

150  
THAYER

FALL 2017

# DARTMOUTH Engineer

THAYER SCHOOL OF ENGINEERING



No. 99  
ALTA MOTORS'  
ELECTRIC  
MOTORCYCLE

## 150 THAYER GIFTS TO THE WORLD

INVENTIONS,  
COMPANIES, BOOKS,  
AND INNOVATIONS  
BY FACULTY,  
STUDENTS, AND  
ALUMNI OVER  
THE LAST 150 YEARS

inside

THE POWER OF CELLS

LAB REPORT

MEMORABLE PROFESSORS

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**DARTMOUTH ENGINEER**

is published twice a year for the  
Thayer School community.

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Printed by Villanti Printers

# Trusted Voices

Solving problems includes engaging in public debate.

JOSEPH J. HELBLE | DEAN

EACH YEAR, AT THAYER SCHOOL'S INVESTITURE ceremony for graduating students, I find myself commenting on numbers that tell the story of this particular moment in Thayer School history. Numbers of degrees granted, number of patents issued to students, number of award-winning projects and theses—all of these describe our graduates in ways that we understand as engineers and that help give gathered family and friends a sense of the collective accomplishments of another outstanding Thayer class.

This year's Investiture, part of the year in which we celebrate the 150th anniversary of the founding of the School, was no different. But this time I also called attention to one particular number with broader national significance: the number eight, the number of members of the current United States Congress that the Congressional Research Service identifies as engineers. Eight. Seven in the House of Representatives, one in the Senate.

That's eight out of 535—just under 1.5 percent.

Not many are surprised to find that engineers do not often pursue political office. We generally view politics as the province of attorneys, business men and women, and "career politicians," and not well suited to the analytical skills of engineers. Yet, that objectivity may be exactly what the public most needs, and most wants.

The polling organization Gallup, well known for surveying trends that affect elections and governance, also samples public opinion on the societal value of different professions. Last December, Gallup asked the American public their view of 22 different professions, asking respondents how they would rate the "Honesty and Ethical Standards" of people in those fields. At the top of the list were nurses, clearly admired for selflessness and their contribution to the greater good. But next, essentially tied, were physicians, pharmacists, and engineers, with engineers being seen by 65 percent of the public as having very high or high standards of honesty and ethical integrity, placing engineers well ahead of members of Congress, business executives, lawyers, bankers, journalists, psychiatrists—even ahead of the clergy.

As engineers, we often complain about a lack of public understanding of the value of engineering as a profession and of engineers as individuals, yet here is a clear signal that the public sees us serving the public good. Seeing the results of this survey, I was struck by the realization that engineers are viewed as perhaps one of the few remaining honest, ethical, trustworthy, and selfless groups of professionals in American society.

We know that engineers are data-driven, analytical, and fact-based, and I suspect this is why we are trusted. And yet this very passion for data and objective analysis causes us to stay on the sidelines and out of the public sphere, feeding the public stereotype of engineers as smart, hard-working, and generally introverted problem solvers.

But as I said to our graduates, Thayer engineers are different. Our students and alumni are anything but inward-facing, something I've seen repeatedly through more than a dozen years of interacting with new groups of students or traveling the country to meet our alumni.

We are at a moment when the public tells us clearly that the engineering voice is a trusted voice, and the Thayer voice, educated at the intersection of engineering and liberal arts, fully aware of the context of engineering in solving today's most challenging problems, is not just an articulate one, but an eloquent one.

For 150 years the Thayer School has been driven by a mission "to prepare the most capable and faithful for the most responsible positions and the most difficult service." These words were never intended to be restricted only to developing new technologies to solve technical challenges. Today, I do not believe there is any more responsible position nor any more difficult service than informing the public debate, regardless of partisan view or political affiliation. For if we as engineers do not speak out, using data and recognizing the trust the public places in us, then who will?



Far-Reaching Impact  
Working for DEKA,  
Alex Streeter '03  
Th'04 '05 helped  
develop the Luke  
prosthetic arm, now  
transforming life for  
injured veterans.  
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PHOTOGRAPH COURTESY OF ALEX STREETER

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with Professor Rahul Sarpeshkar

BY KRISTIN (COBB) SAINANI

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150 inventions, companies, books,  
and innovations by faculty, students,  
and alumni over the last 150 years

COMPILED BY LEE MICHAELIDES  
AND KIMBERLY SWICK SLOVER

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COVER: Alta Motors' Redshift electric  
motorcycle. Photo courtesy of Alta Motors.

# THE Great Hall



NEWS FROM AROUND THAYER SCHOOL



## INITIATIVES

### Project Links Thayer and Ghana Students

THAYER STUDENTS MIZA MWANZA TH'19, Taringana Guranungo '18, and Samantha Modder '17 recently met via video chat with students from Ashesi University in Ghana to design a device that distinguishes between upper and lower respiratory infections.

Working together through the Ashesi-Dartmouth Engineering Project (ADEPT), a pilot program launched by Thayer Professor Kofi Odame, the two teams developed a stethoscope retrofitted with an embedded computer chip that analyzes sound to detect fast breathing, a symptom of lower respiratory infection.

The modified stethoscope, which was sent to Ghana after completion, uses a piezoelectric sensor to detect chest movements and breathing rates. The novel device is self-contained and doesn't require an Internet connection. The team hopes to refine the invention over the next year and eventually distribute it to community clinics in rural Ghana.

Odame, who is from Ghana, set the task of creating a diagnostic device for respiratory diseases based on his previous research in asthma-monitoring wearable devices. "In recent years, an effective vaccination program has reduced the urgency of pneumonia in Ghana," he says. "However, community health centers in rural parts of the country do not have the resources to distinguish between upper and lower respiratory infections. Patients are referred to regional hospitals, which is inconvenient, costly, and causes a delay in treatment."

The Ashesi team conducted field research in Ghana, while Thayer students oversaw the development phase to make and assemble the prototype in the machine shop. With her biomedical engineering expertise, Mwanza developed the interface between the user and the device and a questionnaire to improve the accuracy for detecting lower respiratory infections. Guranungo built an electric circuit for the system, and mechanical engineer Modder drew the sketches of the device.

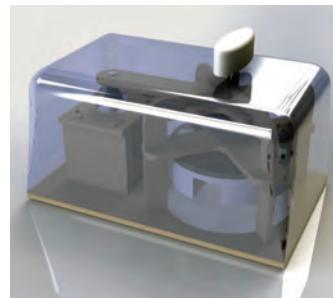
"Thayer's approach of giving students the freedom to choose classes without department limitation gave our group skills in many different areas," says Mwanza. "Our ENGS 21 experience helped guide us through the process and we invested almost half of the eight weeks in identifying the real problem. We knew our end users were the only ones who could help us come up with a product that they would want to use."

"One of the biggest things I learned from the project is the broadness and complexities of community health in Ghana," says Guranungo. "The role that human-centered design played in problem identification and solution ideation allowed us to profoundly explore global health science in rural Ghana."

ADEPT's eight-week summer program, funded by the Dartmouth Provost's office, is a first step in collaborations between Thayer and Ashesi. Says Odame, "The objective of the pilot project was to crystallize the relationship between Dartmouth and Ashesi around a concrete, collaborative design project."

—Anna Fiorentino

I Want  
One of  
Those!



## STUDENT PROJECT

### THE DOORMAN

Forgot your dorm room key? No problem, if you have the Doorman, a keyless access system that can be easily retrofitted to deadbolts on dorm room doors. The Doorman scans a student's ID and twists the lock open. It even works via smartphone app and has a manual override. Inventors Joey Carleo '20, Michael Duane '19, Avery Kaplan '19, Tony Kirumba '19, and Ben Wolsieffer '20 won the Spring Term Phillip R. Jackson Award for outstanding performance in ENGS 21: Introduction to Engineering. Their teaching assistant was Sean Howe '16 Th'17. Watch the Doorman in action at [engineering.dartmouth.edu](http://engineering.dartmouth.edu) (search: keyless dorm lock).

**CALLING IN**  
From left, BE student Miza Mwanza '18, Taringana Guranungo '18, and BE student Samantha Modder '17 Skype with their project collaborators in Ghana.

# Q&A

## Professor Jeremy Faludi

Thayer's newest assistant professor, Jeremy Faludi, is a sustainable design strategist whose research interests include design methods, life-cycle assessment, sustainability metrics, green 3D printing, additive manufacturing, and green building. He created the Whole System Mapping sustainable design method, co-authored the *Autodesk Sustainability Workshop*, and designed the prototype of AskNature.org for the Biomimicry Institute. He has contributed to six books on sustainable design, including *Worldchanging: A User's Guide for the 21st Century*. He holds a BA in physics from Reed College, an MEng in product design from Stanford, and a PhD in mechanical engineering from the University of California, Berkeley.

curve of a door handle, the heft of silverware in my hand, the navigation of a website—all these things delight or annoy me to maybe an unreasonable extent, so I want them all to be wonderful.

### >> What is the Whole System Mapping sustainable design method you created?

It came about because most people know we need to address sustainability concerns on the whole system level to make the greatest impacts, but whole systems are hard to hold in your head all at once, so designers and engineers usually only last a few minutes there before collapsing back into the weeds of detailed design. At the same time, quantitative assessments of environmental impact are usually done at the end of the design process, when you have the best data, rather than at the beginning, where you have the most leverage to change things. So I tried to fix both of these problems by making the Whole System Mapping design method use quantitative environmental impacts to set the design priorities from the beginning and draw out the whole system map so people can use it for their idea generation, getting into the weeds and seeing the big picture at the same time.

### >> What attracted you to Dartmouth at this point in your career?

I loved the idea of a department without discipline boundaries, since everything I do is interdisciplinary. I also loved the ethos of engineering in a liberal arts college, because the thing this world needs most is for the people who build the material world—engineers, business people, etc.—to rebuild it in service to society and nature. Studying engineering by itself only teaches you to build things right; studying humanity and nature also teaches you to build the right things.

### >> How did you go from physics to design?

Two reasons: One, because I've always been torn between being an artist and a scientist, and design is one of the few places that you can be—and, indeed, should be—both. Design thinking is a scientific method for complex messy things that are not amenable to reductionism. The other was that I specifically wanted to do green design, to make the world a better place in a tangible way that improves people's daily lives while helping the planet.

### >> Why is design so important to you?

Partly because of the artist/scientist balance, partly because I'm strongly affected by the immediate experience of things in everyday life—the

**"I loved the idea of a department without discipline boundaries, since everything I do is interdisciplinary."**



## Kudos

**ELECTED** Dean Joseph Helble has been elected a fellow of the American Academy of Arts and Sciences (AAAS), the world's largest general scientific society and the publisher of the journal *Science*. AAAS cites Helble "for contributions in the areas of air pollution, aerosols, nanoscale ceramics, and air quality, and for excellence in teaching and professional service."

**AWARDED** Three professors recently earned tenure: Margie Ackerman, an "immuno-engineer" who focuses on understanding and enhancing the role of antibodies in fighting and treating disease; Jason Stauth, an expert in power electronics who focuses on power management in solar arrays, energy-efficient operation of devices, and power management in energy storage systems; and Douglas Van Citters '99 Th'03 '06, who heads the Dartmouth Biomedical Engineering Center for Orthopaedics and focuses on improving orthopaedic implants.

**AWARDED Professor Margie Ackerman** has been awarded an Amgen Young Investigator Award in recognition of her "work in developing high-throughput experimental and computational technologies for therapeutic antibody and vaccine design and evaluation." In addition to receiving a \$25,000 research grant, Ackerman delivered a lecture at the Amgen Young Investigators Symposium at Caltech in October.

**NAMED Professor Brian Pogue** has been named editor-in-chief of the *Journal of Biomedical Optics*, published by SPIE, the international society for optics and photonics. Pogue directs Thayer's MS and PhD programs and Dartmouth's medical physics program and cofounded the Optics in Medicine research program to advance imaging technologies for cancer diagnosis and management.

**AWARDED** PhD candidates Andrew Allee Th'20 and Ethan LaRochelle Th'20 have received National Science Foundation Research Fellowships, which include a three-year annual stipend of \$34,000. Allee's research focuses on developing process, economic models, and design of facilities to utilize innovations for advanced cellulosic ethanol. LaRochelle is helping to develop a multi-spectral imaging system for assessing the efficacy of photodynamic therapy for treating pre-cancerous skin lesions.

# lab report

## CLASSROOM

### Engineered for Learning

**WHEN PROFESSOR ERIC HANSEN began teaching electrical engineering at Thayer in the early 1980s, the tech world was regaling the debut of the personal computer and the microprocessors—developed by electrical engineers—that made them possible. Since then, Hansen says, he has “melted down and recast” ENGS 31: Digital Electronics every five years or so to keep pace with evolving technologies.**

But until recently, his teaching methods remained relatively constant: in-class lecture, weekly lab, final exam, big design project. While this is a fairly standard approach, Hansen wasn’t getting the results he was hoping for. “It was pretty clear that 90 percent of the learning in the course was happening in the lab,” Hansen says. “And I was always unhappy that we couldn’t bring more building into the classroom.”

Then Hansen witnessed colleague Peter Robbie ’69 teach. “He treated his classroom like an art studio,” says Hansen. “I thought, why couldn’t I do that?”

So two years ago, Hansen experimented with reserving one class meeting each week for design exercises. Students gathered during x-hours at whiteboards in Thayer’s Couch Project Lab to work in groups of four. “The x-hour became a time where I could interact with students as they were solving problems,” Hansen explains.

But lab time and space were limited and components and materials, such as silicon, were costly. As Professor Geoffrey Luke, who also began teaching the course, says, “We had to figure out how to build components in the regu-



lar classroom. And with 60 students, one instructor couldn’t give feedback to everyone.”

With support from the Dartmouth Center for the Advancement of Learning (DCAL), Hansen and Luke adopted EDA Playground software, which allows students to build in simulation rather than silicon, and worked with engineering Professor Petra Bonfert-Taylor to restructure the course.

“We started by asking: what do we want students to get out of this class?” says Hansen. “Then we refined our learning objectives to emphasize the important parts, and looked at which content we could offload into videos.”

Hansen and Luke recorded a dozen or so videos each, and developed classroom exercises for students to apply the concepts from the videos. Luke taught the redesigned course in Spring 2017, and Hansen followed with a Summer Term offering. Learning Fellows, students who took the course previously, helped in class.

“It was tough at first developing relevant exercises that were at the right level,” says Luke. But, he says, he noticed that students’ final projects were better designed than in previous terms.

Luke points to Learning Fellows and the students as sources of in-the-moment feedback. “It’s a much shorter feedback loop than I’ve had previously,” he says.

“The whole flow of the class hour is different, and I’m trying to get that right,” Hansen says. “But leapfrogging the class [by teaching in consecutive terms with Luke] has allowed us to iterate much more quickly. It has been a real learning experience.”

—Elli Goudzwaard

(Condensed from an article published on DCAL’s website)

## FIELDWORK

### Core Ideas: Assessing Permafrost

**PROFESSOR IAN BAKER AND RUSSELL BECKERMAN ’19 recently headed underground in Fairbanks, Alaska, to drill into the permafrost that underlies 24 percent of the land in the Northern Hemisphere. Working in a permafrost tunnel operated by the U.S. Army’s Cold Regions Research and Engineering Laboratory (CRREL), Baker and Beckerman collected 21 nine-inch cores, some drilled from ice wedges and some from cemented silt consisting of rock and dust held together by ice.**

Baker, an expert in materials, including ice and snow, plans to analyze the two types of cores, which are now stored at CRREL’s Hanover facility. “We are interested in how the microstructure is related to the mechanical properties and ultimately how the mechanical properties change as the permafrost warms up,” he says.

“I wanted to study permafrost because it poses such interesting and difficult problems to be solved by our generation,” says Beckerman, an engineering major. “Building structures on it is one challenge because it can crack and melt, creating sinkholes. Another issue is the high amounts of carbon and methane that get released when it thaws.”

In fact, says Baker, “there is twice as much carbon locked up in permafrost as in the atmosphere. As the planet warms this will be released.”

Seeing permafrost in its natural state proved instructive, according

**TUNNEL VISION**  
CRREL researcher Tom Douglas ’94 G’01 and Russell Beckerman ’19 drill permafrost cores for Professor Ian Baker’s research.

to Baker. “There were fossils in the permafrost tunnel. We saw a mammoth shoulder bone and the tusk of an extinct bison,” he says. “The complexity of the structure and the size of the ice wedges was surprising. You can read about this in books, but seeing it in person gives one a different perspective.”



# investiture



## Class of 2017

THE LARGEST GRADUATING class in Thayer School's 150 years was honored at Investiture, held June 10 in Spaulding Auditorium. With Dean Joseph J. Helble presiding, Thayer School handed out hoods and awards to a record 183 recipients of BE and graduate degrees. At Commencement the next day, an additional 98 students received AB degrees in engineering.

The annual Robert Fletcher Award, named for Thayer's first dean and recognizing distinguished achievement and service in the highest tradition of the school, was presented to Frances Arnold, the Dickinson Professor of Chemical Engineering, Biochemistry, and Bioengineering at the California Institute of Technology.

"I have worked with and drawn inspiration from the greatest engineer of all time: nature," Arnold told graduates. "Nature has discovered amazing solutions to an incredible array of difficult problems, not the least of which is the problem of being alive! Nature figured out how to extract materials and energy from widely different sources and convert them to a vast collection of brilliant self-repairing, adaptive materials, molecular machines, control systems, and chemical factories, with

great efficiency and often minimal waste. We should strive to match this elegance and efficiency in any of our human-engineered systems."

Nature has a societal message for us as well, Arnold added. "Innovation comes straight out of diversity—of recombining different parts and recombing different experiences. Without that diversity, we all move down the same path, and we accumulate a lot of wrong ideas. Nature teaches us that's a sure route to extinction."

In his remarks, Helble cited a recent Gallup Poll finding that Americans view the trustworthiness and integrity of engineers as second only to nurses. "My message this morning is that the public tells us that this voice—the engineering voice—your voice—is a trusted voice. And I am asking you, each of you, in your own way, to think about at this moment in time, what it would mean to use it in a more public way...to think about engaging in the issues of your day in whatever way works for you, but that pushes you slightly outside of your engineer's and engineering comfort zone."

For full texts and videos of these speeches, see [engineering.dartmouth.edu/events/investiture/2017](http://engineering.dartmouth.edu/events/investiture/2017).

## Kudos

**NAMED** Professors Paul Meaney and Rahul Sarpeshkar have been named Fellows of the Institute of Electrical and Electronics Engineers (IEEE), the world's leading professional association for advancing technology for humanity. The IEEE cites Meaney "for contributions to microwave tomography and its translation to clinical use" and Sarpeshkar "for contributions to ultra low-power biomedical electronics."

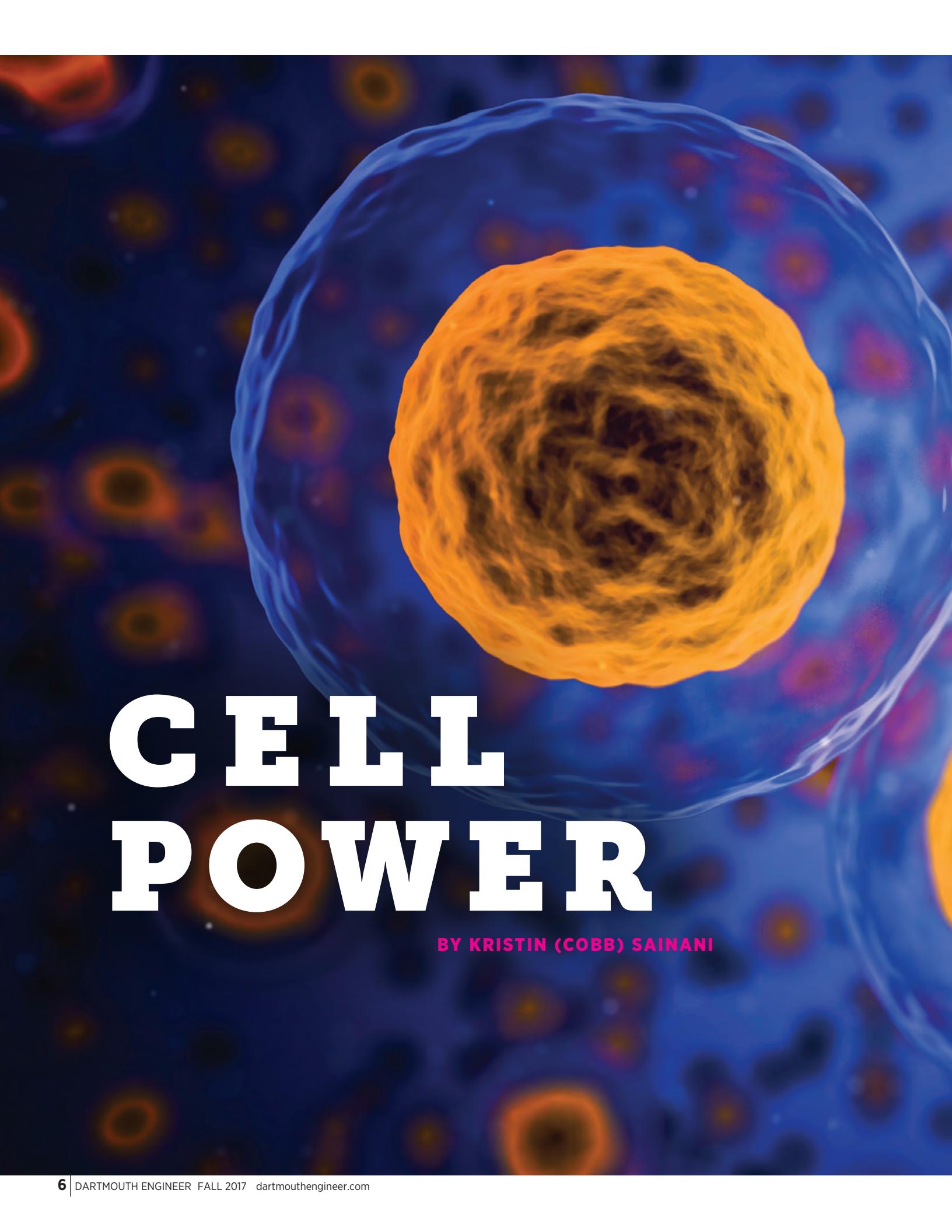
**AWARDED** Two members of the Thayer community received Outstanding Presentation Awards at the IEEE Applied Power Electronics Conference last spring. MS student **Benedict Foo Th'20** won for his poster presentation, "A Step-by-Step Guide to Extracting Winding Resistance from an Impedance Measurement." Post-doc **Aaron Stein** won for his lecture, "High-Q Self-Resonant Structure for Wireless Power Transfer."

**NAMED** Engineering major **Kevin Kang '18** was named a Goldwater Scholar, the top award for undergraduates in the sciences. Kang plans to pursue biomedical research.

**AWARDED** Adjunct Professor Richard Greenwald Th'88 has earned the USA Hockey 2017 Excellence in Safety Award. A vice president of the Hockey Equipment Certification Council and cofounder of the National Institute for Sports Science and Safety, Greenwald works on biomechanics, injury prevention, and sports equipment improvement.

**NOTED** Professor Lee Lynd Th'84 Th'87 is leading the U.S. Department of Energy BioEnergy Science Center's efforts to create new methods of improving biofuel yields from non-food plant sources. He and his team recently demonstrated a cheaper, more effective method of biomass deconstruction and conversion using a naturally occurring microbe and a standard milling practice.

**AWARDED** PhD candidate Keji Wei won the Bronze Anna Valicek Medal given by the Airline Group of the International Federation of Operational Research Societies for his research paper "Modeling Crew Itineraries and Delays in the National Air Transportation System." The medal promotes innovative airline-related operations research. Wei works with Professor Vikrant Vaze.



# CELL POWER

BY KRISTIN (COBB) SAINANI

A microscopic image showing several cells with distinct yellow and orange nuclei against a blue and purple background.

## ON THE FRONTIERS OF BIOMEDICINE

WITH PROFESSOR  
**RAHUL  
SARPESHKAR**

**BEST OF BOTH WORLDS**  
Sarpeshkar's blended mastery of both biology and engineering holds much promise for significant new medical advances. "You have to be an amphibian—comfortable swimming in the water and the wet biological circuits and comfortable walking on land when you do the electronic circuits," he says.



uman brains, like supercomputers, can perform quadrillions of operations per second. But a supercomputer guzzles a lot more energy, enough to power hundreds of houses. A brain, on the other hand, runs on the energy equivalent of an electric shaver.

"Cells are the most energy-efficient computers ever built," says Rahul Sarpeshkar, an inventor and multifaceted professor—of engineering, physics, microbiology and immunology, and physiology and neurobiology—who arrived at Dartmouth two years ago after working at the Massachusetts Institute of Technology for 16 years. With him came his work on mimicking the way the human body computes.

Sarpeshkar has built low-power and battery-free implants that aid the deaf and paralyzed. He has turned a cell into a calculator. He's working on an ultra-fast supercomputer that can test drugs virtually, and he is figuring out how to reprogram immune cells to fight cancer.

At Dartmouth, Sarpeshkar aims to build a new kind of supercomputer by filling a room or building with millions of his cell-inspired computer chips. Together the chips would simulate the actions of all the cells in an organ, such as a liver, and eventually an entire body. This would allow scientists to test drugs in a computer rather than on patients or animals. "We would be able to google medical cures," Sarpeshkar says. Though this vision may take 10 years to implement, "it's not science fiction," he says. "I've laid the foundation already. A lot of the stuff is now way past the risk stage."

Sarpeshkar is also using circuit design principles to repurpose living cells. Genetic engineering has been around for decades, but most examples are simple: Insert one gene into a cell to make a useful protein, such as insulin. Sarpeshkar and others want to insert multiple genes that will work together to accomplish more sophisticated tasks, such as sensing and attacking tumors. "In biology, if you can engineer the cell, you can do anything," Sarpeshkar says.

Digital thinking has colored much of the work in this area, but complex and bulky digital circuits quickly drain energy. Sarpeshkar believes an analog approach is needed. To prove the point, he showed that he could turn a cell into a calculator by inserting just two proteins—one that ramps up production of a fluorescent molecule and one that dampens levels. This is sufficient to allow the cell to add, subtract, multiply, divide, and even take square roots. An equivalent digital solution would take about 130 genetic switches.

Sarpeshkar is collaborating with Edward Usherwood, professor of immunology and microbiology at the Geisel School of Medicine, to re-engineer immune cells to fight cancer. One of the most promising new cancer treatments involves taking a patient's own T cells and genetically engineering them so they can better recognize and kill cancer cells. The therapy has dramatically prolonged survival in some patients with aggressive blood cancers. One major problem, however, is that the cells don't last long in the body. Sarpeshkar and Usherwood plan to introduce new genetic circuits that improve the cells' longevity.

Usherwood says that Sarpeshkar has become a "focal point" around which larger collaborations are forming across engineering, computer science, biochemistry, and biology at Dartmouth. "Rahul has big, ambitious visions. He wants to build the program at Dartmouth into something that is of international stature," says Usherwood.

**SARPESHKAR WAS INTERESTED IN SCIENCE, MATH AND** engineering from an early age. As a child he tinkered with chemistry and electronics kits and solved math problems for fun. "I took naturally to science and numbers. It was born in me," he says. As an undergraduate at MIT he studied physics and electrical engineering.

Sarpeshkar's dive into biomedicine began as a PhD student at the California Institute of Technology, where he studied under computing legend Carver Mead. By 1990 Mead had pioneered the concept of "neuromorphic computing"—building computer chips inspired by how the brain and nervous system work. "Carver taught me that intuition, imagination, and common sense are more important than formal education," Sarpeshkar says. "He also opened my eyes to how amazing biology is."

## **SARPESHKAR SHOWED HE COULD TURN A CELL INTO A CALCULATOR BY INSERTING JUST TWO PROTEINS TO ALLOW THE CELL TO ADD, SUBTRACT, MULTIPLY, DIVIDE, AND EVEN TAKE SQUARE ROOTS.**

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Biology's power budgets are incredibly low compared with computers. The key is that biology uses a combination of analog and digital computing, whereas computers are almost exclusively digital. To understand the trade-offs, consider how one might add graded lighting to a room: The analog solution is to use a dimmer switch. A digital solution is to install 10 light bulbs, each with a separate on/off switch. The digital setup offers extreme precision—turning on five bulbs gives the exact same lighting each time, whereas sliding a dimmer is inconsistent. But the analog setup saves energy, space, time, and parts.

The inherent imprecision of analog computing has led most modern engineers to avoid it, but Sarpeshkar has made it a cornerstone of his work. He has succeeded in making electronics both efficient and reliable by using the right mix of analog and digital circuits, as well as by building in feedback loops and error correction—other tricks used by nature.

Keeping energy requirements low is particularly important for electronic devices implanted in the body, such as heart pacemakers. The batteries in these devices need to last as long as possible, since swapping them out requires surgery. Implantable batteries also can't get too hot, or they risk cooking surrounding cells and tissues.

After joining the faculty at MIT in 1999, Sarpeshkar set out to build a

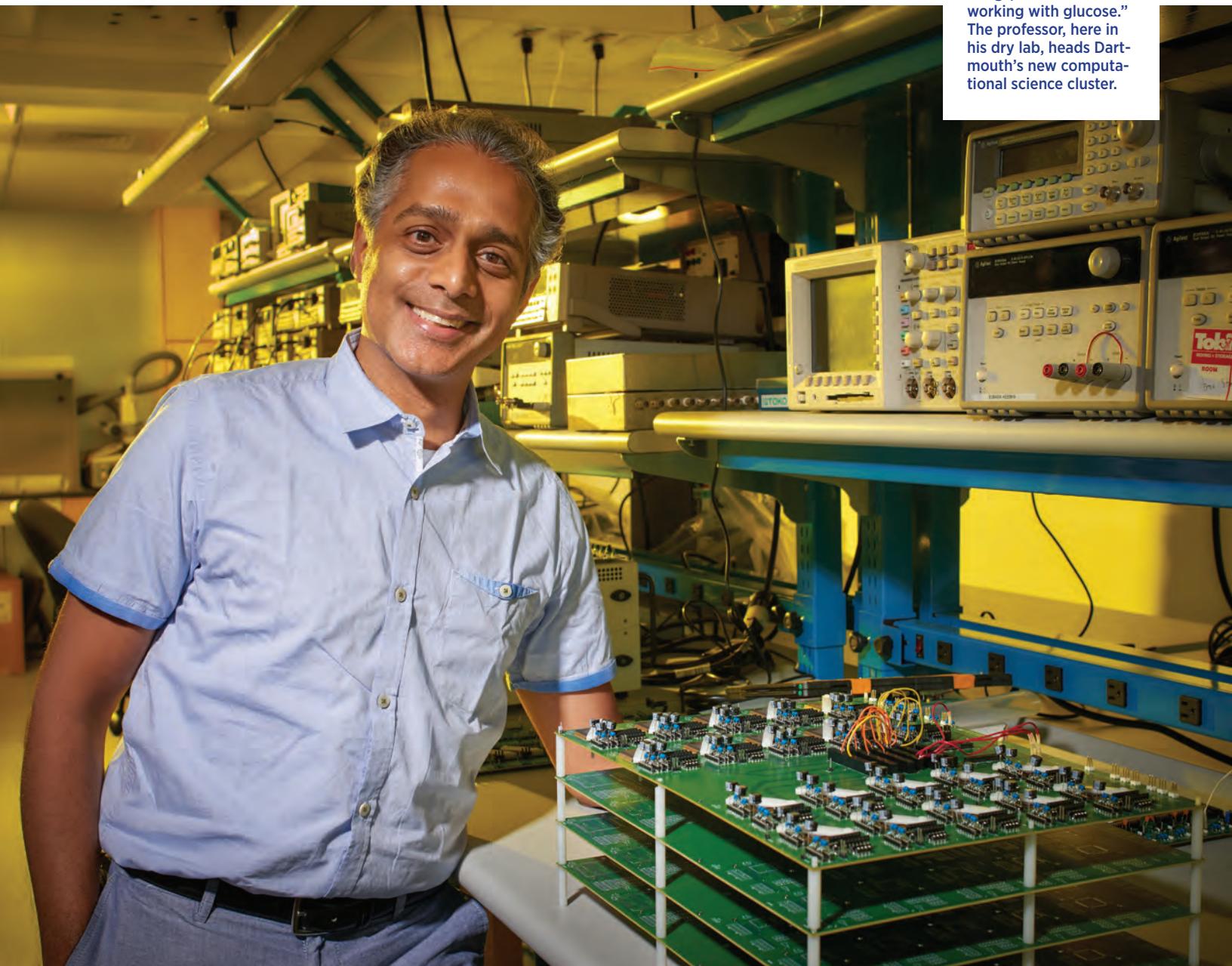
better cochlear implant. Cochlear implants restore hearing in the deaf by taking over the job of a damaged inner ear—converting sound waves into electrical pulses the brain can recognize. Most cochlear implants digitize sound right away, but Sarpeshkar noticed that the ear first processes sound in an analog form, which it later digitizes. Sarpeshkar's team built a cochlear implant that, by delaying digitization, outperforms available devices for listening to music and hearing in noisy environments but requires just one-20th the energy—250 microwatts.

Sarpeshkar's lab also worked on brain-machine interfaces. These devices have allowed a handful of patients with quadriplegia to control a prosthetic arm with their thoughts. When people are paralyzed, the

electrical signals in their brains that tell their arms and legs to move are stranded. Using implantable brain chips, scientists can extract this neural chatter, transmit it to a computer, and figure out a person's intended movements. The systems are bulky: Signals are fed to an external computer through wires sticking out of the skull. Sarpeshkar's team has reduced the energy needs and size of the computer to fit on an implantable chip, and they've created a wireless link for getting signals in and out of the brain. The system has yet to be fully tested on humans.

They also figured out how to power the

**EUREKA MOMENT**  
After asking himself how cells power themselves, Sarpeshkar had a realization: "We shouldn't be working with batteries to power things, we should be working with glucose." The professor, here in his dry lab, heads Dartmouth's new computational science cluster.



chip without a battery. “I asked, ‘How do cells power themselves?’” Sarpeshkar says. “That’s when I realized that we shouldn’t be working with batteries to power things, we should be working with glucose.” His team fashioned a fuel cell that can extract energy directly from glucose present in the brain. Since the fuel cell has an unlimited supply of energy, it never needs to be replaced.

Sarpeshkar’s innovations could be used in many other medical implants in development, including devices that restore vision to the blind, return muscle movement to stroke patients, and continuously monitor

## “I TOOK NATURALLY TO SCIENCE AND NUMBERS. IT WAS BORN IN ME.”

blood pressure. “Rahul was doing low-power biomedical implants when very few people were doing it,” says Soumyajit Mandal, who was a doctoral student with Sarpeshkar at MIT in the 2000s and is now an assistant professor at Case Western Reserve University. “Now the field has exploded. He set the stage for a lot of what is happening.”

Indeed. The glucose fuel cell was named one of *Scientific American’s* 10 “World Changing Ideas” for 2012. Sarpeshkar, who holds 36 patents for his inventions, is working on commercializing his devices to bring them to patients. His 2010 book, *Ultra Low Power Bioelectronics* (Cambridge University Press), lays out general principles for low-power electronics that could even have applications outside of biomedicine, such as for making low-power cars.

While writing his book—which, at 890 pages, took two and a half years to complete—Sarpeshkar had an epiphany. He noticed striking parallels between living cells and analog computer chips. The same mathematical equations that describe the flow of DNA, RNA, and proteins through a cell also describe the flow of electricity through analog circuits. Plus, biological molecules have electronic counterparts—a protein that represses gene expression is similar to an electronic component that dampens current flow. This means that one can mimic a cell in a computer chip or, conversely, treat a cell like a programmable computer.

In 2010 Sarpeshkar took a two-week crash course at Smith College to learn hands-on lab work, such as how to clone genes, run gels, and sequence DNA. “I knew a lot of theory, but I had never done any pipetting or real stuff before,” he says. Pipettes are precise chemical droppers used to measure and transfer liquids. Pipetting turned out to be enjoyable, Sarpeshkar says. “There’s almost a yoga technique to it: You take the stuff in with a breath, and then pipette it out as you breathe out.” When he returned to MIT, he converted half of his electronics lab into a wet lab for working with living cells.

During the next six years Sarpeshkar built prototypes of cell-inspired computer chips with the help of Sung Sik Woo, a doctoral student at MIT who continued to work with Sarpeshkar at Dartmouth until recently. Woo’s admiration for Sarpeshkar is evident. “Even though he is in a senior position, he’s always trying to learn new things,” Woo says.

“He emphasizes the importance of pursuing high-hanging fruit, not just doing something that’s trivial.”

The cell-inspired computer chips have a hybrid analog/digital design that allows Sarpeshkar to do “lightning-fast” computing. The chips can already simulate the behavior of a cell 20,000 times faster than available technology—and Sarpeshkar believes that a million-fold speed-up is possible. Simulating everything that goes on in one cell, without taking any shortcuts, would take 12 years on an available supercomputer. “We’re planning to do it in seven minutes,” he says.

**“ONE THING THAT’S VERY UNUSUAL ABOUT RAHUL IS THE** ease with which he moves between engineering, physics, and biology,” says Joseph Helble, dean of Thayer School of Engineering. “He’s able to bring these things together in ways that are extraordinary and that I’ve not seen in many other individuals.”

Sarpeshkar’s commitment to interdisciplinary research is one of the things that drew him to Dartmouth. He heads Dartmouth’s first cluster initiative—the William H. Neukom Academic Cluster in Computational Science. The cluster initiative brings together interdisciplinary faculty teams to solve urgent global problems. “Rahul is a cluster unto himself, the way he spans different perspectives, methodologies, and worldviews,” says former Provost Carolyn Dever. “He understands that this is a place where he can succeed because he can go across lines of discipline and school so easily.” [The Neukom cluster has hired a second professor, and when it hires a third it will be “fully launched,” says Sarpeshkar. “My research is being leveraged in an immune-engineering center that cluster members will actively participate in.”]

Sarpeshkar encourages students to get out of their disciplinary silos. Orville and Wilbur Wright, whom he idolizes, had no formal training or degrees—no disciplinary labels or boxes—and this freed the brothers to think outside of the box, he says. “You have to be a bigger thinker than your petty department or your petty school or your petty discipline.” He is developing a course for undergrads and graduate students for next year that will be called “Biological Circuit Engineering” and cross-listed in biology, physics, and engineering. In his lab at the medical school, students from the life sciences and technical fields will work together in the adjoining wet and dry spaces.

Outside of the classroom Sarpeshkar enjoys swimming, yoga, hiking, skiing, detective fiction, James Bond movies, playing with his 4-year-old son—who delights in running around the Green—and exploring the Hanover area.

“He always says: ‘Health is first, love is second, science is third,’ ” says Woo. When Woo had to have surgery as a doctoral student, Sarpeshkar told him to stay out of the lab and focus on recovery. “He wasn’t just a boss who wanted me to publish papers for him. He was different.”

Since arriving on campus Sarpeshkar has also ventured into quantum physics and the mysterious behavior of subatomic particles such as electrons and protons. “I recently got an important insight into how to understand quantum physics by reformulating it through the lens of analog circuits and analog computation. When this understanding clicked, it was a moment of great joy,” Sarpeshkar says.

“I’ve always followed my nose and my heart,” he adds. “And every single time I do this, I end up doing something amazing.”

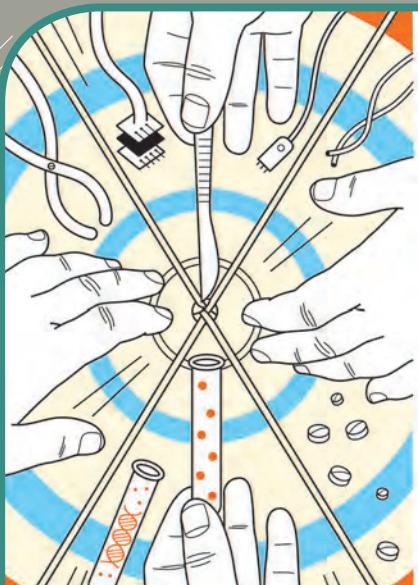
KRISTIN (COBB) SAINANI is an associate professor of health research and policy

at Stanford University. She writes about health and science.

This article originally appeared in Dartmouth Alumni Magazine.

THAYER SCHOOL

# GIFTS TO THE WORLD



150 INVENTIONS,  
COMPANIES, BOOKS,  
AND INNOVATIONS  
BY FACULTY, STUDENTS,  
AND ALUMNI OVER  
THE LAST 150 YEARS

COMPILED BY LEE MICHAELIDES  
AND KIMBERLY SWICK SLOVER

ILLUSTRATIONS BY HARRY CAMPBELL

150

GIFTS TO THE WORLD

**HUMAN GLYCOSYLATION OF YEAST**

 Professor Tillman Gerngross achieved a biomedical feat that most experts said couldn't be done: engineering yeast to produce fully human proteins. The ability to humanize the sugar structures—or glycosylation—of the yeast *Pichia pastoris* not only increases the capacity to produce therapeutic proteins, but also allows for precise control of protein structures, making drug production far more efficacious.

**CENTER FOR SURGICAL INNOVATION**

 The nation's first surgical facility dedicated to translational research, the Center for Surgical Innovation (CSI), located at Dartmouth-Hitchcock Medical Center, features two operating rooms that share MRI and CT scanners for intraoperative imaging and have space for multiple researchers and equipment. Keith Paulsen Th'84 '86, Thayer's Robert A. Pritzker Professor of Biomedical Engineering, and Dr. Sohail Mirza, chair of Dartmouth-Hitchcock's Department of Orthopaedics, codirect the CSI.



NO. 2

THE NATION'S  
FIRST SURGICAL  
FACILITY DEDICATED  
TO TRANSLATIONAL  
RESEARCH

**NO. 3 MINIATURE MEDICAL SYSTEMS**

Professor John Zhang is developing miniature medical systems to improve global health through innovations in bio-inspired nanomaterials, lab-on-chip design, advanced nanofabrication technologies for probing complex biological networks critical to human development and disease, and multi-scale modeling of the underlining fundamental force, flow, and energy processes. He received the Wallace Coulter Foundation Early Career Award for developing handheld microphotonic imaging scanners and microsystems for early oral cancer detection.

**NO. 4 FRAMELESS STEREOTACTIC OPERATING MICROSCOPE**

Ever since early humans drilled holes into patients' heads in Paleolithic neurosurgery, doctors have longed for a way to navigate the brain and pinpoint lesions. In the 1970s computerized tomography (CT) produced amazing two-dimensional images of the brain, but the only way to use the scans as navigational guides during surgery was via a cumbersome metal frame that ringed the patient's head, got in the surgeon's way, and had to be screwed directly into the skull. In the early 1980s Dartmouth-Hitchcock neurosurgeon David Roberts DMS'75 and Thayer Professor John Strohbehn created an instrument to map CT data onto the visual field of a microscope to produce a precise three-dimensional (aka stereotactic) view of the brain. They tested their prototype in the operating room in 1983 and patented

the invention three years later. The frameless stereotactic operating microscope was a hit. Not only was it more comfortable for the patient, it was the beginning of image-guided surgery.

**NO. 5 ADVANCING MEDICAL IMAGING**

Thayer researchers led by Professors Keith Paulsen Th'84 '86 and Brian Pogue are developing new imaging technologies to model breast cancer, pancreatic cancer, brain glioblastoma multiforme, soft tissue sarcoma, and certain types of bone cancer. They are also using non-invasive photo-activated drugs to target tumors and using imaging techniques to assess radiation dosage and efficacy.

**NO. 6 MICROWAVE THERMOKERATOPLASTY**

Professor Stuart Trembly developed a less invasive alternative to laser eye surgery: reshaping corneas with microwave thermokeratoplasty (MTK). Microwave energy, applied around the pupil outside the field of vision, causes collagen fibers in the cornea to shrink, flattening the optical surface in the center of the eye. The procedure is fast, requires no cutting, and uses less expensive equipment than laser surgery. Trembly advanced MTK therapy with two patented devices. One is an improved applicator with embedded sensors to measure temperature or mechanical strain of the cornea during the procedure; the other is a feedback system that analyzes the signals to determine when the myopia is corrected.





# COMPANIES

## Founded by Thayer Faculty

(continued from previous page)

### IMAGING SYSTEM TECHNOLOGIES

**Founders:** Professors Paul Meaney Th'95 and Keith Paulsen Th'84 '86  
**What it does:** Develops noninvasive breast cancer imaging system

### LODESTONE BIOMEDICAL

**Founders:** Professor Solomon Diamond '97 Th'98, Lidia Valdés '14 Th'15, Brad Ficko  
**What it does:** Developing Iron-Wand, a non-invasive device for diagnosing iron deficiency in children

### MASCOMA CORP.

(sold in 2014)  
**Founders:** Professor Lee Lynd Th'84 '87, former professor Charles Wyman, Bob Johnsen  
**What it does:** Produces biofuels using recombinant yeast

### MICROWAVE SOUND INNOVATIONS

(acquired by Gentex Inc. in 2014)  
**Founders:** Professors Laura Ray and Robert Collier, Christopher Pearson Tu'02  
**What it did:** Developed noise-cancelling headsets

### NANOCOMP TECHNOLOGIES

**Founder:** Professor Robert Dean Jr.  
**What it does:** Produces advanced carbon-nanotube materials

### NANOLITE SYSTEMS

**Founders:** Professor John Zhang, Ting Shen  
**What it does:** Performs point-of-care diagnostics through blood tests

### OMEQ DIAGNOSTICS

**Founder:** Professor Jane Hill  
**What it does:** Developing diagnostics for infectious diseases

### PATIENTRULES

**Founders:** Professor Vikrant Vaze, Sujana Chalasani  
**What it does:** Facilitates demand and capacity matching in health system operations

### QVSENSE

(acquired by Solar Semiconductor)  
**Cofounder:** Professor Jason Stauth Th'00  
**What it did:** Developed integrated and distributed circuit architectures for power management

### RYTEK MEDICAL

**Founder:** Professor Ryan Halter Th'06  
**What it does:** Developing bioimpedance sensing technologies coupled to surgical tools for enhanced guidance during surgery

### SIMBEX

**Founders:** Professors Robert Dean Jr. and Richard Greenwald Th'88  
**What it does:** Bio-inspired devices for injury prevention and rehab

### STEALTH BIOLOGICS

**Founders:** Professor Karl Griswold, computer science Professor Chris Bailey-Kellogg  
**What it does:** Re-engineers therapeutic proteins to evade the human immune system

### SUSTAINX

(merged with General Compression Inc. in 2015)

**Founders:** Professor Charles Hutchinson '68A, Dax Kepshire Th'06 '09, Ben Bollinger '04 Th'04 '08, Troy McBride Th'01  
**What it did:** Isothermal energy storage

### SYNTICOS

**Founders:** Professor Robert Dean Jr., Erik Johnson '06 Th'11  
**What it does:** Developing abrasive slurry jet cutters

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28-41



## NO. 42 UNDER- STANDING AIRLINE DELAYS

**Professor Vikrant Vaze studies the causes of flight delays, analyzing a complicated network in which even minor delays can cause a ripple effect of missed connections and further delays. Among his finding: Mondays and Saturdays have the fewest delays. June is the worst month for delays.**

## NO. 43 SYNCLAVIER

The brainchild of Thayer Professor Sydney Alonso, student programmer Cameron Jones '75 Th'77 and music Professor Jon Appleton, what began as a research project at the Thayer School became the world's first digital synthesizer. Pioneering digital sampling, hard-disk recording, and professional sound editing, the Synclavier rapidly became the Rolls Royce of the music industry. Despite a starting price of \$75,000 and topping out at \$500,000, the Synclavier was the instrument of choice for Stevie Wonder, Frank Zappa, Sting, and Michael Jackson. Synclavier engineers developed a guitar interface with jazz guitarist Pat Metheny. Pianist Oscar Peterson's wish for better response led to a touch-sensitive keyboard. Lucasfilm's interest in the sound editor function resulted in software that made post-production editing as easy as music recording. "Being able to hear instantly what you've just composed is very seductive," Zappa, told *The New York Times* in 1988 after he composed his Grammy Award-winning album *Jazz From Hell* on a Synclavier. At the onset, the Synclavier had the market to itself. But other people developed more compact and less expensive alternatives, and in 1993 New England Digital, the startup founded by Alonso and Jones ended production.

But that isn't the end of the story. The Synclavier now lives virtually. A company called Arturia partnered with Jones to reboot the Synclavier as a \$200 app. "We even used part of the original code," says a company press release. "It doesn't get more authentic than that."

## NO. 44 PLASMA TORCH

Half a century ago Thayer Professor James Browning '44 was nicknamed Hanover's firebug for his study of flame stability and combustion. In the 1950s he created a plasma torch that produced flames twice as hot as the sun's surface. Passing nitrogen or hydrogen through a high-intensity electric arc, the torch cut metal like butter. Browning and Thayer colleague Merle Thorpe founded Thermal Dynamics Corp. to manufacture the device. Within three years the start-up had sales of \$1 million. A decade later, Thayer Professor Rob-

ert Dean Jr. and Richard Couch '64 Th'65 formed Hypertherm Inc. to produce a water-injection plasma torch that was nine times hotter than the sun. Today the employee-owned company has employees in 25 countries.

## NO. 45 FINDING UNEXPLODED ORDNANCE

For electromagnetic sensing technology that could help rid battle sites of unexploded ordnance (UXO), Professor Fridon Shubitzidze received a Project-of-the-Year award in 2011 from the Department of Defense. UXO is an enormous problem worldwide. In this country, approximately 11,000,000 acres of land hold a potential UXO hazard. Near Verdun, France, an estimated 12 million unexploded shells remain in the ground, many in degraded condition and full of toxic materials. "Our approach has consistently performed better than that of other teams during live-site studies where we were the only group to correctly identify all UXO items," said Shubitzidze. "That success is due to the advanced forward models developed at Dartmouth over the last 10 years which fully take into account the underlying physics of low-frequency electromagnetic sensing phenomena and are able to utilize all information provided by the sensors."

## NO. 46 WHISTLERS

In the early 1950s Professor Millett Morgan established a research program to use the newly discovered phenomena of naturally occurring audio-frequency radio waves produced by lightning and the aurora as a tool to study the properties of space plasma in the vicinity of Earth, a region now known as the upper ionosphere and the magnetosphere. These studies made it possible to gain insights about the properties of this region of near-Earth space in the years before spacecraft began to make direct observations. Morgan recorded the naturally occurring signals, referred to by descriptive names such as "whistlers" and "dawn chorus," at a network of receiving stations and interpreted them to obtain some of the earliest measurements of the density of free electrons many thousands of kilometers above Earth. His work provided

# FACULTY INVENTIONS

experimental foundations for early studies of how Earth and its magnetic field interact with the solar wind.

## NO. 47 UNDERSTANDING SUPERCOOLED LIQUIDS

Professor George Colligan and research engineer Victor Surprenant studied the supercooling of liquids to temperatures below their equilibrium melting point. As Erland Schulson, Thayer's George Austin Colligan Distinguished Professor explains: Highly supercooled liquids possess such a high thermodynamic driving force for solidification that the process occurs too rapidly for the microstructure of the solid that forms to coarsen. The result is a material with extremely tiny grains with very high strength. Colligan and Surprenant had to apply novel methods of observation, including high-speed photography and heat detection. Their studies of supercooled nickel, cobalt, iron and other metals showed that the liquid-to-solid growth velocity increased with the degree of supercooling, scaling with the square of the suppression of the freezing temperature—helping to confirm theory. Previously, Colligan developed a cobalt alloy that a former student, Professor John Collier '72 Th'73 '75 '77, uses in orthopedic implants.

## NO. 48 ADVANCES IN POWER ELECTRONICS

Professors Charles Sullivan and Jason Stauth Th'00 are brighten-

ing the future of solar energy by improving power electronics. "Power electronics is the glue that holds together all the different parts of an energy system," says Sullivan. "It's what interfaces between the solar panel and the grid, between the grid and the device that uses energy." Sullivan works on the inverters that convert DC to AC and drive power to and from the grid. "We want to make inverters as efficient as possible so that we don't lose energy during that conversion process," he says. Stauth develops solutions to the problem of current mismatch in strings of solar cells. A cofounder of the company QVSense (acquired by Solar Semiconductor), Stauth has developed a device that lets all the strings of cells operate independently.

## NO. 49 NEW MATH FOR A SMARTER GRID

Professor Amro Farid, an expert on intelligent energy systems and the head of the Laboratory for Intelligent Integrated Networks Engineering Systems at Thayer, along with researchers from the Massachusetts Institute of Technology, 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. These formulas—useful to the energy industry and public policymakers—tell exactly how much reserve capacity the power grid should have.

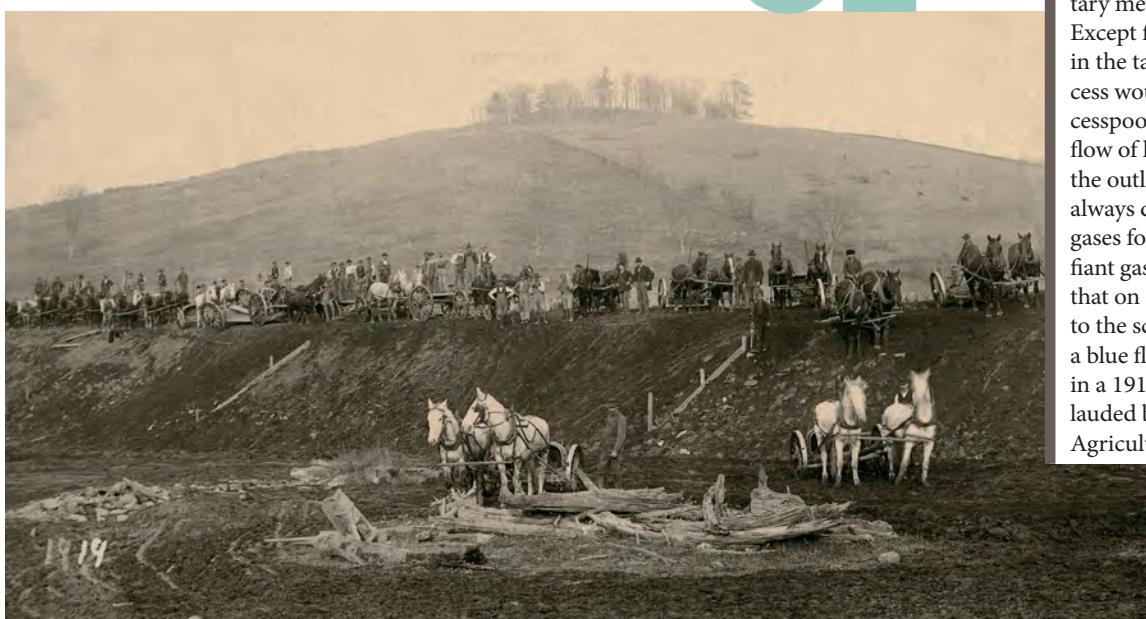


NO. 50

PROFESSOR ERIC FOSSUM INVENTED THE COMPLEMENTARY METAL-OXIDE SEMICONDUCTOR (CMOS) ACTIVE PIXEL IMAGE SENSOR THAT IS IN VIRTUALLY EVERY DIGITAL IMAGE SYSTEM, FROM CELL PHONES TO MOVIE CAMERAS

AS A FOUNDING MEMBER OF THE HANOVER WATER WORKS, ESTABLISHED IN 1892, PROFESSOR ROBERT FLETCHER OVERSAW CONSTRUCTION OF THE TOWN'S FIRST RESERVOIR

NO. 51



## BREAKTHROUGH IMAGE SENSORS

 Professor Eric Fossum invented the revolutionary complementary metal-oxide semiconductor (CMOS) active pixel image sensor that is in virtually every digital image system from cell phones to movie cameras—while working for NASA's Jet Propulsion Laboratory long before he joined the Thayer faculty. Dubbed the "Father of the Selfie," Fossum has been honored with the world's largest engineering award, the Queen Elizabeth Prize. But he isn't resting on those mighty laurels. He is working on the next generation of image sensors: the Quanta Image Sensor, which is poised to revolutionize imaging in extreme low-light conditions.

## PROVING THE WORTH OF THE MODERN SEPTIC TANK

 Professor Robert Fletcher, Thayer dean from 1871 to 1918, conducted a series of experiments using vegetables, bread, and bodies of dead animals to prove the value of a septic tank over other less sanitary methods of sewerage disposal. Except for bones, everything he put in the tank decomposed. "This process would not go on in a stagnant cesspool, only in one allowing a free flow of liquid from the inset end to the outlet. This was proven by trial. It always develops heat, and some of the gases formed (marsh olefiant and olefiant gases) are very inflammable, so that on applying a lighted match close to the scum, when that is disturbed, a blue flame appears," Fletcher wrote in a 1915 paper. The research was lauded by the U.S. Department of Agriculture.

## BOOKS by Thayer Faculty



### Antibody Fc: Linking Adaptive and Innate Immunity

*By Professor Margaret Ackerman and Falk Nimmerjahn* (Academic Press, 2013)

### Platform Revolution

*By Professor Geoffrey Parker, Marshall Van Alstyne, and Sangeet Paul Choudary* (W.W. Norton & Company, 2016)

### Operations Management for Dummies

*By Professor Geoffrey Parker, Mary Ann Anderson, and Edward Anderson* (Wiley, 2013)

### The Neurolab Spacelab Mission: Neuroscience Research in Space

*Edited by Adjunct Professor Jay Buckey Jr. and Jerry Horlick* (Lyndon B. Johnson Space Center, 2003)

### Space Physiology

*By Adjunct Professor Jay Buckey Jr.* (Oxford University Press, 2006)

### Optimization

*By Professor Al Converse* (Holt, Rinehart and Winston Inc., 1970)

### Introduction to Geophysical Fluid Dynamics

*By Professor Benoit Cushman-Roisin* (Prentice Hall, 1994)

### Physical Oceanography of the Adriatic Sea: Past, Present, and Future

*Edited by Professor Benoit Cushman-Roisin et al.* (Kluwer Academic Publishers, 2001)

### Introduction to Geophysical Fluid Dynamics: Physical and Numerical Aspects

*By Professor Benoit Cushman-Roisin and Jean-Marie Beckers* (Academic Press, 2011)

### Mixed Models: Theory and Applications with R, 2nd Edition

*By Adjunct Professor Eugene Demidenko* (Wiley, 2013)

### Axiomatic Design in Large Systems

*Edited by Professor Amro Farid and Nam Suh* (Springer, 2016)

### Deformation-Mechanism Maps: The Plasticity and Creep of Metals and Ceramics

*By Professor Harold Frost and Michael Ashby* (Pergamon Press, 1982)

### This Business of Television: The Standard Guide to the Television Industry

*By Adjunct Professor Oliver Goodenough and Howard Blumenthal* (Billboard Books, 2006)

### Law and the Brain

*Edited by Adjunct Professor Oliver Goodenough and Semir Zeki* (Oxford University Press, 2006)

### Law, Mind and Brain

*Edited by Adjunct Professor Oliver Goodenough and Michael Freeman* (Ashgate, 2009)

### Big Brain: The Origins and Future of Human Intelligence

*By Adjunct Professor Richard Granger and Gary Lynch* (Palgrave Macmillan, 2008)

### Fourier Transforms: Principles and Applications

*By Professor Eric Hansen* (Wiley, 2014)

### Long Shot: Vaccines for National Defense

*By Adjunct Professor Kendall Hoyt* (Harvard University Press, 2012)

### Cellulosic Biofuels: Importance, Recalcitrance, and Pretreatment

*By Professors Lee Lynd and Mark Laser and former Professor Charles Wyman* (John Wiley & Sons, 2013)

### Coastal and Estuarine Studies: Quantitative Skill Assessment for Coastal Ocean Models

*Edited by Professor Daniel Lynch and Alan Davies* (American Geophysical Union, 1995)

### Numerical Partial Differential Equations for Environmental Scientists and Engineers: A First Practical Course

*By Professor Daniel Lynch* (Springer, 2004)

### Sustainable Natural Resource Management for Scientists and Engineers

*By Professor Daniel Lynch* (Cambridge University Press, 2009)

### Particles in the Coastal Ocean: Theory and Applications

*By Professor Daniel Lynch, former visiting Professor Ata Bilgili, et al.* (Cambridge University Press, 2014)

### Alternative Breast Imaging: Four Model-Based Approaches

*Edited by Professors Keith Paulsen and Paul Meaney with Larry Gilman* (Springer, 2004)

### Physics of Ice

*By Professor Victor Petrenko and Robert Whitworth* (Oxford University Press, 2002)

### Identification and Control of Mechanical Systems

*By Professor Minh Phan and Jér-Nan Juang* (Cambridge University Press, 2006)

### Handbook of Biomedical Fluorescence

*Edited by Professor Brian Pogue and Mary-Ann Myslinski* (CRC Press, 2003)

### Creep and Fracture of Ice

*By Professor Erland Schulson and Paul Duval* (Cambridge University Press, 2009)

### Physics of the Magnetopause

*Edited by Professor Bengt Sonnerup et al.* (American Geophysical Union, 1995)

### Ultra Low Power Bioelectronics: Fundamentals, Biomedical Applications, and Bio-inspired Systems

*By Professor Rahul Sarpeshkar* (Cambridge University Press, 2010)

### The Next Production Revolution, Chapter 5: 3D Printing and its Environmental Implications

*By Professor Jeremy Faludi* (OECD Publishing, 2017)

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52  
E3

## NO. 84 CELLULOSIC ETHANOL BREAKTHROUGHS

Professor Lee Lynd Th'84 engineered a cellulose-dissolving bacterium and a single-step consolidated bioprocessing method that could lead to cheaper and more sustainable ethanol production. Hailed as an “alternative fuels pioneer,” Lynd received the first-ever Lemelson-MIT Award for Sustainability for “work that has the potential to improve global quality of life and protect the environment.” Lynd’s work centers on converting non-food biomass, such as grass, wood, straw, and corn stover, into ethanol—and on public policy issues surrounding energy. According to Nathanael Greene, a senior policy analyst at the Natural Resources Defense Council, “Lee’s ground-breaking research has driven forward the public policy debate, the business world, and the fundamental science of bioenergy.”



## NO. 85 DIGITAL MODELS OF HUMAN BEHAVIOR

To Professor George Cybenko, the Internet is a vast storehouse of data about human behavior that can reveal everything from buying habits to hacker and other malicious activities—if you have the right kind of analytical tools. In 2007 he and colleagues developed a new approach—Process Query Systems (PQS)—to assess huge

83  
TO SPACE AND BACK

**Professor Arthur Kantrowitz's Jupiter-C nose cone**, built in the late 1950s, was crucial for getting early rockets back to earth without them burning up. The first such nose cone has been enshrined at the Smithsonian.

There's also a Thayer connection with getting early spacecraft into orbit. The Henry C. Beck Company, headed by Henry C. Beck Jr. '38 Th'39, built the first launch facility at Cape Canaveral for the *Saturn* rocket in 1961.



amounts of online information and data collected by acoustical, video, seismic, and other monitoring means. The method provides a way to watch for deviations from normal interaction or activities, which may indicate malevolent and other kinds of anomalous organizational and individual behavior. The goal, Cybenko explains, is to build quantitative digital models of human behavior.

## NO. 86 PULSE ELECTROTHERMAL DE-ICING

Professor Victor Petrenko pioneered the study of pulse electrothermal de-icing (PETD), a method of ice removal and prevention that uses short pulses of electricity applied directly to an ice-material interface. PETD uses a thin, electrically conductive film applied to the substrate. The film is then heated with a milliseconds-long pulse of electricity. Because only a micrometer-thin layer of ice is melted, PETD achieves nearly perfect efficiency even in extreme cold. Regular pulsing can keep surfaces consistently ice-free while maintaining low overall power consumption. Research is ongoing for the extensive applications of PETD, such as de-icing of airplanes, ships, refrigeration systems, windshields, power lines, bridges, buildings, roads, walkways, and windmill turbines.

# NO. 87

ON FEBRUARY 3, 1896,  
THE WORLD'S FIRST  
DIAGNOSTIC X-RAY  
OF A SCHOOLBOY'S  
BROKEN WRIST

PROFESSOR LAURA RAY'S YETI ROBOT CARRIES INSTRUMENTS TO DETECT CREVASSES IN ANTARCTICA, USING METHODOLOGY DEVELOPED BY ADJUNCT PROFESSOR STEVEN ARCONC TH'77

# 88

NO.



# 150

GIFTS TO THE WORLD

## FIRST MEDICAL X-RAY

 Weeks after German scientist Wilhelm Roentgen announced in late 1895 the discovery of a "mysterious light" emitted from Crookes tubes, scientists and engineers from all over the world began experiments. One such person was Frank Austin, Class of 1895, a physics assistant at Dartmouth and later a professor at Thayer. Using equipment he built, Austin made a number of X-ray photographs, including one of his own hand in January 1896. On February 3, 1896, at Austin's suggestion, Hanover physician Dr. Gilman Frost and his brother, physics professor Edwin Frost, took the world's first diagnostic X-ray—of a schoolboy's broken wrist.

## POLAR ROBOTS

 Professor Laura Ray did research in system dynamics and controls when then-Thayer colleague Mark Lessard brought her an idea for an autonomous rover for carrying scientific instruments over polar ice sheets. Adjunct Professor James Lever of the Cold Regions Research and Engineering Laboratory helped Ray design a solar-powered "Cool Robot," which has been deployed to Greenland and Antarctica to tow instruments that measure air quality and snow structure. A second robot, Yeti, designed and fabricated by two groups of BE students under the direction of Ray and Lever, has been deployed to Greenland or Antarctica ten times since 2008.

## NO. 89 DISSECTING HUMAN INTELLIGENCE

Professor Eugene Santos is trying to understand the nature of human intelligence by unraveling the complex system of human behaviors. "I look at human behavior as: How do people make their decisions and take action. I want to explain the basis for why people do what they do." Examining a wide range of factors that influence behavior, including beliefs and experiences, Santos uses the theory of probability to assess, quantify, and rank degrees of influence. "Our influences aren't deterministic," he says. "Just because I have a cultural experience, you can't say this cultural experience will always produce a particular outcome. But influence can make an outcome more or less likely, so I try to capture those elements of what's more likely and what's less likely. That gives me a baseline. Then once I see an action, I can go back through the influence structure, including what they've told me about their beliefs, their demographics, their personal history, to see how they got from their background to their final action." Sounds like reverse engineering—because it is. "At this point the only way to understand a complex system is to reverse engineer it. To understand the system is to dissect it," says Santos.



**NO. 90****TRACKING POLAR CONDITIONS**

Several Thayer faculty members are studying the health of polar regions. Professor Donald Perovich, a glaciologist, measures ice-albedo feedback in the Arctic to assess rates of climate change. Tracking how much area is covered by sea ice, month by month, year by year, he has documented an accelerating decline in sea ice. Professor Mary Albert, who directs the U.S. Ice Drilling Program, is assessing polar regions in another way: interpreting climate information preserved in ice cores.

**FACULTY INVENTIONS****NO. 91 SOUND AND THE CITY**

Professor Minh Phan is modeling how sound waves travel through a complicated environment, such as a city core. He uses system identification to simplify the process. "We run the supercomputer simulation once and collect data from that simulation, then process the data to arrive at a mathematical model that captures the physics of that specific environment. The model can be used to simulate the propagation of another sound source from that location. It is a simple model of a complicated model," he says. "My research group was able to develop techniques that take data from one run of the supercomputer and quickly arrive at a high-fidelity reduced-order model that can run on a laptop in minutes." The sound propagation model has military, security, and surveillance applications, such as tracing the source of gunshots or bomb blasts. "If we know the dynamics of the forward model, we can produce an inverse model to recover the source signal and its location," says Phan.

**NO. 92 THERMOBLAST DRILL**

In 1977 a new kind of drilling technology, dubbed "Thermoblast" by its inventor, Professor James Browning '44, was successfully field tested on the polar ice. The high-temperature rocket drill pierced the 1,400-foot-thick ice shelf so scientists could study the ocean underneath. Drilling time: nine hours. After his success in Antarctica, he secured nearly \$240,000 in funding from the National Science Foundation to develop a suspension core drill that would make it possible to use flame-jet technology for another tricky task: studying rock formations under ice caps and glaciers.

**NO. 93 CLEANER SMELTING**

In the world of smelting, Thayer Professor Paul Queneau is famous for getting the lead out. Queneau teamed with Purdue University Professor Reinhart Schuhmann Jr. and the German firm Lurgi to invent a cleaner, more efficient smelter. The Queneau-Schuhmann-Lurgi smelter emits half the greenhouse gasses of conventional smelters.

**NO. 94 UNCOVERING MICRO-PLASTICS IN THE ARCTIC**

Assistant Professor of Engineering Rachel Obbard and her colleagues discovered that ocean currents had carried micro-plastics—defined as polymer particles under 5 millimeters long—all the way to the Arctic, where they became trapped in sea ice. Her research, published in a 2014 paper titled "Global Warming Releases Microplastic Legacy Frozen in Arctic Sea Ice," reported that plastic particles exist in the ice at higher concentrations than previously thought. "Our findings indicate that micro-plastics have accumulated far from population centers and that polar sea ice represents a major historic global sink of man-made particulates," she writes. To keep the problem from growing, she advises: "Stop using toiletries and cleaning products containing polymer beads, including some toothpastes and facial scrubs. We can also clean the filters in our washing machines regularly, avoid flushing hygiene products, and reduce the number of plastic containers we buy."

**WORLD'S FASTEST TRACK**

 In 1938 legendary miler Glenn Cunningham came to Hanover for an exhibition race because Dartmouth track coach Howard Hillman believed that Dartmouth's new indoor track was the fastest in the nation. The track was engineered by Thayer Professor Harold Lockwood, who didn't know that tracks of the era were built of hardwood laid atop cement. Lockwood's design called for spruce planks laid over cinders and two-foot banked curves. The College's carpenters screwed up and built three-foot banked curves. The steeper banks and springier surface helped propel Cunningham to a record-braking 4:04.4 mile. "It's the greatest track I've ever run on," Cunningham told *The Dartmouth*.

**NO. 95 MAGNETIC NANOPARTICLES FOR HYPERTHERMIA**

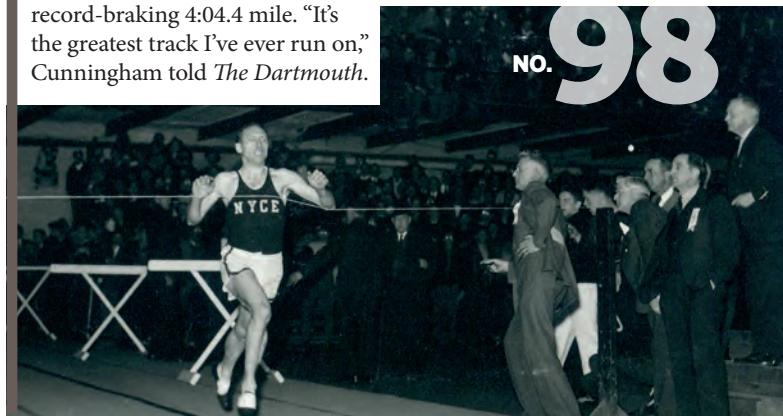
Materials scientist Ian Baker, Thayer's Sherman Fairchild Professor of Engineering, is creating new biocompatible iron-oxide nanoparticles coated with dextran for use in hyperthermia treatment of cancer. "They heat better than those sold commercially," says Baker, an expert in metal alloys. Producing particles that range in size from 8 to 100 nanometers, his group is characterizing the properties of the particles, including measuring how well they absorb electromagnetic power.

**NO. 96 SUPERDARN ARRAYS**

Professor Simon Shepherd Th'98 led construction of two massive radar arrays in Oregon that form part of the global Super Dual Auroral Radar Network (SuperDARN) studying the effects of solar disturbances and coronal mass elections on the ionosphere. He also assisted in constructing other SuperDARN arrays in Alaska and Kansas.

**NO. 97 ANT HOUSE**

Retired electrical engineering Professor Frank Austin, Class of 1895, was in dire need of money following the stock market crash of 1929. Austin, a member of the Dartmouth team that produced the first medical X-ray and the author of numerous papers and texts on electricity, went into his workshop and invented the Austin Ant House. His invention became a national success story. At the peak of production in the mid-1930s, 400 Austin Ant Houses a day left Hanover. Austin's economic success trickled down to the local economy. He hired local handymen to build them and paid Hanover kids \$4 a quart for the estimated 3.6 million ants he shipped to populate his ant communities.

**NO. 98**

**ALTA MOTORS**

 MEM grads Marc Fenigstein '01 Th'04 and David Drennan Th'09 want their Redshift electric motorcycle to be the Honda of the 21st century. Says Fenigstein, "We found a way to make everyone want electric: by making them go faster." Previously called BRD Motorcycles, Alta Motors is producing electric motorcycles that have the power to outperform their gas-powered rivals.

**BIOLITE**

 The BioLite Stove, invented by Jonathan Cedar '03 and Jonathan den Hartog '03 Th'05, is a biomass-powered cook stove that uses its own waste heat to improve combustion efficiency. BioLite claims that its stoves produce 90 percent fewer particulate and carbon monoxide emissions and use 50 percent less wood than cooking over an open fire. The stove addresses a huge problem: Three billion people around the world still cook on open wood or dung-fueled fires or inefficient stoves, leading to more than two million premature deaths every year, according to the World Health Organization. Cedar, who majored in engineering modified with environmental science, sees another potential benefit of the technology: cutting soot's black carbon emissions, a major contributor to global warming. "But the biggest story here is that two million people die," he says. "That's ultimately, in my view, the reason to be doing this."

99  
NO.

ALTA MOTORS  
DEVELOPED AN  
ELECTRIC MOTOR-  
CYCLE THAT CAN  
OUTPERFORM GAS-  
POWERED RIVALS

THE BIOLITE STOVE  
BURNS EFFICIENTLY  
AND CAN CHARGE  
DEVICES

NO. 100

**NO. 101 HYPERTHERM**

In 1968 Richard Couch '64 Th'65 and Professor Robert Dean Jr. started Hypertherm Inc. in a two-car garage to produce a water-injection plasma torch that was nine times hotter than the sun. Today Hypertherm is a world leader in producing plasma, laser, and waterjet systems, software, motion controls and consumables. Couch, a Thayer Overseer, built Lebanon, N.H.-based Hypertherm into an employee-owned company with an award-winning culture of corporate social responsibility.

**NO. 102 SPROXIL**

"The growing trade in fake pharmaceuticals is of great concern in the developing world because of the large impact it has on human life," says Ashifi Gogo Th'10, the first graduate of Thayer's PhD Innovation Program. More than 700,000 deaths a year result from fake and substandard tuberculosis and malaria drugs alone. Gogo founded Sproxil to combat counterfeiting through a cell phone-based product verification service that is now used in Ghana, Kenya, Nigeria, India, and other areas where fake drugs are a problem.

**NO. 103 KONGA.COM**

E-commerce pioneer Simdul Shagaya Th'99 founded Konga.com in 2012 as the Amazon of Africa, selling the region's increasingly affluent consumer class everything from groceries to electronics. The MEM graduate previously founded DealDey, a Groupon-style group-buying site that employed a fleet of motorcycles to meet online shoppers across Lagos, Nigeria, waiting to pay for their purchases with cash. Shagaya, who says that this type of infrastructure is essential to e-commerce in developing countries, was named 2013 Leadership CEO of the Year by the Nigeria Leadership Newspapers Group for "his ardent efforts to making online shopping a mainstream activity" in Nigeria and building the country's largest online shopping mall.

**NO. 104 REVERSE OSMOSIS COMPANIES**

When Dean Spatz '66 Th'67 and Chris Miller '66 Th'67 took ES 21: Introduction to Engineering, commercial applications for reverse osmosis systems were in their infancy. Given a jar of brackish water and told to find a way to make it potable, the pair came up with a prototype for a reverse-osmosis purification system. They ramped up their undergraduate project into graduate-level research that eventually led each to found companies: Spatz's Osmonics (now part of GE) and Miller's Aqua Design.

**NO. 105 PLASTIC SOLAR THERMAL PANELS**

"The key to any entrepreneurial endeavor is finding a need and filling it," observes Freeman Ford '63. He found his opportunity literally in his backyard—his swimming pool. Pool heaters in 1969 were expensive to install and operate. So Ford thought like an engineer. "Swimming pools use a huge amount of energy, they are a big storage tank, and they have a circulation pump, so they have the three things necessary for a solar thermal system," he thought. "The only thing they don't have is a collector." Ford decided to build solar collectors out of plastic. The company he started has sold more than 1.75 million solar heating systems. In 2006 Ford was inducted into an international honor society created by Congress: the Solar Hall of Fame.

**NO. 106 MACLEAN-FOGG**

When Barry MacLean '60 Th'61 took over the business his grandfather founded in 1925 to produce locking fasteners for railroads, he built the company into a global enterprise consisting of two primary businesses, MacLean-Fogg Component Solutions and MacLean Power Systems, with 40 global manufacturing facilities, annual sales in excess of \$1 billion, and a worldwide workforce of more than 4,500 people. MacLean, a longtime Thayer Overseer, is the company's CEO and chairman. His son Duncan '94 Th'95 '96 is president.

**LUMINAID**

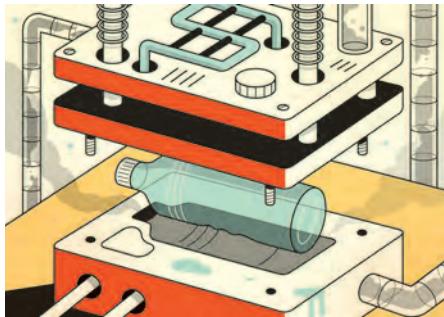
 For millions without power in the wake of hurricanes Harvey, Irma, and Maria, Anna Stork '08 is helping provide some respite. Her company, LuminAID, made the world's first handheld inflatable, rechargeable LED lamp and has stepped up its distribution to these hard-hit areas—along with LuminAID's newest product, a waterproof phone charger-lantern combo called the PackLite Max 2-in-1 Phone Charger. Stork and her LuminAID cofounder won over their first major investor, Mark Cuban, in 2015 on ABC's *Shark Tank*.

**NO. 107**

LUMINAID MADE THE FIRST HANDHELD INFLATABLE, RECHARGEABLE LED LAMP

## NO. 108 PLASTIC TECHNOLOGIES INC.

**Tom Brady '66**  
Th'68 founded Plastic Technologies Inc. (PTI) in 1985. The premise for creating PTI was that Coca-Cola bottlers wanted to develop innovative PET plastic soft drink packaging products. PTI is recognized today as the premier PET technical development and support resource in that industry, with nearly 120 employees worldwide, and offices and labs in Ohio and Geneva.



Recent technological developments include biopolymers, nanotechnology for material additives, flexible packaging and pouches, sustainable packaging initiatives, and instrument development with new sensors.

PLASTIC TECHNOLOGIES CREATED INNOVATIVE SOFT DRINK PACKAGING

**NO. 109 JETBOIL**

Dwight Aspinwall '84 was frustrated with clunky camp stoves so he engineered his own. Jetboil, the company he cofounded to build and sell the stove, is legendary among backpackers. Thayer students helped optimize Jetboil's burner assembly and flame testing.

### NO. 110 TILTING MOTOR WORKS

Bob Michell '85 Th'86, founder of Tilting Motor Works, developed a breakthrough leaning three-wheel conversion system that offers the stability and safety benefits of three wheels with the handling of a motorcycle. The patented device was developed with the help of a team of Thayer students. The invention is cool and fast. At Bonneville Salt Flats, Michell broke the land-speed record for three-wheeled motorcycles by more than 10 mph in 2012, hitting 132.342 mph over one mile.

**NO. 111 LIQUID LIGHT**

Liquid Light, a company co-founded by Kyle Teamey '98, uses energy from light or any electric power source to convert waste carbon dioxide into industrial chemicals and transportation fuels, in a process similar to artificial photosynthesis or reverse combustion. While the company won't be doing large-scale production for several years, it has made a handful of key breakthroughs in catalysis that can eventually lead to improving energy security and reducing oil imports and greenhouse gas emissions.

**NO. 112 OWLER.COM**

Owler.com, cofounded by Tim Harsch '11, bills itself as "the world's largest community-based competitive insights platform." "We track more than 4 million companies around the world to allow people to stay up-to-date on their competitors, clients, partners, and sales prospects and always know when there is a big news event, acquisition, leadership team change, or round of funding at any company they follow," says Harsch. "We also show members how they compare against their closest competition."

**NO. 113 UPSTART**

Dave Girouard '88 Th'89 co-founded the crowdfunding platform Upstart in 2012 to connect enterprising students with people who want to invest in them. A former VP of apps and president of enterprise at Google, Girouard told *Forbes*: "We aim to make Upstart a network that people are engaged with, not just a place where they receive funding." He says he wants to help young people "forgo the traditional job search and pursue what they want to do." He speaks from experience. "My career was really shaped in the early years by my need to pay back student loans," he says. "It wasn't until six years after I left Thayer that I made a career decision based on what I wanted to do, rather than what I felt I needed to do. Younger people have all the energy needed, and are actually in a better position to take on a risky venture. Why not help more grads make the right decision by giving them a bit of economic freedom, coupled with advice and mentorship from those who have done it before." Upstart initially launched at five colleges, including Dartmouth. Today Upstart touts itself as "the first lending platform to leverage artificial intelligence and machine learning to price, credit, and automate the borrowing process."

**NO. 114 POLARIS PARTNERS**

Venture capitalist and Thayer Overseer Chair Terry McGuire Th'82 has the connections and vision that have helped build more than 25 successful new companies. McGuire, who cofounded Polaris Partners in 1996, has raised more than \$3.5 billion to invest in promising companies. He has backed startups including Akamai Technologies (one of the most successful public stock offerings of the dot-com era, and today worth nearly \$10 billion) and the Dartmouth spin-out GlycoFi, acquired by pharmaceutical giant Merck for \$400 million.

**ARTISTIC SUGAR SHAKER**

 Henry C. Keck '43 Th'44 Tu'44 started an industrial design firm, Keck-Craig in 1951. The 1,500 items he and the firm produced include a sugar shaker that is considered a work of art. Design historian Bill Stern described Keck's 1955 sugar shaker to the *L.A. Times* as "the essence of modernism, a perfect meld of function and form. There's not a whit of unnecessary decoration. It's made inexpensively but responsibly, so it won't prematurely break or wear out. Viewed at a distance, it is an extremely elegant object."

**PANAMA CANAL EMERGENCY LOCKS**

 As assistant chief engineer of the American Bridge Co., Otis Hovey, Dartmouth 1885, Thayer 1887, worked on some of the biggest projects of his era, including designing the superstructure of the Bellefontaine Bridge across the Mississippi and designing and building six emergency dams for the Panama Canal. Hovey was also the authority on moveable bridges. He wrote the subject bible, *Moveable Bridges*, published in 1926, and held patents on three moveable bridge designs that he dubbed Types O, E, and H—which just happen to be his initials.

NO.  
**115**

KECK'S 1955 SUGAR  
SHAKER

ONE OF SIX EMER-  
GENCY DAMS FOR  
THE PANAMA CANAL

NO.

**116**

**NO. 117 WEST POINT'S RIGOR**

When Sylvanus Thayer, Dartmouth 1807, was superintendent of the United States Military Academy at West Point from 1817 to 1833, he introduced discipline, seriousness of purpose, and an exacting engineering curriculum. With these measures, he forever changed the previously lax academy, from which he graduated in 1808, and became known as the "Father of West Point."

**NO. 118 BOSTON HARBOR  
FORTIFICATIONS**

In 1833 work began on new fortifications for Boston Harbor. The supervising builder of Forts Independence, Warren, and Winthrop was Sylvanus Thayer, Dartmouth 1807. Earlier in his career, as a second lieutenant in the U.S. Army Corps of Engineers during the War of 1812, Thayer planned and directed the defense of Norfolk, Virginia. Though the British captured many of other coastal fortifications, they were unable to take this one. For this achievement, Thayer was made brevet major (a higher rank without higher pay).

**NO. 119 POCKETCPR**

Mark Totman '71 Th'72 created a free app that teaches users how to perform CPR via an embedded training course and gives feedback when performing CPR (push harder, push faster, etc.). The app has been downloaded more than one million times.

**NO. 120 HISTORY OF  
WOODEN BRIDGES**

In 1932 Jonathan Snow, Thayer Class of 1875, and his mentor, Professor Robert Fletcher, dean of Thayer from 1871 to 1918, published what the New Hampshire Division of Historical Resources describes as "one of the great documents of bridge building history." *A History of the Development of Wooden Bridges* was so highly valued as a pioneering study that it was reprinted by the American Society of Civil Engineers in 1976 and several times since. Four decades earlier, Snow, who had worked his way up to chief engineer of the Boston and Maine Railroad, had written a paper praising the low cost, strength, and resilience of wooden bridges. By the time *A History of the Development of Wooden Bridges* came out, both authors were in their mid-80s and saw that the era of the wooden bridge was over. Still, the pair could not resist making one final pitch for the wooden bridge—"where suitable lumber for lattice bridges is abundant and where fabricated steel is costly, as was the case in New England during the Nineteenth Century, and is now the case in Southern Alaska, Northern Russia, and Siberia, and perhaps in some parts of South America, lattice truss bridges are economical and can be made perfectly good up to spans of 200 feet. If properly covered and maintained, such bridges will give from 50 to 100 years service."

**150**  
GIFTS TO THE WORLD

# ALUMNI INNOVATIONS

NO. 121

## **BIO COMPUTERS**

Drew Endy Th'98, a professor at Stanford's School of Engineering and a pioneer in the field of synthetic biology, led an engineering team that succeeded in making a simple computer inside a living cell. It is the latest step in the field of synthetic biology where—one gene at a time—engineers strive to design organisms unlike anything made by Mother Nature. The tiny computers could deliver true-false answers to virtually any biological question that might be posed within a cell. For instance: Is toxic mercury present in plants or animals used for food? Scientists could introduce a detective “sentinel” organism

—Lisa M. Krieger  
(Originally published in the *San Jose Mercury News*;  
adapted with permission)



# NO. 122

## **CASHEW-SHELLING MACHINE**



 As a BE student, Richard Couch '64 Th'65 saw an opportunity to engineer a solution to a big problem facing a nascent African cashew industry—how to shell the cashews. He wanted to design a machine that could shell the cashews while keeping the nut apart from its toxic oil. Under Professor Robert Dean Jr.'s tutelage, he designed a device that used a controlled explosion to shell the nuts. The two were awarded a patent in 1971. They tried to put it into production, approaching USAID for funding, but Cold War politics intervened: Russians were the primary buyers of African cashews, and the U.S. government didn't want to fund anything that could be seen as helping the Soviet Union. The idea was shelved.

NO. 123 TEHACHAPI LOOP

Dartmouth produced engineers of national importance even before the founding of the Thayer School. William Hood, Dartmouth 1867, for example, was the engineering genius behind California's Tehachapi Loop, one of the seven wonders of the railroad world and a National Historic Civil Engineering Landmark. Professor Robert Fletcher, dean of Thayer from 1871 to 1918, described the Tehachapi Pass between San Francisco and Los Angeles as "a bewildering labyrinth of lofty peaks and ridges where the roadbed twists and squirms by every sort of horseshoe curve, S curve, and spiral." Hood's loop is the crowning glory of the 28 miles of rail line that snakes through the mountain pass. The elegant .73-mile spiral alone ascends at a 2-percent grade for an elevation gain of 77 feet. A train longer than 4,000 feet—some 85 cars—passes over itself as it travels along the extraordinary layout. William Hood's Tehachapi Loop in the mountains between San Francisco and Los Angeles was completed in 1876 and still carries up to 40 trains a day.

had something to do with that. That bridge will be there not just one or two but probably three generations from now because these big bridges will last 150 years. It is a matter of some pride."

## **NO. 125 PUSHING BUSINESS SUSTAINABILITY**

Chris Davis '76 gave up a high-powered legal career to spread a message the world cannot afford to ignore: "Climate change is a risk to the entire global economy." As director of the investor relations program at Ceres, a nonprofit that advises corporations and institutions on sustainable business practices, Davis works at the intersection of big money and environmentalism. He rubs elbows with Fortune 500 executives, money managers who control billions of dollars, and eco-celebrities such as Bill McKibben, who founded 350.org to help solve the climate crisis. The economic case Davis makes for sustainable business and investment strategies is straight and to the point: Socially conscious investing isn't code for poor monetary returns. "Big companies are starting to get that sustainability issues should be integrated into corporate strategy and management. These things are important and impact the bottom line," he says.



## NO. 127 TRAILERTAIL

Jeff Grossmann '06 Th'07 and Chuck Horrell '00 Th'01 were part of the team that invented and commercialized the TrailerTail, a collapsible, rear-drag-reduction technology that reduces the fuel consumption of 18-wheel tractor-trailers by 5 percent due to improved aerodynamics. More than 50,000 TrailerTails are now being used across North American highways—and they have already saved more than 60 million gallons of diesel fuel. The parent company, ATDynamics, was founded by Andrew Smith Tu'07 while he was at Tuck. Austin Duncanson Th'13 is now a key leader on the full-time engineering team.

## NO. 128 DARTMOUTH JEWISH SOUND ARCHIVE

Launched in 2002 by Thayer Professor Alex Hartov Th'88 '91 and Jewish studies Professor Lewis Glinert, the Dartmouth Jewish Sound Archive is one of the world's leading online archives of Jewish recordings. The archive collects, restores, and digitizes recordings of the pre-digital age, including rare and often unique recordings, including folk songs, synagogue music, radio programs, humor, children's stories, and anything that reflects the Jewish experience in English, Hebrew, Yiddish, Ladino, Russian, Arabic, French, and other languages. More than 50,000 tracks are now online at djsa.dartmouth.edu.

## NO. 129

A TRICYCLE THAT FILTERS WATER

FORWARD-FACING ROWBOAT

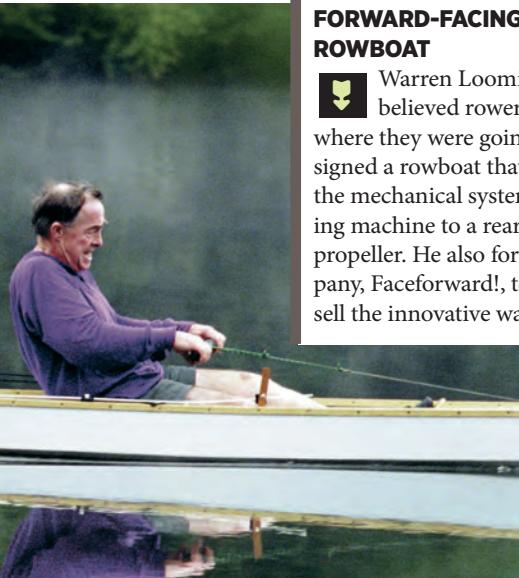


## AQUADUCT

In 2008 Brian Mason '03 Th'04 '05 led a team that engineered a tricycle to bring clean water to families living in the developing world. Their invention, the Aquaduct, took first prize in Google's "Innovate or Die Pedal-Powered Machine Contest." The Aquaduct is a pretty simple idea: The trike is ridden to a water source and filled with a day's supply of water. Pedal power filters the water on the ride home. The team didn't expect the invention to go into production. "It was designed to demonstrate an innovative concept and draw attention to the need for clean water in the developing world," they wrote in their blog. "In its current state, the design would be too expensive for many parts of the world."

## FORWARD-FACING ROWBOAT

Warren Loomis '62 Th'65 believed rowers should see where they were going so he designed a rowboat that connected the mechanical system of a rowing machine to a rear-mounted propeller. He also formed a company, Faceforward!, to build and sell the innovative watercraft.



## NO. 130 THE CIVILIZED ENGINEER

Thayer School's emphasis on the need for liberally educated engineers has no better spokesperson than Samuel Florman '46 Th'46. His book *The Civilized Engineer*, published in 1987, has become a classic. He was elected to the National Academy of Engineering "for literary contributions furthering engineering professionalism, ethics and liberal engineering education" in 1995. In this excerpt from an article he wrote for *The Scientist*, Florman makes the case for Thayer School's approach to an engineering education: "I am convinced that the quality of our technology, and consequently the quality of our lives, would be improved by the liberal enrichment of engineering education, by the broadening of horizons, the deepening of cultural awareness—in short, by the civilizing—of engineers...I suggest that liberal education for engineers would bring members of the profession into leadership roles from which they are presently excluded, and that this, in turn, would bring significant economic and political benefits. Engineers do not have answers to all the great questions, but their absence from decision-making groups clearly works to our nation's disadvantage."

**GYROBIKE**

 The GyroBike, a stabilizing beginner's bicycle, rode all the way to *Popular Mechanics* magazine's 2006 Breakthrough Awards. "It's an elegant, simple solution to the eternal problem of learning to ride a bike," wrote Jim Meigs '80, the *Popular Mechanics* editor who oversaw the awards project. Hannah Murnen '06 Th'07, Augusta Niles '07, Nathan Sigworth '07, and Deborah Sperling '06 Th'07 created the bike in ENGS 21: Introduction to Engineering in 2004. They sold the rights to their invention in 2013 to a British firm that sells the bike under the name Jyrobike.

**HUMANITARIAN ENGINEERING**

 Thayer students have carried out several humanitarian projects since the 2000s, including creating clean-water and micro-hydropower systems and a clean-burning cook stove program in Africa. Students working with VillageTech Solutions, a California-based non-profit run by Thayer Overseer Edward "Skip" Stritter '68, have built wire bridges and developed inexpensive systems to filter arsenic out of drinking water.

**STUDENT PROJECTS****NO. 133 MOBILE VIRTUAL PLAYER**

It takes a smart team to build a really good dummy. In the case of the Mobile Virtual Player (MVP) the project began with two Dartmouth '79s, Thayer research engineer John Currier Th'81 and football coach Buddy Teevens. The pair had brainstormed about how to simulate tackling after Teevens ended full-contact practices in order to reduce head injuries. "We decided the most effective way would be to take it to the Thayer School and position it as a capstone project," says Currier, who reached out to Elliot Kastner '13 Th'14 '15, an engineering student and Dartmouth football player. Kastner assembled a BE team that included Noah Glennon Th'14 '15, Andrew Smist '13 Th'14, and Quinn Connell '13 Th'14 to design and build the MVP. The MVP debuted at the football team's training camp in 2015.

After field testing on the Dartmouth gridiron and tweaking it back at Thayer, the team took the MVP to the next level: They started a company. Now half the NFL teams have MVPs, and the dummy has appeared with Stephen Colbert on *The Late Show* and in an NFL commercial aired during the 2016 Super Bowl. New BE student teams are working to modify the MVP for use in other sports and applications.

**NO. 134 EXPANDABLE EYE-SOCKET IMPLANT**

In a BE project sponsored by Aurolab, Amanda Christian Th'12, Elizabeth Chang Th'12, and Chris Ng Th'12 created a hydrogel sphere as an expandable eye-socket implant to treat infants born with no or atrophied eyeballs. The sphere, made of cross-linked polymers, can grow with the infant's skull by absorbing fluid from the surrounding tissue, reducing the number of implant surgeries children have to undergo.

**NO. 135 MICROFLORA ISOLATION FOR FECAL MICROBIOOTA TRANSPLANTATION**

For a BE project sponsored by Pureflora Inc., Jennifer Freise '12 Th'13, Taylor Gray '13 Th'13, Pauline Schmit '13 Th'13, Alison Stace-Naughton '11 Th'13, and Sharang Biswas '12 Th'13 developed a clean solution to a messy problem: preparing healthy fecal microbiota for transplantation into patients suffering from *Clostridium difficile* (*C. diff*), a virulent intestinal pathogen. The device, which borrowed from prior BE work by Peter Ankeny '12 Th'12, Alex Engler '12 Th'13, and Will Hart '12 Th'12, is a healthy step forward for fecal microbiota transplantation as a treatment for *C. diff*.

**NO. 136 CUSTOM MUSICAL KEYBOARD**

When taking ENGS 21: Introduction to Engineering, Renee Foisy '88, David Lindahl '86, Christoph Mack '88, Corey Brinkema '86, Susan Smith '86, and Patrick Walsh '88 met Maureen Gaynor, a young musician with cerebral palsy who wanted to be able to play chords. The students "decided they would make her a piano," says Professor John Collier '72 Th'73 '75 '77. "They talked to Casio and got them to donate an electronic organ. They tested her ability to move and realized one hand had much more control than the other and that she could only put her hands out to the sides. They did lots of testing with Maureen and got the angle of the keyboard just right and the size of the keys right. The students went to the wood shop at the Hopkins Center and made this whole electric piano case out of cherry so it looked like furniture. Here at Thayer they tested the tactile feel of all the different plastics, picked the most appealing, and then machined each key individually and

NO. 137



hooked each up electronically to the organ. Toward the end of the term one member of the group took the piano down to Crotched Mountain, set it up, and set up a video camera. Maureen rolled over to the keyboard and began to play ‘Silent Night.’”

#### NO. 138 COLLAPSIBLE NEBULIZER

When taking ENGS 21: Introduction to Engineering, Zakieh Bigio ’10, Elizabeth Dain-Owens ’10, Catherine Emil ’10, Sarah Feldmann ’11, and Sarah Rocio ’10 developed a handy device for asthmatics: a collapsible portable nebulizer with a novel two-way valve that allows the patient to hold the device in his or her mouth while breathing normally.

#### NO. 139 LONGBOARD BRAKE

The Hill Breaker, an ingenious ENGS 21: Introduction to Engineering project, makes longboarding down steep hills a lot safer by using centrifugal force to automatically regulate speed. On each front wheel a pair of pivoting brake shoes rotates within a brake drum fixed to the axle. At low speeds the brake shoes are held retracted by springs. As speed increases and the centrifugal force of the brake shoes exceeds the spring force, the brake shoes pivot outwards against the brake drum, generating smooth resistance that increases with speed. The Hill Breaker was the brainchild of Katherine Conway ’13, Ethan Dreissigacker ’13, Scott Lacy ’13, and Christopher Magoon ’13, with assistance from Anastasia Milano ’10.

#### NO. 140 NATION'S FIRST OVERHEAD SKI TOW

F. Bryon Tomlinson ’35 Th’36 designed the Dartmouth Ski Tramway when he was a Thayer student under the direction of Professor William Kimball ’28. The J-bar, installed at Oak Hill in 1935, is considered the nation’s first overhead ski lift. With an 80-horsepower engine, the lift moved 600 skiers per hour 1,200 linear feet up Oak Hill for an elevation gain of 350 feet.



#### NO. 141 STETHOSCOPE FOR HEARING-IMPAIRED DOCTOR

Dartmouth medical student Rob Nutt ’88 had to wear hearing aids since age 3 because of bilateral sensory hearing loss. In 2003 a team of Thayer students made it possible for him to use a stethoscope. They created a high-fidelity stethoscope by using an FM assisted-hearing system to mike up a stethoscope and amplify it into Nutt’s hearing aids.

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## CURRICULAR ADVANCES

#### V-12 PROGRAM

After Pearl Harbor, America’s standard four-year college experience became a casualty of war. With the draft age lowered to 18, many young men could not enroll in college before entering the military. Adjusting to the consequent shortage of college-educated commissioned officers, the Navy developed a way to combine college education with military service: the V-12 Navy College Training Program. Dartmouth became host to the largest V-12 unit in 1943, when some 2,000 enlisted men and an officer staff came “on board” at the College—including 300 students from Dartmouth and 74 from Thayer. Dartmouth operated like a naval base for the rest of the war.

#### PHD INNOVATION PROGRAM

In 2008 Thayer School started the nation’s first PhD Innovation Program to address the need for leaders with both technical and entrepreneurial expertise. “Students learn about intellectual property, funding, capitalization, cash-flow issues, how to operate a business, management practices, ethics, how to hire a good team, how to balance an organization, and how to be a leader,” says the program’s faculty coordinator, Professor Eric Fossum, an inventor, entrepreneur, and CEO with decades of experience commercializing technologies.

#### WOMEN IN SCIENCE PROJECT (WISP)

In 1990 Carol Muller ’77, an associate dean at Thayer, and chemistry Professor Karen Wetterhahn launched WISP to increase the number of women in science. Twenty-six years later, Thayer awarded 54 percent of its undergraduate engineering degrees to women, the first national research university to award more bachelor degrees in engineering to women than men. WISP has hit other milestones: The number of Dartmouth women majoring in the sciences

jumped from 45 in 1990 to 246 (52.3 percent of all science majors) in 2016; more than 4,500 students have been placed with mentors; and more than 1,800 have become research interns.

#### ENGS 21: INTRO TO ENGINEERING

Life-changing. That’s how countless students have described Thayer’s signature introductory course since it became a real-world problem-solving experience in 1961. Over the years various projects became the foundation for patents and companies, including Osmomics, Aqua Design, GyroBike, and Tray Bien. “My entire work life is an extension of the concepts I learned in Engines 21,” says Thayer Overseer Andrew Silvernail ’94, CEO of IDEX. Various students have replicated ENGS 21 abroad; most recently, George Boateng ’16 launched Project iSWEST, an ENGS 21 experience for high schools students in Ghana.

#### ENGINEERING AND PUBLIC POLICY

Thayer’s engineering and public policy modified major, offered in conjunction with Dartmouth’s Rockefeller Center, is a program for the aspiring public servant who realizes it will be useful to understand technology—and for the engineer who realizes that public policy affects which technologies are funded and chosen for development and adoption. “Society needs more than technical skill from engineering graduates today. We need graduates with the ability to apply those skills to solve society’s most pressing problems in critical areas, such as energy, communications, the environment, and medicine,” says Thayer Dean Joseph Helble. “Our collective future depends on it.”

#### MEM PROGRAM

When Charles Hutchinson ’68A became dean of Thayer School in 1984, the Board of Overseers asked him to launch a program similar to the Tuck-Thayer program, offered from 1942 to 1962,

in which students attended Dartmouth for three years and then Thayer and Tuck for two more years. The Master of Engineering Management program that grew from that beginning set the tone for similar programs at other schools.

#### HANDS-ON MACHINE SHOP

Back before maker spaces became a thing, Thayer’s machine shop operated as a hands-on creative hub for students, both engineers and non-engineers. Teaching the “doing part of engineering,” as machine shop manager Kevin Baron puts it, the shop has been crucial to Thayer’s project-based curriculum for decades.

#### PROJECT NORTHSTAR

From the vantage point of 2017 the idea of a “general-purpose computer environment uniquely suited to the research and educational needs of engineering” seems quaint. But back in 1986, when Professor Daniel Lynch launched Project Northstar, the concept was a big step forward in academic computing. His idea was to create a high-speed network built around complementary hardware and software. By the project’s second year it had more than 300 users and 11 classes took advantage of its initial applications, including a 3D crystal lattice modeler, graphical calculator, and a data grader.

#### FORMULA HYBRID

When Thayer students were barred from entering a hybrid vehicle in a Society of Automotive Engineers competition, they started their own in 2015, with major help from Thayer instructional engineer Douglas Fraser. Racing may drive many of the Formula Hybrid student competitors to design and build fuel-efficient high-performance cars. But for director Fraser, the real motive is getting students from other institutions to do what Thayer students do all the time: work across disciplines to solve complex problems.

# Alumni News

FROM AROUND THE WORLD

## spotlights

Laura DeNardis '88



Growing concerns about cybersecurity, censorship, and social media regulation are on the front pages of national newspapers and before congressional hearings—and former engineering major **Laura DeNardis '88** has become the go-to expert on Internet governance. *Slate* magazine called her one of the field's top seven international players in its "Cheat Sheet Guide to Who Controls the Internet," citing her research into the power structures that have shaped Internet policy. In October, Google, Facebook, and Twitter were embroiled in controversy surrounding Russia's involvement in last year's U.S. elections, and DeNardis weighed in on the topic of greater regulation. "There is a lot of pressure to intervene in this case because of the democratic implications," DeNardis, director of the Internet Governance Lab at American University in Washington, D.C., told *Bloom-*

*berg.* "Because of the rising stakes for cyberspace, for the economy, for democracy, there is greater attention on the part of all actors." DeNardis warns against too much focus on the regulation of content; instead, as she told Yale Law School students at a recent lecture, the more pressing issues are infrastructure and security. It's a topic she covers in detail in *The Global War for Internet Governance* (Yale University Press, 2014), "a rigorous exploration of obscure but important issues with potentially global effects," according to *Kirkus Reviews*.

Rear Admiral **Bill Hayden '66** retired in 1996 after a 30-year career in the Navy, where, among other roles, he served as the first commanding officer of the *USS Abraham Lincoln* aircraft carrier and as the chief of air training for all Navy, Marine Corps, and Coast Guard aviators. For the past 15 years, he has turned his attention to teaching STEM skills to the

next generation of scientists. Through a public-private partnership he founded called Starbase Victory, more than 15,000 fourth-, fifth- and sixth-graders in Portsmouth, Virginia, have "learned that math and science are an important part of their lives and are actually fun subjects to study," says Hayden, who last year earned a national Point of Light Award for developing and raising funds for the program. "When you make it fun and interesting, you change a child's perception of what school is all about," he says. Fourth-graders learn spatial awareness, measurement, and mapping in a four-day interactive learning track; fifth-graders explore the parameters (and causes) of weather, followed by a discussion of rainwater run-off and erosion; and sixth-graders build and launch their own rockets while studying simple physics and the forces of flight. "Learning to be a critical thinker can't start early enough," says Hayden. "We want to focus on teaching, not testing. Starbase Victory gives me great hope for what our young people can do in the future."

**Jesse Foote '01 Th'02** is combining rhymes, color tiles, and a cellphone app to lead children on treasure hunts with his new game, *Color Clues*. "*Color Clues* lets parents easily set up treasure hunts for their kids, even before those kids can read, by using sequences of colors and audio clues," says Foote. Users tap in the proper sequence from an initial color tile to unlock an audio clue—in a recent game Foote led his 4-year-old daughters, Hazel and Paloma, through their house with a series of Dr. Seuss-style rhymes ([youtube.com/watch?v=piNcGxgnv0A](http://youtube.com/watch?v=piNcGxgnv0A)) to the next color tile and subsequent clue, and so on until they discovered the treasure. The platform he is building will also allow parents and teachers to share the treasure hunts they create, building an ever-growing database of challenges "dreamed up by creative

people all over the world," he says. Foote is currently running a beta test at [colorclues.com](http://colorclues.com) to gather feedback to improve the game.

When **James Kaiser '99** returned to Maine after earning his AB in engineering, he wrote and published a guidebook to Acadia National Park. It became the bestselling guidebook to Acadia, and through his Destination Press he has since published travel guidebooks to Costa Rica and the national parks at Joshua Tree, Yosemite, and the Grand Canyon. "Thayer taught me to view everyday objects critically, instead of passively, and consider how those objects could be improved. Most engineers apply this to household and industrial objects—I applied it to travel guides. I looked at what was available, realized improvements could be made, and made those improvements." He also offers musings on various outdoor adventures and international travel at his blog, [jameskaiser.com/blog](http://jameskaiser.com/blog). Beyond the writing and photography, Kaiser credits the skills he sharpened at Thayer with his success. "My familiarity with computers helped me quickly learn self-publishing software and enabled me to build a website, which I used to market my books," he says. "And I have often used my mechanical skills to customize my outdoor and photography gear."

**Chrissy Bettencourt '13** is over the moon with her first kids' snow boot design. "Jack" is part of the fall/winter Interstellar collection at eco-friendly Plae, which incorporates such materials as recycled milk jugs and cork in its products. Bettencourt also worked with the factory to develop the boot's construction process and determine hardware details, materials, and colors. "I took inspiration from space-age materials and construction to develop a boot that not only keeps the kids foot warm with 400 grams of Thinsulate insulation, but also has

# On the Job

SEAN CASTEN TH'98 | CANDIDATE FOR CONGRESS

A clean-energy entrepreneur, MEM grad Sean Casten Th'98 hopes to bring an engineer's approach to policymaking as he vies for a U.S. House of Representatives seat in the 2018 Democratic primary in Illinois ([castenforcongress.com](http://castenforcongress.com)).

## You have said running for Congress is a lot like running a business—in what ways?

The first job of an entrepreneur is to identify an opportunity and articulate a vision that motivates people to come work on a project that is statistically likely to fail—and layered on top of that is the psychological requirement that you be comfortable taking risks. And it's exactly like running a political campaign. You have to make a decision to go without a salary for a year. You have to get very good very quickly at things you haven't done before. You have to have a strong enough vision of what you want to achieve to be able to ignore the inevitable negative things that will be said about you by your opponents.

## What is the value of having a more scientific approach to governing?

Scientists and engineers are trained to look at big, diverse sets of data, identify a problem, hone in on the root cause, and solve it. We don't waste a lot of time talking about "alternative facts" or worrying about the political fallout. To the contrary: We pride ourselves on being the first to identify and correct problems with a flawed paradigm. For example, Svante Arrhenius explained more than 100 years ago how higher CO<sub>2</sub> levels will increase atmospheric temperatures. A review of energy consumption data shows that 50 percent of all the CO<sub>2</sub> we have ever released has been in the last 40 years. That correlates closely with the sudden ramp in global temperatures. Those facts demand urgency and action—and yet the political pressure will always be to move slowly. Political laws may pace the rate at which we can act as a species—but the laws of thermodynamics have no such patience.

## Can you describe an issue that would benefit immediately from a more fact-based approach?

Look at immigration: The overwhelming majority of undocumented immigration to the United States is from visa overstays, not from illegal border crossings. Consistent with this data, Texas has seen virtually no increase in its undocumented immigrant population during the last decade. Whatever views one may have on our immigration policy, there is no reason why a border wall solves anything—and yet that discussion is consuming most of our political bandwidth on that front. If we were using facts and data to inform our policy discussions, we'd be having a much different conversation.

—Interview by Theresa D'Orsi

**"Political laws may pace the rate at which we can act as a species—but the laws of thermodynamics have no such patience."**

—SEAN CASTEN TH'98

## spotlights



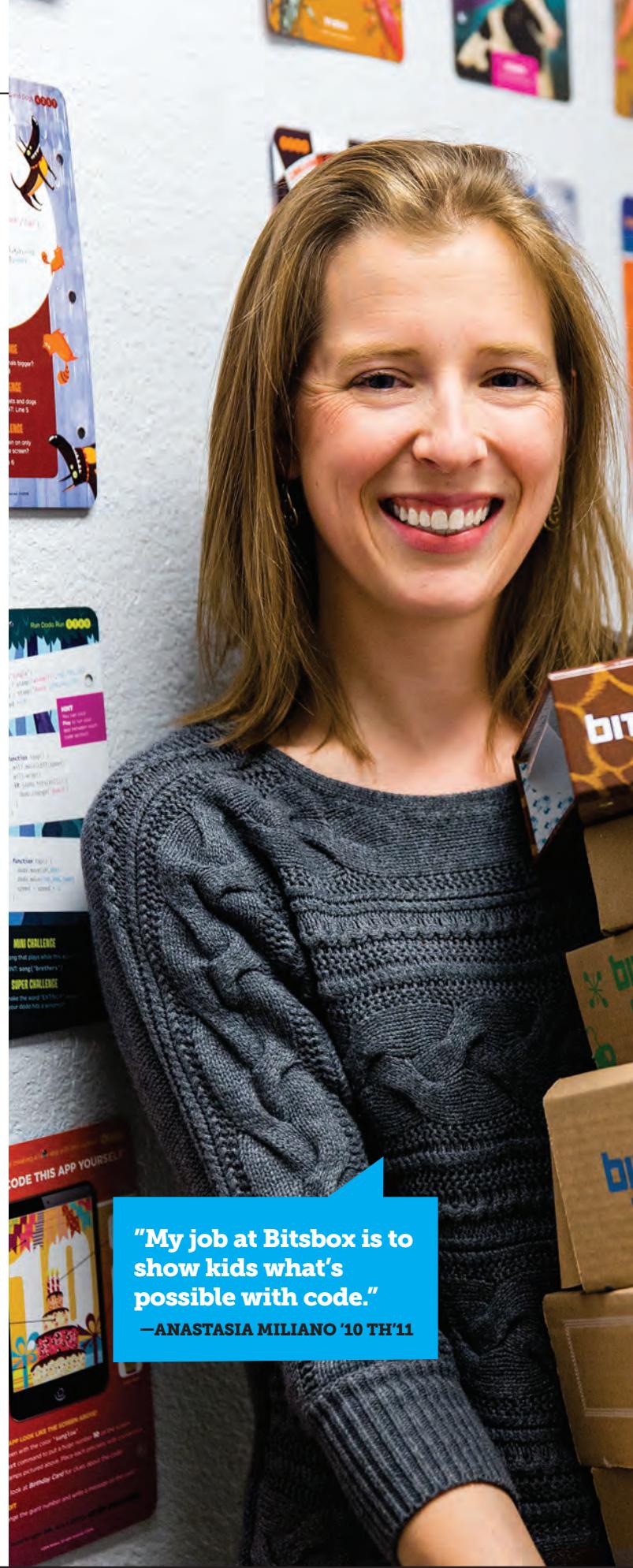
Chrissy Bettencourt '13

them feeling like they're walking on the moon," says Bettencourt, who earned her AB in engineering modified with studio art. "I always strive to create products that are stylish, fun and active, but most importantly stand up to the test of kids, who can be extremely hard on their shoes." Her next steps are to help launch the company's first adult shoe collection.

An experience designer with Medici Group by day, **Sharang Biswas '12 Th'13** explores other aspects of art and technology by night. He has developed several games touching on these topics with fellow engineering sciences major Max Seidman '12, including Mad Science Foundation, which won the 2015 DFW Nerd Night Game Design Competition. Mad Science is about mad scientists dividing up inventions and resources (lasers, dark matter, cryptonium, sharks) in a race to craft the most nefarious invention. The pair's next collaboration—the performance game Basic Principles of Incantation and Applied Esoterics—drew on Biswas' interest in immersive theater and his linguistics classes at Dartmouth and was first exhibited at a gallery in Manhattan. In the interactive theater game about linguistics and magic, players wrangle with tricky phonetics to learn and practice magic. Biswas' most recent project, Feast, earned the Dark Horse Award at October's IndieCade, where the judges raved that the role-playing game "transforms the

experience of a potluck dinner into a collaborative storytelling experience, where different foods are used to convey particular emotions." Biswas says his various roles only enhance his creativity. "I think of myself as a cross-disciplinary practitioner, with the different projects I make feeding into each other," he says. "I feel that the line between interactive theater and performance game is pretty blurry—my game design and performance experience feed into my work at the Medici Group. For example, we recently created a new corporate workshop, and I brought in a few theatrical techniques to enhance the pedagogical elements."

**Sharang  
Biswas '12  
Th'13**



**"My job at Bitsbox is to show kids what's possible with code."**

—ANASTASIA MILIANO '10 TH'11

# On the Job

ANASTASIA MILIANO '10 TH'11 | COO AT BITSBOX

What started out as an offer to help launch a Kickstarter campaign for a kids coding product quickly grew into a full-time gig for Anastasia Miliano '10 Th'11. Three years on, the COO, based in Boulder, Colo., enjoys delivering a subscription service that "kids can use as a jumping off point for their own ideas," raves *Tech Age Kids*.

## What does Bitsbox offer?

Bitsbox delivers insanely fun app-building projects to thousands of kids all over the world. We print the projects on beautiful books, trading cards, stickers, and (sometimes) whoopee cushions. The boxes build on each other, introducing a new coding concept each month. Kids take the projects they receive and type the simplified Javascript code in on our website. From the very first box, we encourage kids to modify and hack the projects to make the apps their own. Our goal is ultimately to teach kids to love coding, because coding is about making stuff, and making stuff is empowering and important. (Shout out to the machine shop!)

## What might you work on during a typical week?

We're a team of nine, so I wear a lot of hats. Right now, I bounce back and forth between operations and product. On the product side, I write the fun apps that kids build as they learn to code. Operationally, I handle all the logistics of making sure our customers receive their Bitsboxes every month—from working with box manufacturers and printing facilities to overseeing our fulfillment center and customer support team.

## How has your Thayer background informed your approach to product development?

Thayer taught me how to deliver products. Startups (and students) have incredibly limited resources—time, money, connections, etc. We have a unique challenge at Bitsbox in that we're still figuring out how to best teach coding. We're constantly altering our product offering—number of apps, which concepts come when, what type of support to provide—while we're still delivering boxes to subscribers who have been with us since the beginning. My Thayer education was invaluable in teaching me to identify the highest-priority problems to tackle.

—Interview by Theresa D'Orsi

# just one question



## If you had a favorite professor, what made that teacher memorable?

My favorite professor was Ed Brown, "Brownie." Not only did we have good arguments on hydrodynamics theory about what happens to pressure when high-speed water is reflected off a boundary, but also he coached me on a problem consisting of full-pipe flow becoming open-channel flow into a steep tailpipe and gradually turning into full-pipe flow (for accelerated draining of my golf course's lake during storms). He said I could not get that to work, but I was able to anyway by using tailpipe discharge submerged in a catch basin and giving it time for the tailpipe to fill up.

—Tom Harriman '42 Th'43

Two professors come to mind. Professor Ed Taylor taught me about the time value of money, which I used throughout my life in project comparison and analysis. Professor Robert Dean came to Thayer School when our class was in its senior year and taught the fluid mechanics course in the winter term. He was so dynamic that when he offered me the opportunity to work with him as a research assistant, I changed my graduate major from Tuck-Thayer to the most scientific graduate degree, MS, and went on for a PhD in mechanical engineering at Stanford.

—Harris McKee '61 Th'63

Myron Tribus was a wonderful prof not because he was a magical lecturer, but because his subject matter, "thermoeconomics," made so much sense! The idea that all aspects of process could be translated into economic values to allow process optimization is a powerful concept.

—Steve Brenner '63 Th'64

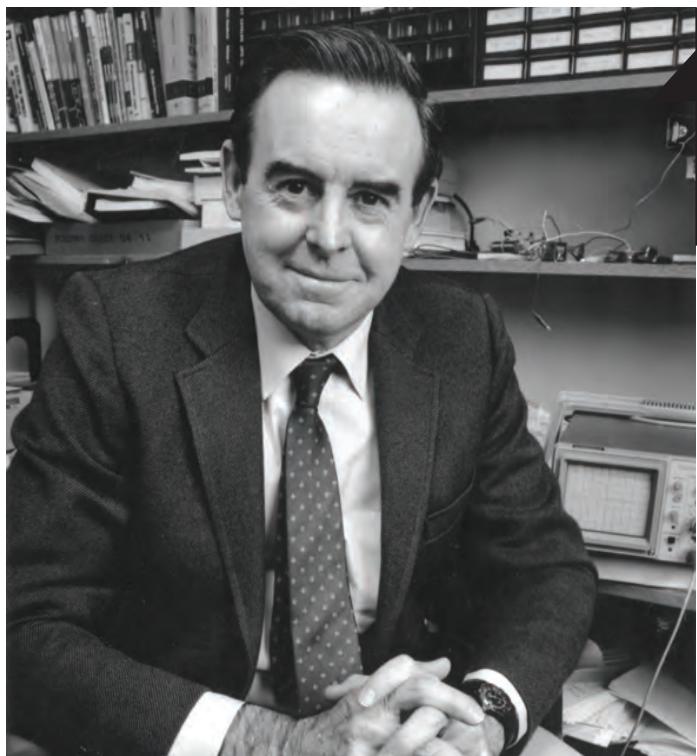
I'll mention four memorable Thayer faculty. Professor Sidney Lee was in charge of my ES 21: "Introduction to Engineering" team. He did not micro-manage us; instead, he led from

the front, performing an analysis of an energy-storing bicycle and showing that the weight of the battery was the critical variable. I converted his analysis to one expressing the effect of energy losses due to conversion from potential, to mechanical, to electric, to chemical, and back again—using whatever values I could measure and making the rest up. My team's presentation, featuring a teammate riding into the lecture hall on a battery-driven bicycle with a sexy transmission, had an electrifying effect on the judging panel. ES 21 was my first A, my first citation, and the first time I understood that I could both do something and explain it.

Professor Alvin Converse taught thermodynamics and every course had a project then. Dr. Converse was worried that mine—involving some applied math—was too hard, but he let me proceed and I succeeded. Bless him. This was the first case where I knew, or learned, more than a Thayer faculty member—but the Thayer ethos was that this was fine. Without a firm grounding in algebra or probability, Professor Myron Tribus set out to merge thermodynamics, information theory, and decision analysis. He made good progress on stuff I'm working on as a data scientist to this day. The one time I was able to correct him (a famous mathematician made the same mistake), he took it really well and wrote a good letter of recommendation for me for more graduate school. Finally, I needed another course to graduate and wanted to study more information theory. Professor John Strohbehn was very busy but consented to sponsor an independent study, letting me grade myself(!). His anchoring in the realities of then extant communication theory was very helpful to me—it balanced my enthusiasm. His skepticism anticipated developments that appeared some 25 years later. Yet another life lesson.

—Mark S. Tuttle '65 Th'66

## just one question



**"Professor David Stratton. He seemed to enjoy teaching the class as much as I enjoyed being there."**

—Steve Askey '76 Th'77

style that included key reinforcements and lots of real-world application notes. I much regret losing contact with him—and never directly thanking him for his excellence and commitment. The best.

—Peter Heymann '81 Tu'83 Th'83

My favorite professor at Thayer was David Stratton. He taught my first electronics class and I took everything I could from him after that. He was so dedicated to the students and to making sure everyone understood how current flowed in a circuit and how transistors, op amps, and analog and digital circuits worked. He really wanted to hear our questions so he could try the explanation from another angle if we didn't understand. The labs were fun, the class was dynamic, and quite a few of us became engineers (and concentrated in electronics) because of his leadership and dedication to teaching. A good friend and fellow student—John McNeil '83—did go on to become an electronics professor at Worcester Polytechnic Institute, very much inspired by David Stratton!

—Kimberley Quirk '82 Th'83

My favorite professor would be Francis Kennedy: a great teacher and his door was always open.

—Tony Shaia '82 Th'82

My favorite professor was Eric Hansen. He taught a great optics course and ultimately was one of my thesis advisors. I also appreciate the encouragement of David Roberts, MD, and Professor John Strohbehn.

—John Hatch Th'84

My Thayer School experience was probably similar to many: Almost every professor was memorable for good reasons, and I can count on only one finger the one who was memorable otherwise. However, if I were to single out a few, which I know is unfair to the many, my list would include Francis Kennedy (for his clarity

and enthusiasm and supportiveness in solid mechanics and in our post-graduation communications), Erland Schulson (for making me a good researcher, helping me get my first published article and find wonderment in something as simple as ice, and for his friendship through the years), Barry Richmond (whose system dynamics class has been applicable in every engineering, political, and socioeconomic situation I have ever found myself in and should have been a required course for every math-and-feedback-loop-challenged politician), and Carl Long (whose ability to start a complex problem in class for which he'd never thought out a solution in advance taught me what it is to be an engineer vs. a technician, and whose passion for structural engineering inspired me to become a licensed structural engineer).

—Scott Sabol '88 Th'88

There were so many great professors, but I really liked and enjoyed learning from and working with Professor Lee Lynd. I had a number of classes with him and continued to stay in touch after graduation.

—Quincy Vale '90

I had many great professors at Thayer, but the one I probably spent the most out-of-class time with is Professor Benoit Cushman-Roisin. He was my informal thesis and life advisor. I also remember having many great chats with Ellen Stein and Andy Tuck (at the Tuck School), who was originally my supervisor for a data collection project, turned into an advisor on which grad schools to apply to, and eventually became a coauthor.

—Nel Dutt Th'06

I had so many outstanding professors, but a few stood out in particular: Doug Van Citters. I have never met someone more passionate about science and education. He worked extremely hard for his students and deeply cared about their education, both academic and with life skills. I remember one day working in the lab on a problem set when he came in and asked if we were getting that free pizza in the Atrium. As one, we all jumped up to go get some. Turns out Doug had been joking about the EBAs delivery that no one had come to pick up yet. Seeing

I had so many good and influential professors at Dartmouth, and not just in engineering, that I would do a disservice to all of them if I tried to pick one out! Perhaps it would be appropriate, however, to mention Professor George Colligan, who influenced me after my MS at Thayer to consider the University of Michigan, where I eventually enrolled for my PhD in materials science. Dr. Colligan not only connected the academic world with the real world of engineering and commerce, but he recognized my interest in plastics and had the foresight to direct me to Michigan, where several new and young professors in the field of polymer science were just getting started. I enrolled there in 1968, received my PhD in 1972, and because of the influence George Colligan had on my training after Dartmouth, I got involved in the development of a whole new business and technology that I eventually turned into a family of Plastic Technologies companies.

—Tom Brady '66 Th'68

There were lots of good professors, though I have to mention Fred Schleipman in the machine shop as being especially memorable for his patience and easy access for all.

—Mike Steed '74

Professor David Stratton. Back in 1977 I wished to compress a second engineering science major into one year. I already got a physics major. For an ES major, I needed to finish "Digital Electronics" in the winter, but the prerequisite "Electronics I" was in the spring. I found "Electronics III" (a graduate course) offered in fall, so I talked with Professor Stratton, who taught the course, and explained my reasons for taking "Electronics III." He politely let me sit in the course without enrolling me. Four weeks later, I took the first test and got a grade of 50. Professor Stratton said, "You are one of three in the class who passed the test. You can enroll in the class." But, I said, "the class enrollment is already passed." Professor Stratton offered to talk to the administration to let me enroll. I finally enrolled and passed the class with an A- and a citation from Professor Stratton. I also was able to complete the ES major in one year. I wish to take this opportunity to say thank you to Professor Stratton.

—Lapyiu Ho '78

Professor Stratton (analog electronics) was simply life-changing. Why? He cared intensely about his students, as one of the most comprehensible pros ever, and had a lecture presentation



**"Vicki May! What most made Vicki effective was her candidness, which created a casual and comfortable atmosphere in her classes."**

—Sam Peck '10 Th'11 Th'12

thanks to his dedication and fun style of teaching. As graduation neared, he was also a great sounding board while exploring various employment opportunities, and he has continued to be a mentor through the better part of the past decade.

—Matt Wallach Th'08

My favorite professor was Vicki May! I even wrote and performed a song for her in the Atrium ([youtu.be/PiOiernd4e-w](https://youtu.be/PiOiernd4e-w)). I've always thought highly of her and have lots of positive words for her. What most made Vicki effective was her candidness, which created a casual and comfortable atmosphere in her classes and during office hours. It made class fun and conversational rather than lecture-like.

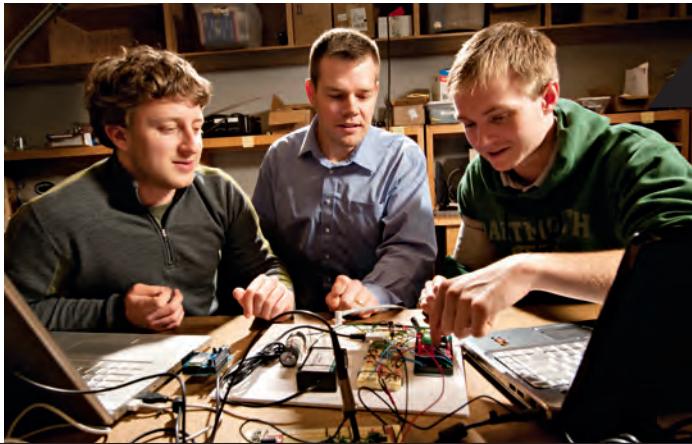
—Sam Peck '10 Th'11 Th'12

our response, though, he bought us pizza to apologize. That's what a favorite professor does! I consider him a friend, mentor, and role model. Thayer is lucky to have him! Francis Kennedy: I still remember his lessons almost 15 years later: "Pay attention to the details. If you don't, people die." I now work in medical devices and I hear his voice every time I think it's close enough. John Collier: He's the reason I'm in medical devices. His ability to ask the right question in ENGS 21, regardless of his experience in the field, was so captivating that I walked into his office, asked if he'd be my advisor, and asked to do research with him. What he studied was less important to me than being near him and learning from him. Erland Schulson: His ability to demand so much from his students while fully supporting them is unparalleled. I would

storm into his office and demand to know why something he taught us was true. His joy at working with students and watching them come to understanding was palpable. Also, because of him, I can still be caught moving my jar around thinking about "Fracture Modes I, II, and III."

—Evan Carlson '08 Th'10

I had several great professors at Thayer, but one in particular stood out: Professor Doug Van Citters was both an excellent teacher and mentor. During our "Applied Mechanics: Dynamics" course, he went above and beyond to make the material engaging and ensure we understood it. We routinely abused his open-door policy to work through tough problems, but it showed how much he cared. While it was one of the most challenging courses I took at Thayer, it was also one of my favorites,



**"Professor Doug Van Citters was both an excellent teacher and mentor. During 'Applied Mechanics: Dynamics' he went above and beyond to make the material engaging and ensure we understood it."**

—Matt Wallach Th'08

ect and I had no idea where to start. Professor Sullivan didn't hesitate to help when I walked into his office and asked for advice. After that term was over, I realized I couldn't afford to ignore electrical engineering if I wanted to be a good engineer, so I made sure to add as many electrical classes as I could for my remaining semesters. Professor Sullivan taught three of them, and while they weren't the best-graded classes I ever took, they were the most productive in terms of vital knowledge gaps closed. And in each of them, Professor Sullivan was patient and uncompromising with his standards of rigor.

—Max Fagin Th'11

Karl Griswold was a great academic advisor, capstone project advisor, and teacher. I love that he assigned innovative homework, such as paper reviews, which made us practice skills that were not directly about the topic of the class, but would still help us in our engineering careers.

—Sharang Biswas '12 Th'13

I had so many memorable professors from Thayer, but I would have to say the two who stand out are Professor Doug Van Citters and Professor Jifeng Liu—both of whom have tenure! D.V.C. has been an incredible mentor to me for the past six years, even outside of Thayer. I enjoyed his teaching so much that I took all five of the classes that he taught (the engineering design process sequence, dynamics, biomaterials, and solids). He was instrumental in shepherding my decision to go to grad school, where I am currently a fourth-year in applied physics at Harvard. This summer, during the Thayer 150th reunion, I made a point to go back and visit D.V.C., particularly for his advice on organizing and teaching an engineering summer school course I designed through Harvard's pre-college program. I took his advice, which was immensely helpful throughout the course.

Jifeng Liu remains an inspiration to me, particularly through all of the work that I have done with him. He advised both my undergraduate and my master's theses, which were my top academic accomplishments at Dartmouth. I still smile when I remember how every time I would enter his office feeling stuck in my research, his



**"Professor Sullivan was patient and uncompromising with his standards of rigor."**

—Matt Fagin Th'11

I'd have to say Sol Diamond. I remember him being very professional and kind and having a keen and contagious interest in the topics he was teaching. I also briefly met him during Dimensions and he encouraged me to study engineering when I got to Dartmouth the following fall.

—Evan Landau '15

Professor Sol Diamond was an incredible professor and mentor. His classes combined engaging design projects with engineering principles and skills, leading to some spectacular experimentation and novel mechanical creations.

—Anna Miller '16 Th'17

Professor Vicki May was one of my favorite professors at Dartmouth, and her structural analysis course was one of Thayer's best. Vicki was an incredible professor and quickly got to know each student by name, so it felt like a very personal experience throughout. She explained every concept with as much humor as she did clarity, and always walked through specific examples in class—an otherwise underrated but profoundly helpful use of class time! Designing and building a children's playhouse from wood in the latter half of the term was a great way to meet other students and learn engineering from an enjoyable, hands-on perspective.

—Matt Rossi '16 Th'17

My favorite professor while I was at Thayer was Dr. Cushman-Roisin. He really involved us in the practical application of environmental engineering and organized field trips to see engineering in action. Outside of the classroom, his open-door policy removed the barrier for asking questions on homework, career choices, and life in general. His compassion for students was visible in his attitude towards the students every day.

—Mariette van der Wegen Th'17

inquisitiveness and scientific perspectives had me exiting feeling as though I'd just made a scientific discovery. I took both his materials science and nanomaterials courses and continue to stay in touch with him personally and academically. For both of these professors, I thoroughly enjoy checking in on them and their families whenever I have the opportunity to venture back to the north.

—Drew Wong '12 Th'14

My favorite professor at Thayer is "Doc," Professor Eugene Santos Jr. His reading classes and seminars were very enlightening. Discussions with Doc were always very exciting. Doc's lectures are well designed. He asked us a lot of questions during lecture and used our answers to move forward. I still remember the excitement of attending his lecture every week. I started studying machine learning in his class, found it interesting, and eventually started a career out of it.

—June Shangguan '13 Th'13

My favorite professor was Simon Shepherd (I ended up working as a teaching assistant for him my last two years). I found him engaging in class and very approachable outside of class. His classes were what actually got me to consider software engineering as a career! Here I am, three years later, a software engineer for BAE Systems in Boston.

—Kendall Farnham '14 Th'14

# thayer notes

## | 1940s |

**Tom Streeter '44 Tu'48 Th'48:** I am alive and well and living in Pacific Grove, Calif. At 95, I'm well beyond my "sell by" date. Regards to all.

## | 1960s |

**Bruce Clark '60 Tu'61 Th'61:** Although never a working engineer, I recently managed the upgrading of our Danbury, Conn., community's water system with filtration, ultraviolet, and new pumps and thereby avoided a bid to purchase our system by a utility. I was the project manager for the filtering upgrade and the UV change, which allowed us to halve the chlorine level in our water. The investment by the community totaled \$300,000, and our financing kept the annual assessments level for about five years. Engineering approaches have served me well repeatedly over my career as a consultant and businessman.

## | 1970s |

**William Kellogg '73:** I have been very involved in a nonprofit organization called the Mt. Soledad Memorial Association, which has endured 27 years of litigation from hostile sources trying to tear down a memorial cross owned by our association. Last year, our association settled the lawsuit. The new and improved, nationally recognized memorial to veterans of all wars—the Mt. Soledad National Veterans Memorial—will now stand in perpetuity in LaJolla, Calif. I was president of the association from 1989 to 2012, and during my tenure I oversaw the design and development of this memorial, which has been declared a national memorial ([soledadmemorial.com](http://soledadmemorial.com)).

**Mike Steed '74:** I got my MBA at Stanford after a stint in a solar heating company, and have been working for Hewlett-Packard since—currently 37 years and counting—mostly in Corvallis, Ore. My present assignment is in Germany for a year-plus. I babysit HP's big T1100 printer—a digital inkjet printer for 110-inch-wide printing on corrugated liner for making into corrugated boxes—at a supplier location and support the few similar ones in Europe.

**Steve Askey '76 Th'77:** I'm retired for the second time; this time from BHP Billiton, where I was an independent contractor for five years or so. I'm now playing lead guitar in a classic rock band in the Daytona Beach, Fla., area, doing 55 to 60 gigs a year for fun and profit, as the saying goes!

**William Fraizer '78:** I completed my site engineering manager role with the Gorgon LNG Project earlier this year, after Train 1 commenced production and shipped its first cargo. In light of the current downturn in the oil and gas industry and the resulting cancellation or deferral of most major projects, I took early retirement at mid-year. I continue to reside in Houston while I enjoy some time off and travel and consider future opportunities.

## | 1980s |

**Peter Heymann '81 Tu'83 Th'83:** I am helping to lead a startup launching a cloud-based application suite at StratusCore ([stratuscore.com](http://stratuscore.com)). We provide a marketplace targeted at digital content creators (the artists who create all the original images, visual effects, and graphical edits that go into movies, episodic shows, ads, video games, animations). Artists log onto our virtual workplace, choose the apps they prefer from hundreds we host, and get to work. Artists can quickly move work around the world, invite additional collaborators, and use as much storage and computing power as they need. The benefits of shifting to the cloud are many: much easier collaboration, workflow automation, improved speed to completion, instant access to all the information technology needed (no need for setup and engineers), tight integration of applications (no need to bounce from one website to another), tight tracking of resource use. And much higher security, plus detailed analytics providing insights on project efficiency and performance of different applications. Downstream, there are much easier online searches for specific clips and artifacts, boosting residuals revenue. I'm using all of my Thayer and Tuck training!

**Kimberley Quirk '82, Th'83:** This

is my ninth year back in the Upper Valley after almost 30 years in the Boston area in various engineering jobs. I started Energy Emporium (energy emp.com) in Enfield, N.H., in 2009 to design, install, and maintain renewable energy systems (solar electric, solar hot water, heat pumps, wood). I really love being in the Upper Valley, running my own company, doing something good for the environment and using the technical, business, and people skills that I have developed through the years.

**John Hatch Th'84:** I have been in private practice as a pediatric and neuro-ophthalmologist in Massachusetts for the last 25 years.

## | 1990s |

**Quincy Vale '90:** After Dartmouth, I moved away from engineering (a bit) and went to graduate school for law and business. Professionally, I continue to integrate law, business, and engineering by working in renewable energy development; primarily solar, hydro, and wind, but I have done some biomass and energy storage work, too. Currently, I own and manage a leading commercial solar energy company, MassAmerican Energy (massamerican.com), and am working with my law, business, and engineering skills and background every day.

**Glenn Liu '92:** I am a professor of medicine and medical physics, director of genitourinary oncology research, and coleader of the developmental therapeutics program at the Wisconsin Institutes for Medical Research at the University of Wisconsin School of Medicine. I have formed AIQ Solutions Inc. with Robert Jeraj, PhD, and with a \$2.3-million grant have pioneered quantitative total bone imaging to assess changes in total functional and individual lesion response in bone (e.g. metastatic prostate cancer). This tool will greatly improve the efficiency of prostate cancer drug development, as well as provide patient-specific information that will someday guide therapies.

**Samantha Truex '92 Th'93 Tu'95:** I am a coinventor on a patent owned by Biogen, now by spin-off Bioverativ, covering an innovative dosing regime for a long-lasting clotting factor used by those with hemophilia B (which is a lack of or defect in clotting Factor IX). Before this innovation, patients had to

give themselves intravenous injections multiple times per week—daily for some with fast metabolism—to treat the serious disorder. Hemophilia B manifests itself in boys (X-linked disease) usually by the age of 2, so parents have to provide these frequent injections to their little boys starting that early. The drug has to be refrigerated as well, adding to the complexity of managing the disease while traveling. The Biogen/Bioverativ innovation allows those families and the boys as they grow into men to live a much more normal life by elongating the dosing frequency to weekly or even less often. This allows for sports participation, vacations, college lives, and work lives that are much more manageable. And that's in the developed world. Biogen has donated millions of units of this innovative clotting factor to developing nations so that hemophilia patients who have often gone undertreated or untreated can get treatment. This innovation helps make possible prophylaxis (to prevent negative effects of internal bleeds that happen routinely in all of us) in a developing world setting, where once-weekly dosing is a stretch for families since they have to travel into the clinic and transport is very unreliable.

**Michelle Fortier '94 Th'95: Jens Vorges '94 Th'95** has a patent on the blender used for F'Real Milkshakes (petrey.com/freal.aspx), which can be found in convenience stores throughout the United States. Jens was COO of F'real, based in Emeryville, Calif., which was acquired by Rich Foods in 2012. **Jason Fortier '94 Th'95** has numerous medical device patents related to applicators for DuraSeal, a sealant used by neurosurgeons to protect the dura, and hemostatic patch Veriset, which is used by liver surgeons to stop bleeding. Most recently, Jason is vice president of research and development at Augmenix, the third-fastest-growing private company in Boston, and he works with **Kolbein Kolste Th'16**. Together, they work on a sealant used by radiation oncologists to protect organs at risk. One product is SpaceOar, used for prostate cancer. Men not treated with SpaceOar are eight times more likely to have sexual, bowel, and urinary declines in quality of life after prostate cancer treatment.

**Keith Lenden '95 Th'95:** I've worked on the business side of biotech since

Dartmouth/Thayer. With a consulting and transactional background in the space, I've been able to help scientists find applications that capture the attention of biotech and pharma companies and venture capitalists. Back in 2007, I started spending a portion of my time meeting and working with academic scientists on commercial applications of their research. In 2009, I started a biotech company with a few scientists in San Diego called Receptos. The company is poised to bring a new drug for multiple sclerosis to market in 2018 that was the basis of creating the company. The company went public in 2013 and then was acquired for \$7.2 billion in 2015. In this case I was the business cofounder and CEO during formation, licensing, and fundraising, after which I transitioned the role to an industry veteran. I was looking to work with the best scientists, not necessarily on MS, but that's where the technology took us in the end. It's unique because the patient and physician communities had been clamoring for a "kinder and gentler" immunosuppressive therapy for MS, and the drug fits that bill very well. It was about two years ago that I started doing the same thing pretty much full time and recently joined a VC fund as a venture partner to drive my future companies.

**Hugh Pfabe '98 Th'99:** After a few years working at Mass General Hospital, DEKA Research & Development Corp., and Blackstone Medical Inc., I helped found Incite Innovation, a startup medical device company in Springfield, Mass. We invented, patented, and secured FDA approval on a number of devices in the orthopedic space, spinning our devices into individual LLCs. I also began attending law school at night during this time. After that company pivoted to purely licensing our previous work, I moved to an existing startup in Connecticut, where, among other things, I developed and patented a new surgical retraction device that allows more variable access for performing surgeries through small incisions than any previous device. After that, I became director of research and development, project management, and process development for a medical device manufacturer back in western Massachusetts, then completed law school and went to work at an intellectual property law firm in Hartford, Conn. Currently, I

run my own intellectual property law practice (PfabeLaw.com), and recently started up a product development company (MetaMotive.US). Both businesses predominantly work with small- to medium-sized businesses, startups, and independent inventors. I am also currently the vice chair for Western Massachusetts SCORE, which offers free mentoring services to small businesses across four counties. I am also a mentor and facilitator with Valley Venture Mentors, which is a volunteer-based incubator and accelerator for startups from across the country and beyond, where I am presently mentoring my third startup (which provides services focused on veterans as well as those with autism).

## | 2000s |

**Joe Brown '00:** After 11 years in Colorado for grad school and work afterwards, this year I got a job as a tenure-track assistant professor of mechanical engineering at the University of Hawaii at Manoa (Honolulu). I started August 1 and it's going great so far. You can find my faculty page at me.hawaii.edu/people/brown. I'm teaching a large lecture class and working on setting up my research here.

**Alex Streeter '03 Th'04 '05:** I am pleased and humbled that, for about five years, I was a part of a team at DEKA Research & Development Corp. (dekaresearch.com) that brought the Luke prosthetic arm into being. This summer, the first commercially available arms were presented to two patients in the Veterans Affairs system. These two patients had, for a number of years, been sporadic users of prototype arms through our clinical trials. Now they get to have these arms—for good; the first of many, we hope. And for the past two and a half years, I have been working on another DEKA project: to update our balancing, four-wheel-drive, stair-climbing wheelchair—the iBot. I hope that it will not be long before people are once again able to experience the independence and mobility that this technology can provide.

**Nel Dutt Th'06:** I now live in Milan, Italy, and am an assistant professor at Bocconi University, where I teach and do research on strategy. My research primarily focuses on understanding patterns of change triggered by firms' problem-solving activities. I examine

## thayer notes

these activities across multiple contexts—renewable electricity, pharmaceuticals, and waste generation—with special emphasis on contexts of environmental significance. In a more recent secondary stream of research, I explore phenomena that capture nascent entrepreneurial activities—both in emerging and developed markets. My research across both streams has been published in *Strategic Management Journal*, *Management Science*, and *Academy of Management Journal*. My research has been recognized with Bocconi research awards (2014 and 2016). I've also kept up with some of my hobbies from my time at Dartmouth (running), but instead of rock climbing, I'm more liable to be found at the local wine bar.

**Jeff Grossmann '06 Th'07:** I was part of the team that invented and commercialized the TrailerTail, a collapsible, rear-drag-reduction technology that reduces the fuel consumption of 18-wheel tractor-trailers by 5 percent due to improved aerodynamics. I left the company in April 2017 and am now in my first year of teaching high school engineering in Richmond, Calif., through Teach for America. I love the opportunity to get a new generation of students excited about problem-solving, creativity, and the importance of quick design iterations, regardless of whether they pursue engineering in college.

**Dan Schneider '07 Th'08:** About a year ago, I moved from the Upper Valley to Seattle, where my wife started her residency program at the University of Washington. Since February, I've been working for a company called Whooshh Innovations ([whooshh.com](http://whooshh.com)) that has developed a system for moving fish from point A to point B through a tube using an air pressure differential. This past summer, I oversaw the installation of a 1,700-foot-long system that transported sockeye up and over the Cle Elum Dam in Roslyn, Washington.

## | 2010s |

**Jeff Spielberg '11 Th'11:** A few years ago, I started River Loop Security ([riverloopsecurity.com](http://riverloopsecurity.com)), named after our favorite cycling route in Hanover) with **Ryan Speers '11** and **Ricky Melgares '11**. With the rapid growth of the cybersecurity industry in the last year or two, what was once a small

side gig has turned into a 12-person security consulting business with strong representation from Thayer and Dartmouth computer science folks. We focus on helping companies from startups to Fortune 500s secure their products and service lines. We mentor engineering teams in secure design, proactively test the security of companies' products, and coordinate response to cybersecurity disclosures and breaches. We're also lucky when we can squeeze in a few hours to build an open-source tool or create a conference presentation. We have a lot of thanks to give to Dartmouth and Thayer for the breadth of skills we learned—we often receive positive feedback on not just the depth of technical work, but also on the collaborative nature of working with a variety of teams and quality of reports and presentations.

**June Shangguan '13 Th'13:** After Thayer, I went to graduate school in Michigan and am now doing research on automatic speech recognition for artificial intelligence products Amazon Alexa and "Ok Google" assistant. I am really grateful for my education in Thayer because the research opportunities (Women in Science Project with Professor Mary Albert and presidential research scholarships with Professor Eugene Santos Jr.) opened a door to my current career. Without these research experiences, I wouldn't have been able to achieve what I have today.

**Evan Landau '15:** I've been working at a research and consulting firm called Kelton Global, where I work in qualitative design research. I go to different cities every few weeks to perform focus groups and ethnographic interviews to help better design products and experiences for clients. For fun, I woodwork, am working on a business plan for an agricultural startup, and am doing an independent research project about homelessness.

**Anna Miller '16 Th'17:** I graduated from Thayer with my BE last March. Since then, I have worked as an intern for the startup Willow ([willowpump.com](http://willowpump.com)) in Silicon Valley, working on the first hands-free, mobile breast pump. I'm now at the Delft University of Technology in the Netherlands on a Dartmouth General-Colby Fellowship, researching a new treatment for Kienbock's disease

using stem-cell scaffolds.

**Matt Rossi '16 Th'17:** I'm currently interning as a mechanical engineer at a company in the San Francisco Bay Area that designs exoskeletons to improve the lives of spinal cord patients, stroke victims, and construction workers. In my free time, I play as much pickup soccer as I can and film new sights in San Francisco and the surrounding area.

**Mariette van der Wegen Th'17:** I am currently working as a manufacturing data analyst for MacLean-Fogg Component Solutions ([maclean-foggcs.com](http://maclean-foggcs.com)). The team I am on is implementing a new enterprise resource planning (ERP) system in all the MacLean-Fogg facilities. We are currently working in the Saegertown, Pa., facility, located between Erie and Pittsburgh.

## obituaries |

**John D. Bowe '41 Th'42** of Charleston, S.C., passed away on June 8, 2017. He earned a degree in civil engineering from Thayer and then received a master's in aeronautical engineering from MIT. Serving in the Navy, he became a lieutenant commander stationed in Florida. After his discharge, he went to Kansas City, Mo., where he met his future wife, Jacqueline Welch. They moved to Basking Ridge, N.J., where he established Bowe Construction. His career in development eventually led to Jamaica, where he and a partner established the Trelawny Club. In retirement, they moved to Charleston and enjoyed playing golf and traveling with friends and family. He is survived by his wife, Jacqueline; sons Richard and Stephen; grandsons Richard Jr., David, Pete, and Adam; and eight great-grandchildren.

**Robert F. Craig '47 Th'48** of Pittsburgh, Pa., passed away June 17, 2017. He earned a BS and MS in electrical engineering from Thayer and then served in the V-12 naval training program and in the U.S. Navy reserves for 10 years. He worked in a managerial capacity for Bell Telephone of Pennsylvania for almost 40 years in Philadelphia, New Castle, and Pittsburgh. He served both his church, Saint Alexis, and his community as a delivery person for Meals-on-Wheels,

a Republican committee member for McCandless Township, an active performer with the Spotlight Players, and an actor in community theater. He was predeceased by his wife of 50 years, Mary. He is survived by children Robert, Stephen, Susan, and Anne and their spouses; and grandchildren Gordon, Kathleen, Michael, Mary Allison, Christopher, Madeline, and Sam.

**Alan Averill Terrill '54 Th'55** of Hillsboro, Ore., passed away on April 11, 2017. "Lefty" came to Dartmouth from Ansonia, Connecticut, where he attended Ansonia High School. At Dartmouth he was a brother of Kappa Kappa Kappa and graduated from Thayer School. He then entered the naval officer candidate school and was commissioned in the Navy Civil Engineer Corps, serving for three years in the Seabees. After discharge he moved to Boise, Idaho, where he worked for Morrison-Knudsen on various construction projects throughout the West. In 1968 he joined MacGregor Triangle Co. as construction engineer. He served as vice president and general manager of a subsidiary company, MacGregor Utility Constructors Inc., which built highways, water systems, sewers, and treatment plants. In 1985 he went to work for Idaho Sand and Gravel, retiring in 1998. He is survived by his wife, Sally, and daughters Susan, Sarah, and Quita.

**Frank P. Strong Jr. '56 Tu'57 Th'57** of Fairport, N.Y., died July 20, 2017, of aplastic anemia. He worked for Kodak for 35 years, serving as group vice president and general manager of the commercial imaging group and spending four years in Australia as the chairman and CEO of Kodak Australasia. He also headed Kodak's portfolio of venture investments. Following his retirement from Kodak, he applied his venture management experience as a founding member and general partner of Trillium Group. He served as member of the Thayer Corporate Advisory Board from 1992 to 2002. His 30-year association with Keuka College included chairing and serving on the board of trustees and as interim president in 1995 and 1997. He received an honorary doctor of humane letters degree from Keuka in 2005. He is survived by his wife, Barbara; children Sally, Lisa, and Doug; grandchildren Regan, Chris,

Eric, Laura, Marshall, Meghan, and Sarah; and sister Nancy.

**Charles W. King Jr. '57 Th'58** of Atherton, Calif., died in his sleep on August 3, 2017. At Dartmouth he majored in modified architecture and was a member of Dartmouth Society of Engineers. After college and completion of the U.S. Army Critical Skills Program, he ventured West to begin a career in real estate. He was involved in the development of 135 industrial and office buildings, mostly in the San Francisco Bay area, and including buildings in southern California, Illinois, Ohio, South Carolina, Texas, Taiwan, and Thailand. He was cofounder, major shareholder, and chairman of the board of SteriGenics International, the world's largest capacity gamma sterilizer of medical disposables and other products. He acquired a bankrupt record storage company and merged it with Filesafe Inc., to create the largest record storage company in Northern California. He was predeceased by his wife, Debbie. He is survived by children Charles III, Michael, and Patricia.

**David Gladstone Campbell Jr. '59 Tu'60 Th'60** of Williamsburg, Va., died on March 5, 2017. Following graduation he served for three years as an engineering officer aboard a Navy destroyer. He and Yvonne, his wife of more than 50 years, lived in the Midwest, where he served as international marketing director for a valve manufacturing company, and then moved to Bellevue, Washington, in 1980, when Dave founded and built a manufacturer's representative business serving the water and wastewater markets with offices in Seattle and Portland, Ore. In 2003 David and Yvonne retired to Governor's Land in Williamsburg, where they enjoyed golf, tennis, and fishing with grandchildren. He leaves Yvonne, daughter Tara, son Michael and seven grandchildren. Son David died in 2004.

**Robert James Haubrich '63 Tu'73** of Claremont, N.H., passed away June 17, 2017, from complications of heart surgery. He majored in engineering sciences at Dartmouth, and worked for about 15 years designing automation equipment and in production management methods and strategy. He then decided on a career change that would enable him to share knowledge and experience with college stu-

dents entering a management career. He spent the remainder of his career teaching in the classroom and in business seminars until his retirement in 2006. He was an avid furniture designer and maker. He was a certified ski instructor at Mount Sunapee, N.H., and for most of his life performed as a jazz drummer. He is survived by his wife, Barbara; son Erich; daughters Ariel and Eden; grandsons Nash and Nate; brother Richard; and nephews Richard and Kyle.

**Edward A. Keible Jr. '65 Th'66 Th'67** of Cornelius, N.C., passed away March 19, 2017 from a heart attack. He graduated Dartmouth and Thayer with a master's in engineering, served in the Air Force in Vietnam, and went on to earn an MBA from Harvard Business School. He had a successful career with Raychem Corp., leaving in 1993 as senior vice president and executive officer of Raychem's worldwide electronics business group, and then founded Endwave Corp. and successfully led its IPO in 2000. He was awarded four U.S. patents in the fields of telecommunications and microelectronics. He served on Thayer's Board of Overseers (2007–09), Corporate Advisory Board (2001–02), and Campaign Executive Committee (1991–96). He is survived by his wife, Terry, brother Bill, and many nieces, nephews, grandnieces, and grand-nephews.

**David Burr Wrisley Jr. '67 Th'70** of Sarasota, Fla., died November 12, 2016. He came from Hinsdale, Illinois, had an Army ROTC scholarship, was a brother of Sigma Phi Epsilon, married Lee Ann in 1967, and graduated with an MS in engineering from Thayer School in 1970. He spent 12 years in product development with Corning. From 1985 he was with AMP Inc., conducting research and developing electrical interconnection devices. He is survived by Lee Ann, son David and daughter Kate '95 Th'96. His father, David Sr., was a member of the class of '44.

**Daniel "Sean" Kersey '87 Th'90** of West Lebanon, N.H., died May 30, 2017 of pancreatic cancer. He earned a master's in biochemical engineering and worked for IBM for 13 years and Timken in Lebanon, N.H. He also served on the board of the American Precision Museum in Windsor, Vt. He was passionate about ministering to



both high school and college students, discussing many topics, most often focused on God and faith. He could often be found in the garage working on automotive projects. He met his future wife, Michelle, while attending Dartmouth and they married in 1990. She survives him, along with their children, Matthew '18 and Kirsten; parents Timothy and Judith; brothers Tim (and wife Tracy) and David; niece Ashley; and nephews Noah, Jacob, Lucas, and Travis.

## Gallery

1. **Alex Streeter '03 Th'04 Th'05** is updating the iBot, DEKA's balancing, four-wheel-drive wheelchair.
2. As president of the Mt. Soledad Memorial Association, **William Kellogg '73** oversaw development of the Mt. Soledad National Veterans Memorial.

# Inventions

## THAYER SCHOOL OF ENGINEERING

### >> INVENTOR:

SYLVANUS THAYER, DARTMOUTH 1807

When Sylvanus Thayer established an engineering school at Dartmouth, he created the kind of institution he wished he could have attended.

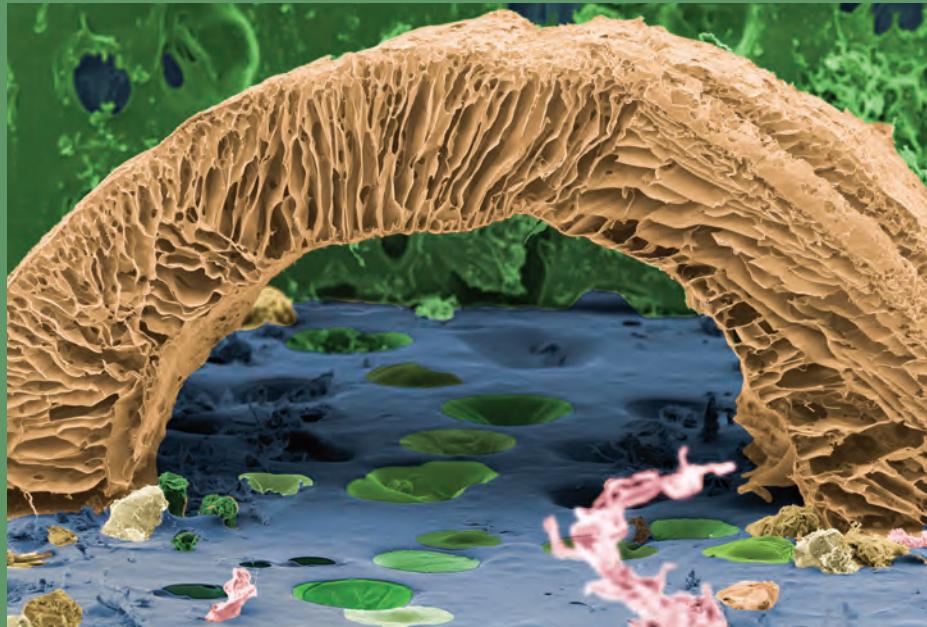


As a young man, he wanted a technical education that would prepare him to be an engineer, but at the time no such institution existed in this country. He pursued the next-best thing: a college that offered advanced mathematics as well as a classical education. In 1803 he entered Dartmouth. Though named valedictorian of the class of 1807, Thayer left before the graduation ceremony to become a cadet at the five-year-old United States Military Academy. Graduating in one year, he entered the Army Corps of Engineers. In 1815 Thayer began a two-year stint studying at the French West Point, École Polytechnique. In 1817 President Monroe appointed him Superintendent of West Point to bring order out of the academy's chaos. Thayer established standards and developed a rigorous curriculum centered on engineering. He also insisted that America's military engineers be educated in the sciences and the humanities. Between 1817 and 1833 he turned West Point into the world's finest military academy and the country's first college of engineering. Carried by West Point graduates to other colleges and universities, Thayer's curriculum became the springboard for technological instruction throughout the country. In 1867, Thayer brought engineering to Dartmouth. He not only offered \$70,000—an enormous sum at the time—to create an engineering school, he also detailed the curriculum: technical studies built on a strong liberal arts foundation. One hundred fifty years later, his Thayer School of Engineering continues the educational model he invented.

(Adapted from "Who Was Sylvanus Thayer" by Nardi Reeder Campion, Dartmouth Engineer, Fall 2004)

JOHN SHERMAN, INSET: THAYER SCHOOL OF ENGINEERING.





## Random Walk

Each fall Thayer holds an image contest in conjunction with the school's Visionaries in Technology lecture series. Students, postdocs, and research associates submit images that turn research into art. Kaiyang Yin, a PhD candidate working in Professor Ulrike Wegst's lab, created this year's winning image, "Water Lily Pond and Japanese Bridge: A Microscopic Garden." Inspired by Claude Monet's garden, Yin used a scanning electron microscope to capture elements of the bio-inspired materials he is developing for medical applications, such as peripheral nerve repair and dissolvable ureteral stents. "The Japanese bridge is a section of freeze-cast scaffolds. The pond and surrounding plants were created by conducting tape and collagen fibers," he says. Add some Photoshop, and the result is magic.

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## Royal Praise

Britain's Prince Charles, right, congratulates Professor Eric Fossum, winner of the Queen Elizabeth Prize in Engineering, at Buckingham Palace, London, on December 6. The world's largest engineering prize recognizes Fossum for inventing the CMOS active pixel image sensor that makes cell phone cameras possible.

PHOTOGRAPH COURTESY OF QUEEN ELIZABETH PRIZE FOR ENGINEERING