

A National First

DARTMOUTH GRADUATES A MAJORITY
FEMALE ENGINEERING CLASS

SUMMER 2016

DARTMOUTH Engineer

THAYER SCHOOL OF ENGINEERING



inside

THE TA EXPERIENCE

NEW TRANSLATIONAL RESEARCH LABS

ALUMNI NEWS

GOOD COMPANY

WITH A THIRD OF THAYER'S TENURE-TRACK FACULTY FOUNDING STARTUPS, PROFESSOR TILLMAN GERNGROSS LED DARTMOUTH TO EASE ITS ENTREPRENEURIAL RULES.

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Gender Parity

How Dartmouth became the first university to grant more than 50 percent of its engineering degrees to women.

JOSEPH J. HELBLE | DEAN

EVERY YEAR ON COMMENCEMENT WEEKEND, Thayer holds an Investiture ceremony to hood our graduating students and recognize their outstanding academic accomplishments. Always a celebratory occasion, this year's Investiture was particularly noteworthy as we announced the graduation of our largest AB class ever. Of the 117* AB graduates, more than 50 percent were women, representing a major milestone: In an era where less than 20 percent of engineering bachelor's degrees are awarded to women nationally, this is the first graduating engineering class from a national research university to achieve gender parity. The vast majority of our graduates are also earning their BE, either completed simultaneously or in four years, or planning to do so in part or all of a fifth.

Over the past month, our milestone accomplishment and the stories of our students have been noticed, and we have been repeatedly asked how we have achieved gender parity. Our answer, of course, is that it has not been a single initiative or program, but rather many small steps, including the development of a culture that is designed, first and foremost, to expose the broadest and most diverse group of students—male and female—to the beauty of engineering as a way to tackle the world's greatest challenges.

We have accomplished this by:

- building, over decades, our program that connects engineering at Dartmouth deeply to the liberal arts, helping all students develop not just the technical knowledge to solve technical problems, but a deeper understanding of the world, of the society that engineering needs to serve.
- avoiding engineering silos and giving students flexibility and choice, which we do by exposing students to all engineering disciplines without regard for departmental walls or disciplinary boundaries, encouraging students to see engineering as a collaborative mindset and a collection of tools to solve real-world challenges.
- placing a premium on hands-on, project-based learning—from the very first engineering class—that is often far more appealing than sitting in a lecture hall.
- providing all Dartmouth students the opportunity to take entry-level engineering design classes, such as ENGS 12 or ENGS 21, alongside engineering majors, offering them a way to experience the creative elements of engineering without having to commit to the major
- building on the success of Dartmouth's 25-year-old Women in Science Project, developing a First Year Research Experience in Engineering program, encouraging first-year women and men to explore engineering by working directly with a faculty mentor.
- hiring talented faculty and staff who are great teachers, are leaders in their scholarly fields, are also often entrepreneurs, and who engage students in their labs or startups taking on problems in medicine, energy, imaging, communications, information security, robotics, and many other areas.
- building a diverse population of role models for students at all levels, from faculty to staff to review boards to student teaching assistants, and enabling our female students to interact with successful mentors every step of the way.

We are enormously proud of our graduating class, who made history this June. And we look forward to the time when gender parity in engineering is the norm, not the exception.

* At the time of Investiture, the number of expected AB graduates was 119. Final figures released by the registrar in July amended the numbers to 117.



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COVER: Professor Tillman Gerngross in his office at Adimab, one of the five companies he started. Photograph by Doug Levy.

Teaching assistant Waad Kahouli Th'16, right, guiding Josie Nordrum '17 in an aircraft design class, says, "Helping someone learn the material is very rewarding."

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THE Great Hall



NEWS FROM AROUND THAYER SCHOOL



THE FUTURE

MacLean Gift Spurs Expansion

THAYER'S PLANS FOR A MAJOR EXPANSION RECENTLY RECEIVED A \$25 million boost from Barry MacLean '60 Th'61. The largest gift in Thayer's 149-year history, MacLean's donation includes \$15 million toward the design and construction of an additional engineering building and a \$10 million challenge grant for creating endowed professorships at Thayer.

"I believe deeply in the school's mission and how the skills gained at Thayer can help prepare all students for their lives," says MacLean. "I firmly believe every Dartmouth undergraduate should experience Thayer."

MacLean, chairman and CEO of the MacLean-Fogg manufacturing company, has been a Thayer Overseer for 42 years, was a Dartmouth Trustee for 10 years, and has a long history of supporting Thayer. He and his wife, Mary Ann, were the major donors for Thayer's 2006 addition, the MacLean Engineering Sciences Center.

MacLean's latest gift serves as a cornerstone for Thayer's planned expansion, with its

DEVOTED
Barry MacLean '60 Th'61, center, with students in the building that bears his name, wants all Dartmouth students to benefit from engineering.

goal of offering every Dartmouth undergraduate the opportunity to explore technology in preparation for leadership in an increasingly technology-dependent world. The expansion will meet growing student demand for engineering; AB majors and BE graduates have nearly doubled in the last 15 years. Thayer plans to double the size of its faculty, expanding expertise in energy and engineering in medicine and increasing entrepreneurship. Dartmouth and Thayer are also exploring relocating the Department of Computer Science to Thayer's new building to facilitate novel collaborations in research and teaching.

The proposed expansion is contingent upon private gifts to cover the estimated cost of at least \$200 million. MacLean is chairing the fundraising effort, working with Thayer Board of Overseers Chair Terry McGuire Th'82 and a committee of volunteers.

"People and place are the defining aspects of Thayer's unique community and approach to education," says Thayer Dean Joseph J. Helble. "Barry's investment in these two areas—and his invitation to others to join him—promises a transformation of our standing and impact around the world."

"Engineering is recognized as a solution to many of the world's challenges, such as hunger, space exploration, or extending life," says MacLean. "All those issues have engineering aspects, and students today are focused on trying to make a better world. Seeing young people going farther than you ever expected is really rewarding, and helping them on their way is a great joy to me."

Q&A

>> Professor Petra Bonfert-Taylor

Professor and instructional designer Petra Bonfert-Taylor received her PhD from the Technical University of Berlin and was a professor of mathematics at Wesleyan University before joining Thayer in 2015. Her research is in complex analysis, geometric function theory, hyperbolic geometry, and the mathematics of medical imaging, and she is avid about improving pedagogy.

students' learning experiences. I am also deeply curious, on an intellectual level, about how humans learn.

What teaching/learning techniques do you think are most effective?

There is no one-fits-all solution to what works best in the classroom. We all care deeply about our students' learning, and that's what is at the core of effective teaching. Strategies that have worked well for me include those that keep students actively engaged with the course material, with each other, and with me, the instructor, during their learning process. For example, rather than lecturing for extended periods, I like to use some of my in-class time to have students work through problems, discuss solutions in groups, and present their work to the class.

Do your research interests have a bearing on how you teach?

My research is in mathematics—geometric analysis, to be precise—and I have spent significant amounts of time thinking about how to most effectively present intricate mathematical theories to those less involved in mathematics. Trying to put yourself into the shoes of people who are just beginning to explore a topic about which you have thought for a decade or more is quite difficult but most helpful in empathizing with new learners. In doing research, one tackles problems to which not only the answers are unknown, but where it is not even *a priori* clear that the question is fully correct. As a researcher I am completely empathetic with my students' struggles to find their own paths through difficult material.

What prompted you to write an op-ed about messages adults give kids about math?

Math anxiety has such a profound negative effect on so many people, including many of our students. For the longest time I have been asking myself where this anxiety comes from and what I could do to help affected students. As I watched my own children and their peers advance through the school system, I developed more and more insight into what might be happening. Combined with my frustration about the al-too-common response I receive when people find out that I am a mathematician ("I was always so bad at math!"), and inspired by the Dartmouth Public Voices Fellowship, which I am fortunate to be a part of, I decided to write the op-ed in order to raise awareness of the issues and their implications.

"There is no one-fits-all solution to what works best in the classroom."



Kudos

AWARDED Professor Emeritus

Graham Wallis was awarded the 90th Anniversary Medal of the Fluids Engineering Division of the American Society of Mechanical Engineers in recognition of his contributions to the advancement of the science and practice of fluids engineering.

NAMED

The American Association for the Advancement of Science and the Lemelson Foundation have named Professor Eric Fossum one of 10 2016-17 Invention Ambassadors. The ambassador program will enable Fossum, the inventor of the image sensor technology used in cellphone cameras and the director of Thayer's PhD Innovation Program, to further demonstrate his role as a problem-solver.

PUBLISHED Professor Geoffrey

Parker—who joined Thayer's faculty in July—charts out the brilliant future of platforms and reveals how they will irrevocably alter the lives and careers of millions as coauthor of *Platform Revolution: How Networked Markets Are Transforming the Economy—And How to Make Them Work for You* (W.W. Norton & Co.).

SELECTED Graduate students chose Professors Margie Ackerman and Ryan Halter to receive Dartmouth's 2016 Faculty Mentor Awards.

AWARDED

Three engineering grad students, Alexander Engler '12, Ellen Weburg '14, and Grayson Zulauf '12, have been awarded National Science Foundation Graduate Research Fellowships for 2016. The fellowships provide three years of support for graduate study leading to a research-based master's or doctoral degree in science or engineering.

AWARDED

Engineering major Jack Kirsch '17 was awarded Thayer's 2016-17 Mazilu Engineering Research Fellowship to support his work with Professor Karl Griswold on antibiotics.

AWARDED

Max Saccone '17 was awarded Thayer's 2016-17 Bengt Sonnerup Fellowship, to support further research with Professor Weiyang (Fiona) Li on understanding the chemical reactions that take place in high-energy sulfur-based batteries through surface-enhanced Raman spectroscopy. "This type of battery is a very attractive energy storage technology due to its high theoretical energy densities and its use of earth-abundant materials," Saccone says.

I Want One of Those!

STUDENT PROJECT

SNOW-CLEARING FIRE HYDRANT COVER

The Hanover Fire Department really does want one of these: a pneumatic fire hydrant cover. The compressed air-activated cover takes only 30–45 seconds to clear a radius of three feet of packed snow from around fire hydrants. Kelsey Catano '18, Jessica Colin '18, Zoe Dinneen '18, and Jarrett Taylor '18, who hope to patent their invention, won the Winter 2016 Philip R. Jackson Prize for outstanding performance in ENGS 21: Introduction to Engineering. Their teaching assistant was Gabriella Grangard '16 Th'16.



▲ From left, Kelsey Catano '18, Zoe Dinneen '18, Jarrett Taylor '18 and Hanover firefighters gather around the students' snow-clearing pneumatic fire hydrant cover.

COMMUNITY

The NSBE Connection

"IT'S AMAZING TO SEE ALL THE OTHER chapters from across the nation as well as from Africa and Canada. It's awesome to see how many black engineers there are. I'm not alone."

That was how the National Society of Black Engineers (NSBE) annual convention struck Kristen Virkler '18, who attended the four-day gathering with Stephanie Emenyonu '16.

The engineering majors were among the thousands of people participating in the convention's career fair, networking opportunities, workshops, and social events. "It's a great atmosphere. It's very encouraging," says Virkler, who talked with several companies about an internship in either finance or aerospace engineering for her off-term.

"Seeing the strong connection between black engineers in different fields made it a worthwhile experience for me," says Emenyonu.

Back on campus, Emenyonu and Virkler view the Dartmouth NSBE chapter as a major source of connection and mutual support. "When I was a freshman I was looking to find a community within Thayer to help me with the challenges I was having," says Emenyonu. "The '13s who were running NSBE at the time told me, 'Come be a part of this; we know you're an engineer as well. Bringing me into the community really helped.'

Emenyonu credits NSBE with helping her navigate through Dartmouth and Thayer School. "NSBE leaders throughout the years have given me tips and tricks, like going to office hours regularly to meet and get to know my professors. The advice the NSBE community has given me really helped me flourish and become more confident as an engineer," she says.

She in turn has worked hard to support other black engineers. As president of the Dartmouth NSBE chapter, Emenyonu advises students about classes and cheers them on. "Engineering is hard. There are times you hear of people wanting to drop the major because of a rough term they're going through, but if I feel you're very capable, if I know you have the passion for it and you're just struggling a little, of course I'm going to be encouraging," she says.

Virkler is among the younger students Emenyonu has mentored. "NSBE offers an environment where it's okay to say, I don't understand it and I'm struggling," says Virkler, who serves as treasurer of the Dartmouth NSBE chapter. NSBE, which has 13 members at the moment, has a lighter side, too, she and Emenyonu say, including dinners with profes-



Kristen Virkler '18, left, and Stephanie Emenyonu '16

sors, lab tours, and science activities with local kids.

While Emenyonu, who is returning to Thayer for her BE, says that, "Students here at Thayer are very collaborative and the faculty are extremely supportive," she also notes, "I do think it's important for Thayer to be diligent in hiring more faculty and staff of color. As a black woman, I think it is important that students of color see professors, researchers, staff—those with relative power in the institution—in positions they aspire to reach. There is great impact in students being able to interact with and learn from faculty and staff of color who can share their perspectives and experiences as well as be visual manifestations of achievement in the engineering field and inspiration for students of color."

Emenyonu, who has been conducting research on breast cancer in Thayer Adjunct Professor Jack Hoopes' lab at Dartmouth-Hitchcock Medical Center, plans to continue connecting with the black community in her career. "As I'm building my passions for engineering, I definitely find that I am driven by issues that affect minority communities," she says. "For instance, I am interested in issues that surround diseases like diabetes, which has affected me personally and people close to me. I know it's a big problem within the African-American community. I would also like to study diseases like anemia, especially sickle-cell. When I'm doing class projects, I try to hone into these things, and that's what drives me to do well. My hope is that one day my skills will be utilized to improve the health of minorities in the United States, specifically that of black women."

In the meantime, Emenyonu and Virkler will continue to work with NSBE to engineer the way ahead for themselves and their peers.

investiture

Class of 2016

AT THE JUNE 11 INVESTITURE ceremony, Dean Joseph J. Helble announced the shattering of a national glass ceiling—gender parity in engineering—with the graduating class of engineering majors consisting of more than 50 percent women.

"To my knowledge this is the first time, ever, in this country's history, that a major research university has graduated an engineering class that has achieved gender parity—and I think this milestone speaks volumes about the culture and community that you, our students, have created, a culture that our faculty and staff have supported, a culture that says that a diversity of thought and perspective and background is not only welcomed but required," Helble said.

Helble also announced that Thayer's largest undergraduate class ever—a final tally of 117 majors—would receive degrees the next day along with 143 BE and graduate students.

Arati Prabhakar, director of the Defense Advanced Research Projects Agency, received Thayer's Robert Fletcher Award in recognition of distinguished achievement and service in the highest tradition of the school. Addressing the audience, she asked graduates to consider the choices they will confront as humans and technologies become increasingly interbound.

"I work in the Defense Department, where we grapple with whether and when to grant certain degrees of autonomy to weapons systems, like missile-defense systems that have to respond instantly if they are to protect the lives of hundreds of sailors on a ship. But that's not the only arena where we engineers need to think through how we grant crucial decision-making powers to machines. Think about self-driving cars, which I suspect will be cruising our streets before long. They too will sometimes have to make extremely difficult, life-or-death choices instantaneously."

"How will *you* assess what machine intelligence can and can't do and when



to trust it? How will *you* decide how much power to delegate to a machine, as we and our machines become increasingly intertwined?"

"Nothing is more rewarding," she said, "than wading into the sublimely rich intersection of technology and humanity, shaping its contours and dimensions, and bringing to that process the very best instincts we each can offer about how to make the world better and stronger, more technically empowered, and at the same time more beautiful and more simply human than ever."

In his remarks, Helble asked students to resist the urge to always be on their smartphones or laptops. Admitting that he's not immune, he said, "I have felt the gravitational pull of my iPhone. I have taken it out of my pocket at a meeting. Put it on the table. Taken it back and put it in my pocket again. Taken it out.

"Remember Newtonian physics that says there's a $1/r^2$ scaling dependence of force on distance? It's a lie. Clearly, the force of gravitational attraction for that device is much, much greater," he said.

"But, our graduates," he said, "I'm asking you to think about what it means to step away from your

devices even briefly and be present in the moment and about when you are, how much you can not only see, but observe, interpret, understand, do what it is that society needs us, as engineers, to do.

"That is how you spent your time here. That's how you did the work that led to incredible accomplishments, from a nicotine monitoring device, to a smartphone tool for the local bus system, to a cerebral shunt to improve treatment of hydrocephalus, to a medical device that uniformly applies minced skin to the wounds of burn victims, to analyzing emerging technologies in haptic surgical robotics, in desalination, in clean-burning power-generating portable stoves.

"This is how you accomplished what you accomplished. You presented, you published, you filed for 17 unique patents, you founded two companies, you started a nonprofit organization."

And he added, "What I hope you'll take away from here is that this is what you are capable of doing when you look up, when you fully engage with the people around you, with your community, and with the world."



ENGINEERING
GRADUATES

14
Doctor of Philosophy

8
Master of Science

1
Master of Engineering

37
Master of Engineering
Management

83
Bachelor of Engineering

117
Bachelor of Arts in
Engineering Sciences

SPORTS

MVP Drafted!



GOING PRO
The Mobile Virtual Player (MVP), a robotic tackling dummy, takes the practice field with the Pittsburgh Steelers. The team is using several MVPs, created by Thayer students, to reduce the risk of concussions.



Senior Heads to Training Camp

DARTMOUTH CORNERBACK AND engineering major Vernon Harris '16 headed to new turf this summer: the Kansas City Chiefs' training camp. With a record-breaking 40 starts in his Dartmouth football career and having made two consecutive All-Ivy first teams, the 21-year-old Harris was signed by the Chiefs this past spring term. Hoping to make the Chiefs' 53-man regular season roster, Harris is putting engineering temporarily on hold. Still two terms shy of completing his undergraduate studies, he plans to return to Thayer during the off season. He also expects to return to engineering after his football career. "NFL stands for 'Not for Long,' so you just gotta enjoy the experience no matter how long it is," he says. "I eventually want to come back to engineering. It's one of my first loves and one of those things I feel is necessary in the world because there are a lot of problems out there and a lot of people need answers, and I feel like engineering, no matter in what capacity, can help. One day I'd love to go back to maybe a startup or somewhere I'd be able to get hands-on and definitely help out."

EXIT INTERVIEW

CFAO Larry McKinnon Retires



LARRY MCKINNON RETIRED IN FEBRUARY after serving as Thayer's chief financial and administrative officer for 29 years. During that time he oversaw a major accomplishment: 23 consecutive years of balanced budgets—though, as he puts it, "I'm here 29 years, and we've only had 23 consecutive years of balanced budgets—oh, shame on me."

We asked McKinnon, who plans to spend his retirement in Massachusetts playing with his grandchildren, about his work at Thayer.

How did you achieve 23 consecutive years of balanced budgets?

During the '90s we worked really hard at diversifying our revenue streams and building up our reserves. When the great recession hit, we stayed in the black because our investment endowment income only represented 12 percent of our operations, enrollments were strong, and our Annual Fund was strong. Even with federal dollars tightening up, we have a diverse portfolio of sponsors that support our faculty: NIH, defense, NASA, commerce, energy, and other government departments, and state foundations. We're in a strong position for Thayer's expansion.

What's been the most challenging part of overseeing the budget of Thayer?

It's staying on top of the finances. My wife would laugh at me, "Oh, you're talking about 2019 already?" You have to be constant. I'm reading *The Wall Street Journal* all the time, I'm reading the federal budget and watching the economy. You have to stay on top of the environment that's going to affect your operations. That was really instilled in me by Hutch [Dean Emeritus Charles Hutchinson] and Jake [Overseer Emeritus John Krehbiel Jr.] at the beginning of my time at Thayer. We took the approach that if we see a problem coming, let's deal with it now.

We want to keep our faculty competitive. We want to keep our financial aid competitive, attracting good students. There are so many details. It's all challenging.

GM technical specialist Scott Lananna '08 Th'09, second from left, inspects the car built by RIT's all-female team.



COMPETITION

Ten Years of Formula Hybrid

THE GARAGE BAYS AT THE NEW HAMPSHIRE MOTOR SPEEDWAY IN LOUDON, N.H., were filled with nervous energy at the 10th annual Formula Hybrid Competition, held in May. Teams of undergraduate and graduate students welded, keyed in computer simulations, and used their share of duct tape as they strove to get their hybrid and electric cars ready to race.

Founded by Thayer School in 2006, Formula Hybrid challenges students to build high-performance, fuel-efficient hybrid vehicles. The task remains difficult to achieve, requiring students to work across disciplines to engineer innovative systems—and then compete in design, acceleration, and endurance events, the latter on a fixed amount of fuel. “Formula Hybrid is the hardest of the SAE student design competitions,” says Thayer research engineer and competition founder and organizer Douglas Fraser.

This year, to help the teams succeed in building cars that would pass technical inspection, Formula Hybrid provided new management guidance and opportunities to work with professional mentors throughout the year. The competition also added an optional Tech Day to give teams more time to pass electrical inspection.

By the end of competition, Canada’s University of Victoria took first place in the hybrid drive class, Binghamton University won first place in the electric drive class category, and India’s SRM Engineering College secured first place in the hybrid-in-progress category.

Thayer School’s Dartmouth Formula Racing (DFR) team worked from last year’s car and made some innovative improvements, including installing a bamboo fiber body. This year’s car featured a hybrid controller and a parallel motor, in which the engine and the motor work together to drive the rear wheel of the car, and the dashboard held an iPad mini to stream data live from the vehicle.

Despite working around the clock, DFR never made it onto the track. “We did not race at competition this year,” says DFR co-captain Margaux LeBlanc Th’16. “It was really heartbreaking to watch us work so hard, get it working on the last day, and never pass mechanical inspection because of a few things in our cockpit.” Even so, the team placed second in the hybrid-in-progress category.

This year’s event attracted 28 teams, including the first-ever all-female team, Rochester Institute of Technology’s Hot Wheelz, which placed third in the electric drive class category and took home the Fiat Chrysler Automobiles Gracious Professionalism Award and the GM Spirit of Formula Hybrid Award.

Fraser is happy with what the competition has achieved over the course of 10 years. “Many Formula Hybrid alums are now working in industry, and a lot of them are returning to the competition as judges and inspectors,” Fraser says. “We hear great feedback from these alums about the value of Formula Hybrid in their careers. One of them went to work for Tesla, and he said everything he had learned in the Formula Hybrid competition applied to his work.”

MILESTONES

Women in Science Celebrates 25 Years

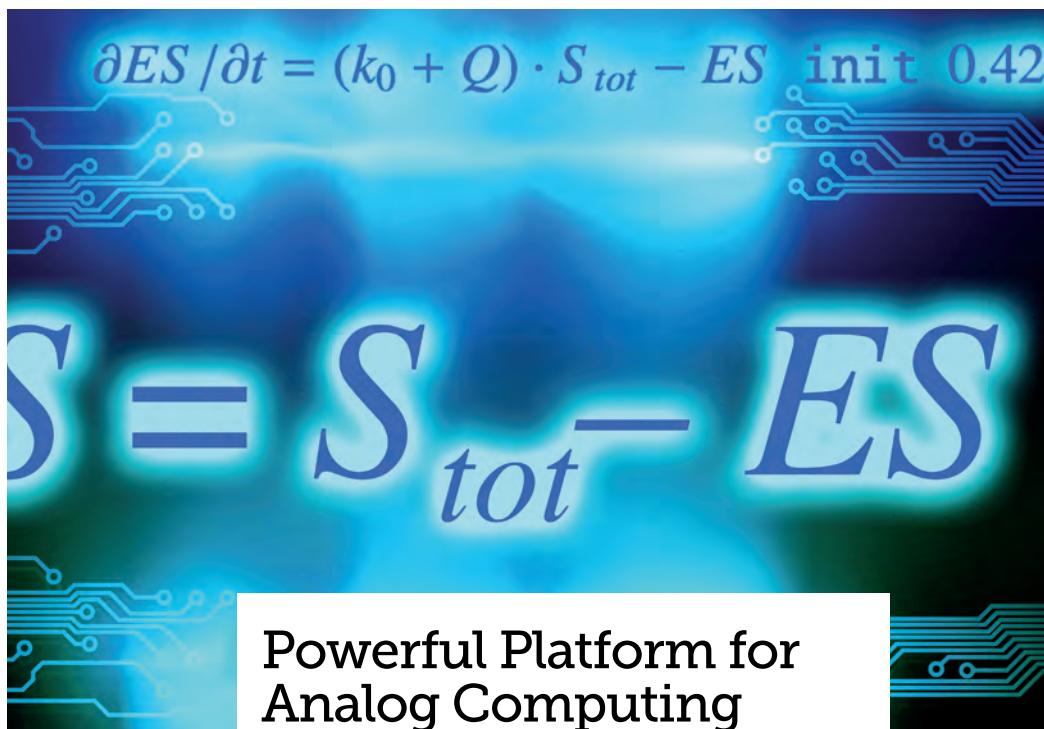
TWENTY-FIVE YEARS AGO, Carol Muller ’77 and Dartmouth chemistry professor Karen Wetterhahn launched the Women in Science Project (WISP) to encourage women to pursue science, engineering, and math studies and careers. At a recent celebration of WISP’s founding, Muller took stock of how far Dartmouth and Thayer have come. “When I first started working at Thayer School in 1987 it was still operating, with respect to gender, as if it was the 1950s,” says Muller, Thayer’s former dean for administration. “At the same time, the dean, Charles Hutchinson, and many of the faculty were eager to have more engineering students.”

Mentorship and research opportunities for first-year women form the heart of the program that Muller and the late Wetterhahn established. Since 1991, WISP has placed 1,707 student research interns with 331 faculty research mentors, and 4,400 students have participated in its peer mentor programs. According to WISP director Kathy Scott Weaver, from 1991 to 2016 engineering has hosted 299 WISP interns, more than any other department.

The opportunities WISP created have paid off. The number of women majoring in the sciences has grown steadily from 45 in 1990 to 114 in 2015. Biology has more female majors than male. And in 2016, the women of Thayer outnumbered men graduating with an AB in engineering—marking the first time a major research institution achieved gender parity.

For more about WISP and an interview with Carol Muller, go to dartmouth.engineer.com.

lab reports



Powerful Platform for Analog Computing

A TRANSISTOR, CONCEIVED OF IN DIGITAL TERMS, has two states: on and off, which can represent the 1s and 0s of binary arithmetic.

But in analog terms, the transistor has an infinite number of states, which could, in principle, represent an infinite range of mathematical values. Digital computing, for all its advantages, leaves most of transistors' informational capacity on the table.

In recent years, analog computers have proven to be much more efficient at simulating biological systems than digital computers. But existing analog computers have to be programmed by hand, a complex process that would be prohibitively time consuming for large-scale simulations.

At a recent Association for Computing Machinery conference on programming language design and implementation, researchers at MIT's Computer Science and Artificial Intelligence Laboratory and Dartmouth College presented a new compiler for analog computers, a program that translates between high-level instructions written in a language intelligible to humans and the low-level specifications of circuit connections in an analog computer.

The work could help pave the way to highly efficient, highly accurate analog simulations of entire organs, if not organisms.

"At some point, I just got tired of the old digital hardware platform," says Martin Rinard, an MIT professor of electrical engineering and computer science and a coauthor on the paper describing the new compiler. "The digital hardware platform has been very heavily optimized for the current set of applications. I want to go off and fundamentally change things and see where I can get."

The first author on the paper is Sara Achour, a graduate student in electrical engineering and computer science advised by Rinard. They're joined by Rahul Sarpeshkar, the Thomas E. Kurtz Professor and professor of engineering, physics, and microbiology and immunology at Dartmouth.

Sarpeshkar, a former MIT professor who joined the Thayer faculty in 2015, has long studied the use of analog circuits to simulate cells. "I happened to run into Rahul at a party and he told me about this platform he had," Rinard says. "And it seemed like a very exciting new platform."

ANALOG COMPILER
A new compiler takes as input differential equations and translates them into voltages and current flows across an analog chip.

The compiler takes as input differential equations, which biologists frequently use to describe cell dynamics, and translates them into voltages and current flows across an analog chip. In principle, it works with any programmable analog device for which it has a detailed technical specification, but in their experiments, the researchers used the specifications for an analog chip that Sarpeshkar developed.

The researchers tested their compiler on five sets of differential equations commonly used in biological research. On the simplest test set, with only four equations, the compiler took less than a minute to produce an analog implementation; with the most complicated, with 75 differential equations, it took close to an hour. But designing an implementation by hand would have taken much longer.

Differential equations are ideally suited to describing chemical reactions in the cell, since the rate at which two chemicals react is a function of their concentrations. According to the laws of physics, the voltages and currents across an analog circuit need to balance out. If those voltages and currents encode variables in a set of differential equations, then varying one will automatically vary the others. If the equations describe changes in chemical concentration over time, then varying the inputs over time yields a complete solution to the full set of equations.

A digital circuit, by contrast, needs to slice time into thousands or even millions of tiny intervals and solve the full set of equations for each of them. And each transistor in the circuit can represent only one of two values, instead of a continuous range of values. "With a few transistors, cytomorphic analog circuits can solve complicated differential equations—including the effects

of noise—that would take millions of digital transistors and millions of digital clock cycles,” Sarpeshkar says.

From the specification of a circuit, the researchers’ compiler determines what basic computational operations are available to it; Sarpeshkar’s chip includes circuits that are already optimized for types of differential equations that recur frequently in models of cells.

The compiler includes an algebraic engine that can redescribe an input equation in terms that make it easier to compile. To take a simple example, the expressions $a(x + y)$ and $ax + ay$ are algebraically equivalent, but one might prove much more straightforward than the other to represent within a particular circuit layout.

Once it has a promising algebraic redescription of a set of differential equations, the compiler begins mapping elements of the equations onto circuit elements. Sometimes, when it’s trying to construct circuits that solve multiple equations simultaneously, it will run into snags and will need to backtrack and try alternative mappings.

But in the researchers’ experiments, the compiler took between 14 and 40 seconds per equation to produce workable mappings, which suggests that it’s not getting hung up on fruitless hypotheses.

“Digital is almost synonymous with ‘computer’ today, but that’s actually kind of a shame,” says Adrian Sampson, an assistant professor of computer science at Cornell University. “Everybody knows that analog hardware can be incredibly efficient—if we could use it productively. This paper is the most promising compiler work I can remember that could let mere mortals program analog computers.”

—Adapted from an article by Larry Hardesty of the MIT News Office and used with permission.



Integrating Renewables into the Grid

THAYER PROFESSOR AMRO FARID and researchers from MIT and the United Arab Emirates’ Masdar Institute of Science and Technology have developed critical new formulas for the smooth integration of renewable energy into the electric grid.

Integrating renewable energy into the electric power system is essential for reducing carbon dioxide emissions. But the variability of renewable energy presents challenges for balancing energy sources feeding the grid. In order to get the balance right, power grid operators must procure operating reserves, a form of excess generation capacity. Yet, while insufficient operating reserves put the grid’s reliability at risk, excessive capacity is costly.

“Maintaining reserve capacity is relatively easy when electricity is generated by fossil fuels, because we can control how much we put into the system,” Farid says. “In contrast, the amount of renewables available to the grid at any time, like the weather that influences them, must be predicted.”

According to Farid, the new formulas he and his collaborators developed tell exactly how much reserve capacity the power grid should have, depending on the amount of renewables on the grid and various parameters, such as market time steps and forecast errors, that influence how the grid is operated. The formulas can be used to calculate the requirements for each type of operating reserves: load following (the extra power-generating capacity needed in case demand exceeds what was predicted), ramping (the ability to flexibly raise or lower power generation), and regulation (power-generation capacity controlled by automatic feedback loops).

The formulas are detailed in “An A Priori Analytical Method for the Determination of Operating Reserve Requirements,” forthcoming in the *International Journal of Electrical Power & Energy Systems*. Farid coauthored the article with Aramazd Muzhikyan of the Masdar Institute and Kamal Youcef-Toumi of MIT.

“These formulas,” Farid says, “will be useful to the energy industry and policy makers.”

Large Fields, Micro Details

RESEARCHERS FROM Dartmouth and the National Institute of Standards and Technology (NIST) have developed a way to quickly scan large fields of view for microscopic-level details, an imaging technique with surgical and other applications.

“Doctors use a microscope to determine if tissue is normal, but during surgery they can’t use a microscope everywhere,” says Professor Stephen Kanick, a member of the research team. “This approach lets the surgeon image the full field to show areas of abnormal microstructure and therefore show where to point the biopsy needle.”

Sensitive to differences in tissue microstructure—such as density, particle size, and characteristics of the extracellular matrix—the new technique takes just minutes to image structural features over a field of view on the order of square centimeters. “It’s like if you were using Google Earth and you wanted to determine which houses are actually clusters of condominiums,” explains Kanick. “Our approach could tell you where to look for the condos without having to do the work of zooming in over and over again.”

The technique is detailed in “Wide-field quantitative imaging of tissue microstructure using sub-diffuse spatial frequency domain imaging,” published in *Optica*, the Optical Society’s journal for high-impact optics research. Authors include researchers from Thayer’s Optics in Medicine group, Dartmouth-Hitchcock, and NIST.

The research continues. Says first coauthor David “Bo” McClatchy ’13, a Thayer PhD candidate, “We want to translate the optical properties data into maps that are even easier to interpret.”

GOOD COMPANY

WITH A THIRD OF THAYER'S TENURE-TRACK
FACULTY HAVING FOUNDED STARTUPS,
DARTMOUTH WIDENS ITS ENTREPRENEURIAL DOOR.

BY ANNA FIORENTINO

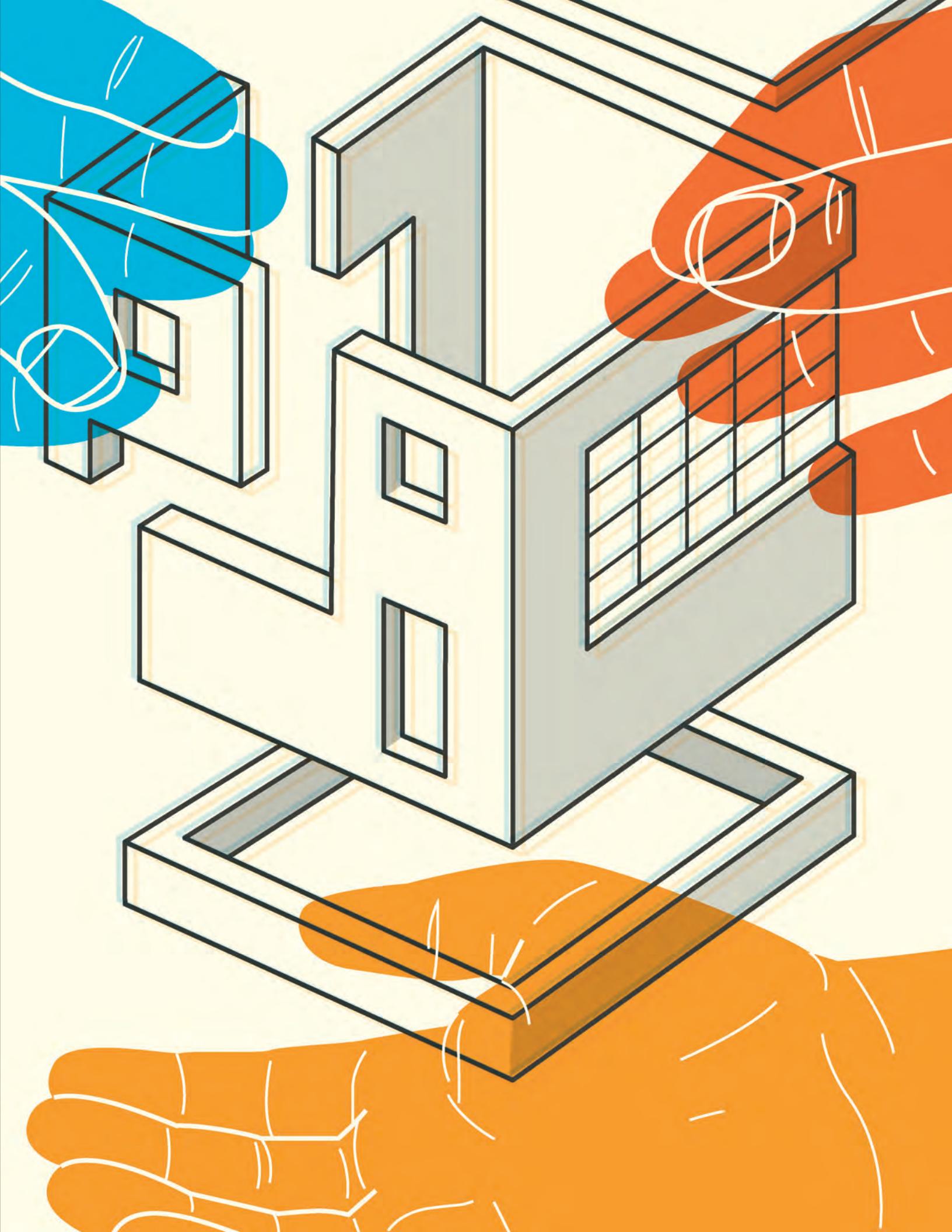
Guided by Thayer professor and serial entrepreneur Tillman Gerngross, Dartmouth recently gave faculty members greater control over inventions and startups stemming from their academic research. Designed to spur entrepreneurial ventures, Dartmouth's new approach to intellectual property allows professors to retain the rights to their patents in exchange for a 4 percent equity stake in new companies. If professors prefer, they can opt for the old model, in which Dartmouth owns patent rights.

The change makes Dartmouth a trailblazer, as most American colleges and universities have yet to hand over patent rights to professors, says Gerngross, who has just finished a three-year term as vice provost of Dartmouth's Office of Entrepreneurship & Technology Transfer.

"When I came to Thayer in 1998, entrepreneurship was something that was tolerated, and before that, in the 1990s, I've even heard it was frowned upon. Today, it is celebrated," says Gerngross, the founder of five biotech companies since 2000. In fact, today 33 percent of Thayer's tenure-track faculty have founded or cofounded companies.

Gerngross predicts that in addition to promoting innovation and facilitating startups, Dartmouth's revamped intellectual property options and reconfigured entrepreneurship office will help recruit top faculty to Thayer and Dartmouth. "One of the most important things for an institution like ours is to be competitive in attracting talent," he says. "It is vital that the office be positioned in the service of faculty and help them have an impact on the world."

Thayer Professor Karl Griswold, cofounder of startup company Stealth Biologics, underscores that perspective. "Thayer's support of



entrepreneurship was a big part of what brought me to Dartmouth,” he says. “Not all schools are like this.”

Four years ago, former Dartmouth President Jim Yong Kim asked Gerngross to think about how to transform the technology transfer function at Dartmouth—which included the Technology Transfer Office, Dartmouth Entrepreneurial Network, and Dartmouth Regional Technology Center—into something more coherent and supportive of the strategic long-term plans for the College. What exactly that meant was open-ended. Gerngross recruited Trip Davis ’90 and unified the three units into the Office of Entrepreneurship & Technology Transfer. Gerngross became vice provost and Davis became executive director. Together they explored new ways to promote innovation and entrepreneurship.

“In the past, the College controlled who inventions were licensed to, and very often inventors wanted something different, putting the faculty in opposition to the office,” says Gerngross. “We said, ‘let’s keep the traditional approach in place, but give faculty a second option.’”

The second option is a win-win for professors and the institution. Professors retain patent rights for their startups, and Dartmouth receives a 4 percent founder’s equity stake in the companies. Professors are free to make their own decisions about their companies, licensing, and lawyers. Dartmouth bears none of the associated expenses and risk but retains a part of the upside.

“We wanted the Tech Transfer Office to be helpful, not a function that is focused on taxing innovators,” says Gerngross. “When you have real insight into something that matters to people, transferring that into something that impacts the world—something that actually leads to a treatment, cure, or device—it is my view that Dartmouth has a responsibility to encourage faculty to see that through, not just focus on publishing or getting grant money.”

Professor Ryan Halter Th’06, who owns startup RyTek Medical, sees advantages to both the new option for faculty control over intellectual property and the old model of Dartmouth holding rights to an invention.

“Taking more ownership of intellectual property will work well for some people but not for others,” Halter says. “Allowing inventors to put money into their own invention incentivizes them to make their company work. The idea is that the company will end up giving back to Dartmouth in some way later on, by reinvesting in academic labs or providing financial assistance.” But, he adds, professors who don’t have money to support a company early on may prefer to have the Tech Transfer Office take control and help with funding.

With innovation-spurring options now in place, Gerngross is stepping down from his vice provost position. That will give him more time to teach—and to run his biotech companies.

The following overviews highlight a few of the startups that Thayer professors have founded to bring the world a range of advances. With several other startups in nascent stages as well, Thayer professors are turning intellectual property into technologies with promise and impact.

► **TILLMAN
GERNGROSS**
has founded five
successful biotech
companies.





Arsanis

Cofounders: Eszter Nagy, Eric Andersen '00 Tu'07
Location: Waltham, Mass., with research in Vienna, Austria
Year Founded: 2010
Number of Employees: 40 employees
What the Company Does: Arsanis discovers and develops monoclonal antibodies that target specific pathogens and pathogenic processes in infectious diseases for which current antibiotics are becoming increasingly ineffective.

Problem Being Solved: The growing public health crisis of antibacterial resistance.

Impact: We have multiple drug programs, with one in clinical trials about to enter Phase 2.

Student Involvement: Tuck students were involved in early assessment of business opportunities.

Long-Term Goal: Arsanis hopes to become a leading anti-infective company that helps the transition into a post-antibiotic era.

Avitide

Cofounders: Kevin Isett Th'11, Warren Kett, Jonathan Sheller '09
Location: Lebanon, N.H.
Year Founded: 2012
Number of Employees: 25
What the Company Does: Avitide purifies antibodies, vaccines, and other proteins for therapeutic purposes.

Problem Being Solved: Accelerating the pace of clinical pipelines and commercial manufacturing processes for new biopharmaceutical drugs.

Impact: We've had multiple collaborations with large pharmaceutical companies.

Student Involvement: The company was cofounded with Thayer PhD graduate Kevin Isett and then-postdoc Warren Kett.

Long-Term Goal: To become the leading supplier of protein purification solutions in the biopharmaceutical industry.

Adimab

Cofounders: Dane Wittrup, Eric Andersen '00 Tu'07
Location: Lebanon, N.H.
Year Founded: 2007
Number of Employees: 100
What the Company Does: Discovers antibody drugs using a proprietary yeast-based technology.

Problem Being Solved: Filling the need for better technologies for the discovery of novel antibody-based drugs.

Impact: Adimab has more than 100 drug discovery programs with over 30 partners. Two drugs are in clinical trials—one for solid tumors and one for ventilator-associated pneumonia.

Student Involvement: Many of my former students work at Adimab or have interned there.

Long-Term Goal: To retain our position as the world's leading provider of antibody discovery technology.

Cofounders: Arnon Rosenthal, Asa Abeliovich

Location: San Francisco, Calif.

Year Founded: 2013

Number of Employees: 20

What the Company Does: Alector is developing novel antibody-based treatments for neurodegenerative diseases, including Alzheimer's.

Problem Being Solved: Curing Alzheimer's and mechanically related neurodegenerative diseases.

Impact: Alector has raised over \$70 million to pursue multiple drug leads.

Long-Term Goal: Having a substantial impact on neurodegenerative diseases.

PROFESSOR RYAN HALTER
TH'06

RyTek Medical Inc.

Location: Lebanon, N.H.

Year Founded: 2011

Number of Employees: 3

What the Company Does: We develop bioimpedance sensing technologies that couple to surgical tools to provide surgeons with enhanced guidance during procedures.

Problem Being Solved: We have two products that are targeted at two different applications. The first is a smart-sensing biopsy needle that is able to detect cancer during the biopsy procedure, instead of having to wait for microscopic review of the tissue. The second is a smart-sensing dental drill that enables oral surgeons to detect critical anatomic structures that they want to avoid, such as nerves and sinuses.

Impact: We are not selling our products yet, but hope to provide a better cancer diagnostic tool to help reduce overdiagnosis of cancer and ensure that patients are treated with appropriate therapies. We also plan to reduce the risk of iatrogenic injuries during dental implant procedures. Our goal is really to provide clinicians with tools that enable them to more optimally treat patients.

Student Involvement: RyTek is currently funded through National Institutes of Health Small Business Technology Transfer grants. Part of these funds are subcontracted out to my Dartmouth lab to support students exploring fundamental aspects of our technology.

Long-Term Goal: Ideally, we will take these technologies to the point that a market leader will be interested in acquiring the technology. Then on to the next technology.

PROFESSORS BRIAN POGUE AND SCOTT DAVIS TH'08

DoseOptics LLC

Cofounder: William Ware Th'94

Location: Lebanon, N.H.

Year Founded: 2015

Number of Employees: 5

What the Company Does: We develop cameras that image the radiation dose as it hits tissue during cancer treatment.



Problem Being Solved: Radiation delivery is an invisible process, where the beam is aimed and launched based on patient positioning and pre-treatment planning, but there is no direct way to visualize radiation dose delivery today. All tools to verify radiation delivery today are indirect, and yet 50 to 60 percent of all cancer patients receive radiation treatment. While delivery accidents are rare, they do happen, and verification of delivery to mitigate errors or quickly recognize them is essential. This camera will help in this process, making radiation therapy safer.

Impact: We are creating the first-ever system to visualize radiation therapy in real time. No other technology allows direct real-time visualization.

Student Involvement: All our employees are Thayer alumni or faculty. We have subcontracted consulting work to an additional three Thayer alumni beyond the current five core employees.

Long-term Goal: We plan to develop unique camera systems that allow this imaging to happen and to license the technology as needed to strategic partners.

PROFESSOR VIKRANT VAZE

PatientRules

Cofounder: Sujana Chalasani

Location: Hanover, N.H.

Year Founded: 2015

What the Company Does: PatientRules uses operations research and systems engineering tools to facilitate proactive demand and capacity matching in health-system operations to improve upon current scheduling practices and tools.

Problem Being Solved: We solve the critical problem of inefficiencies in health-systems operations due to a mismatch between demand and supply.

Impact: We are at an early stage with the company, and while we have some promising projects ongoing, we hope to have examples of provable impact very soon.

Student Involvement: We have been exploring various opportunities for involving students, especially graduate students in engineering, through things such as early exploratory research, market research, and simulation studies.

Long-Term Goal: To reduce healthcare costs while improving patients' care access and outcomes.

PROFESSOR LEE LYND

TH'83 '87

Enchi Corp.

Cofounder: Bill Bradley

Location: Hanover, N.H.

Year Founded: 2014

What the Company Does: Biofuel production using thermophilic bacteria.

Problem Being Solved: Our technology has the potential to positively impact greenhouse gas mitigation and human development.

Impact: We've identified opportunities for potentially transformative reductions in the cost of producing cellulosic biofuels.

Student Involvement: We are working closely with Thayer PhD Innovation Program Fellow Michael Balch, are considering sponsoring projects at Dartmouth, and will consider student internships in the future.

Long-Term Goal: I'm looking to contribute to a transition to a sustainable world.

Mascoma Corp.

Cofounders: Charles Wyman, Bob Johnsen

Location: Lebanon, N.H.

Year Founded: 2006

Number of Employees: 50

What the Company Does: Mascoma focuses on biofuel production and other applications using recombinant yeast.

Problem Being Solved: We are creating engineered yeast for more efficient and lower-cost bioprocessing.

Impact: We created the first recombinant microorganism in the biofuel industry. These new organisms are used in roughly 30 percent of corn ethanol mills nationwide, routinely increasing ethanol yields from corn by two to three percent, and, to date, producing more than 75 million additional gallons of ethanol that required no additional input of corn. We have also commercially deployed a strain of yeast that ferments cellulosic sugars to ethanol.

Student Involvement: We have extensively supported research by Thayer students, have hired several Thayer alumni, and would likely be open to internships going forward.

Long-Term Goal: We are working to develop new products for the corn, sugar (in Brazil), and cellulosic ethanol production industries to further increase the yields and margins in these industries.

PROFESSOR STUART TREMBLY TH'83

Avedro Inc.

Location: Waltham, Mass.

Year Founded: 2003

Number of Employees: 50

What the Company Does: We develop and commercialize technology for correcting vision disorders.

Problem Being Solved: Giving people nonsurgical options for vision correction.

Impact: In April the company received FDA approval for its system to treat progressive keratoconus (cone-shaped cornea), a sight-threatening vision disorder. This technology can be applied to correct near-sightedness.

Student Involvement: In the early days, four graduate students completed theses related to the Dartmouth-owned technology then licensed by Avedro with financial support from Thayer School Overseer Ralph Crump '66A and his wife, Marjorie.

Long-Term Goal: The company would like to adapt its FDA-approved technology to treat mild near-sightedness. My own goal is to secure Small Business Innovation Research funding for a new company that I founded in 2014, **Sarpedon Medical**, for developing new medical devices.

PROFESSOR SOLOMON DIAMOND '97 TH'98

Lodestone Biomedical

Cofounders: Lidia Valdés '14 Th'15, Brad Fick

Location: Hanover, N.H.

Year Founded: 2015

What the Company Does: We're developing the Iron-Wand, a non-invasive device for diagnosing iron deficiency in children.

Problem Being Solved: Low iron in infants and children can adversely affect brain development and cause lifelong cognitive, motor, and social-emotional deficits. The common way to screen for low iron is with a simple anemia test. The problem is that low iron levels can hurt brain development long before anemia shows up. There is no single accurate and affordable screening test for iron deficiency currently on the market. The best available options are complex and costly blood-iron panels or invasive bone marrow aspirates. Our device measures the iron content of bone marrow magnetically. We aim to make iron status assessment quick and painless with immediate and accurate results.

Impact: The company is too young and the problem of iron deficiency is too entrenched for our impact to be felt at this stage. We have a long road ahead of us in establishing the clinical validity of testing

with our device and learning how it can help improve outcomes.

Student Involvement: The cofounder and current CEO of the company, Lidia Valdés, is a recent graduate. Our research at Thayer on the magnetic properties of iron in bone marrow will afford opportunities for undergraduate and graduate student involvement in the future.

Long-term Goal: Our goal is to redefine the gold standard for assessing iron status. We hope the Iron-Wand will lead to new understandings about iron deficiency, its management, and connections between iron, health, nutrition, and brain development.

PROFESSOR JOHN ZHANG

NanoLite Systems

Cofounder: Ting Shen

Location: Austin, Tex.

Year Founded: 2012

Number of Employees: 30

What the Company Does: We perform point-of-care diagnostics through blood tests.

Problem Being Solved: We do early cancer diagnostics and management.

Impact: Nanolite has developed automated instruments for screening circulating tumor cells in blood that are currently under clinical trials.

Student Involvement: We offer internship, research, and development opportunities for students at various levels.

Long-Term Goal: We hope to become a leading company in precision healthcare.



PROFESSOR LAURA RAY ▲

Clarisonic Inc.

Cofounders: Chris Pearson Th'02, Caroline Cannon

Location: Salem, N.H.

Year Founded: 2013

What the Company Does: Signal processing to improve medical ultrasound imaging.

Problem Being Solved: Mammography fails to detect lesions in women with mammographically dense breast tissue because both the lesion and the tissue appear white. Ultrasound improves detection for these women, but also increases the rate of false positives. We are solving the problem of false positives by improving contrast and resolution of ultrasound imaging.

Student Involvement: Our VP for research, Matt Pallone '07 Th'13, is a graduate of Thayer's PhD Innovation Program.

PROFESSOR KARL GRISWOLD ▼

Stealth Biologics LLC

Cofounder: Dartmouth Computer Science Professor Chris Bailey-Kellogg

Location: Virtual

Year Founded: 2013

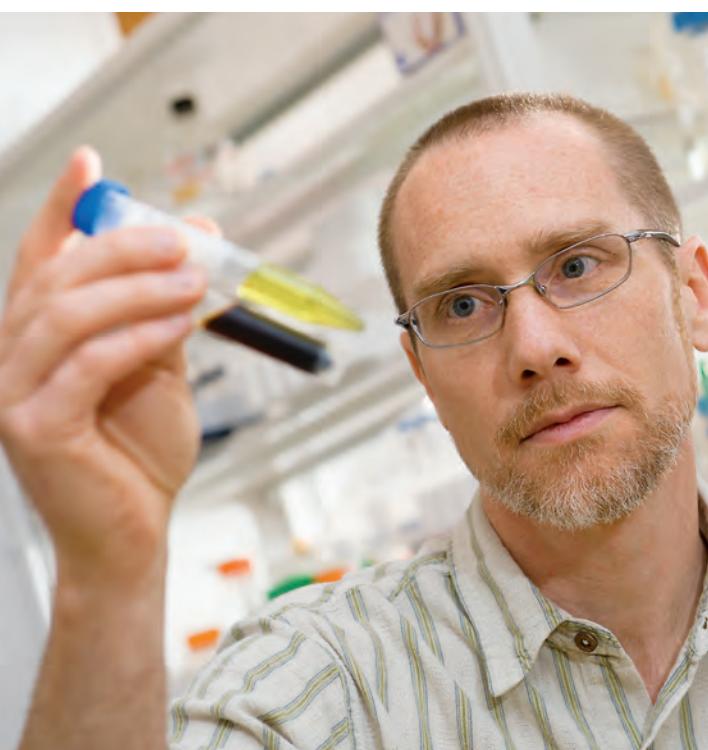
What the Company Does: We design protein drugs for treating human disease.

Problem Being Solved: Unlike conventional drugs, protein drugs are subject to immune surveillance in the human body. The body may mistake a therapeutic protein for a dangerous invader and attack it. Our company re-engineers therapeutic proteins to evade the human immune system—thus the name Stealth Biologics.

Impact: We're still an early-stage company, and we don't yet have drugs in the clinic. In preclinical studies, we've shown that deimmunized drugs are safer and more effective than their unmodified counterparts. We've designed at least two different drug candidates that will soon enter advanced preclinical studies, the final stage before human trials.

Student Involvement: Students, postdocs, and scientists at Dartmouth contributed to the development and testing of an internally generated drug candidate: an enzyme designed to kill drug-resistant bacterial pathogens. The development of this compound was supported by a National Institutes of Health Small Business Technology Transfer grant, which fosters collaboration between companies and academic institutions.

Long-term Goal: We hope to use our deimmunization technologies to similarly expand the frontier of highly potent yet safe protein drugs derived from non-antibody molecules.



The TA Experience

At many institutions being a teaching assistant is considered the drudge work of grad students. Not so at Thayer, where students—undergraduate as well as graduate—eagerly commit at least 12 hours a week to TA duties in a variety of classes. In the following, seven TAs tell us what they put into the job—and what they get out of it.

JAN RENTMEISTER

(left, with dual-degree student Oleksandr Kuzura)

"One important thing is to teach students that it's okay if you need some practice."





JAN RENTMEISTER, PhD Candidate
ENGS 61: Intermediate Electrical Circuits
PROFESSOR: Jason Stauth

My Role: Being a TA is a great opportunity to give back and help students understand material that I only a few years ago had the same struggles understanding. I am closer to the point they're at than my professor.

As a TA I do office hours where I help students who have homework questions. I also grade homework and help during labs. I already meet regularly with Professor Stauth—he is my PhD advisor—and we meet with the other TA for the class to go over what the students are learning and what they should understand. Professor Stauth makes sure that we know what the students need to do in lab.

At Thayer, PhD students don't actually have to TA. I think that's a very special thing. We can do it in addition to what we're doing as research assistants. You're learning so much while doing research, and it's great to add that perspective on what the students are learning. That can help students understand why what they're doing is important.

Best Part: The best thing is helping students understand the subject they weren't understanding before. Being in contact with them for so many weeks, you can really see their progress.

Hardest Part: I'm constantly being challenged with new questions, things that if you think you understand the subject you never really think about. It makes you figure it out for yourself before you can give a good answer.

Being a TA has changed my perspective on education. You're used to seeing education from the perspective of the student, and now suddenly as a TA you're in the position of being the teacher, teaching somebody who has never heard of a concept before. You have to think about things, about technical problems, differently.

Lessons Learned: Failure is a part of engineering. It's okay for students to not understand the material the first time. When you're a student, the professor makes everything look easy because the professor has been doing that work for years. One important thing is to teach students that it's okay if you need some practice. Engineering is hard. If it was easy, everybody would do it.

Influence on the Future: Making tough technical problems understandable for people who might be hearing about them for the first time is a skill that's really important in many areas of life.



WAAD KAHOULI
(right, with Josie Nordrum '17)
"As a TA you get an inside view of what it takes to make a course successful."

GABRIELLA GRANGUARD '16

(not pictured)

ENGS 21: Introduction to Engineering

PROFESSOR: Ian Baker

My Role: It's important for TAs in ENGS 21 to guide students in a project. They're given a topic, such as improving the quality of life, and we guide them on the process of figuring out what problem they want to identify. We take them through the steps of how to come up with a solution that's feasible to complete in 10 weeks. We also help them with machining, resources, and working together as a team, since this is typically their first engineering course. I meet with my group multiple times per week and sit in on their team meetings. I meet at least weekly with Professor Baker. He helps provide feedback, and I give him an update on where our teams are standing and how they're doing.

Best Part: At the end of ENGS 21, it's really rewarding to see the students give their final presentations, to see that you brought this group of students together and helped them along the way. It's fun to know that you helped, that you inspired engineers to continue their pursuit of engineering. It's about giving back to the undergrads.

Hardest Part: Like any Dartmouth student, we TAs are always overcommitted. Sometimes you really want to be involved as much as you can, but it's important to realize you don't feasibly have that time. Another challenge is realizing you can't just tell students what to do, but rather be a guide. It's important to take a step back and reflect and say, "Am I doing the right thing? Am I telling them too much, or too little?" The hardest part is finding that balance.

Lessons Learned: As a TA, you're learning not only the engineering skills—like machining, welding, circuits, and Arduino—but you're also learning a lot about how people interact and communicate. Being a TA really helps you see how people work. Everyone is different. When you're in a leadership role as a TA, you're get-



WAAD KAHOULI, DUAL DEGREE '13 TH'16

ENGG 199: Aircraft Design

PROFESSOR: Brenden Epps

My Role: This is the first time that the Aircraft Design class is being offered, so part of being a TA is to help develop the course syllabus. The second part is to develop a lecture topic and an experiment and deliver it to the class. As the students work on their projects, we're helping them with any kind of support—whether it's SolidWorks, software, or answering questions.

I give Professor Epps feedback about what the students are doing and what kind of questions they have. When I prepare lectures, we go over goals and whatever he expects us to deliver.

Best Part: Helping someone learn the material is very rewarding to me. Seeing students go from being introduced to the material, being confused, struggling to get a hold of things, to arriving at a point where they can actually have a smooth display of what they know and of problem-solving skills that are very well structured is an amazing process. I also enjoy going through how people think and organize their ideas. That makes me more conscious of the way that I organize and deliver my ideas.

Hardest Part: It's challenging to not have an answer for a question that a student expects you to have. Sometimes you discover that you actually don't understand it any more than they do. At the same time, it pushes you to go back again and try to understand



it. Sometimes the student and I will walk through the problem together, and then we both learn something new.

Lessons Learned: As a TA you get an inside view of what it takes to make a course successful, the work that goes into putting a course together and making sure the materials are reinforced. You see how much professors are invested in teaching and working with the TAs. All the professors here at Thayer are very committed. Being a TA made me

have a lot of respect for the effort that they put into supporting the students throughout the whole process.

And as a TA I've learned how to communicate better and express my ideas more clearly. I know that this is a skill that you get from your classes and your projects. But as a TA, I've learned to make an effort to make sure that I'm clear, that I understand people's confusion, and that I'm sensitive to what they're confused about.

It's also like getting a second chance to go

back over the material to reinforce whatever I have had a hard time absorbing. To think more critically about it and to learn from other student's mistakes—and help them get through those mistakes—is a great experience in terms of having that material stick in my head for life.

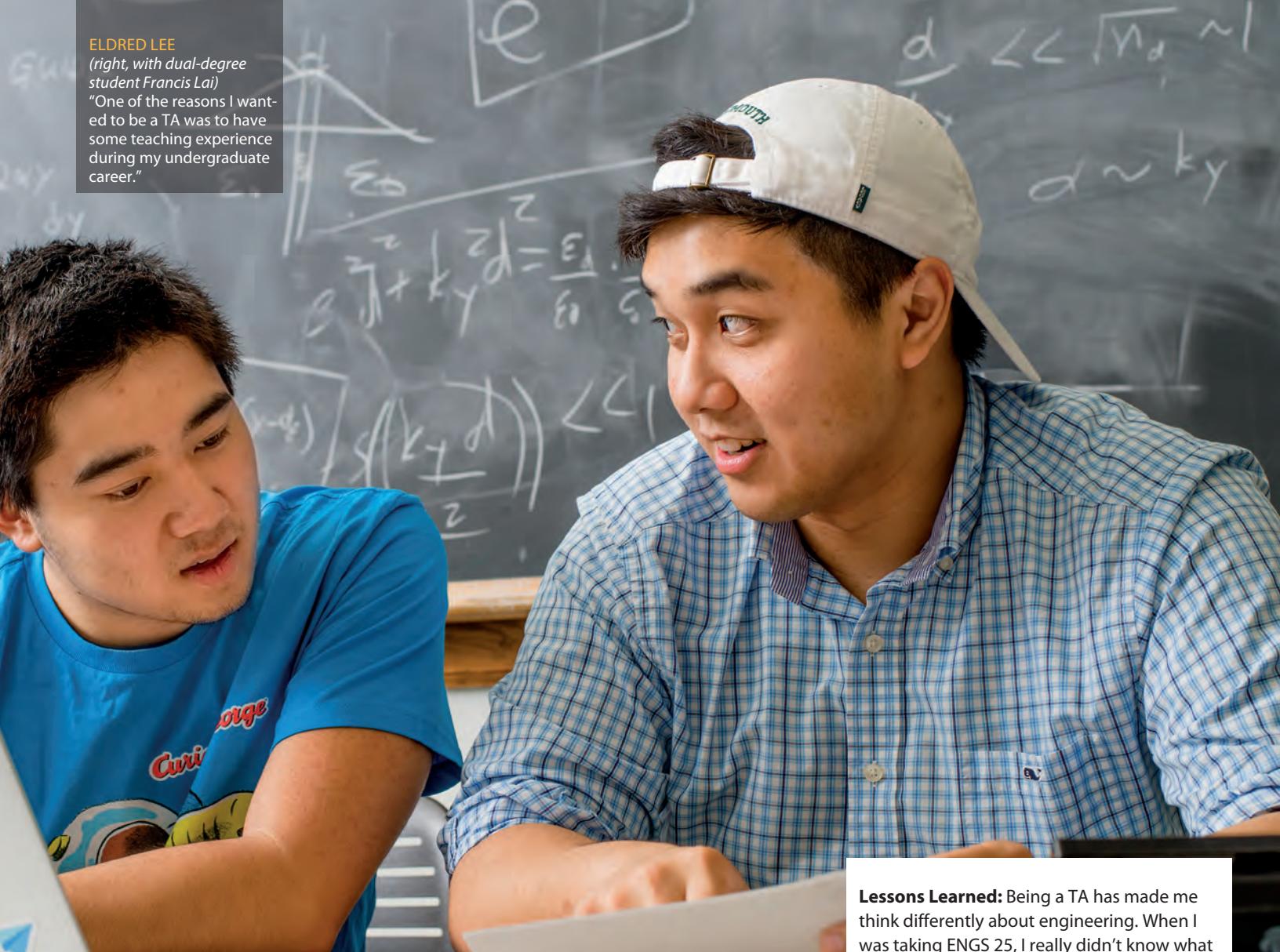
We're very fortunate that Thayer has the resources to make it possible for undergrads to work with other undergrad students to understand the material. You don't have to be a graduate student. Because you took a class and you did well in that class, you can communicate that knowledge and spread it to others.

Influence on the Future: I'm considering an acoustical engineering consulting offer, a career where I get to interact with people. Being a TA has helped me realize that I like working with people. I find it really rewarding when a student has that moment where everything clicks, and they're there because you helped them get there.

ELDRED LEE

(right, with dual-degree student Francis Lai)

"One of the reasons I wanted to be a TA was to have some teaching experience during my undergraduate career."

**ELDRED LEE, DUAL DEGREE '16,
BE CANDIDATE**

ENGS 25: Intro to Thermodynamics
PROFESSOR: Karl Griswold

My Role: I run problem sessions, pick out problems for homework, and guide the students through solving problems and strategies to be successful in the course. We hold office hours where students ask specific questions about the homework, concepts, or lectures. If students have common mistakes in their problem sets, or common misunderstandings from the textbook or the lectures, I actually notice that and let Professor Griswold know so he can go clear up the students' misunderstandings.

I also grade homework, and as the head teaching assistant for the course, I'm in charge of organizing and leading all four TAs. I'm also responsible for leading the Stirling engine tests—the signature project for the Thayer thermodynamics course.

Best Part: As a TA, I can essentially re-learn the concepts that I've already learned in the past and then apply those concepts in other classes and projects.

The social aspect of being a TA is also a huge plus. As a peer of the students, it's difficult to have authority in an administrative position. When the students do something wrong, I have to take off points and essentially let them know that their approach is incorrect. But then I get to guide them through the process to help them clear things up. The most significant thing that I learned from being a TA was how to interact with students and cooperate with them. My social skills have improved through the student/TA interaction. I'm making a lot of new friends.

Hardest Part: A difficult part is managing and organizing the assignments and work. ENGS 25 has well over 50 students, and it takes a long time to go through the process of sorting out and compiling the work that they have done.

Lessons Learned: Being a TA has made me think differently about engineering. When I was taking ENGS 25, I really didn't know what the specific applications of the course material would be or how we could integrate it into different fields and aspects of engineering and science. But the students have been asking a lot of questions about real-life applications. Thermodynamics is primarily a mechanical engineering course, but I've learned that you can apply it to electrical systems, chemical systems, and various other real-life applications. With a clearer understanding of the concepts and the materials for the course, I can apply them to my field of study and to my graduate work as well.

Influence on the Future: I'll be finishing up my BE degree and starting the PhD program here at Thayer, pursuing materials science engineering. I hope to teach material science and its applications to energy, energy systems, or biomedical engineering. One of the reasons I wanted to be a TA was to have some teaching experience during my undergraduate career. The teaching experience I've gained so far is going to help me a lot if I go into academia.



MARC SEPAMA '17

ENGS 20: Introduction to Scientific Computing

PROFESSOR: Professor Petra Bonfert-Taylor

My Role: I help students with their assignments and help the professor grade the midterms, assignments, and exams. We have TA hours, and the students can come in with any questions that they have.

I usually meet with the professor once a week. We talk about how the students are doing and go over anything that we believe they are not understanding.

As a TA, you get to meet a lot of students, and you get to interact with them in a way that the teacher doesn't. I get their perspective on how the course is going and what they find difficult. I think it's easier for them to relate to me as a student who went through the experience that they're currently going through.

Best Part: When I first took this class, I found it very difficult because I didn't program before coming to Dartmouth. I wanted to become a TA because I knew that other students who don't have programming experience would have a lot of the same difficulties that I did. I wanted to help them go through the process. I also wanted to meet new

people who have the same interests that I do. I mean, you just don't take ENGS 20 for fun. You take it because you're interested in it, because it's going to challenge you.

Hardest Part: The hardest thing is being able to recall what you learned one year before. It's tough to be able to remember those things and apply them to what the students are currently learning.

Lessons Learned: Being a TA is more than just explaining things to students. It's about being able to relate to people—and people have different ways of learning. It's easy to just assume that one way of teaching is going to work with everyone, when that's not the case. It's about being able to relate to the students in a way that makes concepts easy to understand and being able to accommodate different ways of learning.

Influence on the Future: I'm from Burkina Faso. In the long term I'm thinking of getting involved in development. Currently I'm working on getting an economics modified with engineering degree. What I hope to learn during my time at Dartmouth is skills that I can apply to my home country so I'm able to go back and help in any way that I can.

Being a TA is about being able to transcend any barriers that exist between you and the students, so I think this experience will help me when I work with people from different backgrounds. Being able to relate to the students now is a skill that I can apply in a different setting years from now. I've had a great experience.



ANDREA PRICE '16

(not pictured)

ENGS 30: Biological Physics

PROFESSOR: Jane Hill

My Role: I grade homework, lead homework help sessions for students, and sometimes help Professor Hill do a demo or create a model. Usually she and I meet every week to go over content, homework, and what's been happening in class. I'll also talk to her about what students seem to be struggling with, what they seem to be really getting, and any questions that I have about the material.

Most of my interactions with students are either one-on-one or in a group at TA hours in the evenings.

I was interested in becoming a TA because the TAs have been crucial to my success in my classes. Just being willing to work through problems with you that you don't understand makes for such a great TA, and I wanted to give back in that way.

Best Part: The best parts of being a TA have been getting to know the professor better and getting to understand the material in the course better. Working with the students is really fun and rewarding.

Harshest Part: Being a TA has helped me grasp the material better because I know that other students are depending on me to understand everything that's happening. I think I've become a better teacher from being a TA.

Influence on the Future: My career plans don't explicitly include teaching, but I think it's a really important skill. For any field you might go into or any job you might have, it's great to know how to help people who are new on the job or are doing something new in the field.



STEFFI MUHANJI, DUAL DEGREE '13 TH'16

ENGS 73: Materials Selection and Processing
PROFESSORS: Harold Frost and Ulrike Wegst

My Role: Because the class is project based, we have a lot of TA duties in the machine shop. We have labs based on materials—polymers, ceramics, metals, and hybrids. I usually prepare the labs, set up the space, write the lab write-ups, and then make sure that we have everything that we need. Then I run the lab and guide the students through the activities.

Best Part: My favorite part about being a TA is that I get a chance to connect with students, learn from them, and assist them, too. I learn a lot from students about myself and about the subject as well. It is always so wonderful when I am able to help students feel better about the material to a level where they can carry on by themselves. When you're working with the students, you don't know what's going to come up at the



STEFFI MUHANJI
(center, with, clockwise from left, Isabella Caruso '17, Amaris De La Rosa-Moreno '16, and Ben Conley Th'16)
"When I'm assisting students, I step back and approach problem solving from their perspective."

last minute. Each week is different. You also get to interact with professors more outside of class.

Hardest Part: The hardest part about being a TA is not being able to help a student feel less stuck. There are times when I cannot offer a level of clarity, and therefore a student doesn't really feel comfortable about the material. Being a TA is more of a learning experience than just a job. As a TA, I constantly have to think about the impact that I have on

the students' performance and try to ensure that I guide them in the right direction.

Lessons Learned: When I'm assisting students, I step back and approach problem solving from their perspective. And even though I'm a student myself, it's not always the same when you're TAing a class because the way you understand a problem is not the same way other people understand it. It has really improved my understanding of different materials. I've learned more about

the subject, more than when I was taking the class. And I've learned that problem solving is very important.

The fun thing is working with the professor to get everything scheduled for the class. When you're planning for a lab, and you start two weeks before, and then it's two days before, and still things aren't working out—it's really taught me to be patient.

Influence on the Future: Coming into engineering from a physics background, I was a theoretical thinker. As a TA and as an engineer, I had to start thinking more critically. I had to apply the theoretical things I'd learned in class and make something out of it. TAing has helped me solidify my engineering experience. Teaching students how to do things also helps me understand more about how to interact with different people. This will be helpful in case I go into teaching, something that I think I would like to do in the future.



A NEW LABORATORY
BUILDING IS HELPING
THAYER ENGINEERS
CREATE BETTER MEDICAL
TECHNOLOGIES BY
PUTTING THEM INTO
DIRECT CONTACT
WITH DOCTORS.

FOUND IN

BY MICHAEL BLANDING

PHOTOGRAPHS BY JOHN SHERMAN
(unless otherwise noted)

◀ LAB MATES: clockwise from left, Professors Ryan Halter Th'06, Geoffrey Luke, Stuart Trembley Th'83, Paulsen Th'84 '86, Zi Chen, Brian Pogue, Jonathan Elliott, Shudong Jiang, and Scott Davis Th'08.

► LAB SITE: Williamson Translational Research Building at Dartmouth-Hitchcock Medical Center. Photograph by Mark Washburn.

T

o the eye, breast cancer tissue looks just like normal tissue. The only way surgeons can tell the difference is by palpating it—feeling it with their hands. Even then, sometimes when the cancer is deep inside the breast, it's difficult to feel from the surface; and some cancer you can't feel at all. That makes it very difficult for surgeons performing a lumpectomy to make sure they've removed all of the cancerous cells from a breast tumor. Studies have shown, depressingly, that more than a third of the time, surgeons leave behind cancer cells on the margins of a lumpectomy—leaving patients to go through the trauma of cutting all over again. "It's not good for the patient, it's expensive, and it's painful," says Dr. Rick Barth, a cancer surgeon at Dartmouth-Hitchcock Medical Center (DHMC).

Part of the problem, he says, is the way that surgeons are guided. Radiologists traditionally scan patients in an MRI machine while they are lying on their stomachs with their breasts hanging down—inserting a wire to pinpoint the location of the tumor. But when patients enter surgery, they are placed on their backs. "It's not a very accurate technique," says Barth. "The breast looks a lot different." There had to be a better way, thought Barth. To find it, he traveled a few miles up the road to Thayer to talk with Professor Keith Paulsen Th'84 '86, who had for years been working on new techniques to use imaging to guide brain surgeons. What if women were scanned lying on their backs, asked Paulsen, and then a 3-D model of cancer in the breast was created similar to the way neurosurgeons create a model of brain cancer.

Paulsen tasked Thayer research scientist Venkat Krishnaswamy with developing the system, which included a video screen that Barth could consult during surgery and use of a tracker on his scalpel to make sure he was cutting in the right place. A study published by the team a few years ago showed that the technique was just as accurate as palpation; now they are a year into a clinical study comparing it head-to-head with the wire technique. As promising as it was, however, the technique still had its limitations. Chief among them was that Krishnaswamy had to be in



TRANSLATION

the OR during surgery, constantly performing the proper mathematical equations in order to make the image render correctly. "We realized this had to be simplified drastically," Krishnaswamy says.

After going back to the design table for several months, the team developed an even simpler technique: a 3-D printed shell that is customized to each patient, slipped over her breast to show the location of the tumor. Named the Breast Cancer Locator, it has pre-cut holes that allow the surgeon to mark the edges of the cancer on the breast surface, insert

wire directly into the middle of the cancer, and inject blue dye under the skin surface to guide the surgeon to more accurately remove the cancer. Now, after using the technique on more than 10 patients, Barth says it is proving to be very accurate. “We think with this Breast Cancer Locator, the positive margin rate will be less than 10 percent,” says Barth. “It’s a way to make the surgery much more precise, so patients won’t have to come back for another surgery and will have an optimal cosmetic result as well.”

The concept of “translational medicine”—turning discoveries made in the laboratory into practical tools to help patients in the clinic—is a goal often strived for and rarely achieved. To create breakthroughs such as the one Paulsen, Krishnaswamy, and Barth made takes countless hours of meetings and consultations to refine devices and plan clinical trials—with all of the driving back and forth between engineering lab and hospital that entails. “Even two or three miles does not seem like a large distance, but that matters a lot,” says Krishnaswamy. “We refine this device with patients on a day-to-day basis as we go. Proximity is a force multiplier.”

Dartmouth took a giant leap forward in facilitating such collaborations with the construction last fall of the Williamson Translational Research Building, a new project by the Geisel School of Medicine to bring scientists directly into contact with doctors. The building is literally connected to the main arcade of the Dartmouth-Hitchcock Medical Center; the seventh floor houses a dedicated space for Thayer School engineers, including an 8,000-square-foot open laboratory with work stations, offices, live animal housing, and advanced equipment that the engineers are using to develop new ways to diagnose and fight cancer.

“My lab has been at the hospital for 20 years, but I didn’t have a desk,” says Thayer Professor Brian Pogue, who is also a professor of surgery at Geisel. “If I needed a desk, I had to go to the cafeteria and get a cup of coffee. Now we have desks and a physical laboratory co-located in the hospital. That’s something 90 percent of engineering schools don’t have.”

Pogue is codirector of the newly created Center for Imaging Medicine, which is housed at Williamson and brings together experts in optics, electronics, ultrasound, and biochemistry, including Paulsen and Krishnaswamy. Pogue’s own research investigates the use of molecular tracers injected into tissue to help guide surgeons during surgery. “Doctors are making second-by-second decisions on which tissues to remove and which tissues to leave,” says Pogue. “This could help them determine what types of tumors have this molecular biology.” Specially designed protein molecules interact with and bind to protein receptors in the tissue; when lights of different colors are used to illuminate the surgery, they can show up on the camera image, and this display can show doctors the difference between cancerous and non-cancerous tissue in real time.

Another area of research for Pogue is developing cameras to aid in radiation therapy for cancer. Patients routinely come in for radiation treatment every day, but there are few ways to tell if it is working, or even where the radiation is hitting the patient. Pogue’s invention, developed with engineering Professor Scott Davis Th’08, makes use of a barely detectable glow called Cherenkov light that is released by the tumor when it is radiated. Measuring the amount of that light, the radiation therapy team could verify if they are giving the proper dosage of radiation in the exact location planned. “Verification that the treatment is being given properly is a big deal, because the treatment must be designed to limit damage in normal tissues, and small things, such as patient movements or breathing at the wrong time, can lead to large radiation delivery errors,” says Pogue. Both of these projects are currently being tested on animals, and Pogue is meeting weekly with physicians at DHMC to prepare for human clinical trials early in the fall.



That kind of contact with doctors is crucial for engineers as they develop their devices, says Thayer Professor Jonathan Elliott, who is also working on a project involving imaging molecular tracers, this time to image brain cancer. In a video, he shows how the imaging system works: As the molecular tracers move through the brain vessels and tissue, they light up like a supernova exploding in different colors. The dynamic quality of the image, says Elliott, provides much more information than the usual static images neurosurgeons work with. “There is such a rich amount of information there,” he says. “It’s seeing a whole movie instead of going into a movie for a minute at the beginning and a minute in the middle and trying to tell a friend what the movie is about.”

Still, says Elliot, it’s a challenge to convey this information in the tense environment of an operating room. Some of the tracers are only visible under infrared light, and much of the surgery is done looking through a microscope, making it impossible for a surgeon to look back and forth between the patient and a video screen. “I spend a lot of time thinking about how to visualize this data and trying to understand the optimal way of integrating these things, saying, ‘Is this going to be a distractor or is this going to be helpful?’” he says. Spending time in the OR watching how procedures are done is crucial to developing the right equipment.

“As soon as you get in there, you realize that half the things you thought were good ideas won’t work and things you thought wouldn’t make sense could totally work,” says Elliott. “Being able to work alongside the surgeon and see the whole process means ideas advance much more quickly.”

That’s true whether a device is just starting out or in the refining process. Geoffrey Luke, a new engineering professor who is in the early stages of developing a method of imaging lymph nodes to detect cancer without an invasive biopsy, says one of the reasons he came to Thayer is the ability to work closely with clinicians. “You need that feedback from the clinic about what will be most helpful,” says Luke, who works with oncologist Barth. “I’m hoping that will steer it in the right direction in the earlier stages of the research.”

In some cases, that feedback has resulted in radical redesigns of medical devices. Engineering Professor Ryan Halter Th’06 uses a technique called electrical impedance tomography to identify prostate cancer. The devices he creates send electrical currents into tissues; from differences in conductivity, clinicians can distinguish between cancerous and non-cancerous tumors. Halter first designed a side-fired prostate imaging probe that would send currents around the outside edges of a cylindrical ultrasound probe (like the exterior of a paper towel roll). But the patient had to be lying on his back

TO CREATE BREAK-THROUGHS TAKES COUNTLESS HOURS OF MEETINGS AND CONSULTATIONS TO REFINE DEVICES AND PLAN CLINICAL TRIALS.

PROXIMITY IS A FORCE MULTIPLIER.



◀ BENCH WORK:
Professor Jonathan Elliott uses
feedback from surgeons to improve
brain cancer imaging techniques.

with his legs in the air, a very uncomfortable position. Normally, a patient lies on his side and an end-fired probe takes images from the front of the tube (like the open end of the roll). Even though the side-fired probe takes better images, Halter knew that in order to have doctors use it, he'd need to redesign it as an end-fired probe. "The first time you put an instrument in the hands of a clinician, you start learning what works and what doesn't work," he says. "Clinicians were trained to do a procedure in a particular way. Unless you are revolutionizing a treatment procedure, it's going to be tough to get them to adopt a brand-new technology."

Halter is now in the process of using the technology to design a new probe that will help surgeons remove all of a prostate tumor. "The surgeon can press the probe around the tissue surrounding the prostate and then produce a map that ideally will show where there is cancer left behind," says Halter. Currently collecting data in the OR from surgeons using the device, he hopes eventually to use that data to help guide surgeons during procedures. Being based in the Williamson building has made it easier to coordinate with surgeons than when he was coming from Thayer. "We would make meetings with physicians at 1, and they wouldn't be out of the clinic until 2:30. Now if a surgeon can't meet, we can still do our work, and then when they are available we can meet for 15 minutes very quickly."

The proximity of the labs to the clinics also makes it easier to tweak equipment on the fly, says Thayer Professor Shudong Jiang, who has developed a novel imaging system to gauge the effectiveness of chemotherapy on breast cancer treatment. Some tumors don't respond to chemotherapy, but women can undergo several rounds of treatments—and harmful side effects—before that is apparent. Jiang's system shines a laser light on the breast to measure hemoglobin, a key indicator of vasculature in a tumor that can make chemotherapy effective. "This will help them not to suffer if the treatment will not help them," she says.

For years, Jiang had to shuttle the equipment back and forth from Thayer in order to modify it. "Before the Williamson building, all of our testing instruments and lab equipment were back at Thayer," she says. "Now all of our tools are here; it's so much easier." Currently, Jiang is gathering data on breast cancer patients at DHMC using the device; the next phase of the clinical trial is to bring it to other hospitals to see if nurses or physician assistants can use the system without the researchers being present.

Having all of the engineers in one place helps not only in communication with physicians, but also with each other. Even though Thayer researchers are looking at different cancers and ways to diagnose and

treat them, they are able to learn from one another as they design their equipment. "My group has already benefitted from being in this environment," says Professor Zi Chen, who works with Paulsen and Pogue on using nanoparticles to deliver drugs into the body and on understanding how cancer cells metastasize. "My postdocs are communicating with each other and with the other PIs."

The faculty have also already helped one another in the sometimes arduous task of taking inventions beyond usage at Dartmouth-Hitchcock. "The incentive system today is just grant to grant. It gives you money and allows you freedom to publish papers and support grad students, but there is not much incentive to work with people outside of Dartmouth," says Pogue. There is a well-known "valley of death" between developing technologies and commercializing them; unless an investor or a company immediately picks it up, even promising inventions often die. According to Pogue, gathering engineers together in the Center for Imaging Medicine makes it easier to help one another with the process of commercialization, including patenting technologies and seeking out investors. A case in point: Pogue and Davis have created a company, DoseOptics, to develop and commercialize their radiation dosing technology, with Krishnaswamy serving as VP of technology.

Krishnaswamy will also lead Cairn Surgical, a new company started with Barth and Paulsen to produce the Breast Cancer Locator for use in surgery, with help from the Center for Imaging Medicine and a Dartmouth SYNERGY Clinician-Entrepreneur Fellowship awarded to Barth. Krishnaswamy eventually envisions a world in which doctors can scan breast cancer patients in the MRI and send the data to their company, which will then ship a custom-designed Breast Cancer Locator back to the physicians to use during surgery.

Resources such as the Williamson Building and the Center for Imaging Medicine are critical to ensuring that inventions find their way into the world, where they can help reduce suffering and improve prognoses for cancer patients. "The most important thing is taking these innovations that have been developed at Dartmouth over the years and getting them out into the world," says Pogue. "At Thayer, we are very good at inventions, but usually when the grant ends, the technology ends. This center will allow us to get beyond that, directly taking inventions into human clinical trials with interested physicians and encouraging translation beyond the walls of Dartmouth as well."

MICHAEL BLANDING is a Boston-based writer and author of *The Map Thief*.

Alumni News

FROM AROUND THE WORLD

spotlights



The go-to guitar for J.D. Optekar '91 Th'92 is a Lentz JR Reserve. "I just love the feel and sound of this specially made hand-built guitar," he says.

On the stage and behind the scenes, guitarist **J.D. Optekar '91 Th'92** is bringing Tweed Funk to the forefront of soul and blues. Drawing on his previous career as a project manager and cofounder of a software development company, Optekar is expanding the sound of the Milwaukee, Wisc.-based band. "My background has helped me in taking a group of talented musicians and putting

together a plan that gets their music out to a wider, global audience," he says. The band released its fourth album, *Come Together*, in April. With two new musicians and a determination to involve each member in the song-writing process, the six-member group is drawing strong reviews and comparisons to Daptone Records artists Sharon Jones and Charles Bradley. Optekar, one of *RockWired* magazine's "25 Guitar-

ists You've Gotta Know" in 2012, continues to play guitar and serve as the group's primary songwriter. He left engineering and software for music in 2006, after he and wife Dr. Tina Yen '91, a surgical oncologist at Froedtert Hospital and the Medical College of Wisconsin, started their family. He became a stay-at-home dad during the day, a performer at night. "I became the domestic engineer," he says. Now, with three children ages 8, 9, and 12, he juggles the business of the band as well as coaching and PTO duties. "Similar to my previous roles in small businesses or product development groups, my focus is to help set a vision for where the band is going—most recently presenting a case for recording a new CD, hiring a publicist, advertising and promoting the CD, and touring in support," says Optekar. "With a band, since we aren't anyone's sole source of income, you need all the members to buy in to the vision." That includes organizing a 10-day East Coast tour—with a stop in Hanover to play during his reunion in mid-June—in support of the new CD. You can also get a taste of Tweed Funk on YouTube.

Bob Chamberlin Th'84

brings a scientific approach to stalking trout. "The best anglers are those who have keen observational talents that they put to use in approaching a stream, positioning themselves in it, selecting the right fly, and presenting that fly perfectly to a hungry trout," he says. He also brings his artistic side to the stream, painting watercolors such as "Hag Trout of Coos," one of several paintings included in *The Confluence: Fly-fishing & Friendship in the Dartmouth College Grant* (2016, Peter E. Randall). Chamberlin's watercolors brighten the collection of

essays from seven friends with ties to Dartmouth, including **David Van Wie '79 Th'84**. Painting is an art that Chamberlin says exercises his brain differently than his role as senior director at RSG, a market research and consulting firm in Burlington, Vt. "So much of life, including much of the engineering field, involves our interactions with rectangular screens that it is rewarding to be engaged in pursuits that require us to use our hands," he adds. "Both flyfishing and painting require skilled manual dexterity. 'Real engineers' also use their hands to manipulate materials, so they fit into this description; however, the technologies that make us effective engineers often displace the use of our hands in this way. The Thayer education is smart to keep our hands in the game building small bridges, using the machine shop, and building circuits on a breadboard."



"Hag Trout of Coos" by Bob Chamberlin Th'84

Javelin thrower **Sean Furey '04 Th'05 Th'06** took a brief hiatus from his work as a senior mechanical design engineer at Raytheon in San Diego to compete at the Summer Olympics in Rio de Janeiro, Brazil, in August. "Qualifying for the Olympics means giving myself another chance to 'swim in the deep end' and compete against the world's best on the biggest stage," he says. "I have had major success at every level of my career so far, except for top international competitions, and I am determined to conquer this last obstacle." This is Furey's second

On the Job

MONICA MARTIN DE BUSTAMANTE '08 TH'09
| COFOUNDER, CBPARTNERS

Monica Martin de Bustamante founded biopharmaceutical consulting firm CBPartners two years after graduating from Thayer School and now serves as a managing director of the New York City-based company. Much of her efforts are focused in Latin America and southern Europe, where she uses her double major in biomedical engineering and Romance languages to better understand how those markets are evolving.

What market were you hoping to address by starting CBPartners?

We were looking to establish a global organization that could remain nimble in decision-making and deliver on high-touch project work. A number of our competitors are very large firms that, from the perspective of our clients, create uncertainty as to who is actually going to deliver and work on their engagements. Additionally, from an employee perspective, these larger consultancies are pretty well established and set in their ways, so to actually impact the environment and effect change tends to be an arduous process.

Is there a particular field or region you prefer to work in?

I am most focused on pricing and market access, which in simple terms would be associated with the pricing and reimbursement—payment by a government or health insurer—of a new pharmaceutical product. I have worked across most geographies and chose not to specialize in any one geography, as I like the excitement of always having a different challenge in front of me and being able to think through our client's issues from a global lens.

What are some of the challenges you enjoy tackling?

The ones that are most exciting tend to be highly collaborative situations in which our clients had an initial strategy and then realized that it was unlikely to work, at which point they have brought us in to help them think through potential paths forward. Our thinking process can have a significant impact on how a trial is eventually designed, whether a product gets acquired, or how fast a client launches in a given country. Ultimately, what is most rewarding is keeping in mind the end goal: for patients to have access to better therapeutic alternatives. My Thayer experience taught me how to work in a team environment and how to break down a problem in a logical way. The time spent at Thayer challenged me to think outside the box and always come up with varied alternatives that could be tried to make something work. I think that translates very well into my everyday role, as our job as consultants is to challenge our clients' thinking and come up with innovative ways to tackle their issues.

—interview by Theresa D'Orsi

"I like the excitement of always having a different challenge in front of me and being able to think through our client's issues from a global lens."

—MONICA MARTIN DE BUSTAMANTE '08 TH'09

spotlights

Olympics; he came in 37th in London and 35th in Rio. He has racked up other significant honors recently. With a personal best javelin throw of 272 feet, 7 inches last year, he won the 2015 USA Outdoor Track & Field Championships, which he also won in 2014 and 2010. He came in fifth at the 2015 Pan American Games and third at the 2014 Pan American Sports Festival. At Dartmouth his record of 241 feet, 9 inches, still stands. The sport infused his studies at Thayer, where he co-created a "TurboJavelin" with **Daniel Has-souni '05 Th'05** and **Colin Murray '04 Th'05** as an ENGS 190/290 (now ENGS 89/90) engineering design project.

Shounak Simlai '05 Th'07 and **Maia Josebachvili '05** have earned Dartmouth's 2016–17 Young Alumni Distinguished Service Award. MEM grad Simlai, an advisor to CVS Health, serves on the Alumni Council and the Thayer School Annual Fund Executive Committee. Engineering major Josebachvili, a VP at hyper growth software company Greenhouse, served on the Alumni Council and, as VP of the Class of 2005, helped endow a Seed Fund for Social Good to aid student entrepreneurial ventures.

Almost a century after the first poles and wires brought electricity into American homes and businesses, **Keith Dennis '03 Th'05** is championing a transformation from fossil fuels to cleaner, more efficient electrical options. As the senior principal of National Rural Electric Cooperative Association (NRECA), he is the technical expert on energy efficiency and end-use of electricity for more than 900 consumer-owned cooperatives that provide service to 42 million people in 47 states. "Trends in energy are expanding opportunities for 'environmentally beneficial electrification'—increasing the use of electricity for end-uses such as space and water heating and transportation to reduce greenhouse gas emissions," says Dennis, who recently made his case in *The Electricity Journal*. He is also exploring the idea of community storage, or finding common resources such as electric water heaters and electric vehicles throughout communities that

could be aggregated to help make the electric grid operate more efficiently. In an article published in *Public Utilities Fortnightly*, Dennis explains how coordinating existing devices may offer previously untapped storage capacity. He explains the concept of using a water heater like a battery for the grid in a *Popular Science* online article with a video at popsci.com/need-high-power-home-battery-use-your-water-heater. "If the sun is shining, you can say, 'Now it's time to heat the water.' If a cloud goes down, you can say, 'Stop heating the water.' And you can really balance the grid that way. That's what the water heater does for integrating renewable energy."

Young women with irregular menstruation cycles often experience anxiety about staining and leakage—issues that **Jacob McEntire Th'15** is determined to alleviate. "We're developing a tampon monitor that will let women track the saturation level of their tampons and make leakage obsolete," he says. As the lead hardware engineer at women's health startup my.Flow (trackmyflow.com), McEntire writes software, designs and tests hardware iterations, and sources components. He also recently finished a four-month stint developing hardware at HAX Accelerator in Shenzhen, China. He draws on his previous tech and team experiences as a research and development intern with Takamoto Biogas in Kenya and an engineering fellow at Burro Brand Solar in Ghana to coordinate my.Flow's design and mechanical engineering efforts. One of the biggest challenges is convincing investors, most of whom are men, of the market for menstruation-related solutions. But McEntire is optimistic he'll soon bring peace of mind to many young women. "The most rewarding experience is seeing potential customers light up when you hand them something that they've always wanted, but never even known to ask for," he says. "That sigh of relief and excitement as their world changes because of your work, even just a little bit, is the whole reason I'm doing this."



"Our vision is to democratize the art of tailoring through leveraging the power of technology."

—JINCHENG LI TH'12

On the Job

JINCHENG LI TH'12 | COFOUNDER, COTTONBREW

When he first tried on custom-fit clothing while traveling abroad, Jincheng Li was sold on bespoke tailoring. However, when he returned to California and his job as a product manager at Credit Karma, he struggled to find the perfect fit through several online tailoring services. Now he and partners George Li at the firm's base in Palo Alto, Calif., and **Yicai Bao Th'13** in Shanghai, China are bringing a scientific approach to making custom suits.

Can you explain CottonBrew's unique fitting technique?

Every year, Americans spend \$11 billion on suits and shirts, yet 30 percent of men can't find clothing that fits. Most online tailors take multiple tries before delivering a perfect fit because they ask the customer for the measurements, and significant training is required to take body measurements accurately. CottonBrew uses high-fidelity data—three photos and one's height and weight—and runs the data through an imaging process to get the perfect fit. As a result, we have an almost perfect first-try satisfaction rate, significantly better than what's seen by industry leaders.

What is your production process?

After generating 15 exact measurements, such as stomach and bicep, we send them over to our partner tailors in Shanghai, who make the garment manually. When the garment is ready, Yicai and his team conduct a thorough quality check to make sure that all measurements and details are correct and made according to what the customer wants. He then ships the garment to our customer directly from Shanghai. Typically, it takes less than four weeks to deliver a custom-tailored suit (starting at \$449) or shirt (starting at \$79).

What resources have you been drawing on since you opened in spring 2015?

CottonBrew was part of Stanford StartX's spring 2016 program and has benefitted greatly from it. Being one of the top startup accelerators, StartX has a network of great entrepreneurs who have done it before and are willing to answer any question that we might have, from fundraising to marketing to R&D. Also, I think Thayer's MEM program is a great preparation for starting a company. The engineering projects help you understand how to get things done as a team, while the courses at Tuck enable you to see things on the business side, such as financial projection and marketing, which are equally important when starting a company.

—interview by Theresa D'Orsi

just one question



What were the greatest strengths of your Thayer education?

We were detailing a steel truss—ink on velum, remember these?—when Professor John Minnich looked over my shoulder and advised me to never try making my living on a drawing board. It was a hunk of advice I took very seriously. I kept my work on the job in the field, never in the office. Then I found sales engineering at Caterpillar and never looked back. Thanks, John, wherever you may be!

—Hal Johnston '47

There were three main lessons: learning how to think; converting those thoughts, logically organized, in both conversation and writing; and never giving up, even when you think it is the only way to resolve the "insurmountable" issue.

—Arville Hickerson '56 Th'57

I was privileged to attend Thayer School as a full-tuition (plus room and board) student, enrolled in the five-year program. I will be forever grateful for the opportunity.

The greatest strengths of my education were twofold. First was the liberal arts background along with my technical education. This has benefitted me greatly as I progressed into engineering management and through life. Second was the first-rate teaching and a curriculum jam-packed with content. I didn't fully recognize this until I went on to graduate school (mechanical engineering) at Yale. While there, I was able to reflect on my Dartmouth education and to realize its value. I greatly enjoyed and appreciated my graduate experience, and now realize that Dartmouth helped provide a very solid foundation. If I have any regrets, they are due to the fact that I was so busy keeping up academically and with my Thayer Dining Hall schedule that I had very little extra time to partake of the many extra-

curricular activities that Dartmouth offered, though I was a Glee Club regular and a Sig Ep brother.

—Jerome Allyn '59 Th'60

A process of analytical thinking and problem solving.

—D. Barry Sibson '60 Th'61

George Taylor's course in engineering economics. And, as with all education at Dartmouth, leaning how to learn.

—Tom Jester '63 Th'64

Thayer was part of a liberal education institution that required five years for a BE. I was not bound by a cookie-cutter curriculum. I was spoiled by the available contact with faculty. My wife recalls that I went ballistic if there were more than five students in my advanced engineering classes. As for the atmosphere, the path to inquiry was open. I created a curriculum that included microbiology and biochemistry before these topics became mainstream in environmental engineering studies. That Thayer encouraged independent construction of a curriculum implanted and nurtured the realization that solutions to problems come from many quarters.

The outcome was my professional career, which spanned 47 years and involved commercialization of new technologies. New is good, but it is also full of unknowns for the developer and the first adopter. I endeavored to translate the new into the desirable and dependable. I was trained initially as a classical civil engineer and evolved to be able to collaborate with protein chemists and biochemists to solve and optimize biotech purifying processes. At Dartmouth and Thayer I learned how to learn; in industry I continually sought new learning experiences. My Thayer education was based on thinking outside the box, and I used and applied this skill to harness new technologies that had not

just one question

yet been conveniently “boxed.”

—**Ivars Bemberis '64 Th'65**

Here are some positives, balanced with a few negatives. A positive: The opportunity to learn experientially during my first two engineering classes my sophomore year was life-changing. One year earlier, the first engineering course had been devoted to drafting. For me, that would have been terrible: Producing hand-drawn stuff with strict neatness requirements would have been difficult and very discouraging. Instead, my class was the first to have the new, solve-a-problem version of ENGS 21. That year the challenge was for each team to develop an energy-storing bicycle, to store energy going downhill and use it to help go uphill. This was a project way ahead of its time, but very cool. Among many other things, I learned to attach mathematics to physical reality and data. Our faculty team leader was a big help. I received my first A and an academic citation, much appreciated given my overwhelming academic performance during freshman year. The second sophomore engineering class enabled me to develop an air-bearing seismograph, again an opportunity to combine math and a prototype. Another A and another citation. Again, my instructor was a big help. These experiences were life-changing and probably then unavailable at any other engineering school in the country.

A negative at the time: The Thayer faculty included some professors who were not encouraging regarding new ideas or new technology. I wanted to learn about the then-emerging field of automata theory, the foundation of digital circuits; I was discouraged from doing this and told I wouldn't understand it. Regarding the algebra involved, that was correct, but this missed the point: The then-extant electrical engineering signal processing paradigm was wrong for digital circuits, and automata theory was right. It's not that the students were always right and the faculty always wrong—quite the contrary—but sometimes the students were right and the faculty were wrong, and the faculty were not prepared for this alternative. Later, during my senior year, I think, I knew more about probability and information

theory than the faculty—a comment on them, not me (I was just getting started). Again I was told I would not succeed on a specific project. Fortunately, I was allowed to proceed anyway, and I was right. Even if I hadn't been right, it was very important that students be allowed to make mistakes and fail—Dean Myron Tribus was very clear about this, but many of the rest of the faculty weren't so sure. Decades later, while a lecturer in computer science at UC Berkeley, I watched undergraduates be allowed to create real integrated circuits (computer chips, in other words). Many of those students and the sponsoring faculty went on to change history. But even then, allowing students to actually do something and at the same time risk failure—chip design and fabrication was hugely risky and very expensive—was still a rare educational opportunity. Not long after, biology students started making gels, and, still later, sequencers, and that changed history also.

—**Mark S. Tuttle '65 Th'66**

The hands-on element, being able to design real “stuff.” My BE project was designing a footbridge for the Second College Grant. It was actually built—and it made us really have to think about how our design would work in real life.

I went into information technology after graduation, so, unfortunately, I have not done much in mechanical engineering. However, in my field today as a director for a research and development department, I often find myself in discussions with engineers who design stuff, trying to figure out whether the design (which very often looks good on paper) is actually useful in “real life.” So from that perspective, I would be able to say that the experience from Thayer is useful on a daily basis for me.

—**Thom Birkeland Th'97**

It was definitely the emphasis on communication skills. I go to conferences to present my work and people come up to me afterwards to tell me how I am “a natural public speaker” and “so comfortable and confident.” What they don't realize is that I am a major introvert who gets nauseated just thinking about talking to a large group. Ten years ago I couldn't have

“Flexibility, personal relationships, and emphasis on collaboration over competition!”

—**Stefan Deutsch '14**

done it, but I gained so much practice at Thayer in presenting my work that now it seems natural. I've won more than one “best presentation award,” not because my work was any more interesting or better, but because I was clearly the only speaker who had any practice in presentation skills.

—**Steve Reinitz '09 Th'09 '14**

I think it is the ability to problem solve with a group of people. I was an MEM student, and now I wish I spent more time at Thayer than just for the MEM program. I came from overseas, so I guess the BE was not in my reach back in the day, but even the short tenure taught me to think deeply, bounce ideas around with teammates, go back to the drawing board together, and add to each others' work rather than subtract. The project in our entrepreneurship class required teamwork and creation of both the prototype and the business plan for it. “How can we get this done?” was the question to answer, not “Can we do this?”

My whole life, not just career (now as a VP at Synthetic Biologics), is so much richer because my teammates and professors pushed me that year to never stop looking, listening, searching, comparing, thinking, measuring, scratching, and starting all over. I just think I see to the bottom of the ocean and the details on the surface of the moon because Thayer taught me, “You can!”

—**Katya Vert-Wong Th'02**

The most important and enduring part of my Thayer education has been the interdisciplinary aspect of the education. While I tend to find myself most often called an engineer in my work, I mostly work as a translator between engineering and policymakers. Much of my ability to do this goes back to the broad approach of Dartmouth and Thayer's engineering program.

—**Keith Dennis '03 Th'05**

The aspect of my Thayer education that has best served me is its breadth and variety. Because the Thayer curriculum is not rigidly siloed into mechanical, electrical, or other areas of engineering, students are free—encouraged, really—to follow their curiosity and learn in a variety of disciplines. This, I feel, produces young engineers who are more conversant and useful in the workforce, where multidisciplinary teams are the norm.

Equally important is the amount of hands-on work that happens at Thayer. I have colleagues who have recently graduated, yet have never learned to solder, operate power tools, or whip up some Arduino code. Not only does this hands-on work reinforce the learning process, but it also makes graduates that much more able to bring their designs to life quickly and appreciate what is possible.

—**Alex Streeter '03 Th'05**

My greatest takeaways from my time at Thayer were the interdisciplinary education and team-based project experiences, as well as development of presentation and general communication skills. I feel these skills set me up for success in my first job out of school, where I took part in a rotational program with BMW. I feel that my ENGS 190/290 [now ENGS 89/90] class, “Engineering Design Methodology,” actually helped land me the job. There was a role-playing portion of the interview in which I had to deal with a difficult team member. I think most of us had a similar experience at one point or another during our time at Thayer, so I felt well prepared and able to deal with the issues during my interview. Later on, after I was hired, I was given several opportunities to present to senior management, and I received positive feedback for communicating clearly and remaining calm and at ease. I wouldn't have been able to do that without the experience I had at Thayer.

—**Matt Wallach Th'09**

Breadth before depth.

—**Max Fagin Th'11**

The creativity and design-thinking skills I have gained through my Thayer education have served me the

most in my years post-graduation, currently during my PhD Because of it, I have been able to collaborate across diverse disciplines and to work on a number of projects with a variety of exceptional people.

I am doing my PhD in applied physics at Harvard's School of Engineering and Applied Sciences, focusing on organic redox flow batteries and trying to understand how and where chemical reactions take place within porous electrodes. The eventual hope is to inform engineering efforts to optimize the power and therefore efficiency of this class of batteries. I recently finished my quals (phew!) and most of my time outside of research has been focused on the undergraduate community: I am a resident tutor in Winthrop (one of the Harvard undergrad houses) and am involved in academic advising for sophomores in addition to helping to coordinate a number of intramural activities.

—Drew Wong '12

Flexibility, personal relationships, and emphasis on collaboration over competition!

—Stefan Deutsch '14

The amount of resources available, the open-minded, open-door policy of networking and collaboration amongst the professors and a well-defined curriculum. From a Master of Engineering Management perspective, I would also vouch for the resources at Tuck and the opportunity to gain a very diverse and dynamic skill set by choosing and mix-'n-matching what you like. Every student can step out with a totally different skill set.

—Raghav Mathur Th'15

The greatest strengths of my Thayer education were the intentionality of the Thayer faculty and community, the real-time, project-based application of theory, and the network of alumni willing to help me navigate career options throughout my program. I am now working as the VP of manufacturing for FreshAir Sensor, a Dartmouth-based startup in Lebanon, N.H. We develop chemical sensors using molecularly imprinted polymer chemistry.

—Drew Matter Th'15

reflections

Akwugo Nnama '12: I am currently a senior energy consultant in Navigant's technology, management, and policy group. I graduated from Thayer in 2013 and joined Navigant as an energy consultant. I am very fortunate to work with people I consider to be among the smartest professionals in the energy industry. During every meeting, I am always impressed by the caliber of the discussions, ideas shared, and the innovative solutions proposed. My team primarily focuses on energy efficiency regulatory policy for the U.S. Department of Energy. This includes developing market and benchmark assessments, reverse-engineering teardown analyses, and drafting of policy documents. I have spent a lot of time in our test facility, where I work with the lab manager to test, take apart, and sometimes fix appliances. One of my project highlights was tearing down a commercial boiler. My time spent in the machine shop and Couch Lab at Thayer has played a major role in my career success. I strive daily to embody the boldness and strength that Thayer instills in its students, especially women.

I remember building a Stirling engine in ENGS 25: Introduction to Thermodynamics, which gave me the opportunity to spend some time in the machine shop and gain hands-on experience. My Stirling engine currently sits on the mantelpiece in my apartment—a daily reminder of the “can-do” attitude that Thayer inculcates in its students. A good friend and former colleague, **Caitlin Johnson '10 Th'11**, recently borrowed my Stirling engine for a demo in the high school physics class she teaches.

I had the amazing opportunity of getting to know Professors Mark Laser, Steve Peterson, Vicki May, John Collier, Elsa Garmire, and Karl Griswold and they helped shape my experience tremendously. I was incredibly fortunate to have Mark Laser as my senior thesis advisor. Steve Peterson provided invaluable support and guidance as well. My thesis, “Rural Electrification in Nigeria: Solar Home Systems as a Potential Solution,” explores the financial constraints, social issues and unsuccessful deployment mechanisms preventing mass deployment of energy technologies in Africa. Using Nigeria as a case study, I found that when financial resources can effectively support a business model, beneficial “tipping points” potentially exist, leading to massive adoption of energy technologies. Upon request, I have sent my thesis to African entrepreneurs in the energy space. I hope that by leveraging our collective knowledge, we can engender social change. Universal access to electricity, to help improve the lives of Africans, is a cause that my father and I hold dear. Therefore, I was elated when Mark Laser invited my father, Emmanuel Nnama, to give a phone lecture in an energy conversion course, in which my father discussed his exciting career as an electrical engineer and encouraged the students to use their talents to improve the lives of others.

The collaboration and community at Thayer is like no other. This is a place where everyone knows your name and is willing to do everything to help you thrive. Each person—from the custodial staff to the dean—plays an important role in keeping our well-oiled machine running. Teamwork and a drive for excellence continue to fuel our successful ecosystem. I was sad to leave Thayer,



but it was inevitable. Four members of my family attended my Investiture and were treated warmly. Professors sought out my family to congratulate them and eat lunch with us. Thayer will forever have a special place in my heart, especially because it was one of the last places I saw my father, who is now deceased. I am happy that I got a chance to share this special place with him, as my family walked through the Great Hall, peered into the machine shop, and marveled at the projects in Couch Lab. We ended the tour in M210, where my dad sat in my favorite spot, beaming from ear to ear.

It is with these sweet memories of Thayer and my unparalleled experience at Navigant that I march on to the Wharton School at the University of Pennsylvania to pursue my MBA. I view my academic journey as a three-legged stool. My engineering degree gave me a strong technical base (first leg), enabling me to solve problems innovatively. At Navigant I have developed expertise in how government policy (second leg) shapes the energy industry and helps to achieve aggressive national goals. The Wharton MBA will provide the third leg, from which I will acquire the necessary business acumen to help play an integral role in Africa's energy transformation. I am incredibly grateful to Thayer for preparing me for the most responsible positions and the most difficult service, as I continue to make the world's troubles my own. I'll forever bleed green—I love Dartmouth!

thayer notes

| 1950s |

Tom Harriman '42 Th'43: I'm involved with the Dynamic Brain Initiative at the University of California, Santa Barbara—a campus-wide research effort for improved resolution of brain imaging with a souped-up fMRI to identify which neurons are impaired, with the goal of rehabbing or replacing them. My role started 30 years ago, when I got to know the Neuroscience Research Institute (NRI) at UC Santa Barbara with its emphasis on vision as part of the brain. I now serve on the NRI's advisory board. When the NRI needed a new executive director, my family came up with funding for a chair as an incentive in recruiting and they were able to bring in a star in neurodegenerative disorders research and teaching. Fast forward to NRI—winning a \$1.25-million grant from the medical division of the W.M. Keck Foundation, founding a clinic for the treatment of mild cognitive impairment, and learning that "reduction of risk factor" doesn't sell (even though it works) because it doesn't seem like a cure. We are now back to research to sharpen imaging and gain the capability of growing neurons where needed, as clinical protocols.

| 1970s |

Michael Geilich '79 Th'82: I recently had the pleasure of working with a group of Dartmouth engineering students who built a smartphone app for a class project. The app was funded by Advance Transit and is available for public download from both the iTunes and Google Play stores. Advance Transit provides free bus service around campus and the Upper Valley, and this app shows users bus stop locations and estimates of bus arrival times. The company I work for, Resource Systems Group Inc., had previously put together the bus tracking and estimation system for Advance Transit. For this project, we built a software application programming interface to the bus location data that the Dartmouth app accesses over the Internet in

real time. Incidentally, the project to put together the original bus tracking system for Advance Transit, which used cellphones to track bus locations, was managed by a classmate of mine from Thayer, **Bob Chamberlin Th'84**. Bob has a new book out about fishing and friends in the Dartmouth grant.

| 1980s |

Ed Eacueo '84 Th'85: In January 2016, I launched E-Tech Consulting (etech consulting.co), a limited liability company located in Massachusetts. E-Tech Consulting delivers progressive consulting services for data center providers and owners with a focus on defining products and integrated solutions to drive maximum energy efficiency and power density in data center environments.

Since graduating from Thayer School, I devoted more than 30 years to the corporate high-technology market, leading sales, marketing, and engineering organizations with innovation and delivery of energy-efficient solutions for data center environments. During this time, I held several executive-level positions of increasing responsibility with Eaton Corp., Schneider Electric, and Pentair.

In my personal life, I continue to produce an annual batch of homemade wine and still enjoy playing ice hockey with friends and family on our personally crafted ice rink.

Boris Levin Th'87: After completing my M.Eng in 1987 at Thayer, I worked at Bain & Co. in Boston as an associate, followed by earning an MBA from Wharton and a two-year stint at BCG Munich as a consultant. For almost 25 years now I have been an active investor in and manager of different companies, most in a distressed state and most located in Germany. Most of the recent projects involved both straightforward restructuring as well as some sort of technological development, key to a company's future. Examples of these are Beissbarth Group (held from 2005 to 2007, then sold to Bosch), with the development of optical recognition technology in order to align the wheels

and axles of cars and trucks; Gehring Group (held from 2009 to 2013, then sold to Penta), with the development of nano-spray honing technology for the final stage of motor block manufacturing for cars and trucks; and Loewe Technologies (holding since 2014), with the development of comprehensive, high-end home audio, video, and security packages in the consumer electronics space (similar to Bang & Olufsen in terms of positioning). My partner and I use mostly our own funds and run the whole thing as a little family holding.

| 1990s |

Qi Wang Th'97: I entered the financial services industry on Wall Street as soon as I graduated from Thayer. Since then I have been applying the problem-solving and critical-thinking skills that Dartmouth and Thayer taught me in my daily work. Having an engineering background differentiated me somewhat from the crowd and enabled me to see things that many others were unable to pick up. This is absolutely critical in the investment business. But I never expected technology and finance would converge in such a big way until a few years ago. Admit it: The financial industry is way behind in the technology adoption curve. Just look at how technology changed the retail business. So far, technology has barely made a dent on the financial industry, even though financial services companies are big spenders on information technology.

In 2014, I led a team at MSCI that conducted a comprehensive study on "smart beta" for the Government Investment Pension Fund (GPIF) of Japan. This is the largest institutional investor (asset owner) in the world, with approximately \$1.4 trillion in assets. In short, the study was to address the GPIF's investment challenges using modern technology, something like trying to replicate human investment managers. In doing so, the GPIF aims to have better transparency, risk control, and investment results. It is a ground-breaking study on this topic and it challenges much of

the conventional thinking on money management.

Today, I am the CEO of MegaTrust Investments (Hong Kong), aiming to use technology to solve another big investment problem for institutional investors, the China A-share market. This is the second largest stock market in the world but very opaque and difficult to trade.

Hubert "Hugh" Pfabe '98 Th'99:

I have just opened my own intellectual property law firm, specializing in patent law and including trademark, copyright, and trade secret protection as well as intellectual property-related asset transactions. This is a very exciting time for me, and I am hoping to bring my clients the unique benefits of a patent attorney who also has been the client himself at a number of start-ups. My prior experience includes 15 years as an engineer, designer, project manager, and director of research and development and manufacturing. As the law firm website is being set up, I invite anyone to reach out to me at hwpfabe@gmail.com.

| 2000s |

Nicholas Schaut '05 Th'06: I joined the Haas Formula 1 team in November 2015 as a CFD engineer. Those who don't follow F1 but have been in the Thayer machine shop in the last few years may still recognize the name from their Haas Super Minimill. Indeed, it's one and the same. Haas Automation Inc. was founded by Gene Haas, the co-owner of Stewart-Haas Racing in NASCAR and the Haas F1 team in the FIA Formula One World Championship. Growing up surrounded by amateur racing, I feel very fortunate to have received a great education at Thayer, to have further developed my skills at Exa Corp., and now to have the opportunity to put it all to work in a job that feeds my passion for racing. The environment is fast-paced and challenging. It's thrilling to be part of the first American F1 team in 30 years and fun to be reminded occasionally of my time with Dartmouth Formula Racing.

Andrew Argeski '06 Th'07 Th'08:

I'm working at Public Service Enterprise Group in New Jersey as the company's gas planning and design manager. I have a great team of engineers working for me and lots going on! The group that I lead is currently rolling out the design of a three-year, \$905-million program that is accelerating the replacement of the aging natural gas pipeline infrastructure in our service territory. This year we are also wrapping up a \$350-million gas main replacement project that targeted infrastructure at risk from natural disasters such as Hurricane Irene and Superstorm Sandy.

In my spare time, I'm a volunteer supervisor with the New York/New Jersey Trail Conference and am in charge of 50-plus miles of trails in Harriman and Bear Mountain state parks in New York. Through that work, I have become a certified chainsaw operator for some of the more heavy-duty work, which has been a lot of fun! **Kyle Sherry '09 Th'10** maintains a trail in my area, and we meet up to work and hike when we can. When schedules allow, **Matt Malvezzi '06 Th'07 '08** and I brew beer together and have been really pushing the boundaries with some amazing experimental beers. I guess we never got tired of being lab partners at Thayer.

Matt Wallach Th'08: After nearly eight great years with BMW, I'm heading back to New England to begin a dual master's program with MIT. The Leaders for Global Operations program consists of an MBA and an MS in engineering over the course of two years. I'm excited to make the move with my significant other, Katie Esper.

Steve Reinitz '09 Th'09 '14: My day job is as a senior innovation fellow at the medical devices center at the University of Minnesota. Basically, it's a team of eight of us who get paid to invent stuff all day. We shadow in the hospital to identify clinical needs, then build solutions. In addition, I have been continuing to work on a startup, Iometry Inc., with **Professor Doug Van Citters '99 Th'03** and a partner of ours at Brigham and Women's Hospital. The company was born out of a project at Thayer in collaboration with the Defense Advanced Research Projects Agency as part of the Ebola response. We are developing the Tib-Finder, a device that enables placement of infusion tools that can then be used to provide life-saving resuscitation for individuals affected

by Ebola. We recently presented at the Design of Medical Devices Conference and took the grand prize in its three-in-five competition (authors of top papers give a five-minute presentation with three slides)! My current role on the Tib-Finder is as cofounder and CEO of Iometry. I am running the business side and working with Dr. Alex Slocum to move the device through the FDA, while Doug is at Dartmouth doing the research side. Our next step is filing our FDA submission, which is ongoing and then getting these out in the field.

| 2010s |

Heather Kluk '11 Th'11 '15: There are quite a few Dartmouth alumni working at SpaceX—in addition to **Julianne Scheimann Th'11** and **Paul Seebacher '11 Th'11** (mentioned in a recent Thayer Coolstuff article)—who deserve recognition: **Sean Currey '11 Th'11**, **Rachel Forman '09**, and **Erik Dambach '04 Th'05**. Sean was involved in designing the thermal protection system for three recent rocket landings, Rachel is involved on the astronaut side of things, and Erik works on the Dragon propulsion systems.

Alfredo Velasco '13 Th'14: I'm actually changing jobs now. I stopped doing the PhD at Duke and am graduating with a master's. I'm starting a job doing iOS development with Ticketmaster in Durham, N.C. In the field of computer architecture I noticed that the best research was being developed by people who had industry experience, and I'm thinking it will be very good for me to have that experience now. Something cool that just came up was an article in *The Atlantic* about research **Reed Harder '13** and I did with Daniel Rockmore in Dartmouth's math department (theatlantic.com/technology/archive/2016/04/wikipedia-open-access/479364). Reed and I coauthored the paper, "Measuring Verifiability in Online Information," that the article cites. Reed is still at Thayer doing a PhD with Professor Vikrant Vaze. The paper is also reviewed in wikipedia at [blog.wikimedia.org/2016/03/08/research-newsletter-february-2016](https://en.wikipedia.org/2016/03/08/research-newsletter-february-2016).

Kristopher Brown '14 Th'15: After having spent this past year doing catalysis research at the École Polytechnique Fédérale de Lausanne in Switzerland

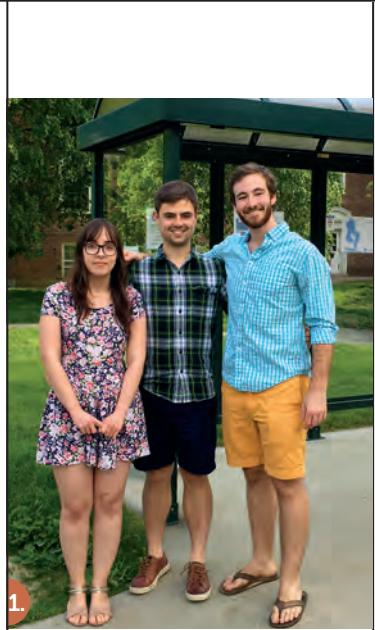
(supported by Dartmouth's Reynolds Scholarship), I will be pursuing a PhD in chemical engineering starting next fall at Stanford University. I don't know yet what my upcoming work will be, outside of a focus on advancing how we model chemical systems and improving computational and mathematical techniques.

My research project is still in progress, so I will not know about its success within the very near future. I worked on a procedure for depositing nano-scale overcoats to stabilize heterogeneous catalysts used for biomass conversion reactions. I also drew from a variety of atomistic modeling techniques to assemble a predictive model of our over-coating process. On both experimental and computational fronts, I was dealing with types of work quite different from anything I saw at Thayer, which was a challenge and also the reason why I chose to work at this lab in the first place.

Brendan Nagle '14 Th'15: Currently, I work for Oracle in Silicon Valley doing hardware engineering. Specifically, I work in power electronics, and I manage two of the subcontractors who design and build our AC-DC converters for us. The job is a blend of management skills and engineering knowledge, and I have been learning about industrial, supply, power, and other kinds of engineering on a daily basis.

I also have to travel for work, and have been to Hong Kong, southern China, and Munich so far. When I was in Arnstorf, Germany, to meet with one of our suppliers for part of Oracle's engineered systems, I was able to tour Munich on my own. At the Mariaplatz in Munich I enjoyed some mulled wine after a parade came through in a snow-storm. While in Hong Kong, I enjoyed the waterfront along Victoria Harbor during Christmas time. And during a business lunch in Shenzhen, China, I tried a dish that involved sucking bone marrow out of a pork hip bone with a straw.

With respect to alumni groups, I am in the process of joining the board of the Dartmouth Outing Club of Northern California, and I have been participating in its events during the past few months, which have included a cabin maintenance trip and a West Coast Winter Carnival celebration.



Gallery

1. From left, **Roxana Gheorghe Th'16**, **Donald Stayner Th'16**, and **Adam Grounds Th'16** are three of the five students who worked with **Michael Geilich '79 Th'82** to develop an app for Advance Transit.

2. **Ed Eacueo '84 Th'85** produces an annual batch of wine.

3. **Nicholas Schaut '05 Th'06** works on the Haas Formula 1 team.

Inventions

BASE LANTERN



>> INVENTOR:

JONATHAN CEDAR '03 | COFOUNDER AND CEO, BIOLITE

"Many people know us for our breakthrough stoves, but ultimately that is just one dimension of BioLite and our vision to bring energy everywhere," writes CEO and cofounder Jonathan Cedar '03 on his company blog. "We are committed to designing off-grid technologies."

This magazine first reported on BioLite four years ago when the company had modest ambitions: Cedar, who majored in engineering, and business partner Alec Drummond wanted to make a camping stove that didn't burn gas or use batteries.

Since 2012 Brooklyn-based BioLite has grown from a camp stove maker into a social enterprise that recently raised \$5 million in growth capital. What captured the attention of the venture capitalists has been the company's inventive approach to meeting energy needs: a process called "parallel innovation."

"What if we used our experience with camping and our aspirations to help improve energy poverty to mutually reinforce one another," blogged Cedar in recounting the history of the idea. "As we began to understand the synergies between our camping and emerging market customers, our business model emerged—parallel innovation."

BioLite invents energy technologies and markets them in parallel to poor rural families and to campers from rich countries.

"We re-invest revenues from our camping market into our work in India and Sub-Saharan Africa," says Cedar. "The success or failure of our work lays entirely in the hands of our users in both markets. It is a form of social enterprise, bolstered by the merging of two distinct audiences, bonded by the common need for off-grid energy."

BioLite's business model is based on selling products that meet the needs of rural consumers at a price they can afford. This business plan has caught the attention of venture capitalists (including the Disruptive Innovation Fund), banks, and 4,860 backers who recently pledged more than \$816,966 on Kickstarter for BioLite's soon-to-be released BaseLantern.

The BaseLantern is the Swiss Army knife of the digital era. It is the first backpacker lantern that uses Bluetooth, creates a tiny power grid, lights a campsite for up to 114 hours, and charges a phone or other device via two USB ports. An optional solar panel can keep the lantern charged on the trail.

And as treehugger.com raves: "One of the cool added features of the BaseLantern is proximity activation. If you turn on that setting in the smartphone app, the lantern will turn on when you're within its proximity. As someone who often camps in state parks with my kids and has struggled to find our campsite when making the trek back from the bathroom in the dark, this is basically worth the price alone."

How's that for disruptive innovation?

—Lee Michaelides





Random Walk

Jousting mechanical beasts took over the Dartmouth Green one afternoon during Spring Term as a test of the creative powers of students in ENGS 146: Computer-Aided Mechanical Engineering Design. Building pedal-powered machines that can walk rather than roll was the latest brainchild of Professor Solomon Diamond '97 Th'98, who previously had ENGS 146 students design, build, and race twist cars and diwheels. This year's class project featured "multifaceted technical challenges — leg linkage design, drive system, steering system, complex chassis, and the need to support a rider," he says. His TAs, Hunter Black '15 Th'16 and Lillian Huang'15 Th'16, dubbed the machines beasts and turned the end-of-course competition into a medieval jousting tournament. Transitioning from indoors to outdoors proved too much for four of the five student teams. "All five teams actually had walking beast prior to the tournament. They all worked on the level floor in the Atrium. This is really impressive for the level of project difficulty and diversity of mechanical engineering solutions devised by the students," Diamond says. "The rough and uneven gravel paths on the Green made it much harder, though, and brought out various levels of mechanical failures in all but one beast. Every problem encountered was addressable, so there was a high level of accomplishment overall, and this would have been on full display if the teams had iterated to debug all the issues prior to the tournament day. Dartmouth terms are short, however, and so some of this iteration occurs in the form of transmitted knowledge when former students become TAs the following year. This cycle provides both experiential learning and learning from the experiences of peers."

PHOTOGRAPH BY DOUGLAS FRASER

THAYER SCHOOL OF ENGINEERING
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Engineering Gender Parity

Krystyna Miles '16 Th'16, left, and Shinri Kamei '16 Th'16 are members of Thayer's first graduating class in which more women than men earned undergraduate degrees in engineering—distinguishing Dartmouth as the nation's first research university to reach gender parity in engineering. For Dean Joseph J. Helble's view of how Thayer achieved this historic milestone, see the Perspective column on the front inside cover of this issue.

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