 Random Walk

COVER: Professor Lee R. Lynd in his Thayer School lab. Photograph by John Sherman.

# THE Great Hall



NEWS FROM AROUND THAYER SCHOOL



## COMPETITION

### Dartmouth Wins at Formula Hybrid

AFTER COMPETING FOR TWELVE YEARS IN THE FORMULA HYBRID Competition, Dartmouth Formula Racing (DFR) has taken home the gold—well, more accurately, the green First Place Hybrid Category trophy. The team's hard work and preparation paid off at competition, which was held April 30–May 3 at the New Hampshire Motor Speedway in Loudon, N.H., and drew 23 teams from across the United States and from Canada, India, and Turkey.

The DFR team passed all levels of inspection and completed dynamic events in record time; they were also the only team to finish all 44 laps of the endurance event. "It's sort of the behemoth event," says DFR team member Sean Sengupta '17 Th'18. "And we actually completed it with a decent portion of energy remaining. It's a testament to our team's engineering."

In the past, the DFR team hit various roadblocks to success. Some years their DFR car failed safety inspections. Last year the car managed to complete only half an endurance lap. "As part of the redesign this year they reevaluated the energy needs for the car and how to distribute the power between the engine and the motor," says Raina White, Thayer lab instructor and DFR team advisor.

Much of the hardest work was completed as part of an ENGS 89/90 BE capstone project. A team of six Dartmouth engineers, including three DFR members, reconfigured the car's battery packs and worked on the accumulator system and the enclosure for the system. DFR also put project management skills to use to successfully drive the timeline of work.

**NEW HEIGHTS**  
Dartmouth's formula hybrid race car raced through the tilt test and other mandatory safety inspections on the way to a first-place finish.

"We focused on when certain components needed to be delivered," says Sengupta. "We were able to meet all the deadlines, which allowed us to test really early." Noting that the car was on the road in late February, he says, "We put 50 to 60 kilometers on the car before competition, which allowed us to work out a lot of kinks."

With the car weighing 672 pounds—almost 200 pounds lighter than last year—DFR drivers Leina McDermott '19 and Alie Stasior '20 finished 75-meter acceleration runs in impressive times ranging from 6.5 to 5.1 seconds. "We were able to create a true race car that we're all really proud of," says Sengupta.

In addition to their success in endurance and acceleration, DFR took first place in the hybrid category for engineering design and autocross. The team received also received Fiat Chrysler Automobiles' Industrial Design Award and the Institute of Electrical and Electronics Engineers' (IEEE) Engineering the Future Award.

Georgia Tech secured a first-place finish in the electric category with high scores in project management, design, and endurance.

Formula Hybrid was founded by Thayer students and Thayer research engineer Doug Fraser in 2006. Thayer continues to organize and host the competition, which is endorsed by the IEEE and Society of Automotive Engineers (SAE). It remains the most difficult of SAE students competitions. For more, see [formula-hybrid.org](http://formula-hybrid.org).

—Kathryn Lapierre

# Q&A

>> George Boateng '16 Th'17

Besides being a research scientist in computer science who is exploring the intersection of health-care and wearable tech, George Boateng is a social entrepreneur. His Thayer experience led him to cofound the Nsesa Foundation in 2014 to bring engineering classes to young people in his native Ghana. The foundation's educational programming continues to expand, and Boateng, who recently received a 2018 Dartmouth Social Justice Award for Emerging Leadership, has big plans for its future growth, even as he heads off to Switzerland to begin a PhD at ETH Zurich.

### What is the goal of your Nsesa Foundation?

We want to ignite an "Innovation Revolution" in Africa. The foundation's Project iSWEST is an intensive three-week summer adaptation of Thayer's ENGS 21 for students in Ghana. This summer will be the fifth year for the program, and it will be the first time we are operating it in two regions of Ghana simultaneously. Eventually, we hope to operate in all 10 regions, as well as in other parts of Africa.

### Why did your foundation also launch SuaCode?

We want to teach millions of people how to code. SuaCode is an online course that teaches coding on a smartphone. We noticed that only 25 percent of people in Ghana have laptops, but 100 percent have smartphones. This year we are doing some pilot tests with groups of students to compare the learning experience on a laptop versus a smartphone. Our idea is that the basic course would be available for free online and that schools could access more advanced courses for a fee, like a subscription. Part of the pilot will be looking at the feasibility of that.

### How else are you encouraging an innovation revolution?

In our first few years, we had very few female participants, and we wanted to address the gender gap in STEM. In 2015, we celebrated eight Ghanian women doing amazing things in STEM, hoping to inspire the younger generation. We were able to reach 30,000 people on Facebook, which is where we're sharing the stories. This year, from January to June, STEM WOW (Woman of the Week) will feature 24 women.

### Has Project iSWEST inspired participants to continue in STEM?

Yes. It has turned out to be a pipeline for people who are interested in getting involved. The leader of STEM WOW, Princess Allotey, was one of two girls in Project iSWEST in 2014. She loves math and has founded Kids and Math, a project to spread the love of math to kids all over Ghana. Another participant developed a program called My Home Teacher to match students with tutors. That has taken off and won a lot of awards.

### What drives you to keep your Ghana work going as you study abroad?

Part of the reason I left Ghana is that the research and the hands-on work that I want to pursue doesn't exist there. I'm focused now on trying to create the ecosystem that I wish was there when I was growing up. I've been seeing progress, and I think there are people in business and other industries who are pushing boundaries, and that's very encouraging.

"We want to ignite an 'Innovation Revolution' in Africa."



## Kudos

**AWARDED** Professor **Vikrant Vaze** earned a Career Award from the National Science Foundation. Vaze is developing mathematical approaches and computational algorithms for efficient planning and operations of multiple civil infrastructure systems.

**AWARDED** The New Hampshire High Tech Council named **Professor Petra Bonfert-Taylor** the 2018 TechTeacher of the Year for making Introduction to ENGS 20: Scientific Computing an active learning course and developing Thayer's Dartmouth Emerging Engineers program.

**INDUCTED** Professor **Richard Greenwald** '88 Th'88 was inducted into the American Institute for Medical and Biological Engineering. Greenwald, the cofounder and president of Simbex, was elected for developing devices that record head impact in helmeted sports and assist amputees with walking and geriatrics with balancing.

**AWARDED** Professor **Eric Fossum**, inventor of the CMOS active pixel image sensor, received the 2018 Yale Science & Engineering Association Award for Advancement of Basic and Applied Science because he "revolutionized optical sensor array technology and made whole fields of research possible." Fossum earned his MS and PhD degrees from Yale in 1980 and 1984, respectively.

**CITED** *The New Yorker* highlighted the research of **Professor Erland Schulson** and **Professor Don Perovich** in its April 9 article "Black Ice, Near-Death, and Transcendence on I-91." It quoted Schulson's explanation that "Warm ice" is the state of "most ice we encounter in the world—nothing slipperier than that."

**NOTED** The team of MEM '19 students **Abhishek Agarwal**, **Sadie Doran**, **Adithyan Karunakaran**, and **Poorna Suresh** took second place in the annual virtual business simulation run by the Master of Engineering Management Programs Consortium. The five-week competition placed students at the helm of a virtual automotive manufacturing company.

**AWARDED** Dual-degree program student **Lisa Je '18** earned the Mazilu Engineering Research Fellowship for 2018–19. The award will support her work with **Professor Jifeng Liu** on developing environmentally friendly and economical materials for solar cells.

I Want  
One of  
Those!

## STUDENT PROJECT

### BREATHTABLE BUFF

It's hard enough for asthmatics to breath. Add in cold and exertion and the problem is even more dire. That's why students created the Breathable Buff, a face mask that retains heat and moisture to make breathing far easier for asthmatic athletes during the winter. The washable buff has interchangeable filters to use in different weather conditions. Inventors Carly Tym '20, Ruth Nordhoff '20, Samuel Gochman '18, dual-degree student Madeleine Genereux, and Kevin Yang '20 won the winter term Phillip R. Jackson Award for best overall performance in ENGS 21: Introduction to Engineering. Their teaching assistant was Brandt Slayton '18.



## HUMANITARIAN ENGINEERING

### Beauty and the Motorbike

A WORLD-TRAVELING CONCEPTUAL artist has enlisted Dartmouth Humanitarian Engineers (DHE) to work with Moroccan craftsmen on a project he hopes will help revolutionize a country and revitalize an art form.

The Mahjouba Initiative, a long-term effort to design, build, and manufacture an electric motorbike that uses local materials and looks exquisite, aims to reintegrate Moroccan craft traditions into the mainstream.

"Art can manifest in any form, whether it be a canvas or a moped," says Eric van Hove, an Algerian-born Belgian artist who spent a year as an artist-in-residence at Dartmouth and now lives in Marrakech.

Van Hove conceived of the Mahjouba Initiative after working with Moroccan craftsmen on *V12 Laraki*, an ornate sculptural replica of a Mercedes engine now owned by Dartmouth's Hood Museum of Art. Inspired by Moroccan sports car designer Abdeslam Laraki, who built

the luxury Laraki Fulgra using all local parts, except for the engine, van Hove picked up where Laraki left off. He took apart a V12 engine, asked 42 Moroccan crafters to replicate the parts, and reassembled their work into art. Then he drove the idea further: Could the craftsmen build a functional, sustainable moped that contributes to the country's renewable energy goals?

During his 2016–17 Montgomery Fellowship at Dartmouth, van Hove spoke with Nat Healy '19, now copresident of the student-run DHE, about a partnership. DHE worked with van Hove to produce a prototype of the moped using materials such as bone, wood, and leather, and accepted his invitation to visit Morocco.

"We thought a trip to Morocco would really give us a sense of who the craftsmen are, what they're interested in, and what we can actually do with this project, because a lot of it depends on what the craftsmen are capable of making and what materials they use," explains Healy.



#### REINVENTING THE WHEELS

Five Dartmouth students joined artist Eric van Hove's crew to translate his motorbike sculpture, above, into a usable elegant electric vehicle.

Matt Spencer '19 is leading the DHE project team. Spencer says he immediately "fell in love with the idea of this multidisciplinary project that uses this craft I'd never seen and makes an actual moped, but it's gorgeous; it truly is art."

In July 2017, Healy, Spencer, and three other students arrived in Morocco to find challenges unlike any engineering problem they'd faced. As van Hove describes it: "Everything is open-ended, and I mean everything. It's puzzling at first, but if you get in the mood, it's really exciting."

Although interpreters helped them communicate with Arabic- and French-speaking craftsmen, the students found that showing was usually easier than telling. "If you give them a gear and show them how it works, that's what they love to do," says Healy. "It was amazing to see what they could do with the tools they have. We're using laser cutters and 3D printers and giant mills, and they're doing incredibly precise work with a chisel and a mallet on wood."

At times the students struggled to reconcile their engineering mindset with van Hove's artistic vision. For example, a chain-drive transmission, although efficient, wasn't original enough. "If we use a chain, which they don't view as particularly special or nice, it's not going to have the same impact as if we do something completely different," says Spencer.

"Because it is an art project, it's not all about the functionality of the bike," says Healy. "Of course, the bike has to function, but that's not the number-one priority all the time."

Back at Thayer, Healy and Spencer are applying their Moroccan experience to their engineering courses. "It's been amazing to get on the ground and really talk to the people who it's going to influence and to see the entire process laid out from beginning to end," Healy says. "A lot of the lessons we learned over the summer and with Eric are really applicable to our classwork now and in the future as engineers."

DHE continues to work with van Hove and the craftsmen on the prototype. Tuck business students visited Morocco in March to analyze the commercial feasibility of the Mahjouba Initiative, and the Dartmouth Entrepreneurial Network, with support from the Dartmouth Class of 1968, established a team to work on crowdfunding. Van Hove envisions the craftsmen building the mopeds, which would be priced around \$1,500, and hopes the motorbikes are a vehicle for renewed relevance for craftsmanship in a changing world. As he said in a 2013 TEDxMarrakech talk about the *V12 Laraki*, "Craft is to industry what animism is to religion. It's the mother of it all."

—Kristen Senz



#### A SUPERHERO AMONG US

Professor Eric Fossum came face to face with himself as an "Inventor Superhero" at the National Inventors Hall of Fame Museum's May 3 ceremony for 2018 inductees. Fossum was inducted in 2011 for inventing the CMOS active pixel image sensor that makes cell phone cameras possible. "Thanks, NIHF," he says on LinkedIn. "Hope I can live up to my life-sized image!"

#### ASK THE EXPERT

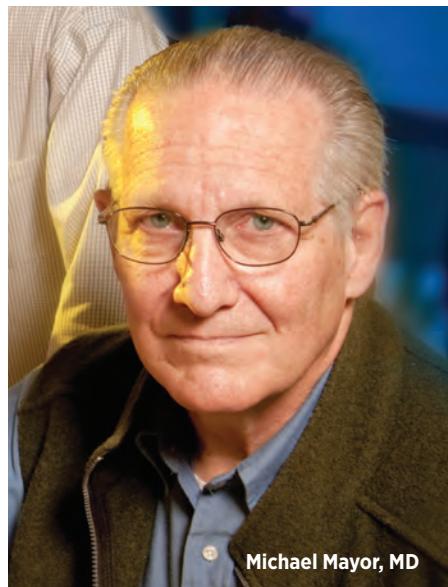
## Hip Advice

We asked Adjunct Professor of Engineering Michael Mayor, MD, retired Dartmouth-Hitchcock orthopaedic surgeon and cofounder of the Dartmouth Biomedical Engineering Center, home to the largest orthopaedic implant retrieval program in the world:

#### What kind of hip implant did you recently choose for yourself?

"Given my fairly close relationship with over 18,000 retrieved specimens, I did have some firmly held convictions about how to go about it. In over 40 years of retrieval analysis at Thayer, we've compiled definitive, long-term outcome data about cement fixation versus porous-coated joint implants, and the answer is clear: Use cement for knees and porous coating for hips. Some of the smaller decisions I needed to leave up to my surgeon based on his experience and skill set, and there were only two other non-negotiables necessary to avoid complications. First was that the acetabular side include cross-linked polyethylene to minimize the production of debris, and second was for the titanium stem to be fitted with a ceramic ball rather than a cobalt chrome ball, which can result in corrosion and the dreaded 'ALTR' [adverse local tissue reaction]. Luckily, this was consistent with what my surgeon was likely to do anyway, which is why I chose him!"

—Catharine Mayor Lamm



Michael Mayor, MD

BEHIND THE SCENES

## Machine Shop as Business Process Lab



Kevin Baron runs a well-oiled shop.

### STATE-OF-THE-ART MACHINES

and tools aren't enough. For a machine shop to effectively foster student learning and building, it also needs an effective strategy for providing access to those tools.

That's the perspective that drives Kevin Baron, manager of Thayer's machine shop. Baron, a staple of the Thayer experience for 18 years, says the shop itself functions as a well-oiled machine by adhering to methods of workplace organization pioneered at Toyota.

"One of the great trends of our time is the standardization of work using digital tools to make better use of temporary, part-time workers, and that's what we're doing here," says Baron, who routinely discusses best practices with visitors from other engineering schools.

Since its renovation and major equipment update five years ago, the Thayer machine shop has fully revamped its business processes, putting in place systems that enable safe, efficient access to all of the shop's resources, both physical and knowledge-based. Through digitization and decentralization, the shop's four professional instructors can effectively manage a staff of about 30 student assistants who work part-time and contribute to the learning and achievements of fellow students.

Taking advantage of an environment full of problem-solvers, Baron identifies problems within the shop that he hopes students in the school's Master of Engineering Management (MEM) program can solve.

One problem was interruptions. Students would come into the shop looking for materials, such as glue or tape measures, for their course-related projects. MEM students found a solution: vending machines. They purchased four and stocked them with various shop necessities, which students can access for free.

The vending machine system is refined each year. MEM student Eric Beauregard '19 and two classmates picked up the project last fall. They selected a single supplier for most of the 56 products available, enhanced a shared spreadsheet to better track inventory, and are working toward a barcode sys-

tem to streamline reordering.

"The basic vending machine system was already in place, but there were multiple issues that we wanted to address and fix," says Beauregard. "As MEM students, we want to create the system and set the process up so that it's easy for an undergrad or someone else to come in and take over."

MEM students have facilitated information-sharing by the machine shop through digital platforms: social media for scheduling, a wiki for instruction manuals and tutorials, and a blog for student articles about past projects. They also created a system for organizing tools within tool chests and drawers and are automating bookings for machine time, enabling users to maximize productivity and learning, Baron says.

Worker profiles cycle across a digital screen at the shop's entrance, showing which staff members have completed the most training hours and tasks. MEM student Joris van der Herten Th'17 wrote the software and is continuing to work out the bugs. "The point," explains Baron, "was to recognize achievement and to make it public," a tenet of the Toyota system.

Another new system helps students identify shop workers who can answer specific questions. Skill areas are represented by colored dots on staff ID badges and a display board. This helps reception desk greeters match shop users with instructors and assistants "just like the maître d' at a good restaurant," says Baron.

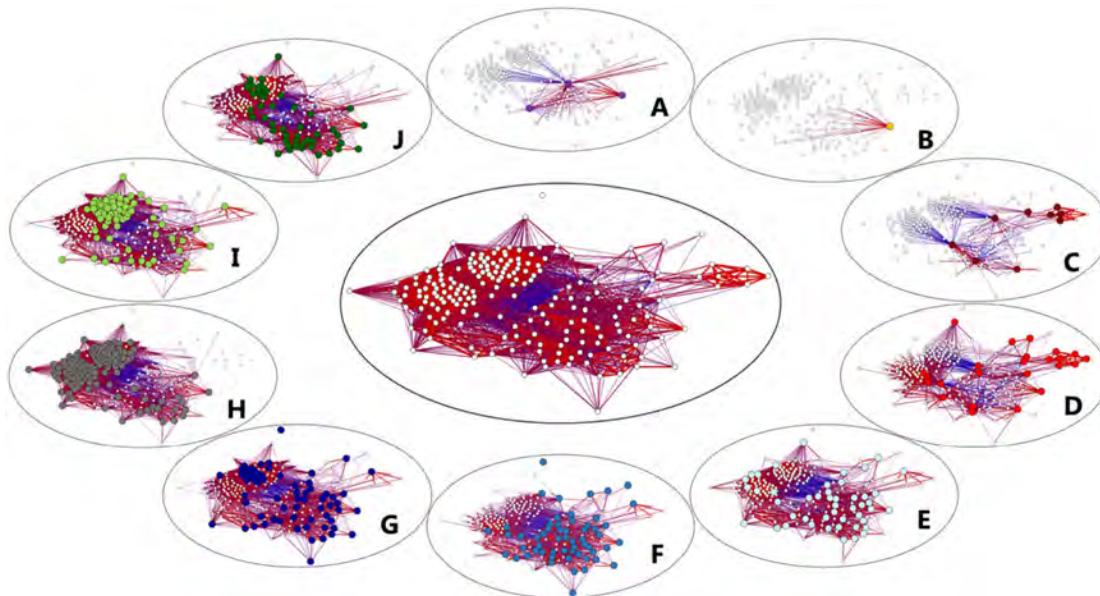
These systems also generate shop usage data, explains Baron, including which machines are in highest demand. Reports help school administrators make informed decisions about courses and shop resources.

"The machines alone are less than half the story," says Baron. "The real challenge is providing access to these budding engineers."

The machine shop, Baron adds, is central to producing graduates who not only understand engineering theory and concepts, but also can apply them in design and fabrication. "Nobody's going to hire you to do problem sets," he says. "They're going to hire you to solve real problems."

—Kristen Senz

# lab reports



## Breath Analysis for Cystic Fibrosis

**BREATHPRINTS**  
Professor Jane Hill plots the distinct identifiers diseases leave in exhalations.

BY ANALYZING A PATIENT'S EXHALED breath, Thayer Professor Jane Hill hopes to develop a more efficient diagnostic tool with the potential to both extend and improve the lives of people suffering from cystic fibrosis. The Cystic Fibrosis Foundation has awarded Hill and her colleagues \$1.2 million over the next three years to study more than 300 adult and pediatric patients at five clinical sites. According to Hill, each patient in the study will receive both the current gold standard test—culturing a sputum sample—and the breath test, in which a breath sample is analyzed using advanced chromatography and mass spectrometry. The team aims to identify and validate molecular biomarkers for a common respiratory infection, *Pseudomonas aeruginosa*, that is particularly dangerous for people with cystic fibrosis.

Cystic fibrosis patients often experience multiple simultaneous respiratory infections, but sputum might contain matter from only part of the lung, giving an incomplete diagnostic picture. In contrast, a patient's breath offers evidence of all the infections at once. Calling breath "a window into the health of the entire lung," Hill says that molecules in a breath sample act "like a fingerprint," enabling the identification of specific infections almost immediately, whereas cultures can take days or even weeks.

"*Pseudomonas aeruginosa* mutates really quickly. It figures out how to live in your lung environment and how to hide itself from your immune system and how to become more drug resistant fairly quickly. The sooner you can discover that it's there and direct treatment toward its eradication, then the better your outcomes are as a patient."

Hill hopes this research will result in a handheld device, similar to a breathalyzer, that could be used with a smartphone app to quickly diagnose certain respiratory conditions. "People already have handheld devices that probably could be modified, once you know what you're looking for," she says.

The three-year study, led by Hill and co-principal investigators from Arizona State University and Colorado Children's Hospital, will include patients at five sites, including Dartmouth-Hitchcock.

—Kristen Senz

## Imaging for Back Surgery

Professor Keith Paulsen, adjunct professors David Roberts, MD, and Songbai Ji, and colleagues have developed an intraoperative stereovision (iSV) system to make back surgery safer and less costly.

While MRIs and CT scans can pinpoint spine problems, such as compressed vertebrae or herniated disks, finding a clear surgical path to those problem areas is not always as straightforward since tissue and bone not only stand in the way, but can also move during spinal surgery. The iSV system, developed with colleagues from Geisel School of Medicine, the University of Vermont, and Worcester Polytechnic University, uses a complex algorithm and two cameras attached to a surgical microscope to produce real-time 3D images on a monitor to guide surgeons during procedures. This type of stereoscopic system has been used in brain surgery—technology pioneered by Roberts and the late Thayer Professor John Strohbehn—but has been unexplored for spinal surgery. Paulsen and a team at Dartmouth's Center for Surgical Innovation tested the iSV system on porcine spines and is now converting the system into a handheld wand. Although use in humans may be several years away, Paulsen remains optimistic about the system's potential impact. "By rendering images in real time with a simple handheld tool, we believe we can make surgeries safer and less costly in the future," he says.

The system is detailed in the article, "Stereovision Co-Registration in Image-Guided Spinal Surgery: Accuracy Assessment Using Explanted Porcine Spines," published in the journal *Operative Neurosurgery*.

—Callaway Zuccarello

# Erasing



## SHARED SPACE

Thayer's new building—shown here as a conceptual image rather than a final design—will architecturally express the spatial and programmatic intermixing of engineering, computer science, design, and entrepreneurship, with open vistas, shared facilities, and thematic rather than departmental groupings.

# Boundaries

AS THE PHYSICAL AND DIGITAL  
WORLDS CONVERGE, ENGINEERING  
AND COMPUTER SCIENCE BUILD AN  
INTEGRATED FUTURE.

BY KRISTEN SENZ & KAREN ENDICOTT



**W**hen trying to solve the world's toughest problems, nothing helps generate innovative ideas more than bringing together people with diverse perspectives and expertise.

That underlying notion is guiding the concept and design of a new 160,000-gross-square-foot building at Thayer School of Engineering that will also house the computer science department, Dartmouth's new Magnuson Family Center for Entrepreneurship, the Digital Arts, Leadership and Innovation (DALI) Lab, design and maker spaces, and the electron microscope center. Along with Tuck School of Business and the forthcoming Arthur L. Irving Institute for Energy and Society, the new building is a key part of Dartmouth's plan to transform the west end of campus into the epicenter of technological and entrepreneurial innovation at the College.

The new building will architecturally express the spatial and programmatic intermixing of engineering, computer science, design, and entrepreneurship, with open vistas, shared facilities, and thematic rather than departmental groupings. Classrooms, project studios, labs, and offices will be interspersed—as they are in Cummings Hall and MacLean Engineering Sciences Center—continuing Thayer's successful strategy for sparking collaboration and fostering a keen sense of community even as the school grows.

"What's exciting is bringing together innovation and entrepreneurship, computation and engineering, all in an integrated fashion and under one roof, not side-by-side in different wings of the building, but really intermixed and integrated," says Thayer School Dean Joseph J. Helble. "This approach says to students, faculty, and staff that taking an idea from the laboratory all the way to application is not only possible but something that's encouraged and celebrated, and we've got the resources here in one place for you to do it. Even more importantly, it says that the artificial divide between the computational world and the physical world of engineering devices, of hardware, is no longer relevant. To be a true technology leader, you really need to draw from the digital and physical."

Dartmouth's erasure of old boundaries between engineering and computer science comes at a time of increasing convergence between the physical and digital worlds—or what the National Academy of Engineering and others call the "Fourth Industrial Revolution." As Professor Hany Farid, chair of computer science, says, "Computer science and engineering have collided, and digital technology is being integrated into everything from toasters to self-driving cars. Our students must be trained in these two worlds."

The new building will feature academic "neighborhoods" uniting computer science and engineering faculty and students who conduct research in areas of shared interest, including advanced materials, biotechnology, emerging technologies, energy technology, machine intelligence, mobile X, and security and privacy.

"To have a shared space that's just for the technology that you're trying to develop is something that we're really emphasizing in this building," says Helble. "These neighborhoods are not focused around any particular curriculum. They're focused around broad areas of technology where engineering and computing come together, where there's opportunity for technical advance."



## THAYER'S NEW BUILDING IS A KEY PART OF DARTMOUTH'S PLAN TO TRANSFORM THE WEST END OF CAMPUS INTO THE EPICENTER OF TECHNOLOGICAL AND ENTREPRENEURIAL INNOVATION AT THE COLLEGE.

Faculty members in engineering and computer science already collaborate on research in biotechnology and mobile health. Now, says Helble, "The materials faculty are thinking about the use of computation to help guide development of specific compounds and compositions, in the same way that computer scientists who are computational biologists are working with our protein engineers to design next-generation therapeutics on a computer before trying to synthesize them."

While roughly half of all computer science departments in the United States are administratively part of engineering schools, Helble says that nowhere are these fields as fully integrated as he envisions they will be at Dartmouth. From undergraduates to post-docs and faculty, Helble foresees chance interactions leading to late-night breakthroughs and early morning mentorship in research laboratories and in the building's next-generation project space, Couch Project Lab II.

"A lot of the richest conversations happen when students and researchers are frustrated by trying to figure out the next step in the design of



CONCEPTUAL IMAGE BY WILSON ARCHITECTS

whatever project they're working on, and they're standing next to each other at 10 or 11 at night, or 1 or 2 in the morning, and they just start talking to the students who are around them," says Helble. "I think by providing that environment and atmosphere, the engineering and computer science students are going to learn from one another."

Along with orchestrating this high level of integrated study and research, Dartmouth intends to grow its faculty ranks in both engineering and computer science. Thayer will expand from today's 39 tenure-track professors to 70, while computer science grows from 18 to 27 over the next decade. Combined, engineering and computer science tenure-track faculty will total nearly 100, a scholarly cohort of unprecedented size in Dartmouth's history.

According to Farid, this larger scale will put Dartmouth on a different level for recruitment and research collaboration. "We will be punching at a different weight class, and I think that means we can really seriously compete at a level that is difficult for us now," he says. "When we lose faculty, it is almost always because they want to be in a bigger department, with more collaborators, more colleagues, and a bigger population of students. To compete in this modern age, size actually matters."

Already the computer science department is bringing on new faculty whose expertise bridges engineering and computing in fields such as robotics and sensor design, adds Farid.

Helble and Farid anticipate that faculty will find ways to collaborate in the classroom as well, with the addition of new space to facilitate connections. The Technology-Enhanced Active Learning (TEAL) Classroom, a centerpiece of the new building, will feature the latest in smart technology, seating for 80, and maximum flexibility in room configuration. The space will be ideal for active learning approaches such as the flipped classroom, which maximizes in-class interactions between students and professors

and lets faculty see student progress in real time and adjust lessons accordingly. Helble expects this and other new instructional spaces will help spur development of new co-taught courses in areas where engineering and computation intersect. "I am fully confident that will happen once we're all running into one another many times on a daily basis," he says. "That's how collaborations emerge."

Collaborations also emerge when more students and researchers have access to powerful, state-of-the-art tools. Sherman Fairchild Professor of Engineering Ian Baker, a materials scientist who is the most comprehensive user of Dartmouth's scanning electron microscope, says he will welcome the relocation of the electron microscope center from Geisel Medical School space to the new building—in a purpose-built area that will be free from vibration and electromagnetic interference. The equipment that he and his fellow researchers use daily will be much closer to his lab. Convenience aside, Baker says he looks forward to what the change will bring. "It's just more exciting to have new people around working on new and interesting technologies," he says. "I think we've got a great future."

The execution of Thayer School's multifaceted growth strategy is already well under way and is expected to continue on an aggressive schedule. Before the public launch of Dartmouth's "Call to Lead" capital campaign in April, Thayer School had already raised more than 50 percent of the \$155-million total project cost for the new building.

"We've entered the design-development phase and then construction documents come after that. One phase will flow seamlessly into the other, and we hope to make the transition to the beginning of construction drawing work probably in September, with the goal of finishing all the design work by the end of 2018," Helble says, adding that shovels could break ground as soon as next year.

Meanwhile, student demand for engineering and computer science courses continues to soar among Dartmouth students. In addition to majors, 70 percent of Dartmouth students take at least one engineering or computer science course during their undergraduate years. The expansion of faculty and facilities will build Dartmouth's capacity to give all students access to engineering and computer science courses as technical knowledge becomes an essential part of a contemporary liberal arts education.

"The world of connected devices is upon us," says Helble, "and for us to play a leading role in giving students the opportunity to draw from both engineering and computing in a seamless way is something that I hope will be exciting to our alumni. I think that by bringing engineering and computer science together around this notion of the world's problems that we are trying to solve—not focused on the disciplinary content, but on the outcome—we will see even more success in attracting a diverse student body."

#### TO PARTICIPATE IN THE CALL TO LEAD: A CAMPAIGN FOR DARTMOUTH, SEE [CALLTOLEAD.DARTMOUTH.EDU](http://CALLTOLEAD.DARTMOUTH.EDU).

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KAREN ENDICOTT is the editor of *Dartmouth Engineer*. KRISTEN SENZ is a writer at *Dartmouth Engineer*.

# THE GRAND CHALLENGE OF **CELLULOSIC BIOFUELS**

**WHY CELLULOSIC BIOFUELS  
HAVE FALLEN SHORT OF EXPECTATIONS  
AND WHAT WE CAN DO ABOUT IT.**

BY PROFESSOR LEE R. LYND TH'84 TH'87





A robust second-generation biofuels industry based on inedible cellulosic biomass available as wood, grass, and various wastes was widely expected to be in place by now. Anticipated benefits include climate change mitigation and rural economic development while avoiding the limitations of first-generation biofuels. Progress has been made but at a much slower pace than expected. It is important to understand why. The experience of the past decade and the need for low-cost technology in a world of low oil prices necessitates a strategic reset for biofuels as part of a “grand challenge” renewables strategy.

**THE PROMISE** || Two years ago, at the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21), over 190 nations (including the United States) committed themselves to keeping the increase in global average temperature 2°C below pre-industrial levels, with an aim of limiting the increase to 1.5°C. Plant biomass provides 10 percent of global primary energy today and is widely expected to provide on the order of a quarter of primary energy in prominent low-carbon scenarios for 2050. Biomass provides as much energy as oil, natural gas, and coal combined in Shell's net-zero energy scenario, as well as opportunities for carbon removal that must be deployed at a large scale to have more than a 50-percent chance of achieving the 2°C goal.

Among various types of plant biomass, cellulosic feedstocks are thought to have the greatest potential for mitigating climate change and are widely available at a lower cost per unit energy than petroleum. Transport is both one of the largest and fastest-growing energy sectors and one of the most difficult to decarbonize. Even if the rest of the global economy were completely decarbonized, a failure to displace the fossil fuels used in aviation, ocean freight, and long-haul trucking with low-carbon alternatives would result in emissions exceeding the 2°C COP21 target. Biofuels are the leading low-carbon option for these transport modes, which represent about half of global transport energy.

Recent studies recognize the substantial number of jobs created by renewable energy technologies, including biofuels. Bioenergy is responsible directly and indirectly for almost 3 million jobs globally—about the same as photovoltaics and three times that of wind—with liquid biofuels responsible for a little over half this total and solid biomass and biogas making up the balance. Estimates for direct liquid biofuel jobs in the United States range from 100,000 to 300,000, compared to about 370,000 direct jobs in the U.S. solar industry and about 70,000 for coal mining. Sugarcane production in Brazil, about half of which is used for ethanol, is the largest agricultural employer in that country. Compared with other agricultural workers, laborers in the cane industry have the greatest representation in the formal economy and achieve higher levels of education. Towns with ethanol plants in Brazil have higher tax revenues than comparable towns that do not.

Yet biofuels in the United States and across the globe have progressed little over the past decade—in sharp contrast to other renewable energy technologies. Expansion of global production of biofuels has leveled off, policy support has weakened, and research and development (R&D) funding has decreased and/or narrowed in many countries. Cellulosic biofuel investment and expectations have decreased markedly, although the rationale for their use is widely accepted and in some ways stronger than a decade ago.

**PAST AND PRESENT** || Between 2000 and 2010, the first-generation ethanol industry grew by tenfold in the United States and 2.6-fold in Brazil. In the middle of that decade, the world started paying more attention to cellulosic biofuels, prompted by a sharp increase in oil prices, analyses indicating large-scale availability of low-cost, sustainable cel-

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LYND HAS LED HIS LAB TO RE-EXAMINE HOW TO BREAK CELLULOSE'S NATURALLY TOUGH BONDS.





## PIONEERING POWER

Lee R. Lynd Th'84 '87, the Paul and Joan Queneau Distinguished Professor of Engineering, and Adjunct Professor of Biology has been at the forefront of biofuels research for more than three decades. His basic endeavor is to turn cellulosic biomass—plant matter not used as food—into fuels that can serve as an alternative to fossil fuels and support a low-carbon future. The longstanding challenge, however, has been designing efficient and economic ways of making biofuels. The Lynd Research Lab, made up of six long-term researchers and more than 10 students and postdocs, is a global leader in science and innovation pursuant to this goal.

Over the last 40 years, the field has looked to cellulase enzymes produced by fungal cellulase to convert the carbohydrate in solid biomass particles into a soluble form that microorganisms can ferment. In search of “nature’s best,” as Lynd puts it, he and his group have recently shown that anaerobic bacteria are substantially better at solubilizing cellulosic biomass than commercial cellulase preparations.

According to Lynd, biology needs some help to fully access the carbohydrate in biomass in a reasonable amount of time. “Until recently, it was universally thought that biomass must be exposed to heat and/or chemicals prior to biological processing,” he says. In another deviation from conventional wisdom, the Lynd lab has proposed mechanical milling during fermentation in lieu of heat and chemicals. He and his colleagues have found that their advanced process offers potential for an eight-fold shorter payback period and feasibility at much smaller scale, compared to processing based on the current paradigm. “Realizing this potential will, however require engineering thermophilic anaerobic bacteria, which is challenging,” says Lynd. His group has pioneered the development of genetic tools for these microbes, “but the tools are still not as advanced, we know less about metabolism, and progress is slower than with ‘model’ microbes like yeast and *E. coli*,” Lynd explains. “On the other hand, if we are to fully exploit biological diversity, we will need to work with some desired features in the microbes in which we find them.”

In addition to doing the science, Lynd has long been involved in “big picture” issues surrounding biofuels—why biofuels are necessary, the food-versus-fuel debate, land availability issues—and has cofounded two startups. Says Lynd Lab research scientist Evert Holwerda, “What is special about the lab is that while the core is research, Lee is also involved in many other activities that give people in the group access to broader perspectives.”

lulosic feedstocks, and claims that the technology was ready. The Renewable Fuel Standard, created under the Energy Policy Act of 2005, provided a strong policy driver for market adoption in the United States, and President George W. Bush mentioned switchgrass-derived biofuels in his 2006 State of the Union address. The European Union's 28 member states implemented a "biofuels directive" in 2003 and followed this with more comprehensive biofuels-related legislation in 2009 through its Renewable Energy Directive and amendments to the Fuel Quality Directive.

National governments saw in biofuels, and in particular cellulosic biofuels, a chance to contribute to rural employment and economic development and to enhance energy security. Many startup companies were formed, big companies also got in the game, and investments were made at previously unimaginable scales by both the private and public sectors. Entrepreneurs seeking to raise funds in a competitive marketplace presented their technology in the best possible light, only to be told by investors in many cases that they needed to think bigger and bolder—thereby raising the bar for the next investment pitch. Propelled by this spiral of hyperbole, expectations and reality eventually diverged.

Fast forward to the present, and six precommercial pioneer cellulosic ethanol plants have come on line, providing important opportunities for technology assessment and learning by doing. Global production of renewable diesel and jet fuel increased by approximately 30 percent last year, according to Alejandro Zamorano of Bloomberg New Energy Finance. Still, by any measure, the biofuels landscape today is a pale shadow of what was imagined a decade ago. In 2016, global production capacity for liquid biofuels from cellulosic feedstocks was 4.4 billion liters for thermochemically derived renewable diesel and jet fuel, and 0.7 billion liters for cellulosic ethanol, according to Zamorano. These figures are dwarfed by the production capacity of first-generation biofuels—98 billion liters for ethanol produced from grains, sugarcane, and sugar beets, and 30 billion liters for biodiesel produced from oil seeds. Whereas the U.S. Renewable Fuel Standard foresaw a domestic cellulosic biofuel industry producing 4.5 billion gallons (17 billion liters) in 2016, actual production was 0.16 billion gallons (0.6 billion liters), of which 98 percent was biogas rather than the liquid fuels originally envisioned. The amount of global cellulosic ethanol capacity retired last year exceeded the amount added.

Many advanced biofuel startups have failed. Those that have survived are trading well below their initial public offering price; most are focusing primarily on higher-value products other than fuels: Solazyme changed its name to Terravia and is now focused exclusively on food products; Amyris is active in flavors, fragrances, sweeteners, and rubber; and Ceres shifted its emphasis from cellulosic feedstocks to food and feed and was acquired by Land-O-Lakes. Global investment in next-generation biofuels and biochemicals is now more than 50 percent in chemicals rather than fuels, less than a quarter of its peak in 2011.

**DIAGNOSIS ||** Although widely expected circa 2008, a price on carbon did not materialize in most of the world. The nascent cellulosic biofuels industry was rocked by the global financial crisis. The collapse in oil prices in 2014 was the final knockout punch to many efforts in the cellulosic biofuels space. Yet other renewable energy sectors thrived during this period. Between 2005 and 2015, global solar investment increased by an order of magnitude, and wind investment more than tripled. During the second half of this decade, the cost of battery energy storage for electric vehicles dropped by about threefold.

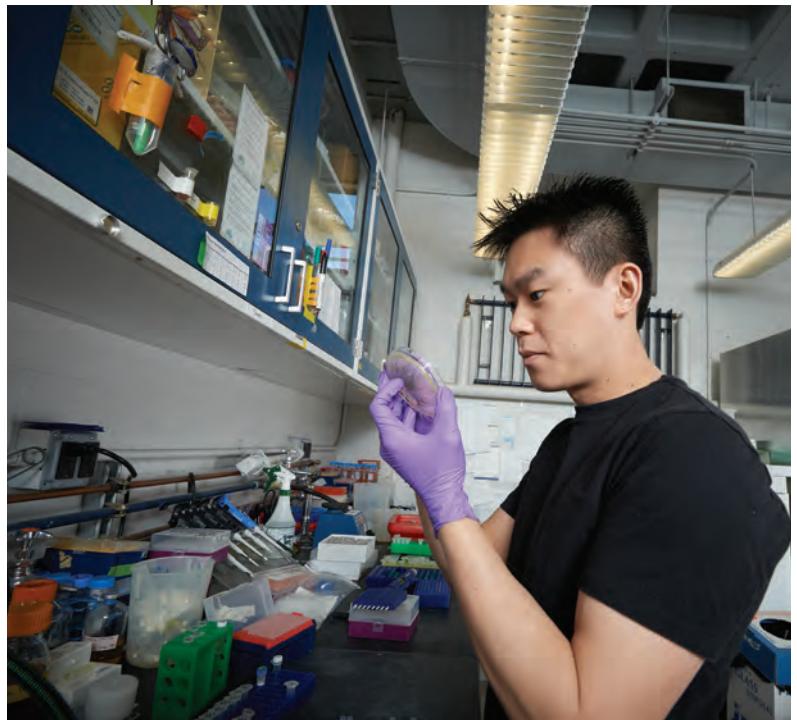
So what has been different about cellulosic biofuels? Overestimation of technological readiness is part of the answer. There has been a marked tendency, encouraged by both government and private sector investors,

PHD CANDIDATE  
SHUEN HON  
METABOLICALLY  
ENGINEERS  
MICROBES IN  
LYND'S LAB.



IT IS TIME TO SEE CELLULOSIC BIOFUELS AS THEY ARE. THEY REMAIN AN IMPORTANT AND LIKELY NECESSARY COMPONENT OF CLIMATE CHANGE MITIGATION STRATEGIES, BUT FACE SUBSTANTIAL TECHNOLOGICAL CHALLENGES TO ACHIEVE FINANCIAL VIABILITY.

—PROFESSOR LEE R. LYND



to focus on large, expensive, stand-alone facilities rather than niche applications. Particularly in the United States, funding agencies prematurely turned away from cellulosic ethanol, although it is now clear that further development is needed to achieve cost-competitive fuel production even with oil prices at \$100 per barrel. Amidst frequent claims that economically viable technology was in hand and investment was needed only in scale-up and commercialization, investment in new, potentially low-cost processing paradigms was generally modest. As a result, technological advancement was slower than it might have been, and policies were designed assuming that deployment, rather than technology, was the limiting factor. The impacts of a tendency to try to vault 100-foot cliffs with 10-foot poles were compounded by the very large size of investments of \$250–\$500 million and relatively long duration of the design-build-operate-learn cycle in the cellulosic biofuels field. In sharp contrast, other renewable energy technologies proceeded in a stepwise fashion, recognized the need for technological advancement and invested accordingly, and benefitted from projects with lower costs and more rapid learning cycles.

There is more to it, however. Biofuels require land. As a result, their production inevitably has strong linkages to food security, rural economic development, and land-based ecological services. Biofuel advocates see these linkages as opportunities to achieve value above and beyond low-carbon energy supply, pointing to the soil fertility and water quality benefits of incorporating perennials into agricultural landscapes, the social benefits resulting from the Brazilian biofuel industry, and the potential role of biofuels in African transformation and enhanced food security. Critics see these linkages as posing risks that arise to a smaller extent with other renewables, and point out that although cellulosic biofuels avoid direct competition with food markets, they do not avoid competition for land. There is a basis for both perspectives, but the critical voices have spoken more loudly over the past decade, and this has contributed to weaker and less-consistent policy support for biofuels compared with other renewables.

**WHAT TO DO? //** Three key measures should be part of any effort to revitalize cellulosic biofuels. First, pursue commercial deployment in achievable, successively enabling steps, proceeding from where the industry is today. Second, maximize social and environmental benefits based on examples and learning from experience. Third, invest in alternative processing paradigms.

Solar and wind energy were deployed first off-grid and at the most advantageous sites. Battery technologies were employed for consumer electronics before use in hybrid vehicles, with grid storage the next horizon. A similar stepwise approach in the biofuels field involves niche applications featuring low-cost feedstock, preferably with established supply chains and/or preexisting infrastructure—an approach exemplified by the Raizen plant, which converts bagasse to ethanol within a larger sugarcane processing facility in Brazil; efforts by several companies to convert corn fiber in the United States; and LanzaTech's conversion of waste gasses in China and elsewhere.

Gracefully integrating bioenergy technologies into the agricultural, social, and environmental systems with which they interact is a challenge that can only be resolved by experience. With supportive policies, suitable safeguards, innovative business models, and on-the-ground projects aimed at benefiting people, planet, and profit, it is reasonable to expect progress as we replicate successes and learn from failures.

Just as battery development focused successively on lead-acid, nickel-cadmium, and then lithium ion chemistries and is now exploring new alternatives to meet the challenge of grid storage, cellulosic biofuels technology must actively look beyond existing processing paradigms. The key challenge to cost-effective production of cellulosic biofuels is the difficulty of converting cellulosic biomass into reactive intermediates, termed recalcitrance. The recalcitrance barrier is manifested in the cost of thermochemical pretreatment and added enzymes for biological processing. For thermochemical processing, it is manifested in the cost of gasification or pyrolysis, including clean-up before fuel synthesis. To maximize the probability of developing a robust cellulosic biofuels industry at a scale large enough to meaningfully contribute to climate and other goals, we need an aggressive effort aimed at new processing paradigms.

**A CALL TO ACTION //** With swings from irrational exuberance to dismissal behind us, it is time to see cellulosic biofuels as they are. They remain an important and likely necessary component of climate change mitigation strategies, but face substantial technological challenges to achieve financial viability. They require learning by doing to maximize favorable social and environmental outcomes and to enhance competitiveness with incumbent fossil fuels, which have benefitted from a century of investment and development. Near-term deployment opportunities need to be realized in a stepwise fashion, along with aggressive investment in R&D aimed at innovation and new processing paradigms. Cellulosic ethanol provides the most direct path to a low-cost platform for biological production of fuels from inedible biomass, and is the logical point of entry and proving ground for new technology aimed at overcoming the recalcitrance barrier for biological processing, but is not yet cost competitive and needs innovation to become so. As with many aspects of the climate change challenge, needed actions in the biofuels domain should be aligned with market realities, but will progress more quickly with policy support than in response to market forces alone.

In the International Energy Agency 2°C scenario, low-carbon biofuels need to provide about 25 exajoules by 2050, which is well within conservative estimates of the resource base. This is likely still possible, but aggressive action, new approaches, and a great deal more progress in the next decade than in the last will be required. Companies wanting to be part of the new green economy need to persevere and, in many cases, reengage. Public and private investors need to revise their strategies. Governments need to realign policies aimed at technology development, deployment, and market support. Non-governmental organizations need to guide and support deployment in ways that realize social and environmental benefits. All must be realistic about the need for cellulosic biofuels as well as their challenges, and there needs to be a recognition that the risks of inaction have become greater than the risks of action.

*This article is adapted with permission from an article of the same name published in Nature Biotechnology. To read the full article, with references, see [nature.com/articles/nbt.3976.pdf](http://nature.com/articles/nbt.3976.pdf).*

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LEE R. LYND is Thayer's Paul and Joan Queneau Distinguished Professor of Engineering and an adjunct professor of biology. A cofounder of two cellulosic biofuel startups, he is focus area lead for biomass deconstruction and conversion for the U.S. Department of Energy's Bioenergy Science Center and is executive committee chairman of the Global Sustainable Bioenergy Initiative.

# The Power of **DESIGN**

Thayer's growing design offerings ground engineers—and other students—in what matters most.

BY KRISTEN SENZ

**I**t was bold, the kind of thing Devyn Greenberg '17 never would have considered doing before. During her senior year at Dartmouth, as a government and Asian and Middle Eastern studies major, Greenberg decided to apply design thinking to her own life.

After a design-related internship and Thayer School's ENGS 12: Design Thinking course introduced her to the design field, she reworked her entire senior-year curriculum to accommodate a minor in Human-Centered Design, a unique program in the Ivy League. "It paid enormous dividends," she says, "and I had an amazing year, because I discovered all these things that I didn't know I could do."

Greenberg is one of a growing number of Dartmouth students and alums who describe ENGS 12 as "life-changing." While providing a frame-



# THINKING



work and shared language for creative problem-solving, students say, the course builds creative confidence, imparts strategies for giving and receiving constructive criticism, and demonstrates the value of failure as a precursor to innovation.

To meet increasing demand for design education, Thayer School is expanding its design offerings dramatically. New sections of ENGS 12 have been added, new instructors hired, and the multidisciplinary Human-Centered Design minor is increasingly in demand. A two-term “Senior Design Challenge” course was piloted last year as a new kind of academic culminating experience for all Dartmouth students, regardless of major.

Looking further ahead, Thayer will add more tenure-track design faculty and open several more design spaces. Those spaces will be in the new building (see page 8) that engineering will share with computer science, the Digital Arts, Leadership & Innovation (DALI) Lab, and the Magnuson Family Center for Entrepreneurship—key ingredients for “transforming the west end of campus into a hotbed of innovation, entrepreneurship, business, and design,” as President Phil Hanlon ’77 recently put it in announcing the launch of Dartmouth’s capital campaign, The Call to Lead.

Professor Peter Robbie ’69, who has been teaching design at Thayer since the 1990s, says the expansion of design at Thayer, and growing interest in design thinking in academia and industry more broadly, has unlocked the creative potential of people across a wide range of disciplines and sectors.

“I think it has opened the door to a lot more people to become creative problem-solvers,” Robbie says. “We have myths about creativity being just for some tiny percent of the population. If you’re talking about major works of art, like writing *Moby Dick*, that’s probably true. But if you’re talking about creative problem-solving, I think smart people can become creative problem-solvers. Creative problem-solving is a practice and a skillset that many people can do.”

Originally used to develop innovative consumer products, including the first computer mouse, design thinking is increasingly applied to complex issues in education, healthcare, civic services, and other kinds of “wicked problems” that require expertise from diverse fields.

In practicing the design thinking process, students in ENGS 12 investigate people’s needs, frame specific problems, and craft solutions through brainstorming, prototyping, and iteration. “They draw on the ethnographic methods of anthropology, the hands-on mentality of engineering, and the entrepreneurial mindset of the business world,” says Robbie.

Student teams present solutions to real-life problems, both on campus and off, but the solutions are not the main focus, Robbie explains. Instead, ENGS 12 aims to equip students with tools they can use to effectively and creatively approach challenges they encounter in their professional and personal lives. “I think having that goal, in design courses at Thayer, differentiates the field from more traditional courses,” says Robbie. “Traditionally, engineering focuses on innovations—the ideas, the products. In this course, we’re focused on the people. We’re trying to grow innovators.”

Students who complete the Human-Centered Design minor gain an even deeper understanding of how to maintain the focus on people throughout the design process. In addi-

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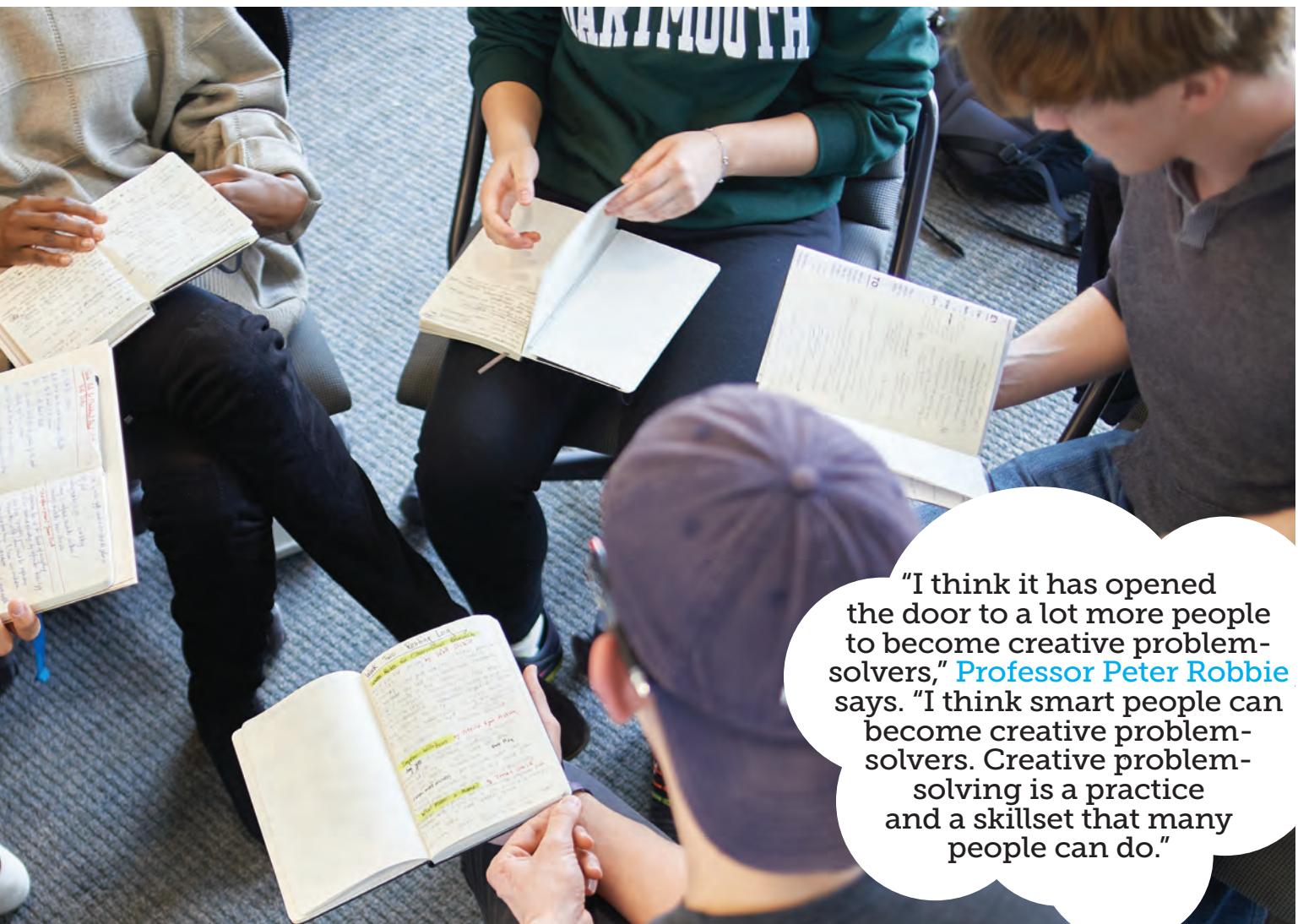
Brainstorming, improvisation, and collaboration are among the design thinking toolkit.



tion to completing ENGS 12 and ENGS 21: Introduction to Engineering, Human-Centered Design minors take two social science courses and two design electives, ranging from engineering courses in product design to computer science courses in digital arts, to studio art courses in architecture. “The reason for including a focus on social sciences,” says Robbie, “is that if you’re designing for humans, you should know how humans think and behave. Human-centered design is technical design informed by social science.”

For students of design thinking, a primary take-away is increased confidence in their own ability to think and act creatively. Through the design process, they experience failure as a precursor to success, which empowers them to take intellectual risks and quiet their inner self-critics, says Eugene Korsunskiy, a new design instructor at Thayer School. “Students describe this mental capacity in different ways,” says Korsunskiy, “but just about every student, after taking a class like this, reports an increased belief in their own powers to be innovative.”

Recently, several Dartmouth students have employed this newfound confidence to craft their own design-related majors. Mary Katherine Milway ’20 hopes to major in “sustainability design.” Jessie Colin ’18 received approval from the College for



"I think it has opened the door to a lot more people to become creative problem-solvers," **Professor Peter Robbie** says. "I think smart people can become creative problem-solvers. Creative problem-solving is a practice and a skillset that many people can do."

a special major in Human-Centered Design, after working on her proposal for two years. "I never studied abroad because I wanted to make this happen, and this became my own narrative at Dartmouth, as something I contributed to the community," says Colin, who, after graduation, will join IBM as a design researcher.

Since Colin's proposal was approved, more than 20 students—all of them women—have reached out to her for advice about special design majors. "I don't know why it's just women," says Colin. "I think it's a way of getting into the field of engineering through a more empathetic and artistic lens."

On average, about 75 percent of students in Thayer's design thinking classes are women, according to Robbie, who adds that the department's focus on design might have contributed to Thayer's milestone of issuing more engineering degrees to women than men in 2016.

"There has been some research around women in general being more interested in engineering within a context, but why that's interesting to women is a much broader sociological question," says Teagan Daly '13 Th'13, who teaches design at Stanford University and has studied cultural issues within engineering. "With design thinking, there's been an interesting backlash, like

we shouldn't pink-wash engineering, and we shouldn't soften what's hard—'hard' meaning rigorous and quantifiable—to attract more women."

Daly says she views Thayer School as the perfect place for the build-out of a design program, because Thayer students already learn engineering in the context of Dartmouth's liberal arts education. "If all engineers were trained to think a little bit more about the people who use the system, even if it's just the safety of the user, my impression is the built world could really benefit from that kind of thinking and problem-solving," she says.

## DESIGN CHALLENGE

With the goal of creating a campus-wide design initiative, Professor Robbie has been working to "extend design at Thayer into design at Dartmouth" for years, he says. In keeping with design thinking's emphasis on meeting the needs of users, Robbie asked his ENGS 12 students how they would structure such an initiative.

Ashley Manning '17 was one of those students. Manning had taken ENGS 12 to complement her geography major, viewing design thinking as a method for taking action on complex problems she had studied. For the final project in ENGS 12 that



term, Robbie challenged Manning and her team to envision a campus-wide design program at Dartmouth, inspired by and modeled on the Stanford d.school. Officially called the Hasso Plattner Institute of Design at Stanford University, the d.school brings together faculty and students from across the university to teach and learn design methodologies, preparing them to tackle problems in their own fields.

Manning and her teammates interviewed dozens of Dartmouth students and other stakeholders. Eventually, they reframed the question. “We started thinking more about how to foster a culture of creative, interdisciplinary collaboration at Dartmouth. That led us to look at experiential learning initiatives that are cross-campus, and bright spots that make learning really engaging and meaningful for students,” Manning explains. “ENGS 12 came up a lot, as well as some other factors.”

The team’s solution was the Senior Design Challenge, in which multidisciplinary teams of seniors would tackle real-world problems through partnerships with businesses and nonprofits.

Manning worked with Robbie to propose the idea to the Dartmouth Center for the Advancement of Learning (DCAL), which awarded a grant to support the pilot. Manning stayed at Dartmouth for an extra year to develop the course with Robbie and Korsunskiy, who was brought in to teach it. Initially, Robbie and Korsunskiy planned to accept 10 students into the Senior Design Challenge, but when 40 students applied, they increased the enrollment cap to 20.

“In our group of 20 students, we have 16 different majors represented, including anthropology, computer science, and history, so it’s a truly interdisciplinary cohort,” says Korsunskiy. “The students are divided into five teams, each team working on a unique challenge that was scoped in partnership with client organizations ranging from Burton Snowboards to a local family shelter. The projects range from mobile healthcare apps to architectural technology.”

The students aren’t the only ones being challenged. “At this point the students are definitely bigger experts on their topics than I am,” says Korsunskiy. “It’s a really different way to teach: I have to be the process coach, not the keeper of knowledge. The

**Left to right,**  
design instructor  
**Eugene Korsunskiy,**  
Senior Design  
Challenge co-cre-  
ator **Ashley Manning**  
**’17,** and Professor  
**Peter Robbie ’69 are**  
**expanding Thayer’s**  
**design offerings.**

knowledge is what the students are creating.”

The Senior Design Challenge will be offered again in 2018-19, and students are already inquiring about applying. Korsunskiy and Robbie say they hope the course will become a new kind of culminating experience for seniors to build their design skills, work in interdisciplinary teams, and have impact beyond the classroom.

## DESIGN FOR LIFE

According to Robbie and Korsunskiy, the growth of the design program at Thayer mirrors a national conversation about design thinking methodologies and their role in liberal arts education. Korsunskiy recently cofounded a national symposium of educators from dozens of schools, including Harvard and Stanford, called the Future of Design in Higher Ed, in which faculty and administrators are coming together to share best practices and advance the field.

With a growing emphasis on experiential learning and collaboration at Dartmouth, college administrators and others are paying attention to the strong demand for design education among students, as well as the skills and lessons students report learning in ENGS 12.

“To put it bluntly, ENGS 12 is what college learning should be,” says Josh Kim, associate director of DCAL, who delights in seeing students’ final presentations about improving aspects of Dartmouth life. “What the science of learning tells us is that: a) learning is hard, and b) authentic learning requires active engagement. It is abundantly clear from the work of the ENGS 12 students that they work enormously hard. It is also clear that the teams of students are massively engaged in their projects. ENGS 12 takes active and experiential learning to its logical end-point.”

Industry has taken notice, too. “Traditionally in business settings there has been a huge work practice and cultural divide between designers (the creatives) and executives (the suits),” says Robbie. “With recent design thinking initiatives at IBM, GE, Ford, and elsewhere, we see companies creating opportunities for everyone in their organization to understand and practice design, leveraging shared language and frameworks to create a more innovative corporate culture.”

Increasingly, traditional business consulting companies and large firms are making substantial investments to acquire design consultancies or set up in-house design teams.

Devyn Greenberg, the alumna who rearranged her schedule to minor in Human-Centered Design, recently joined Bain and Company’s new Advanced Digital and Product Team (ADAPT) design studio, deferring admission to the Stanford Graduate School of Business (and access to the d.school) to do so. “In job interviews, I found myself talking about the minor a lot, and I believe it really was an asset,” she says.

For Greenberg, as with many students, design thinking is a creative means to making a tangible difference.

“I think the optimism of design—this idea that the only way to make a positive impact in the world is to believe that you can—is really important,” she says. “That mindset is something that I developed while doing the Human-Centered Design minor, and it’s something that I’ll carry with me throughout my life.”

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KRISTEN SENZ is a writer at *Dartmouth Engineer*.

# The Power of **DESIGN** **THINKING** IN THEIR OWN WORDS

## ENGS 12: DESIGN THINKING

### Sarah Peck '14

*Major:* French and Italian *Minor:* Psychology  
*Currently:* Associate Manager Global Marketing, Laura Mercier Cosmetics

ENGS 12 helped me understand that human behavior is truly at the core of everything, and that good design is not only physical, but also experiential. Whether it was learning the art of observation, understanding the nuance and complexity of implementing a new initiative, or even using constraints to unlock creativity, these fundamental principles gave me a framework and way of thinking that I carry with me to this day in both my personal and professional life.



### Sara Remsen '12

*Major:* Biology *Minor:* Digital Arts  
*Currently:* UX Technical Fellow, Advanced Development Group, PTC

ENGS 12 taught me that I could build a career on my creativity, empathy, and problem-solving skills as a leader in human-centered design. After working at a tech startup following graduation, I was inspired by my ENGS 12 course to pursue a master's in Integrated Design and Management at MIT. I continued to combine my experience in human-centered design with my technology skills, and in 2016, I founded a company, Waypoint, to bring technology to industrial workers through augmented reality. Waypoint was acquired by PTC in March 2018.



### Sarah Waltcher '16

*Major:* English  
*Currently:* Rhodes Scholar, English literature, Oxford University

ENGS 12 reframed my conceptions of creativity and innovation. I remember feeling shocked that even to me, an English major, much of our work in the course felt familiar. The course was about storytelling: mapping human journeys, identifying conflicts, and imagining solutions from multiple perspectives—the same pathways traveled when I engage with literature. Last year I taught sixth-grade science and engaged my students with the design cycle through a unit on inventions. For kids who do not see themselves as creative or innovative, having a structure for their inventing—investigate, plan, create, evaluate—gave them the confidence to trust and to try. Before ENGS 12, I was one of those kids, too!



### Dan Harburg Th'10 Th'13

*Thayer Studies:* MS and PhD  
*Currently:* Entrepreneur and Investor, Anterra Capital

I have carried important lessons from ENGS 12 into every startup with which I've worked. I learned how to structure brainstorming sessions, interview people to uncover real needs, and the importance of getting early prototypes in front of customers. And ever since ENGS 12 I've kept a "bug list" by my side at all times to jot problems I see in everyday life that might be solved through better design.



## HUMAN-CENTERED DESIGN

### Matt Rossi '16 Th'17

*Major:* Engineer Sciences, BE Concentration: Mechanical Design  
*Minor:* Human-Centered Design  
*Currently:* Content Marketing Manager, Ekso Bionics

The human-centered design minor introduced me to concepts crucial for every creative professional to understand: the importance of collaboration, asking questions, and experiencing problems first-hand to understand end users. Whether you're designing a flyer to explain the benefits of an exoskeleton for spinal cord injury rehabilitation, producing videos to teach construction workers how to set up robotic arms to lift heavy power tools, or even building that device yourself, you must understand your users' pains, limitations, and desires. The minor also taught me that simply thinking can get you only so far. Just make it, show it to someone, and get feedback as early and often as possible.



### Robert Halvorsen '17 Th'17

*Major:* Engineering Sciences  
*Currently:* Thayer Design Fellow

I loved taking the psychology and art courses for the minor that I would not have found otherwise. The minor helped me to become a better engineer and to notice things that I never would have noticed before about the world around me.



### Shreya Indukuri '16

*Major:* Cognitive Science  
*Minors:* Human-Centered Design; Digital Arts  
*Currently:* User Experience Designer at Nutanix

I discovered product design as a possible career path my freshman year after taking Professor Robbie's Design Thinking class. Something about design thinking clicked. It is a fun, exciting, and collaborative approach to problem solving. I spent the following three years honing my design skills by pursuing the Human-Centered Design minor and working as a designer at the DALI Lab. The minor taught me how to think about people and design through an interdisciplinary set of courses.



### Tyler Rivera '16

*Major:* Geography  
*Minors:* Human-Centered Design, Environmental Studies  
*Currently:* Development Assistant, World Monuments Fund

The Human-Centered Design minor changed the course of my life. The wealth of hands-on, technical experience I gained through my engineering courses alongside the observational and qualitative skills I honed through anthropology and psychology coursework remain founts I draw on in my professional and personal life. Whether I am deconstructing a logic model at work or highlighting overlooked resource gaps at a not-for-profit I volunteer with, I always strive to employ a human-centered approach that emphasizes iterative, holistic consideration of stakeholder needs.

# Alumni News

FROM AROUND THE WORLD

## spotlights



Phoebe Suina '98 Th'99

As owner of environmental consulting firm High Water Mark, **Phoebe Suina '98 Th'99 Th'01** helps protect the water and lands where she grew up. After earning a master's in engineering management in 2001, Suina returned to New Mexico to work at Los Alamos National Laboratory. There, she worked on erosion and flood mitigation projects after the Cerro Grande Fire destroyed almost 50,000 acres in the area in 2000. She went on to manage emergency and disaster assistance projects for the Federal Emergency Management Agency before founding High Water Mark in 2013. Suina is from the nearby San Felipe and Cochiti Pueblos, and enjoys tackling issues of floodplain, storm water, and watershed management for numerous pueblos and local governments. Her commitment to the region and its history is evident in her Bernalillo, N.M.-based company's focus. Recent efforts include working with the

Pueblo of Nambe in recovering from successive years of debris flows and flash flooding in the Rio Nambe and with the Pueblo de Cochiti with emergency response and disaster recovery from post-Las Conchas Fire flooding that has damaged transportation infrastructure and traditional structures at the pueblo. "At High Water Mark we recognize the cultural and natural significance of rivers, floodplains, and watersheds in communities throughout New Mexico and the Southwest," Suina tells the *Albuquerque Journal*. "We believe in a community-based approach to addressing environmental and water resources issues that incorporate traditional knowledge with science-based engineering, planning, and management solutions for a resilient future."

Former telemark ski racer **Lorin Paley '15 Th'15** has been stuffing things onto shelves and racks for years. But, as she tells the *Utah Park Record*, "Ei-

ther the racks would bend the skis' camber and ruin their shape over time or the skis would slip off if not placed precisely at the right angle." So the engineer started building her own hangars and shelves—and tinkering with ski rack prototypes. She added magnets (to hold the edges of the skis) and a drip tray, then turned her design eye to improving helmet racks and glove and boot driers. With the help of **Robert Collier '13 Th'13**, she implemented a way to dry boots without using heat. Two years later, Paley opened Real Adventure Design (realadventuredesign.com) in Park City, Utah. The online store offers elegant and rustic products made of steel, maple, and aspen. "Being able to take some of my woodworking and apply my engineering—it's a fun marriage of a lot of things," she says. Paley was a leader with the Dartmouth Outing Club and a competitor on the Dartmouth Woodmen's Team and taught fellow students how to build mountain bike trails for PE credit. Now, as she stashies her winter gear, Paley is on to her next challenge: bike racks.

Project engineer **Rob Mercurio '12 Th'13** welcomes explorers 20,000 leagues under the sea or into deep space through the many immersive adventures he has developed for museums and malls across the country. In 2015 he brought his electro-mechanical skills to Boston-based 5 Wits Productions (named for the five "wits" of Shakespeare: common wit, imagination, fantasy, estimation, and memory). "We're a design-and-build company specializing in immersive adventure experiences, interactive exhibits, and special effects for museums, theme parks, theaters, and other popular destinations," says Mercurio, who handles everything from robotics and pneumatics to carpentry and on-site installation. "It's a really fun and challenging role, where we get to use a lot of design thinking and user-

centered design. I do a lot of technical problem-solving and get to take our ideas right from the page to the shop floor." Players can solve hieroglyphic puzzles to escape a 3,000-year-old Egyptian tomb, navigate a castle inhabited by an enormous dragon, or become underworld spies to stop a world war. At the drawing board, Mercurio says the design team considers the type of experience they are trying to produce for guests: "Are we trying to force them to work together? Make them feel challenged (but not frustrated) by their activity? Teach them something? From there, we can build an experience or gameplay that supports that objective." The team also considers guest inputs and outputs to make the adventure as realistic as possible. "You wouldn't press a button inside an Egyptian tomb, but instead would push on a rock," he says. "So we work to build our technology and control systems beneath a thematically appropriate interface so that it feels the most real for the guest." He has also learned how to develop exhibits that can take abuse. "We rarely work with loads measured in tons, but the relentless destruction that thousands of young kids will put on an interactive or exhibit day after day is very humbling," he says.

Research mechanical engineer **Michael Walsh '77 Th'78 Th'91** has received the Bronze Order of the de Fleury Medal for his "significant service" to the U.S. Army Engineer Association. The honor was presented during his February retirement ceremony at the U.S. Army Engineer Research and Development Center's Cold Regions Research and Engineering Laboratory (CRREL) in Hanover. During his 31-year federal career, Walsh established himself as one of the preeminent experts on military energetics research. In 1986 he joined CRREL's technical staff as a mechanical engineer and has been actively en-



# On the Job

JACOB MCENTIRE TH'15 | GAME DESIGNER

Product director Jacob McEntire uses his training as an electrical engineer to manipulate the forces of nature in the world of Beyonder. It's a tabletop role-playing game his family of scientists has been creating for almost 50 years.

## Where did Beyonder come from?

The game originated with my dad when he was in college. Since then, my parents and three brothers and I have developed a rich and unique landscape for our players to inhabit, with eight playable races and a class system based around science. Basically, you play as a scientist/engineer who studies the physics of the world. And where in our real world we need to use machines to make things that manipulate the fundamental forces of nature into "magical" items and effects (phones, wifi, holograms), in Beyonder our scientists, researchers, and makers can channel energies through their bodies to create miraculous-seeming effects.

## What do you bring to the table?

My main contribution has been building the story for a multi-part series of modules (game stories that moderators can buy and run for their players) and playing a leading role in a lot of outreach. I attend a lot of gaming cons where I run demo games for interested players, and I'm also in charge of the newsletter, blog, and social media at various points. I also bring structure. My family tends to wax poetic about the game and get very excited about new products, and it can be difficult at times to get down to brass tacks, which is something I always try to push us toward.

## What's on the horizon?

Our current plan is to keep building our name locally in the Northeast, with the goal of expanding once our sales pick up. I'm also working on another role-playing game with a focus on personality types, so that people can play as themselves. Game design is quite similar to engineering: It's highly creative and it involves creating sets of rules that constrain a system appropriately to give you a desired result. I want to create a game that shows the incredible things that we're all capable of when we're pushed to our limits and that explores the magic that underpins our mundane, day-to-day lives.

**"I want to create a game that shows the incredible things that we're all capable of and that explores the magic that underpins our mundane, day-to-day lives."**

—JACOB MCENTIRE TH'15

—Interview by Theresa D'Orsi

## spotlights

gaged throughout his career in a wide variety of projects for the U.S. Department of Defense, NASA, NATO, and the National Science Foundation. He has analyzed icecap structures, developed a towed snowplow, tunneled at the South Pole, and conducted military energetics research and environmental cleanup. Much of his recent research was centered on the performance and environmental impact of munitions on military training ranges, with an emphasis on the new generation of insensitive munitions. As cochair of numerous research task groups within NATO, he is recognized in the international community in the field of munitions impacts on military ranges. Walsh also initiated CRREL Junior Solar Sprint program, an engineering-based program for junior high school students. He remains active within NATO, the Finnish ministry of defense, and CRREL.

**Isabella Caruso '17 Th'17** drew on her winter training in the Upper Valley to shrug off the cold and finish as the top New Hampshire female of the 2018 Boston Marathon. "I think that having trained through the winter in Hanover and having spent the last several winters running here helped a lot. I'm used to running in the cold and the snow, so I was happy that at least it wasn't a blizzard!" she says of race conditions, which hovered at a rainy and windy 40 degrees. Caruso, a former member of the Dartmouth Running Team, finished 40th in the women's category and 37th in the 18-to-39 age division with a time of 2:56:18 and a pace of 6:44. She prepared for the marathon by running during winter semester in Hanover, in between her work in the classroom as one of two Dartmouth Teaching Science fellows for 2017–18. She partners with the faculty of introductory chemistry classes to make them more accessible to all students. "I want to see all students succeed in STEM!" she says. She works with students taking general and organic chemistry, leads study sessions, and offers advice on course selection and time management. Caruso can speak from experience on the challenge of juggling it all: As she considers her next career step—"I hope something engineering-related"—she's also preparing for an August 50K called "The Rut," a trail

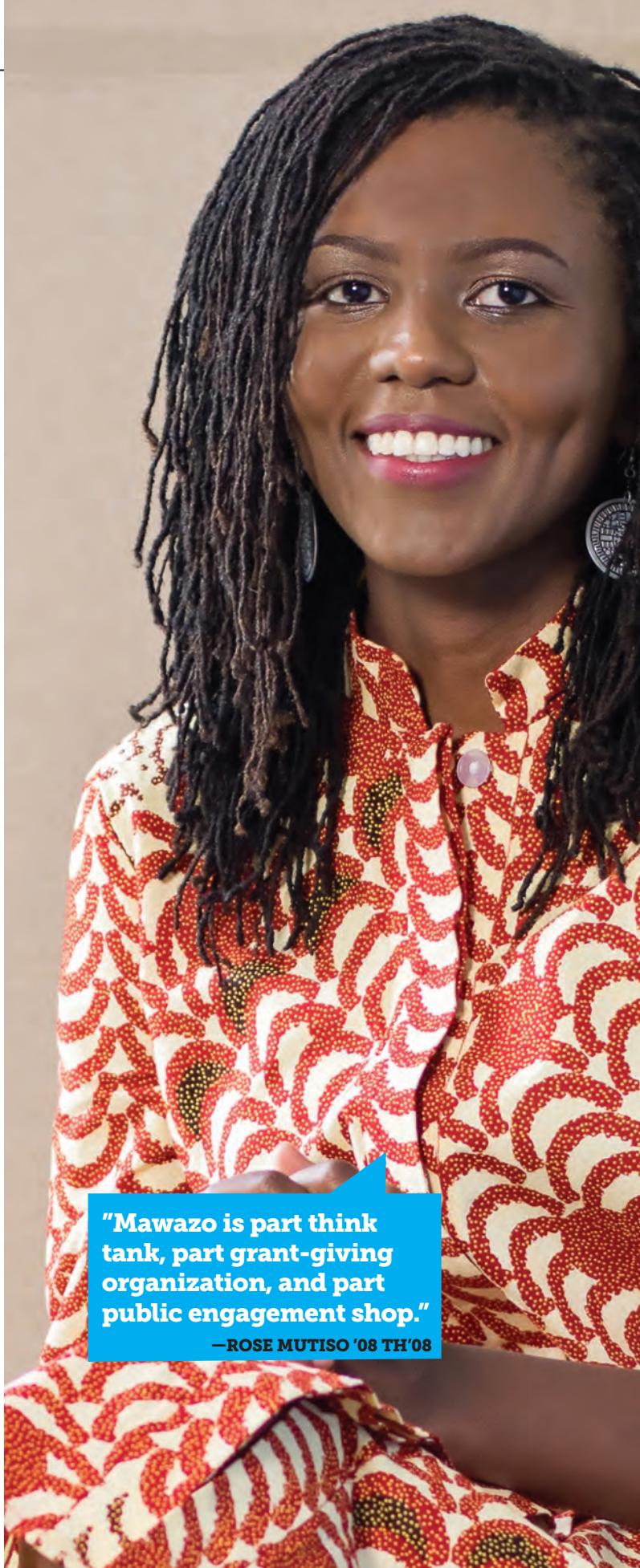
race in Montana with over 10,000-foot elevation gain. "That elevation gain makes things interesting," Caruso says, "but I'm doing it with some of my best friends from Dartmouth, so I'm very excited."

**Harley McAllister '94 Th'95** and his wife, Abby, have just published two "Adventuring with Kids" guidebooks to Yellowstone and Utah's "Big Five" National Parks and have two more in the works. The books are based on the couple's research a few years ago as they planned to introduce their four sons—ages 17 to 6—to the parks. "We found it difficult to plan because there was so little information about the parks that was really aimed at families with kids," says McAllister, who works as a product manager in Bellevue, Wash. "We have homeschooled our kids, so we found wonderful learning opportunities by visiting the parks outside of peak season." His advice for enjoying the outdoors with kids: slow down. "Allow time for discovery," he says. "Adults typically hike with a goal in mind, to get to some destination or some vista, but kids want to engage more with their surroundings. They want to stop and inspect an insect or float a leaf down the creek or dip their toes in the water and simply discover nature at a scale that we adults often overlook. And so, when planning excursions, we parents need to look for locations and activities that provide these types of opportunities for engagement and hands-on learning." The next two guides in their "Adventuring with Kids" series will be published by Mountaineers Books this year—for Glacier and Yosemite.



Harley McAllister '94 Th'95

THIS PAGE: LEFT, COURTESY OF HARLEY MCALLISTER; RIGHT, COURTESY OF ROSE MUTISO



**"Mawazo is part think tank, part grant-giving organization, and part public engagement shop."**

—ROSE MUTISO '08 TH'08

# On the Job

ROSE MUTISO '08 TH'08 |  
COFOUNDER, MAWAZO INSTITUTE

The search for the sweet spot where academic rigor meets societal relevance led Kenyan Rose Mutiso to where she is now: CEO and senior research fellow at Mawazo Institute, a Nairobi-based nonprofit she co-founded with Rachel Strohm '08.

## What does the Mawazo Institute do?

Mawazo, which means “ideas” in Kiswahili, is part think tank, part grant-giving organization, and part public engagement shop. It provides research funds and other assistance to female PhD candidates in East Africa through its flagship fellowship program, PhD Scholars. We aim to be a hub for innovative ideas across a broad swath of academic disciplines. By hosting community events, we also create a platform where the public can engage with the researchers around their work in a fun and relaxed setting.

## What inspired you, an engineer and research scientist in energy and applied physics, to create the institute?

I always wanted to be a professor, but after getting my PhD from the University of Pennsylvania, I noticed that being in the lab made me feel somewhat isolated and removed from public discourse. I wanted to teach, continue with my research, move back to Kenya, and make an impact there. I reconnected with Rachel (currently a PhD candidate in political science at the University of California at Berkeley) and we started talking about what we could do together. The supply and demand for higher education has exploded in East Africa in recent years and, given our expertise, we thought we could help other female PhD candidates by offering research funds and supplemental instruction in what are often thought of as “soft skills,” such as writing and engaging audiences in discussions about research.

## How did Thayer influence you?

Thayer really showed me the possibilities in terms of project- and discussion-based teaching and learning styles. I loved how ENGS 21 immediately requires students to think about answering questions that exist outside the classroom. At Thayer and Dartmouth, you get this emphasis on liberal arts and you get a chance to be young and hopeful. I find that I can still draw from that reservoir of boundless energy and optimism—but I also know how to find that balance between being realistic and feeling like anything is possible.

—Interview by Kristen Senz

# just one question



## How would you finish the sentence: "I'm an engineer and..."

You can see how students finish that sentence at Thayer School's video series at [youtube.com/user/ThayerSchool/playlists](https://youtube.com/user/ThayerSchool/playlists).

I'm an engineer, a pilot, and a teacher. In the Air Force I flew fighter planes (in combat), biz jets, trainers, and bombers. I was an instructor pilot both in the air and in the classroom. On nights and weekends I also worked as an adjunct professor of business management for Embry-Riddle and worked for the Neeley School of Business at Texas Christian University. I was an analyst for the Defense Intelligence Agency studying the Soviet threat. As an engineer I managed a team designing an intercontinental ballistic missile. I designed landing gear for fighter aircraft and wrote lots of design specifications for aircraft, aircraft instrumentation, and support equipment. I wrote and performed software tests and hardware acceptance tests for cockpit engine instruments and test cells. For a while I was supervisor of technical publications and wrote many myself. I wrote proposals for the Lockheed F-22 fighter and managed all the proposals for sustainment, as the aircraft was continually being updated. Currently I am trying to write a sci-fi novel. I think the breath of my experience at Dartmouth and Thayer prepared me well for my wide-ranging career.

It was a great career. On the flip side, the aerospace industry is very fickle. Through the years I've been out on the street looking for work five times for a total of almost two years. I had to study new subjects and reinvent myself, but I never missed a house payment so it was all good. Again, I think Dartmouth prepared me to be flexible and adaptive.

I enjoy photography, woodworking, skiing, and hiking but even in retirement I just don't seem to have the time to do as much as I'd like to do.

—Ward Hindman '65 Th'68

I'm an engineer and an educator. I'm an engineer with AB and MS degrees from Thayer School and a PhD from the University of Michigan College of Engineering and founded six technology companies during my career. I was asked to serve as the interim dean of education at the University of Toledo from 2008 to 2011. I accepted, and the faculty embraced my engagement with the college after less than a year—not because I was the best dean that ever walked into the college; rather, I was accepted because I brought a rational and people-oriented business perspective that helped the college forge a positive pathway during very challenging times in the world of teacher training. I attribute my success in the world of education to the liberal arts-based engineering education I obtained in the 1960s at Thayer School, where, in contrast to most engineering programs, we learned how to think creatively and to connect engineering and technology with the real world. That same philosophy works in the world of education and teacher training!

—Tom Brady '66 Th'68

I'm an engineer and so was my father, so my excuse is genetic defect.

—David Dibelius '68 Th'69

I am an engineer and innovator and I work with people to help them master and solve their own problems so that their lives are easier, more exciting, and uplifting. I am the director of the TESS Innovation Team at the University of Patras in Greece and a professor at the university.

After we finish our joint work, I'd like our clients to feel that they are more in charge of themselves, and they can better understand their needs and how to address them. To be confident

## just one question



**"I am an engineer and innovator."**

—Yorgos Stephanedes '74 Th'80

mechanical problems to people problems. I work as director of life groups at Grace Church in Fishers, Ind. I also enjoy singing in our church choir.

—Laurie (Kormornik) Hartman '80 Th'80

I'm an engineer and I'm okay.

I sleep all night and I work all day.

Sorry, but I could not resist. Google it if you are not a Monty Python fan!

—Bob Migell '85 Th'86

I am an engineer and a mom.

I use my mechanical engineering skills to help with the most intricate of Lego designs.

I use my civil engineering skills to help build strong popsicle-stick structures.

I use my electrical engineering skills to install new vanity lights in my daughters' bathroom.

I use my engineering economics skills to create budgets to guide family decisions.

I use industrial engineering skills to design, manufacture, assemble, and ship up to seven lunches a day.

I use fluids skills to get the hose water pressure just right for water fights.

I use my thermodynamic skills to help me as I change my spark plugs.

I use my organization behavior and negotiating skills to bribe, persuade, and influence my husband,

Steve Hahn '92 Th'93, and kids Brendan (Lehigh '20), Clara '22, Eveleen (age 16), Maeve (14), Delia (12), Quinlin (10), and Tilley (8).

I love my Dartmouth liberal arts engineering education and certainly use my Thayer learned skills daily in my mom passions.

—Maureen (McGrath) Hahn '92 Th'93 Th'94

I'm an engineer and a crochet designer. I've been fascinated with both engineering and needlework for my whole life. I love materials of all kinds, and the design process is exciting, whether I'm designing something that's useful, decorative, or both. I'd always thought of

crocheting as a hobby, but I left full-time engineering when my kids were born. After a few years I opened an online shop to sell crochet ornaments. That shop led to a series of crochet pattern books—which turn out to be very much like the process documents I've written in my engineering life (only with much prettier illustrations). I'm mostly known as a crochet designer now ([facebook.com/CaitlinSainioDesigns](http://facebook.com/CaitlinSainioDesigns)), but I still think of myself as an engineer first—and probably always will.

—Caitlin Sainio '97 Th'98

I'm an engineer and a lawyer. I run a solo law practice (the Law Offices of H.W. Pfabe in Enfield, Conn.) exclusively dealing with intellectual property. The majority of my time is spent drafting and prosecuting patent applications, enforcing issued patents, and helping startups and early-stage companies come up with strategies built around their technologies. One of the reasons that clients come to me is that, in addition to my knowledge of patent law, they get the benefit of my engineering background and 15 years in research and development, product development, and manufacturing.

Since once an engineer, always an engineer, I also run a small product development company (MetaMotive Product Development), helping clients with their design, engineering, and prototyping needs as well as developing products of my own.

—Hugh Pfabe '98 Th'99

I'm an engineer and a ZillionMom ([zillionmom.com](http://zillionmom.com))! I started a financial literacy company developing financial literacy games for young children (elementary school age). I approach the education field with an engineering mindset—doing the product development to solve the world's problems. "Zillionmom" is my blog name, and I have developed games such as Zillionaire Jr., Money Conversations with Your Children, and Money Cards. I am also writing a book on how to talk with your children about money.

—Katya Vert-Wong Th'02

I am an engineer and a dad who loves to do projects in the garage with my kids Lynn (7), Peter (4), and Andrew (1). Most recently, we built a "puzzle board" on which the kids can do

that they can effectively use the solutions on which we worked together, and that they can then generate their own solutions. To be driven to innovation and a better understanding of the real questions, thus becoming happier for themselves and for their fellow human beings.

Our team creates innovative solutions to problems in fields such as trip planning, fleet management, people and product transport, connected transport, safety and security for travelers and transporters, energy management, green- and zero-energy buildings, underwater buildings, and heritage preservation. For a teaser on one of our projects in green buildings, go to YouTube.com and search "GRASPINNO adjectives."

—Yorgos Stephanedes '74 Th'80

I'm an engineer and a youth sport coach. I coached more than 20 seasons of soccer, basketball, and baseball. My training as an engineer helped me be a better coach—making me consider how I am going to organize and convey information (in this case, instruction) to a group of people (youths) in a way they can readily absorb and utilize to meet an objective (play the sport). What is important to convey now, and what can wait for later? What is success?

For example, when I was coaching 5- and 6-year-old soccer players, we wore different colored shoestrings so our players knew not to try to take the ball away from a teammate with the same colored shoestrings. We also

used wristbands—a green one on the right wrist for the right midfielder, a green one on the left wrist of the left mid. Same for the two backs, except in blue. Thus, the girls could see the wristband to reinforce which side was their side.

In basketball and soccer, when I introduced the players to the concept of not being a statue but moving together and not bunching up, they wore a web of bungee cords as we moved the ball around. The kids thought it was silly and fun, but they got the concept. When teaching a new technical skill, breaking it down into smaller steps and sequentially introducing them helped in the player's learning. I credit my training as an engineer with this approach.

And I also learned a lot from the coaching experience that has subsequently helped me with clients—although sometimes they are less patient and less attentive than the kids.

—Mike Sulaver '74 Tu'77 Th'77

I am an engineer and an English-as-a-Second-Language teacher. I learned teaching skills as an engineering team leader, coach, manager, and technical subject matter expert. I learned how to teach a second language from Dartmouth's late Professor John Rassias. Now retired from my engineering career, I teach refugees how to speak and read English.

—Scott Magelssen '75 Th'76

I'm an engineer and a pastoral counselor. I took a mid-career turn from



**"I'm an engineer and I'm passionate about cooking. I enjoy cooking memorable meals for friends."**

—Olusegun Amusan Th'18

both keeps my body and mind healthy. It is a pretty great life.

—Scott Lacy '13 Th'13

I'm an engineer and a percussionist! During my undergrad years I played as part of the World Music Percussion Ensemble, Jabulani African Chorus, and Christian Union worship team.

—George Boateng '16 Th'17

I am an engineer and a physician-scientist in training. I'm currently in my first year of training in the MD-PhD program at the University of Utah.

I was first interested in this career after having numerous surgeries as a competitive ski racer. I was drawn to the surgical techniques and tools used to fix parts of the human body. When I began my studies at Dartmouth, I kept medical school in the back of my mind and focused on finding a major I was interested in. The basis of what attracted me to engineering was using analytical processes to solve real-world problems. It was through biomedical engineering that I discovered that I could use this framework, but narrow the focus of its applications to bioscience. While many mentors and experiences were instrumental in helping me move toward where I am today, there is one experience in particular that stands out. In Dr. Jack Hoopes' Introduction to Biomedical

puzzles and then store them under the coffee table in our small two-bedroom house in Menlo Park, Calif. We are thankful whenever we can be together and build and make and create together.

—Brian Mason '03 Th'04 Th'05

I'm an engineer and I am drawing in preschool and elementary school kids to embark on the path of engineering and sciences. I am the founder of StemChef (stemchef.com), a program that teaches young kids science through cooking. With that theme, I am writing a children's book series and hoping to launch the first book in a couple months.

—Ashie Bhandiwad '13 Th'13

I'm an engineer and a cross-country ski coach! I live in Jackson, Wyo., and



**I'm an engineer and a youth sport coach. My training as an engineer helped me be a better coach—making me consider how I am going to convey information. I use pink shoelaces to help players identify teammates.**

—Mike Sulaver '74 Tu'77 Th'77

Engineering (ENGS 56) course, we toured the Center for Surgical Innovation at Dartmouth-Hitchcock Medical Center. The center is a gigantic operating room equipped with MRI and CT machines that can move in and out of the room. This room perfectly encapsulated the intersection between medicine and engineering: Each technology had been designed and built by engineers, but was utilized by physicians for the care of patients. This experience solidified my decision to pursue a combined degree. It would provide the proper training to prepare for a career in designing, building, and utilizing medical technology to deliver and improve patient care.

The hardest thing about medical school thus far has been accepting that it is not engineering. The mode of learning (so far) is different within medical school. Education is not understanding-based, but rather fact-based and highly dependent on memory retention. I have had to trade my pencil and notebooks for electronic notecards. However, I am sure I will get my fix of engineering when I begin my PhD next summer.

While the content of engineering has not been applicable in the first year of medical school, I believe the framework I developed as an engineer will be highly valuable when I am practicing medicine. For example, accounting for all variables of a problem and understanding how each may affect the outcome, will be useful as I start treating patients. I also think every Thayer graduate has a sense of figuring something out if they immediately do not know the answer. As I've learned in my time away from Dartmouth, this innate characteristic we develop during our time at Thayer is not common to every college graduate. My ability to figure things out if I don't know what is going on has already served me well, and I'm certain it will continue to do so.

In terms of how I plan to utilize engineering in the future, I am currently planning on pursuing my PhD within a bioengineering like-minded lab. My clinical interests are within the surgical subspecialties that are highly dependent on engineering. I plan to use the training within graduate school to inform my clinical practice to improve the care I deliver.

—Rose Caston '16 Th'17

# thayer notes



**"I'm an engineer and a cross-country ski coach. Both sides of my life balance the other and provide inspiration."**

—Scott Lacy '13 Th'13

early in my career made me to realize that engineering is serious business and got me very interested in learning about the business of engineering and technology. My focus area during the MEM program was in energy and the environment, and I chose this because the energy industry has a lot of socioeconomic impacts on the lives of ordinary people around the world. I'm currently involved in development and delivery of energy storage solutions to accelerate the world's transition to sustainable energy.

Besides engineering, I'm also passionate about cooking. I cook the food I eat more than 80 percent of the time. I'm from Nigeria, which is a multicultural country and very rich in diversity, including in its food. When I was growing up my family was always trying out new recipes and cuisines from different parts of the country. By the time I left home for college, I could cook practically anything I wanted to eat, including Jollof rice (a very popular Nigerian dish). When I moved to Hanover for the MEM program, I couldn't find many Nigerian food items in the grocery stores, but with the help of a family friend in the Upper Valley area, I learned how to cook different kinds of American food. Any time my friends visit me—whether they are Africans or Americans—my meals make sure they don't leave disappointed. There is a lot of similarities between engineering and cooking because they both require a systematic approach, precision, and a lot of patience. To deliver a cutting-edge engineering product or service, you have to get your design and analysis right. If you want your friends to always remember the last meal they had at your place, you've got to get your recipes right.

—Mariette van der Wegen Th'17

I'm an engineer and I'm passionate about cooking. My experience cuts across oil and gas, electric power, and energy storage. I got my bachelor's in electrical engineering and worked for three years as a design engineer before joining Thayer's MEM program in 2016. My exposure to large-scale and capital-intensive projects very

To quote Orson Welles: "Ask not what you can do for your country. Ask what's for lunch."

—Olusegun Amusan Th'18

## | 1940s |

**Bob Eckerson '48 Th'49:** At 91 I am told to use it or lose it; therefore, I have formal exercise five days a week to keep using it. I am fortunate to live in Durham, N.H., where the University of New Hampshire is very active, and I meet regularly with recent professorial retirees to keep my mind doing something. So far, so good.

## | 1950s |

**Gib Warren '53:** I left Hanover after my second year due to the language requirement. I entered the University of Wisconsin, where I received my degree in mechanical engineering in 1955 and then went to work as an application trainee with Carrier Corp. I continued in several engineering and construction organizations throughout my career. I retired in 1992 from the Austin Co. in Cleveland, Ohio. I will attend my 65th Dartmouth reunion at the end of September—the great class of '53 remains my class!

**Prentiss Carnell '56 Tu'57 Th'57:**

I've been retired almost 30 years, and am fairly healthy. I value family and friends. I feel sorrow at the diminishment of the size of the Class of 1956 and feel distant from the present Dartmouth, though I enjoyed interviewing admissions candidates for 40 or more years.

## | 1960s |

**Mark Tuttle '65 Th'66:** I continue to help startups and small companies with data and content challenges and consult with larger organizations, mainly in healthcare. I also develop software (my own stuff) and mentor wannabe data science students, occasionally from Dartmouth.

## | 1970s |

**Steve Askey '76 Th'77:** I retired (again) in October 2015, after 38 years in the oil and gas business, this time after five years with BHP Billiton working out of Houston. In spite of rising oil prices and an improving industry climate, it does not appear likely that I'll be returning to the field. So, I have a new career pursuing what has been a lifelong passion. I currently play lead guitar in a classic rock band—The Cat. 4 Band (as in the hurricane rating)—

in the Daytona Beach, Fla., area. We are on Facebook, Vimeo, YouTube, etc. I graduated from Thayer with an electrical engineering degree (and was kind of an analog guy), so it seems appropriate that I play through old tube amps and have a pedalboard full of stompboxes! As an aside, it was great seeing all of the changes to Thayer School last year during reunion.

## | 1980s |

**Mark Bunker '82 Th'83:** I'm the head of digital security at Fidelity Investments. I oversee Fidelity's cloud security strategy, implementation, and operations. I split my time working with my development team engineering, testing, deploying, and operating controls to protect Fidelity applications and customer data in the cloud; working with Fidelity business lines to inform them of these security controls and what it means to their business; and working in partnership with internal and external audit teams to assess our controls, identifying any gaps requiring remediation and certifying them to fulfill regulatory obligations. It is a constant refinement process.

**Bob Pattillo '82:** I am the co-founder of Gray Ghost Ventures, and invest about 65 percent of its capital. Since we started in 2005, our portfolio companies have been quite busy, with several having raised funds and others currently fund raising. Recent new product launches include a digital services platform in India (BEAM), a new mobile wallet in Latin America (BillMo), and new product licensing agreements with several South Asian and Sub-Saharan African countries (PharmaSecure). M-KOPA has provided lighting to more than 500,000 homes in East Africa, and is proving that off-grid TV owners are becoming connected and informed. bKash has positioned itself to become the largest mobile money provider in the world, and has nearly 27 million customers and 165,000 agents—just in Bangladesh. Gray Ghost Ventures has long held a fundamental investment thesis: break down the systems of exclusion that penalize the low-income and poor mass markets through early-stage investments into innovations and ventures to bridge the access gap with technology-led products and services.

## | 1990s |

**Kevin Franck '92:** I've had to be relatively quiet recently due to startup and private company involvement. But now that I'm an academic and with a nonprofit, I can share what I'm trying to achieve: I want people to hear better. My biomedical engineering education at Dartmouth got me started in this effort. First, I led a clinical-academic program at the Children's Hospital of Philadelphia and the University of Pennsylvania to help deaf children hear with cochlear implants. Then I moved to Australia to work for Cochlear Ltd. ([cochlear.com](http://cochlear.com)), the global leader of this technology, and build new clinical access tools. Returning to the United States, I got involved in startup companies, working in bionic leg technologies with BiOM Power Ankle (now sold by Otto Block, [ottobock.com.au/prosthetics/lower-limb/lower-limb-overview/empower](http://ottobock.com.au/prosthetics/lower-limb/lower-limb-overview/empower)) and with Ear Machine ([earmachine.com](http://earmachine.com)). This Small Business Innovation Research-funded hearing-access company was acquired by consumer electronics giant Bose, where I helped launch a new class of hearing headphone products ([bose.com/en\\_us/products/headphones/conversation\\_enhancing\\_headphones/hear\\_phones.html](http://bose.com/en_us/products/headphones/conversation_enhancing_headphones/hear_phones.html)). New legislation that was passed during this time mandated a pending FDA class of over-the-counter hearing products. Now that I'm at Massachusetts Eye and Ear and Harvard Medical School, I'm looking to create the new clinical-consumer hybrid marketplace to prepare for these devices. I'm also in Hanover this spring to lecture on bionics for ENGS 5: Healthcare and Biotechnology in the 21st Century.

**Vishal Gupta Th'94:** I am senior VP of engineering and product management at Symantec, a global leader in cybersecurity. The machine learning techniques that I used 20-plus years ago at Thayer for my MS thesis are more relevant than ever to both detect and protect against cybersecurity threats. One of the most interesting transitions that is happening is the move toward digital infrastructure—with focus on cloud, mobile, and Internet of Things—and we are creating cybersecurity solutions to enable consumers, enterprises, and governments to move to digital infrastructure with confidence.

## | 2000s |

**Matt Wallach Th'08:** We have some exciting changes in the works for this summer! I'm graduating from a dual-degree MBA/MS in mechanical engineering at MIT in June and then getting married to Katie Esper (who is set to graduate from the Dartmouth Master of Health Care Delivery Science program in January) and starting a new job at the Toyota Research Institute in Ann Arbor, Mich., in August.

## | 2010s |

**Devon Anderson Th'10:** After graduating in June from Oregon Health & Science University in Portland, Ore., with my MD and a PhD in biomedical engineering, I will be starting a residency in orthopedic surgery at the University of Rochester in New York. My dissertation research entailed tissue engineering articular cartilage from stem cells and evaluating novel surgical methods in cartilage restoration and joint preservation. My passions in both medicine and engineering emerged at Thayer when I was a research assistant in the Dartmouth Biomedical Engineering Center with Drs. Van Citters, Collier, and Mayor. I am so grateful for the meaningful and unique undergraduate research experiences I had as a Colby-Dartmouth 3–2 student that led me down this long, yet fulfilling, academic path.

**Sharang Biswas '12 Th'13:** My work as the experience designer at the Medici Group has brought me back to campus twice to run diversity and innovation workshops (once for the general staff, one for the Master of Healthcare Delivery Science program). My game Feast, which won an IndieCade award last year, was included in an exhibition at the Institute of Contemporary Art in Philly ([icaphila.org/exhibitions/8899/tag-proposals-on-queer-play-and-the-ways-forward](http://icaphila.org/exhibitions/8899/tag-proposals-on-queer-play-and-the-ways-forward)). I have three more games coming out soon, one of which involves sound design by Rebecca Drapkin '13. I have been giving lectures on game design, including in a film and media studies class at Dartmouth and at the Living Games Conference. I am still writing short stories and the like. I was particularly proud of my Black Panther movie review ([zam.com/article/1695/black-panther-review](http://zam.com/article/1695/black-panther-review)).

panther-review). On the interactive-theater front, I have no new shows yet, but I've been pitching to museums and festivals. We'll see what comes up!

**Cole Sulser '12 Th'13:** I play professional baseball as part of the Cleveland Indians organization for its triple-A-level farm team, the Columbus Clippers. I spent the last few years playing for various farm teams under the Cleveland Indians after being drafted by them in 2013. I have found many principles learned at Thayer to be beneficial in the professional sports world: a world that is ever increasing its use of technology and data to evaluate players, train them, and try to create the best approach for reaching our highest potential. I know I wouldn't be where I am today, if it wasn't for the lessons and skills I learned while at Thayer.

**Mike Henson Th'14:** Within the last three years I retired from the Air Force and began my career as a contractor with ManTech International, supporting the U.S. Department of Defense. My last job in the Air Force (2013–15) was as director of operations with the 33rd Communications Squadron, stationed at Andrews Air Force Base. There, I led 300 military, civilian, and contractor personnel to maintain critical command-and-control networks, systems, and services for multiple bases in the national capital region (NCR). Additionally, I planned and directed a team of 10 project managers providing sustainment and modernization projects totaling about \$12 million annually in support of the NCR. One of the things I'm most excited about now is a course I developed to teach folks in various cyber commands mobile development and debugging skills in ARM assembly—the language which underlies most mobile technologies today, including Android and iOS smartphones. No problem! The course is based in part on the experience I gained under Professor Stephen Taylor doing my thesis research (a DARPA-sponsored project). The three-day course builds up from the simplest ARM instructions through an understanding of the procedure call standard and ARM coprocessors—such as the single-instruction, multiple-data NEON coprocessor—as well as teaching how to debug

mobile programs. You can link to it at: [mantech.com/solutions/Cyber%20Security/Pages/ARMAAssembly.aspx](http://mantech.com/solutions/Cyber%20Security/Pages/ARMAAssembly.aspx).

**Olivia Herbert '14:** I work at Facebook in New York City and have been there for just over two years. Last July I got engaged to **Thomas Mattimore '12 Th'13**, who is also working in New York as a product manager at Makerspace.

**Liliana Ma '14:** Since graduation I've been enrolled in an MD-PhD program at Northwestern. I'm finishing up my fourth year of the program and second year of the PhD. I'm pursuing a PhD in cardiac MRI, and I've been lucky during the PhD years to collaborate internationally and attend conferences in exotic places. Last year the annual meeting of the International Society for Magnetic Resonance in Medicine was in Hawaii. I gave an oral presentation on my research and participated in a 5K race with other MRI nerds. Later in the year, I attended a conference in South Africa! That was truly an amazing opportunity. In addition to the awe-inspiring and diverse landscapes and whales at the coast, I got to see my favorite animals—penguins—up close.

**Anna Miller '16 Th'17:** I am living in Alaska, mooching off my parents, and working part-time in a fancy dog boutique. My friends are concerned by this break from a promising engineering career. I have been learning to crochet, and most recently made a tardigrade. Not at actual scale, of course, but enlarged so that it's easier to make. In July I will be moving to Boston, where I would like to take up urban beekeeping. I would appreciate any pointers the Thayer community may have.

**Coralie Phanord '16 Th'17:** I currently work as an engineer at Magnopus, a virtual reality and augmented reality company in Los Angeles. My latest project is Coco VR, Pixar's debut into virtual reality. It's an adventure into the Disney-Pixar film *Coco*. Players follow the magical alebrije, or creatures, into the world of Coco, filled with lovable characters and beautiful settings from the film. Here's a link to the project: [cocovr.magnopus.com/index.html#overview](http://cocovr.magnopus.com/index.html#overview).

## | obituaries |

This issue's obituaries appear online at [dartmouthengineer.com](http://dartmouthengineer.com).

# Inventions



## LASER LIGHT SHOW

>> INVENTOR:

PROFESSOR ELSA GARMIRE

Elsa Garmire, Sydney E. Junkins 1887 Professor of Engineering Emerita and former Thayer School dean, holds ten patents in the fields of optics and lasers. But it was her artistic experimentation with lasers that showed millions of people the light.

The light shows that lit up Seventies-era rock concerts were inspired by laser-art created by Garmire a decade earlier when she was a post-doc at Cal Tech. She made photographic images of diffracted laser beams dubbed "lasergrams." The lasergrams led to a collaboration between Garmire and filmmaker Ivan Dryer. They formed Laserium in 1973—a company that produced light shows for planetariums and concerts using Garmire's knowledge of lasers and optics. Laserium shows, which are still running today, have been seen by an estimated 20 million people.

Garmire also promoted the idea that people could create their own light shows in a "how-

to" television demonstration in 1971. Backyard laser shows didn't become a "thing" back then because the lasers cost about \$12,000 in today's dollars. Nowadays, with the advent of cheap laser pointers, the only limit to creating your own laser show is imagination. (Besides the lasers, which can cost as little as \$10, you need Duco cement and a glass slide to get going.)

Laserium's light shows were initially accompanied by classical music. The era of the big rock bands, such as Pink Floyd, came later.

Appearing on the public radio program "Science Friday" in 2016, Garmire was asked by host Ira Flatow if she was prepared for how big the laser light show concept would become. "Well, I'll tell you. I loved it. I loved the classical music," she answered. "And when they switched to the rock music, that's when I decided to absent myself."

Garmire left Laserium and returned to academia and research, arriving at Thayer in

1995. "When I came (to Thayer) I transferred a project from California that investigated the use of lasers to remove graffiti," Garmire noted in the Dartmouth Presidential Lecture she gave in 2006. "A Nd:YAG laser has enough power to 'zap' the paint off highway signs and concrete walls. We built a portable, practical system, but graffiti doesn't seem to be the problem in New Hampshire that it was in California, so we did not pursue this any further."

Ironically, her graffiti-removing laser system was her only patent to make money. The invention eventually found a niche market in the aviation industry to remove paint from aircraft.

—Lee Michaelides

*Garmire's Presidential Lecture is at [thayer.dartmouth.edu/assets/pdf/garmire-presidential-lecture.pdf](http://thayer.dartmouth.edu/assets/pdf/garmire-presidential-lecture.pdf). Her "Science Friday" interview is at [sciencefriday.com/segments/when-laser-science-was-far-out](http://sciencefriday.com/segments/when-laser-science-was-far-out).*



## Random Walk

During spring term, Professor Ulrike Wegst held an outdoor raku lab for ENGS 73: Materials Processing and Selection. A ceramics technique that dates from 16th-century Japan, raku is as much a science as an art. With help from Wegst, students heated their hand-molded glazed bowls to about 1000°C in a kiln set up behind Thayer. When the bowls glowed red-hot, the students transferred them from the kiln into a bucket filled with flaming materials and closed the lid on the bucket—subjecting the glaze to reduction where it came in contact with the flames and oxidation where it didn't. “The result is a glaze with beautiful metallic luster in areas where reduction occurred and the color of the metal oxide in its absence,” says Wegst. “The unpredictable range in glaze colors that results, combined with crackling due to the considerable thermal stresses that develop in and between ware and glaze during the rapid cooling, offer a rich, aesthetic, and tangible illustration of materials science phenomena.”

PHOTOGRAPH BY KAREN ENDICOTT

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## I'm an Engineer and a Rock Climber

"There are a lot of overlaps between engineering and rock climbing. The problem-solving process is present in both. It's all about iteration and trying new things. My rock climbing has influenced my engineering in that it has taught me to take risks and commit to things. And sometimes for the engineering process, that's what it takes. You have an idea, and you just have to go with it and not be afraid to fail."

—Max Saccone '17 Th'17

*Watch Saccone, who is now a grad student at Caltech, and other students in Thayer's "I'm an Engineer and ..." video series at [youtube.com/user/ThayerSchool/playlists](https://youtube.com/user/ThayerSchool/playlists).*

Photograph courtesy of Max Saccone