150 THAYER

SPRING 2017

DARTMOUTH Engineer

THAYER SCHOOL OF ENGINEERING

HISTORY IN THE MAKING

FROM THAYER'S FIRST CLASSES IN SURVEYING TO THE INNOVATIONS OF TODAY, WE TAKE THE MEASURE OF 150 YEARS OF ENGINEERING AT DARTMOUTH.

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150 Years and Counting

Sylvanus Thayer's prescient educational vision is alive and well in the school he founded.

JOSEPH J. HELBLE | DEAN

EARLIER THIS YEAR, THE THAYER COMMUNITY gathered for a celebration to mark the start of our sesquicentennial year commemorating the founding of our school by U.S. Army Colonel and Brevet Brigadier General Sylvanus Thayer, valedictorian of the Dartmouth Class of 1807.

In his long-serving capacity as superintendent of the United States Military Academy at West Point, Colonel Thayer brought the foundations of contemporary engineering education to a young United States. In April of 1867, at the age of 81, he sent a letter to Dartmouth President Asa Dodge Smith stating his intention to make a gift that would enable "the establishment and maintenance of a Department or School of Architecture and Civil Engineering connected with Dartmouth College, the institution in which I was educated and in the prosperity of which as my Alma Mater I feel the deepest interest."

Three months later, on July 4, 1867, Thayer's intention was formalized in an agreement committing an initial sum of $40,000—which he later increased to $70,000—and outlining the curriculum for a two-year course of study, designed to be undertaken by students who had completed a general education.

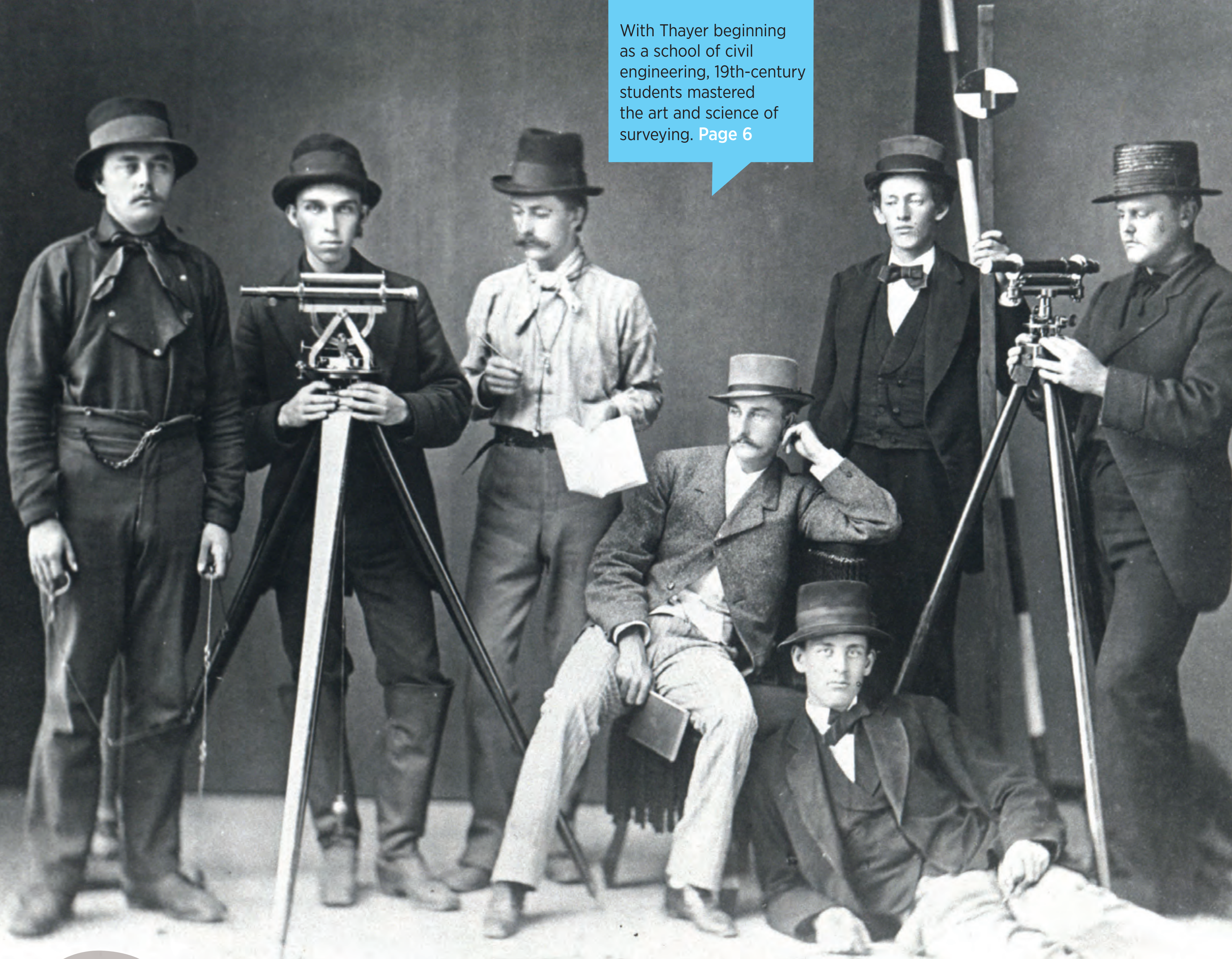
With that gift, the Thayer School of Engineering came into being.

A few of the nation's engineering programs are older, generally tracing their roots to programs in applied science that started a few years earlier. But from its beginning, the Thayer School of Engineering has been different, founded as a professional school, not as a standalone but as a complement to a broad college education.

It isn't much of a stretch to say that Colonel Thayer would recognize his ideas in the school of today. His notion of an engineering education built on a more general foundation, highly unusual in its day, lives on, enabling our undergraduates to experience a program integrating the liberal arts and engineering in a way that leaves them well-prepared to adapt—and lead—in a changing world. What he gave us, however, was more than a curriculum and an organizational structure. Thayer established a philosophy, one that challenges us to see the world of engineering broadly, to draw knowledge from all corners, and to understand that the true measure of engineering is not in the cleverness of the technology, but in how it touches and improves lives. It is this philosophy that over 150 years has encouraged us to experiment—to eliminate disciplinary degrees in the early 1960s, to build a design-focused project-based curriculum, to bring together engineering and business in a joint Tuck-Thayer program that led to a pioneering MEM degree, and to focus much of our research in areas of clear societal need, such as medicine and energy.

It is this philosophy that has encouraged the intellectual risk-takers, and over the past few years, has brought increasing recognition to the school, from the National Academy of Engineering (NAE) Gordon Prize for Innovation in Engineering and Technology Education to the historic graduation of a majority-female engineering class, to seeing two of our faculty members (an impressive 5 percent of our growing tenure-track faculty) elected to the NAE, to the Mobile Virtual Player BE capstone design project team receiving national headlines and Super Bowl coverage for their efforts to reduce concussive head injury, to a member of our faculty this year receiving the Queen Elizabeth Prize for Engineering, the world's highest engineering award.

The philosophy that Colonel Thayer handed down to us continues to excite and inspire us, providing a dynamic foundation for our vision for growth, for deep and integrated partnership with computer science, and for the next 150 years.



With Thayer beginning as a school of civil engineering, 19th-century students mastered the art and science of surveying. Page 6

THAYER SCHOOL ARCHIVES

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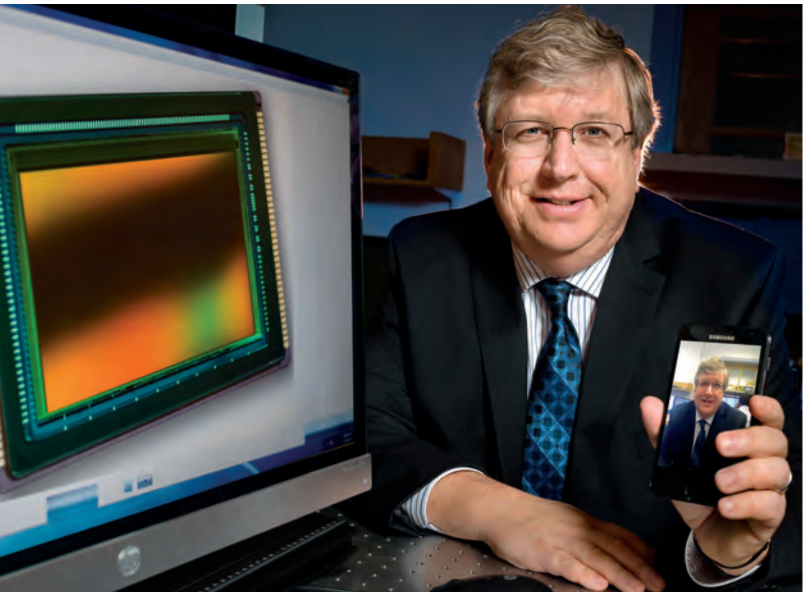
COVER: Made in the 1860s, this Wye level was used by Thayer students to measure elevation. Photograph by John Sherman.

THE Great Hall

NEWS FROM AROUND THAYER SCHOOL



SELFIE PORTRAIT Professor Eric Fossum earned Queen Elizabeth's seal of approval for the technology behind cellphone images.

AWARDS

Fossum Wins Highest Engineering Prize

PROFESSOR ERIC FOSSUM, INVENTOR of the CMOS (complementary metal oxide semiconductor) active pixel image sensor that is in every modern cell phone has been awarded the world's highest engineering honor, the Queen Elizabeth Prize in Engineering. Modeled on the Nobel Prize, the £1m award recognizes innovations in engineering that have globally benefitted humanity.

Fossum shares the prize with co-winners George Smith, Nobukazu Teranishi, and Michael Tompsett, who invented other key elements of digital imaging technology. Fossum, Teranishi, and Tompsett attended the announcement ceremony Feb. 1, 2017 in London, where Princess Anne represented her mother, the queen. The winners will be presented with the prize at a ceremony at Buckingham Palace later in the year.

Though Fossum is no stranger to recognition—he has been inducted into the National Inventors Hall of Fame and is a member of the National Academy of Engineering and a Fellow of the National Academy of Inventors, among other distinctions—the award seems to have taken him aback. "All I can say is, holy cow, this is the biggest engineering prize in the world. This is utterly fantastic, and, to use the vernacular, I am gobsmacked. It's really astonishing. It's terrific and, well, I'm speechless," he said at the conclusion of the announcement ceremony.

When Fossum invented the modern image sensor while working at the NASA Jet Propulsion Laboratory, his original goal was to miniaturize cameras for use in space. He ended up changing everyday life on Earth. Each year more than 3 billion cameras are made using CMOS image sensors, which are now essential to the worlds of entertainment, automotive safety, medicine, science, security, defense, and social media.

"Like most engineering achievements, mine came by standing on the shoulders of earlier engineers' accomplishments," Fossum told the Thayer community at a reception in his honor. "The QE Prize this year is a good example of that. George Smith co-invented the charge-coupled device or CCD at Bell Labs in 1969 along with the late Willard Boyle. Shortly thereafter, Mike Tompsett, also at Bell Labs, figured out how to use the CCD as an effective solid-state image sensor in 1970. When CCD technology was picked up by Japanese consumer electronics companies, many improvements were made. The best of these was the invention of the pinned photodiode by my friend Nobu Teranishi, then at NEC in the early 1980s. This device allowed much better low-light performance. The CMOS image sensor, developed in the 1990s at the NASA Jet Propulsion Laboratory, used an active pixel with intra-pixel charge transfer to allow a micro-CCD in each pixel and permit good imaging performance in a baseline CMOS technology process—the same as mainstream microelectronics. The idea really took only a moment to come into being once I asked the right question, common with many inventions. And then it took a team of people to put it into practice, both at JPL and later at our spinoff, Photobit. After that, thousands of engineers around the globe continued to improve the technology and bring it to the level of the performance you find today in your smartphone."

Now Fossum and his PhD students, including Saleh Masoodian, Jiaju Ma, and Dakota Starkey, are working on what may be the next major breakthrough in imaging technologies: a quanta image sensor that can count every photon for use in low-light conditions. A Dartmouth spin-off company is in the works. In addition, Fossum, who joined the Thayer faculty in 2010, is sharing his entrepreneurial expertise as director of Thayer's PhD Innovation Program and as the newly appointed associate provost for Dartmouth's Office of Entrepreneurship and Technology Transfer.

"All of you know something about Eric," Dean Joseph J. Helble said at the Thayer reception. "Few of you know how transformative his work has been, and how deeply engaged he is in the life of this university. Eric, we are deeply honored to have you at Thayer, and proud of what you have done as an engineer for the world."

Q&A

Zoe Dinneen '18

When studio art major and Thayer human-centered design minor Zoe Dinneen '18 took ENGS 21: Introduction to Engineering last year, she helped invent a pneumatic fire hydrant cover that easily clears hydrants of snow. The device interested the Hanover Fire Department and turned Dinneen into an entrepreneur. She and engineering major Kelsey Catano '18 have filed a patent with their ENGS 21 team, founded a company, ClearPressure, and sponsored an ENGS 89/90 group of BE students to further develop the invention.

>> What is it like to have an ENGS 89/90 group working for you?

It has been exhilarating to develop our solution from inception to manufacturing to implementation. Building a company has been a practice in tapping the Dartmouth network. I have met so many professors, alums, and graduate students who have shaped my approach to solving design and business challenges. I was nervous about my first meeting with the 89/90 group we're sponsoring because I'm a junior, I'm not an engineer, and I had to come to them and say, "Hi, I'm basically your boss, I'm paying for your work, and I'm really excited for you to be working with me, and this is what I want" in a very clear way. Managing an upper-level engineering team without having a formal engineering background has been the most incredible learning experience.

"Managing an upper-level engineering team without having a formal engineering background has been the most incredible learning experience."

What problem is your group trying to solve?

We patented a works-like prototype consisting of a stack of tire inner tubes connected by a hose that uses air to displace snow in one minute. We tasked the 89/90 team with transforming our concept into a manufacture-ready device that can also move ice. The questions we posed were: What materials are going to stand up to the stress of air pressure and winter? What design has the fewest seams, the simplest aesthetic, and is the most cost effective? We also want the design to easily integrate into the established system to ensure that firemen can respond to an emergency immediately.

How is the project progressing?

The team has been iterating different shapes and designs and is thinking about it in a holistic way. I have been impressed by their methodical approach. There was so much forward momentum this past fall that Kelsey and I decided to dedicate our off-term to bringing this product to market.

Future plans?

I'm working to secure a partnership with Hanover, in which they will financially support the progress going forward so we can do some testing. I'm also hoping to partner with a team of graduate business students who will be able to help me take the company to the next level. I am interested in design, in entrepreneurship, and fostering connections through alumni. I'm trying to keep an open mind about my career plans. The way I think about things has been changing so rapidly as I learn more about business, engineering, and the infinite possibilities that arise when you refuse to take no for an answer.

OPPOSITE PAGE: JOHN SHERMAN. THIS PAGE: KATHRYN LAPIERRE

Kudos

ELECTED Professor Tillman Gerngross has been elected to The National Academy of Engineering (NAE). Cofounder of five highly successful biotechnology companies for the discovery and manufacture of biopharmaceuticals—GlycoFi (acquired by Merck), Adimab, Arsanis, Avitide, and Alector—he joins **Professors Eric Fossum, Elsa Garmire,** and **Robert Dean** as NAE fellows.

NAMED Professor Eugene Santos Jr. has been named a fellow of the American Association for the Advancement of Science (AAAS), the world's largest general scientific society and the publisher of the journal *Science*. He was cited "for distinguished contributions to the field of information and decision sciences, particularly for computational modeling of decision-making under uncertainty with application to human behavior modeling."

NAMED Adjunct Professor Richard Greenwald Th'88, cofounder of Simbex and the nonprofit National Institute for Sports Science and Safety, has been named a fellow of the National Academy of Inventors (NAI). His work focuses on sports injury prevention and medical devices, including technology that monitors the frequency, severity, and location of head impacts in helmeted sports. He joins engineering **Professors Eric Fossum, Tillman Gerngross, Elsa Garmire, Axel Scherer,** and **Robert Dean** as NAI fellows.

AWARDED Professor George Cybenko, the Dorothy and Walter Gramm Professor of Engineering, received two awards in 2016: SPIE's Eric A. Lehrfeld Award "for outstanding contributions to global homeland security" and the U.S. Air Force Commander's Public Service Award in recognition of "service or achievements which contribute significantly to the accomplishment of the mission of an AF activity, command, or staff agency."

AWARDED Professor Lee Lynd, the Queneau Professor of Environmental Engineering Design, received the Society for Industrial Microbiology and Biotechnology's 2016 Waksman Outstanding Teaching Award.

NAMED Professor Keith Paulsen Th'84 '86, the Robert A. Pritzker Professor of Biomedical Engineering, was named a Fellow of the Optical Society of America (OSA). He joins **Professors Brian Pogue, Eric Fossum,** and **Elsa Garmire** as OSA fellows.

I Want One of Those!

Left to right, George Cheng '19, Allison Chuang '19, and Jonathan Martin '19.

STUDENT PROJECT

ICETRAX

Wintry sidewalks will be a lot easier for wheelchairs to navigate with IceTrax tire covers. The inexpensive PVC and nylon covers add grip to tires and are easy to use. Juan Castano '19, George Cheng '19, Allison Chuang '19, Jonathan Martin '19, and Zoe Yu '19 won the Fall 2016 Philip R. Jackson Prize for outstanding performance in ENGS 21: Introduction to Engineering for their invention. They have filed for a provisional patent, developed a company website, and are seeking funding to continue development of their product. Their teaching assistant was Daisy Xu '19.

Ebony Smith '18 is a Dartmouth Emerging Engineers tutor.

STUDENTS

Smoothing the Road to Engineering

FOR SOME ASPIRING ENGINEERS, THE road to the major may seem too rocky as they grapple with math, physics, chemistry, and computer science prerequisites. Recognizing that all some students may need is a little help and encouragement to complete those preparatory courses, the Dartmouth Emerging Engineers (DEE) program is providing study aid and support for three hours a night at Thayer every Sunday through Thursday.

"Our data indicate the majority of engineering dropouts—meaning switching to a different major—occur in the prerequisite mathematics and science courses for the major, often before students have taken a single engineering class," says Professor Petra Bonfert-Taylor, who heads the program with Assistant Dean for Academic and Student Affairs Holly Wilkinson. "Our goals are to help students be successful and keep the doors to the engineering major open for them by supporting them both academically and emotionally."

Tutoring by peers is one of DEE's main activities. "We carefully select and train our TAs so as to provide academic as well as emotional support to our students," Bonfert-Taylor says. "Students are especially vulnerable during their first year here since, after having been high achievers in their high schools, they now might experience their first class in which they struggle and receive a poor or even failing grade. We want to prevent a first poor grade from derailing a student's path."

As engineering major Ebony Smith '18, a DEE tutor who was previously a tutee, says, "A professor can schedule an exam at a time when you don't have all the pieces together—you're still trying to sort them out in your head. Working with a tutor helped me voice and piece together bits and pieces I had gotten from lecture and forced me to explain what I thought the concepts were. All I really needed was for someone to just listen and tell me, you know, you're really on to something there. A lot of times the student just needs to hear that. I feel that some of our best engineers could come from that person who might give up if there's not another person saying that you can do it."

"I remembered how I struggled my freshman year trying to go through all those prerequisite courses," says DEE tutor Sandile Dube '19. "In a class of 80 people a professor has to assume some level of knowledge that people are coming in with, but the truth is that people are coming in with different levels of preparation. DEE meets people where they are and helps them work from there."

According to Wilkinson, DEE deliberately holds study sessions at Thayer to incorporate prospective majors into the Thayer community from the start.

"Freshmen get to interact with other people pursuing engineering and watch them work on their projects," says Sandile, who tutors math. "The question that comes up most often is: 'Will I ever need this in engineering?' I think it's encouraging for them to hear, yes, you need it and you can apply it to this and to that and to this. They need to be in Thayer because they get to see the relevance of the prerequisite courses even before they start taking an engineering course."

Smith says that DEE offers students a place where they "are able to voice what they are feeling, their frustration. If they say they failed a midterm, I can say I understand because I got a D on my first math midterm, but I still passed the class with a high B. They come back for those conversations, for the community. It's about the laughs, working over a problem, and having someone there to encourage you. Being in an atmosphere where people keep trying encourages you."

DEE study sessions have attracted 95 students this year, according to Bonfert-Taylor.

"One of the reason I'm here," says Smith, "is to inspire the students who have similar thoughts of doubt or fear, that if they don't voice them can turn them around from their dream, from what they have passion for just because the road looks too difficult and has too many bumps in it. My hope for DEE is that students are exposed to different experiences of what it is like to be an engineer at Dartmouth. We each have our weaknesses, we each have our strengths, and you have to find what works for you."

TRIBUTE

Myron Tribus

MYRON TRIBUS, DEAN OF Thayer School from 1961 to 1969, died August 31, 2016 in Pensacola, Fla., at age 94.

An expert in thermodynamics, probability statistics, decision making theory, quality management, and business theory, Tribus led Thayer through a period of growth and innovation during his eight-year deanship. Stating that "knowledge without know-how is sterile," he led the faculty in developing a new curriculum based on engineering design and entrepreneurship. He initiated systems courses and the hands-on design projects—including in Engineering Sciences 21: Introduction to Engineering—that remain strengths of the Thayer curriculum. He launched BE, ME, MSc, DE, and PhD programs, increased the faculty from 18 to 34, boosted research, and created partnerships with industry to give students real-life engineering experiences.

"Myron was a true visionary who led the Thayer faculty to develop our novel teaching approach using systems for the analytical side and project courses to stimulate the design side of the engineering mind," says John Collier '72 Th'73 '75 '77, Thayer's Myron Tribus Professor of Engineering Innovation.

"It is partly thanks to the Tribus initiatives of the 1960s that the National Academy of Engineering awarded Thayer with the 2014 Gordon Prize for its successful program in developing future engineering leaders," says Elsa Garmire, Dean Emerita and Sydney E. Junkins 1887 Professor Emerita. "Tribus' impact has lasted more than 50 years. He will long be remembered at Thayer School of Engineering."

Tribus is survived by two daughters and five grandchildren. He was predeceased by his wife of 66 years, Sue Tribus, and one grandson.

For a full obituary and more remembrances by Collier and Garmire, visit dartmouthengineer.com.

OPPOSITE PAGE: LEFT, KATHRYN LAPIERRE; RIGHT, MAYELLEN MATSON. THIS PAGE: LEFT, THAYER SCHOOL ARCHIVES; RIGHT, XIAOTIAN WU

lab reports

Fluorescent-Guided Surgery

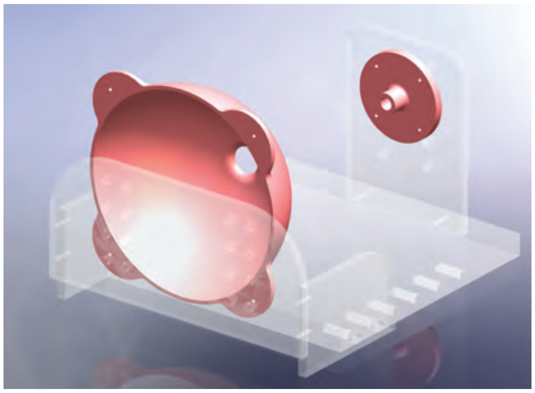
DARTMOUTH RESEARCHERS received FDA approval to conduct a clinical trial of a fluorescent agent for guiding tumor surgery. The agent, ABY-029, will be tested in six to 12 patients with recurrent glioma, a tumor that starts in the brain or spine. The fluorescent imaging agent will "allow surgeons to resect small amounts of residual disease that can be very difficult to detect otherwise," says lead clinical investigator and Dartmouth-Hitchcock neurosurgeon David Roberts.

"Our approach will dramatically accelerate the paradigm shift towards molecularly guided surgical oncology," says principle investigator Keith Paulsen Th'84 '86, Thayer's Robert A. Pritzker Professor of Biomedical Engineering and scientific director of Dartmouth's Center for Surgical Innovation.

Surgical Model ▼

IMAGINE REMOVING A CANCEROUS prostate by using a console with robotic arms instrumented with forceps and grabbers that enter the abdomen through several tiny openings. The tricky procedure just became easier to master with a training device created by Professor Ryan Halter Th'06 and his team: a 3D-printed model of part of the pelvic anatomy. Resulting from a request from Dartmouth-Hitchcock urologist Elias Hyams. Thayer PhD candidate Xiaotian "Dennis" Wu Th'14 designed and fabricated 3D-printed molds to produce silicone models of the bladder neck and distal urethra. Ten surgical residents helped test and refine the models.

"The huge benefit of this is that training can be accomplished on devices instead of on patients," says Halter. *—Anna Fiorentino*



Kudos

AWARDED **Professor John Zhang** received a 2016 National Institutes of Health Director's Transformative Research Award for his work on bio-inspired nanomaterials, scale-dependent biophysics, and nanofabrication technology. The grant will fund his project, "Implantable Cardiac Power Generation Using Flexible 3D Porous Thin Films."

AWARDED **Assistant Professor Fiona Li** was selected to receive an Air Force Office of Scientific Research 2017 Young Investigator Award, given to junior faculty who show "exceptional ability and promise for conducting basic research."

PUBLISHED **Professor Zi Chen** has uncovered the role of mechanical forces in embryonic development, as he explained in a paper titled, "How the embryonic chick brain twists," published in the Royal Society journal *Interface*. "The rightward torsion of the brain is one of the earliest organ-level left-right asymmetry events in development," he writes. "Our work uncovers the role of mechanical forces in this morphogenetic process and will open new venues of research on how molecular genetics and mechanical factors cooperatively regulate morphogenesis in development."

PUBLISHED **Professor Petra Bonfert-Taylor** made a case for using instructional videos to enhance active learning in the October 31, 2016, issue of *Inside Higher Ed*. "Watching a video before class is an engaging and more easily digestible form of reading a chapter in a textbook before class and very beneficial to prime student learning during subsequent in-class activities," she writes.

AWARDED **The Clare Boothe Luce Program**, which encourages women to pursue science, math, and engineering, has awarded a grant to Dartmouth in support of 12 Undergraduate Research Awards at Thayer School over a three-year period.

AWARDED **Mobile Virtual Player**, maker of the robotic football tackling dummy that originated as a Thayer BE student project, won the "Training the Athlete" category in the second annual 1st and Future competition, a collaboration between the NFL and the Texas Medical Center (TMC) to award startups focused on improving sports technology and athlete safety. MVP received $50,000 from the NFL to further develop the tackling dummy, which also got a plug in a Superbowl ad.

Thayer School's First

THIS PAGE: *GENERAL SYLVANUS THAYER, CLASS OF 1807*, BY THOMAS SULLY. HOOD MUSEUM OF ART, DARTMOUTH COLLEGE; GIFT OF GENERAL SYLVANUS THAYER, CLASS OF 1807. OPPOSITE PAGE: LOWER RIGHT, DARTMOUTH COLLEGE ARCHIVES

1867

Colonel and Brevit Brigadier General Sylvanus Thayer, valedictorian of Dartmouth's Class of 1807, initiates the establishment of an engineering school at his alma mater. He draws on his Dartmouth education, his experience developing an engineering curriculum as superintendent of the United States Military Academy at West Point (1817–1833), and his subsequent career in the U.S. Army Corps of Engineers to create a civil engineering curriculum for students with a firm grounding in the liberal arts. He donates $70,000 and a library of books, manuscripts, and plates about engineering in Europe and the United States.

ALL IMAGES: THAYER SCHOOL ARCHIVES UNLESS OTHERWISE NOTED.

150 Years

BY THERESA D'ORSI

1870

After a three-year search, 23-year-old Lt. Robert Fletcher is selected to become the first dean and professor of Thayer School of Civil Engineering.

1871

Thayer School opens with three students and five small rooms in Wentworth, Reed, and Thornton Halls. Dean Fletcher, the only full-time faculty member, teaches 14 engineering courses during the first academic year and 36 the following year.

1872

Sylvanus Thayer dies, leaving a legacy as founder of Thayer School, "Father of West Point," and initiator of engineering education in the United States.

1873

Thayer graduates its first three students.

1879

Dean Fletcher introduces a curriculum that forms the mainstay through 1918. The 12 courses: Surveying Mechanics, Resistance of Materials, Properties of Construction Materials, Materials and Structural Elements, Bridges and Roofs, Hydraulic Works, Heat and Heat-Engines, Sanitary Engineering, Rivers and Harbors, Rockwork, Tunneling, and Mining, and Masonry and Foundations.

1891

Thayer School's first capital campaign seeks $50,000 for the endowment to cover the cost of books and instruments, visiting lecturers, class tours, and a salary increase for the school's second professor, Hiram Hitchcock.

1892

Thayer School buys a building on Park Street.

1893

Dartmouth seniors are allowed to study at Thayer School and graduate with an engineering degree after a fifth year.

1896

Using equipment he built, Professor Frank Austin, Class of 1895, (standing in photo) helps Hanover physician Dr. Gilman Frost take the world's first diagnostic X-ray.

1902

The Thayer Society of Engineers (now Dartmouth Society of Engineers) forms "to further the interests of the Thayer School of Civil Engineering."

1912

Thayer School moves into Bissell Hall, next door to the Hanover Inn.

1918

Dean Fletcher retires from the deanship after 47 years but teaches for another 18 years.

1922

Dean Charles Holden arranges for Thayer students to take business courses at the Amos Tuck School of Administration and Finance.

1925

Professor Raymond Marsden, Class of 1909, becomes dean. He modifies the academic calendar and rearranges first-year courses to strengthen Thayer's relationship with Dartmouth.

1933

Professor Frank Garran becomes dean. "Engineering is alive and real. We should make it that way in our teaching," he tells the faculty.

1936

Dean Fletcher dies at age 88 and is buried in the Dartmouth cemetery.

1939

Cummings Memorial Hall opens. Named in memory of Horace Cummings, Class of 1862 and husband of donor Jeannette Cummings, it is the first facility built specifically for Thayer School.

1940

Thayer offers a civilian pilot training program as World War II widens.

1941

The school drops "Civil" from its name and adds electrical and mechanical engineering courses.

1941

Professor Millett Morgan's radiophysics study of the upper ionosphere and magnetosphere forms Thayer's first large-scale research program.

1941

Thayer professors teach surveying, engineering drawing, and mathematics to regional government and defense industry workers at Hanover and Lebanon high schools.

1942

The Tuck-Thayer program—three years of liberal arts at Dartmouth topped with two years of engineering and business—launches.

1943

Operating the Navy's largest V-12 College Training Program, Thayer School shifts to year-round operation and accelerated engineering degrees. With reveille at 6 a.m. and taps at 10 p.m., Thayer School operates like a naval base for the rest of the war.

1943

Specialized V-12 courses include naval organization, law, history, and strategy.

1945
Dean Garran dies. The Thayer School Register praises him for reshaping the school "for the greatest service to the Country, the Profession and the College."

1945
Professor William Kimball becomes dean.

1947
Two wings are added to Cummings Hall.

1955
Dartmouth establishes the Department of Engineering Sciences as part of the science division.

1957
Professors James Browning '44 (pictured) and Merle Thorpe '53 found Thermal Dynamics Corp. to market plasma-cutting technologies they developed at Thayer. It is Thayer School's first startup.

1958
ES 21: Introduction to Engineering debuts to give students a theoretical foundation at the beginning of their engineering studies.

1960
Dartmouth's trustees authorize Thayer School to increase research and grant doctoral degrees.

1961
Myron Tribus becomes dean. He expands the faculty, research, the curriculum, and partnerships with industry.

1961
Dean Tribus and Professors Robert Dean and Russell Stearns '37 Th'38 revamp ES 21: Introduction to Engineering into a hands-on project-based experience. The first challenge for students: develop a bicycle that stores energy on the downhill for use going uphill.

1962

Chris Miller ’66 Th’67 ’68 and Dean Spatz ’66 Th’67 ’68 (pictured left to right) are among the ES 21: Introduction to Engineering students who solve the challenge of making brackish water potable. The experience leads each to found reverse-osmosis companies.

1966

Women are allowed to take graduate courses at Thayer School, although Dartmouth is not yet coeducational.

1970

David Ragone becomes dean. He continues the trajectory Dean Tribus set.

1964

Thayer School graduates its first PhD student, Michael Turner.

1965

Thayer School graduates its first Doctor of Engineering (DE) students, Thomas Black and Andrew Porteous.

1971

Professor John Strohbehn launches Thayer School’s biomedical research program.

1972

Carl Long becomes dean. He strengthens ties with industry, expands research collaborations with Dartmouth Medical School and the U.S. Army Cold Regions Research and Engineering Laboratory, and launches the Dual-Degree Program by bringing in female undergraduates from other colleges.

1972

Charlie Nearburg ’72 graduates after having combined engineering with studio art, creating a model for modified majors in engineering.

1973

Visnja Gembicki ’73 Th’73 (pictured) and Susan Liu Yang Th’73 become the first women to earn MS degrees at Thayer School.

1975

The Robert Fletcher Award is established to honor graduates or friends of Thayer School for distinguished service.

1975

Visiting Assistant Professor Nancy U. Crocker becomes the first woman on the Thayer School faculty.

1976
The Board of Overseers creates the Dean's Fund, later renamed the Thayer School Annual Fund, to help support the school.

1978
INVENTE, later renamed Cook Engineering Design Center, is established to promote industry-sponsored research.

1979
Thayer and Dartmouth Medical School offer an MD/PhD program in biomedical engineering.

1981
Diane Knappert Clark '77 Th'78 '81 becomes the first woman to earn a Thayer Doctor of Engineering (DE) degree.

1982
Professor Horst Richter establishes a BE foreign study program with Germany's University of Aachen.

1982
Professor John Collier '72 Th'73 '75 '77 and Michael Mayor, M.D., found the Dartmouth Biomedical Engineering Center to collect, analyze, and improve artificial knee and hip joints.

1983
Thayer establishes a Resource Policy Center, later incorporated into Dartmouth's environmental studies program.

1984
Charles "Hutch" Hutchinson '68A becomes dean. He expands the faculty, research, programs, facilities, and the endowment.

1984
Professor John Collier '72 Th'73 '75 '77 begins teaching ES 21: Introduction to Engineering. He adds entrepreneurial elements to the course.

1987
Thayer's first product design course, taught by Professors John Collier '72 Th'73 '75 '77 and Peter Robbie '69, attracts studio-art majors and engineers.

1988
Cummings Hall expands, adding the Great Hall and doubling Thayer School's size.

1988
Thayer School creates a program combining engineering and management courses for an ME degree, led by Tuck School's Professor Kenneth Baker.

1988
Students race a solar-powered car, SunVox, in the Tour de Sol, a six-day race through the Swiss Alps.

1989
Cassandra Fesen becomes the first woman on Thayer School's core faculty.

1990

Joyce Mechling Nagle Th’90 becomes the first woman to earn a PhD at Thayer School.

1991

Thayer Associate Dean Carol Muller ’77 cofounds Dartmouth’s Women in Science Project (WISP) to encourage female students to pursue science, math, and engineering. The project includes placing first-year students into research internships.

1995

Students found Dartmouth Formula Racing to compete in Formula Society of Automotive Engineers (SAE) races.

1995

Elsa Garmire becomes Thayer School’s first female dean. She advocates for research centers of excellence and a building expansion.

1997

The engineering management (ME) degree is renamed the master of engineering management (MEM) degree.

1998

Lewis Duncan becomes dean. He oversees the expansion of research and lays the groundwork for an additional building.

2001

Professor Horst Richter establishes a foreign exchange program with Helmut Schmidt University in Hamburg, Germany.

2003

Students build a hybrid racecar and exhibit it at the annual Formula SAE competition.

2004

Thayer students found a Dartmouth chapter of Engineers Without Borders, which later becomes Humanitarian Engineering Leadership Projects (HELP), which in turn becomes Dartmouth Humanitarian Engineering in 2010. Students work on clean-water, pico-hydropower, sanitation, and cook-stove projects in Africa.

2004

The Corporate Collaboration Council is founded to mentor MEM students and advise MEM faculty.

2005

Joseph J. Helble becomes dean.

2006

MacLean Engineering Sciences Center opens, doubling the size of Thayer School’s facilities. The building is named for lead donors Barry ’60 Th’61 and Mary Ann MacLean.

2006

GlycoFi, a biotech startup founded by Professor Tillman Gerngross and Dean Emeritus Charles Hutchinson ’68A, is sold to Merck for $400 million.

2006

Thayer founds and hosts a Formula Hybrid International Competition.

OPPOSITE PAGE: LEFT, JOHN SHERMAN; UPPER RIGHT, CHAD HUNT; LOWER RIGHT, DOUGLAS FRASER

2006

The GryroBike, a stabilizing bike for beginners, wins a Breakthrough Award from *Popular Mechanics*. Hannah Murnen '06 Th'07, Deborah Sperling '06 Th'07, Nathan Sigworth '07, and Augusta Niles '07 Th'08 (pictured left to right) invented it as their ENGS 21 project.

2007

The faculty selects Engineering in Medicine, Energy, and Complex Systems as research focus areas.

2008

Thayer establishes the nation's first PhD Innovation Program to provide entrepreneurial training to doctoral candidates. Ashifi Gogo Th'09 '10 graduates in its first cohort and founds Sproxil, a company that identifies fake drugs.

2008

Professor Francis Kennedy organizes an undergraduate exchange program with Chulalongkorn University in Bangkok, Thailand.

2009

Lindsay Holiday '07 Th'09, Dana Leland '09, and Philip Wagner '09 (pictured left to right) invent an arsenic removal system for use in rural Nepal, where naturally occurring arsenic is a major groundwater contaminant. The project, created for Thayer's capstone design sequence, wins the National Inventors Hall of Fame's Collegiate Inventors Competition.

2011

Thayer launches an undergraduate exchange program with the Chinese University of Hong Kong.

2011

Professor Eric Fossum, inventor of the CMOS image sensor used in most cell phone cameras, is inducted into the National Inventors Hall of Fame.

2012

Dartmouth Humanitarian Engineering students build a zero-emissions, sustainable hydroelectric generating station in Rwanda.

2013

Professor Tillman Gerngross becomes associate provost for Dartmouth's newly reconfigured Office of Entrepreneurship and Technology Transfer. He uses his experience as a serial biotech entrepreneur to smooth the way for others.

2014

The Center for Surgical Innovation opens at Dartmouth-Hitchcock Medical Center under the direction of imaging expert Professor Keith Paulsen Th'84 '86. It is the nation's first such facility wholly dedicated to research.

2014

The National Academy of Engineering awards its Bernard M. Gordon Prize for Innovation in Engineering and Technology Education to Professors John Collier '72 Th'73 '75 '77, Robert Graves, Joseph Helble, and Charles Hutchinson '68A for integrating entrepreneurship into all levels of Thayer's curriculum to prepare students for technology leadership.

2015

Professor Robert Dean, founder of 11 companies, is named a National Academy of Inventors Fellow. He joins Professors Eric Fossum, Tillman Gerngross, Elsa Garmire, and Axel Scherer as NAI Fellows, scholars who have demonstrated a prolific spirit in creating or facilitating inventions to improve quality of life

THIS PAGE: ABOVE CENTER AND LOWER CENTER, JOHN SHERMAN; UPPER RIGHT, NATIONAL ACADEMY OF ENGINEERING; LOWER LEFT, KURT KOSTYU. OPPOSITE PAGE: CENTER, ELI BURAKIAN '00; RIGHT, JOHN SHERMAN

2015 ▲

The Mobile Virtual Player (MVP), a remote-controlled robotic tackling dummy, takes the football world by storm. Invented by Noah Glennon Th’14 ’15, Andrew Smist ’13 Th’14, Elliot Kastner ’13 Th’14 ’15, and Quinn Connell ’13 Th’14 (pictured left to right with advisor John Currier ’79 Th’81) as their ENGS 89/90 project, the MVP reduces the risk of concussions during practice. Football coach and project sponsor Buddy Teevens ’79, Kastner, Connell, and Currier cofound the Mobile Virtual Player company to make the dummy available to NFL and other teams.

2016

Overseer Barry MacLean ’60 Th’61 pledges $25 million, the largest gift in Thayer's history, to help fund an additional building and endow professorships.

2016 ◄

In a national first, women earn more than 50 percent of undergraduate engineering degrees.

2016

Thayer's Center for Imaging Medicine opens at the Williamson Translational Research Building at Dartmouth-Hitchcock Medical Center to put new medical imaging techniques into clinical practice.

2016

Thayer launches an undergraduate exchange program with the Technical University of Denmark.

2016

Professor Eric Fossum, head of Thayer School’s PhD Innovation Program, takes over from Professor Tillman Gerngross as Dartmouth’s associate provost for the Office of Entrepreneurship and Technology Transfer.

2017

Thayer School begins a year-long celebration of its 150th anniversary.

For more historical photos and celebration information, visit: Thayer150.dartmouth.edu.

THERESA D’ORSI is Alumni News Editor of *Dartmouth Engineer*.

Looking to the Future

THE BEGINNING OF THAYER SCHOOL'S NEXT 150 YEARS CAN BE SUMMED UP IN ONE WORD: EXPANSION.

BY KAREN ENDICOTT

ILLUSTRATION BY MICHAEL AUSTIN

THE NEXT 150

Picture more faculty, more students studying engineering, more research, more startups, more impact on the world. And picture an additional building that will extend Thayer School's facilities and co-house Dartmouth's Department of Computer Science, creating novel educational opportunities and powerful research collaborations.

Those are the plans that Dean Joseph J. Helble and Thayer's Board of Overseers are championing and that form a key component of the vision that President Phil Hanlon '77 has forwarded for all of Dartmouth.

Kicking off the growth initiative, Overseer Barry MacLean '60 Th'61 has already pledged $25 million—the largest gift in Thayer's history—toward the new building and professorships. "Our exciting vision ensures Dartmouth's sustainable and long-lasting impact on the world," he says.

The growth of engineering at Dartmouth comes at a time of upward trajectory for Thayer School. Demand for engineering courses continues to grow, with record levels of student enrollments and record numbers of non-majors taking engineering courses. Thayer achieved gender parity among undergraduate majors in 2016—a national first for a comprehensive research and teaching university. A recent student invention, the Mobile Virtual Player robotic football tackling dummy, is taking the sports world by storm, with teams ranging from the NFL to high schools practicing with the "MVP" to reduce the risk of concussion among athletes.

Faculty distinctions are growing as well. One in three Thayer professors have founded companies, likely the highest rate of engineering faculty entrepreneurship in the nation. Thayer professors are receiving engineering's highest accolades, including inductions into the National Inventors Hall of Fame, National Academy of Engineering (NAE) fellowships, and the NAE's Bernard M. Gordon Prize for Innovation in Engineering and Technology Education. Most recently, Professor Eric Fossum, inventor of the CMOS active pixel image sensor, received the world's top engineering recognition, the 2017 Queen Elizabeth Prize for Engineering (see page 2).

Thayer's research labs have expanded beyond Cummings Hall and MacLean Engineering Sciences Center. At Thayer's Center for Imaging Medicine, which occupies a floor of the Williamson Translational Research Building at Dartmouth-Hitchcock Medical Center, researchers benefit from proximity to clinicians. Researchers in energy will be able to collaborate with colleagues at Dartmouth's new Arthur L. Irving Institute for Energy and Society, which will be housed in a building to be constructed between Thayer and Tuck School of Business.

Thayer's new building will bring together disciplines that share a language of increasing global importance: the language of technology.

"The new building will embody the complete and seamless integration of the digital (computer science) and physical (engineering) sides of technology," says Helble.

"Research labs and spaces will be located by theme rather than department in order to bring together faculty and students from engineering and computer science who work in similar or overlapping areas," he says. "For example, computational biologists, such as computer science professor Chris Bailey-Kellogg and Gevorg Grigoryan, will have space adjacent to bioengineers, such as engineering professors Margie Ackerman and Karl Griswold, as they tackle protein engineering challenges from both *in silico* and *in vitro* perspectives. Similarly, faculty working on energy, robotics, security, and other challenges that have computer science and engineering components will be co-located according to their intellectual areas."

Further, Helble says, "The ground floor—and possibly another main floor—will be dedicated to integrated design. Engineering and computer science students will learn side-by-side, sharing project space late into

PROPOSED BUILDING FOR ENGINEERING AND COMPUTER SCIENCE

(CONCEPTUAL IMAGE)

THAYER'S NEW BUILDING WILL BRING TOGETHER DISCIPLINES THAT SHARE A LANGUAGE OF INCREASING GLOBAL IMPORTANCE: THE LANGUAGE OF TECHNOLOGY.

CONCEPTUAL IMAGE BY WILSON ARCHITECTS

WHEN BIGGER IS BETTER

Expansion will allow Thayer School to:

- give all Dartmouth students opportunities to enhance their liberal arts education with problem-solving skills to prepare them for life and leadership in a technology-driven world
- offer more experiential courses to both majors and non-majors
- double the size of the faculty from 50 to 100 to optimize class sizes for experiential learning and increase the impact of research
- provide cutting-edge research facilities and funding to attract more leading professors from across the world
- double the number of graduate students empowered with a Thayer education
- expand Thayer's PhD Innovation Program to prepare more doctoral students to turn their research discoveries into world-improving technologies
- facilitate novel educational, research, and entrepreneurial collaborations between engineering, medicine, computer science, and business to solve global problems and better the lives of people throughout the world

the night, which is when some of the most interesting conversations happen. Working on the same teams, they'll bring multiple perspectives to problem-solving and learn from one another in the process. They'll combine their technical knowledge and skills to innovate in areas of growing importance and opportunity, such as the world of connected devices, the Internet of things. In addition, professors and students from both engineering and computer science will have access to a comprehensive machine shop supporting both programs—computer science already has 3D printers in Thayer's machine shop—and new maker spaces that could be open to a broader Dartmouth community."

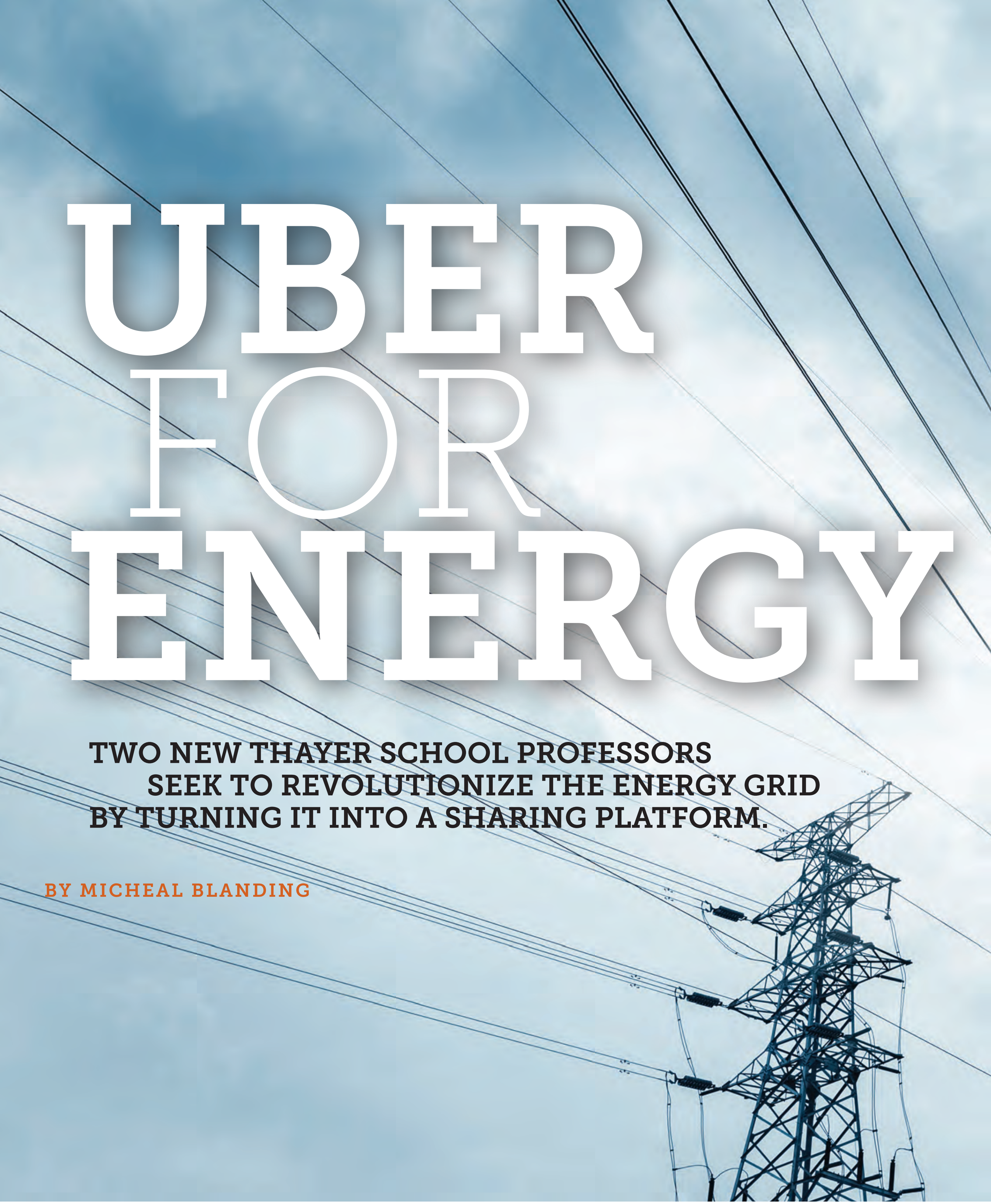
Professor Hany Farid, chair of the Department of Computer Science, takes a similar view. "We believe that the landscape of computer science and engineering is rapidly changing because the digital and physical worlds have collided with nearly every physical device containing a digital component," he says. "We believe that in order to prepare our computer science students for this future, we must re-envision our core computer science curriculum to teach our students how to build physical devices as well as how to program them. As a relatively small department, we simply could not accomplish this without this integration of Thayer and computer science."

Farid sees other advantages in engineering and computer sciences working together more closely. "As we look to the future of faculty hiring, we also envision hiring faculty that work at the intersection of the physical and digital worlds, including robotics, computational manufacturing, and security. There is no doubt that recruiting and retention will be strengthened by a critical mass of engineering and computer science faculty working collaboratively in new and exciting areas. The combined Thayer and computer science faculty will allow us to compete with our peer institutions that currently dwarf our respective departments," he says.

Terry McGuire Th'82, chair of Thayer School's Board of Overseers and a leader of the expansion efforts, sees growth as a major means of achieving a valued goal: using technology to "touch live," as he puts it.

"There are very few rewards in life as great as making a positive impact on the people, organizations, and world around us," he says.

KAREN ENDICOTT is the editor of *Dartmouth Engineer*.



UBER FOR ENERGY

TWO NEW THAYER SCHOOL PROFESSORS SEEK TO REVOLUTIONIZE THE ENERGY GRID BY TURNING IT INTO A SHARING PLATFORM.

BY MICHEAL BLANDING

These days, it seems like there is a sharing platform for everything. Want a ride? Uber. A place to crash? Airbnb. A new dress? Rent the Runway. Anything someone isn't using seems fair game to trade to someone else. But what about the thing we use more than just about anything else in our lives—electricity?

Two new Thayer School professors, Geoffrey Parker and Amro Farid, are examining ways that we can take the excess power in the energy grid and get it back into the system where it can be used by someone who needs it. That practice, they say, holds the key to not only making our energy grid more efficient, but also to dramatically increasing our ability to use clean, renewable energy sources.

"If you think about Uber or Airbnb, they are really taking spare capacity in the economy and matching it with demand," says Parker, who joined Thayer last July as a professor of engineering and director of the Master of Engineering Management program. "In the energy system, especially on the demand side, there is a lot of capacity that is idle or not being used as much as it might because there is no platform to get that capacity to do something valuable."

Parker studied electrical power and communications networks as an engineering student at MIT before pursuing a PhD in management science from MIT's Sloan School of Business. In the early days of the Internet in the 1990s, he explored the very first sharing networks, including FTP file transfer programs; the first Web browser, Mosaic; and Amazon.com. Parker co-developed the theory behind two-sided markets with Marshall Van Alstyne, now a professor at Boston University; together they authored the book *Platform Revolution*, released last year.


Geoffrey Parker

Parker and Van Alstyne pioneered the idea of the "two-sided network effect"—the idea that networks are made of distinct user types who attract one another and become more valuable as more people use them, which then causes them to attract more people in a virtuous circle. "Network effects are the huge engine that makes a platform work or not," says Parker. The past two decades have seen dozens of platforms spring up, including Google, iTunes, Facebook, Netflix, and YouTube, that all function according to network effect principles. In each of these cases, as people consume more content from the service, more people will provide content and the better the service is able to tailor itself to each individual's needs, improving the experience for everyone.

In spite of the ubiquity of these platforms, however, Parker was initially skeptical that it could be applied to something as highly regulated as the energy market, which is dominated by large industrial producers wired together in a complex grid. In 2015, however, the New York State Energy Research and Development Authority approached Parker and Van Alstyne, asking them to propose a market to make the state's energy system more efficient.

Over the next year, the two worked with colleagues from the energy and economics consulting group Tabors, Caramanis, and Rudkevich to sketch out a white paper that focused not on the large power plants upstate, but on the thousands of smaller sources of energy scattered throughout the state, including photovoltaic solar cells, Tesla batteries, and microgenerators. These distributed energy resources (DERs), they found, could be key to revolutionizing the energy grid by constructing a network to allow them to coordinate with one another.

In fact, what we think of as the grid actually consists of three different types of power—real energy, which is actual power we use to, say, turn on a lightbulb; reactive power, which helps balance fluctuations and helps keep alternating currents in phase; and reserve power, which kicks in when supply is low in order to prevent outages.

That reserve power is key to using renewable energy sources, such as solar and wind power, says Amro Farid, an associate professor of engineering who joined the Thayer faculty in 2015 and has similarly explored the creation of a smart-grid distributed energy network.

"With fossil-fuel generation, you can dispatch power at will and always keep the lights on, regardless of demand, and frankly at whatever price," says Farid, who also studied engineering at MIT before earning his PhD at the University of Cambridge in 2007.

> If you think about Uber or Airbnb, they are really taking spare capacity in the economy and matching it with demand. In the energy system there is a lot of capacity that is idle or not being used as much as it might because there is no platform to get that capacity to do something valuable.
>
> **—PROFESSOR GEOFFREY PARKER**

Renewables, however, depend on the whims of the weather. "You don't know if it's going to be sunny or windy—and even if you could predict it accurately, it will still change over time," Farid says. Such variability makes it even more important to have reserve power on hand to make sure that power doesn't fail.

As Parker explains, "If a cloud comes through or the wind dies, we saw in Texas a 3 gigawatt drop in generation over the course of an hour—that's the equivalent of losing six natural gas combined cycle plants."

To compensate, most power systems employ complex—and costly—machinery, such as natural gas combustion turbines that are available 24 hours a day so that they can quickly respond to an emergency, or large reservoirs in which water is pumped uphill at night, ready to flow downhill during high demand periods or an outage.

According to Farid, the question of exactly how much reserve energy to set aside is an important one for power generators hoping to optimize their energy use. "Too much energy, and I've lost money, too little and I am risking the reliability of the grid," he says. He recently worked to create a formula to determine that amount, publishing the results in a recent paper written with his doctoral student Aramazd Muzhikyan and colleague Kamal Youcef-Toumi of MIT for the *International Journal of Electrical Power and Energy*. The formula calculates the amount of reserve energy needed to keep the grid operating stably, based on a number of factors, including the percentage of renewables in the grid and the historical accuracy of predicting the energy load.

That's where distributed energy resources come in. By creating a network that connects the need for reserve power with supply from thousands of DERs, you could theoretically match supply and demand much the same way Uber matches drivers and passengers. That, in turn, would dramatically decrease the need for big machinery to respond to fluctuations in renewable energy generation. "If you had the ability to coordinate a lot of little actors, you could avoid a lot of really big capital investments, and hopefully better accommodate some of the variability coming out of the system with renewables," says Parker.

What's more, those resources don't have to be actual energy producers—they could also be anything that is currently storing power it is not using—including big buildings or even households running heating, air conditioning, or other energy intensive appliances. "If the wind dies off, you can tell them to back off a little bit. That 20 or 30 minutes might be all you need to get some larger equipment going or reduce demand in other parts of the system," says Parker.

That kind of process, called demand-response, is absolutely essential if we want to significantly expand renewable energy, says Farid. Ultimately, the degree to which the power grid can accommodate renewable energy is limited by the need for reserve energy capacity. Shifting that capacity from conventional generation to buildings and household appliances can yield a grid that is less carbon-intensive and much more cost-effective.

Of course, the big question is how exactly do we network together all of the "little things" that are needed to balance out the grid. Much like any sharing app, says Parker, "you do it with prices," setting up a system whereby distribution companies pay back consumers for providing reserve power on an ongoing basis. Some power systems have already experimented with such a process, crediting industrial energy users for the megawatts they don't use compared to a baseline—dubbed "negawatts." (In another paper published in January, Farid argues that the system could be even more efficient if power plants measured energy use from zero instead of a pre-calculated baseline.)

Expanding this system through a market that includes commercial and residential users could essentially create a giant platform that would incentivize all users to give back power they are not using to stabilize the grid. Turning off the heating or cooling system in a building for half an hour might not change the internal temperature much, if at all—but if hundreds of buildings did that, it could make a huge difference in compensating for disruptions due to variability in wind or solar power.

At the same time, sharing that energy could be a source of revenue for companies. "All of a sudden my large building is something I could generate some real money with," says Parker. "Those blowers and compressors that seemed like pure expense all have some spare capacity they could supply to the system."

In the same way that Uber uses surge pricing to spur more drivers to hit the road at times of higher demand, the market could also vary prices by time and location. Parker explains that these are called locational marginal prices. As it stands, energy prices can vary dramatically across a geographical area. For example, in New York State, energy might be cheap upstate near the power plants but more expensive down in the city after you figure in the cost of transmitting it long distances and the relatively high cost of producing power in the city.

A market could subdivide those prices even more finely, for example, on a single street in Brooklyn, where prices could vary depending on how close you were to a substation. "The idea is to get prices as granular as possible," says Parker, "so you could say exactly how much it is worth for a particular resource at this time in this place."

Of course, businesses and homeowners aren't going to spend all their time monitoring price fluctuations. "I am not going to sit in front of my thermostat and turn it down every time I see a penny change in electricity," says Farid. Instead, both he and Parker envision third-party vendors who could monitor those changes, turning on and off equipment for hundreds of users according to demand. "They'll say, we will trade on your behalf, and when we make you money, we'll take a cut of that," says Parker.

The same thing could happen for residential customers. "Third-party companies would come in and ask, if we help install this new technology in your home and save you $25 a month, would you give us $10?" Farid says.

With new smart appliances connected to the web through the "Internet of Things," some of these functions could even be carried out automatically. "You could imagine your home thermostat or water heater would have a controller on it and sense changes in the grid in order to respond to price incentives," says Farid. When, for example, energy prices

> **"The evolution of the market will provide so many win-win scenarios. It has the potential to reduce energy costs for consumers, make the grid more reliable, bring about new jobs, and of course create the environmental benefits so many of us care about."**
>
> **—PROFESSOR AMRO FARID**


Amro Farid

go up due to a shortage, your thermostat could shut off and sell energy back to the grid for a set period of time, then switch back on again before the temperature falls below a certain level.

By the same token, a dishwasher could automatically run at 2 in the morning when demand is lower rather than at 7 at night when energy usage is at its peak, thus saving energy and saving a consumer money. "This type of measurement would empower consumers to make their own decisions about how and when they are going to use their energy," Farid says.

Having more distributed energy sources could help make the grid more efficient in other ways as well. When a hurricane or an ice storm knocks out power lines in some areas, says Parker, the system could reroute energy around the point of failure rather than having to wait until the line to the power plant is restored. And it would also allow for construction of more alternative energy sources like wind and solar, leading to high-paying construction jobs.

"The evolution of electricity markets will provide so many win-win scenarios," says Farid. "It has the potential to reduce energy costs for consumers, make the grid more reliable, bring about new jobs, and of course create the environmental benefits so many of us care about."

While Parker and Farid haven't actively collaborated yet, they are looking forward to combining Parker's knowledge of platform markets and economics with Farid's renewable energy and demand-response expertise to help make smart power grids a reality. "Geoff and I have very similar paradigms for where this is all going," says Farid.

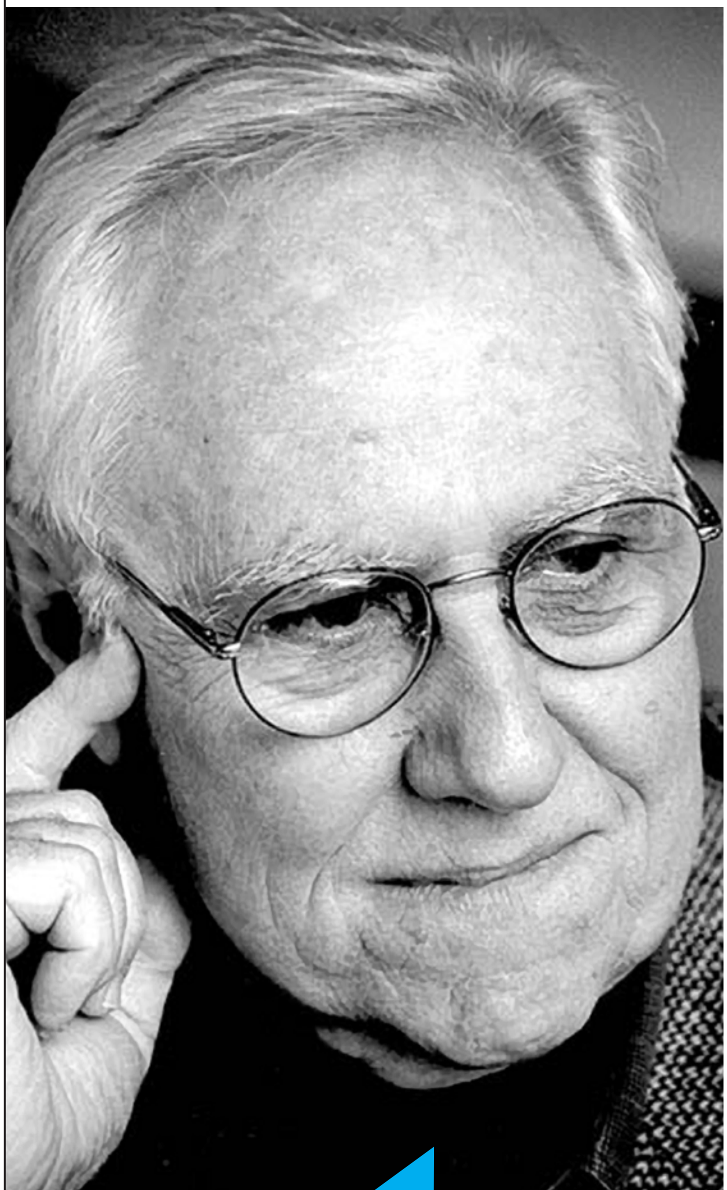
If there will be any pushback, Farid says, it will be from traditional energy companies that don't diversify their energy offerings to include renewable energy and demand response services. But Farid and Parker both hope the positive benefits of saving energy and running a more efficient grid overall will outweigh any individual financial concerns. "Naturally, there are some energy stakeholders who would like us to consume energy as we always have," says Farid. "But in terms of the benefit to the overall economy, the best megawatt is the one you don't waste."

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

Alumni News

FROM AROUND THE WORLD

spotlights



"Intellectually appealing, financially sensible, and with a touch of romance and adventure—engineering seemed like an ideal calling."

A Letter to Thayer Students

| SAM FLORMAN '46 TH'46

Sam Florman '46 Th'46 is a former Thayer Overseer and the recipient of Thayer's 1983 Robert Fletcher Award for distinguished achievement and service. His career in construction spanned more than 60 years. He has served on numerous civic boards and is a member of the National Academy of Engineering. A tireless advocate for engineering and the liberal arts, he is the author of seven books, including *The Civilized Engineer* and, most recently, *Good Guys, Wiseguys, and Putting Up Buildings: A Life in Construction*.

As I join the celebration of Thayer School's 150th anniversary, my thoughts flash back a mere 75 years to December 7, 1941, Pearl Harbor Day, the beginning of World War II. It was a Sunday and I spent the afternoon in a car on my way home to New York City after a trip around New England. A high school senior, I was taking a final look at prospective college options, and an older brother-in-law had offered to be my driver on a quick tour. The visits only helped to confirm a decision already made: Dartmouth was my first choice. I fell in love with the place for many reasons, but Thayer School—the study of engineering and liberal arts in a five-year curriculum—was very much a factor in my thinking. Our nation had been living through Depression years and I had seen the Hooverville shacks in Central Park and the breadlines all over town. I didn't have a clear concept of what engineers did, but I had formulated my own definition: math and science, which I liked a lot, along with a paycheck, which seemed important. Also, after a fashion, I viewed engineers as cultural heroes with talents that the nation needed. The newsreels that I saw every weekend between two movies at my neighborhood theater often featured the dedication of a new TVA dam or some other impressive public work, each event celebrating a counter-attack against rural dust bowls or urban slums. When the movies themselves depicted engineers, they were stalwart men in high-laced boots engaged in heroic endeavors such as building railroads across the desert. And often those lucky guys ended up with the pretty heroine. So there it was: Intellectually appealing, financially sensible, and with a touch of romance and adventure—engineering seemed like an ideal calling.

When news of the Pearl Harbor attack came over the radio—in the middle of a New York Giants football game—it was a shock to be sure, but remote, hardly believable. At school the next day we gathered in the gym to hear a radio broadcast of President Roosevelt's "Day of Infamy" speech. Soon there were air-raid drills, evening black-outs, and many other indications that life had changed. Yet I was just on the verge of turning 17 and the draft registration age was 21, not lowered to 18 for another year. News of the fighting lacked immediacy, and when we graduated from high school in the spring of 1942, few dreamed that the war would last for more than another three years.

I was admitted to Dartmouth, entering in July 1942—a year-round schedule having been established—and good fortune granted me one full year of fairly normal college life, including football weekend hijinks. And when, shortly after my arrival in Hanover, the Navy and Dartmouth, and specifically Thayer, offered students a plan to enlist yet remain in school until a degree was earned, followed by military training leading to a commission, I signed up. The Navy needed a flow of college-educated engineer officers, and Dartmouth and Thayer met that challenge by developing the largest V-12 College Training Program in the nation.

Along with a number of classmates, I was called to active duty in July 1943. We put on sailor uniforms and moved into assigned dormitory rooms, four to a suite. We were in the Navy, yet we were students with daily schedules determined by classes. There was military discipline, reveille at six, taps at ten, rigorous physical ed, and long sessions of marching in parade. Doesn't sound like fun. Yet, morale was high. Thayer Dean Frank Garran gave guidance and encouragement, and I recall especially his urging us to take liberal arts courses while we still had the chance. Bill Kimball, destined to become Thayer's next dean, led a small faculty that I remember as being friendly and upbeat.

Like all engineers, we studied math and science and took basic courses in electricity, fluid mechanics, and thermodynamics. As civil engineers, we especially studied structures—designing beams, walls, trusses. Then soil mechanics and highways, water supply and sanitation. There was a good amount of "hands-on" work, pouring concrete into tubular forms, curing it and testing it to failure, analyzing the behavior of water in pipes and over weirs. We visited the river to check water flow, spent hours at a local construction site, and one cold midnight trained our transits on the North Star.

"I viewed engineers as cultural heroes with talents that the nation needed."

Our learning experience didn't end within the halls of Thayer School. In November 1944, two and a half years after arrival on campus, a few of us qualified for a four-year degree and were granted a Dartmouth BS. After one more semester, still a bit short of the five-year Thayer degree but educated enough by Navy standards, we were sent to Rhode Island for two months of Officers Training School. Commissioned as ensigns, we spent two months in military training, hiking, crawling, tenting, shooting, taking guns apart and putting them back together again. We then journeyed to the Philippines, where we joined Seabee units mustered for the invasion of Japan. As the fates would have it, the war was in its final days.

Once the war ended, discipline among the troops tended to ease, and in my Seabee battalion the enlisted men took special pleasure in teaching us rookie officers the tricks of the hardhat trades. My first overseas assignment was maintenance of dirt roads on the Philippine island of Samar, and I suddenly found myself operating bulldozers, road graders, backhoes, and cranes. When we were sent to repair damaged buildings, I laid brick and wielded a variety of tools. This was an introduction to construction that I cannot imagine encountering under any other circumstance.

When my battalion was sent to restore facilities on Truk, the Japanese control center in the Pacific that had been bombed almost into oblivion, I shared in the design and oversight of a small earth-fill dam, a challenging project. Most of the reconstruction work on Truk was performed by Japanese soldiers under a special provision of the surrender agreement, and friendships evolved between our men and our former enemies. The written certificate of friendship given to me by the young Japanese lieutenant who was my counterpart on the dam project is one of my most prized possessions.

The post-war years saw hectic catching up for Thayer students and for just about everyone. In spite of an urge to return to Hanover, I stayed in New York. Most of my friends were returning to complete their schooling, but I had a degree, considered myself an engineer, and my first thought was to get a job. Belatedly I recalled Dean Garran's advice not to forget that liberal arts education. Also, the GI Bill encouraged vets to return to the classroom. So I signed up for a master's degree in English literature at Columbia. I also attended classes to prepare for tests leading to a Professional Engineer license, not required for most engineering careers but which I earned and maintained with pride. I found a solid job with an old established firm and then partnered with a couple of young daredevils who had just started a construction company. Our firm, Kreisler Borg Florman General Construction Co., has recently been closed after 60 splendid years.

We erected apartment houses, schools, hospitals, nursing homes, college dormitories, religious edifices, just about every type of building. Along with architects and structural and mechanical engineers, we builders, we construction engineers, take pleasure in a handsome facade, in a daring and exhilarating structure, and delight in successfully putting it all together, cleverly, on time and under budget. And then, when the project is dedicated to good purposes—for example, affordable housing for low-income citizens—how rewarding it is to be associated with such works, to attend the ground-breaking ceremonies celebrating the goodness of human endeavor.

Engineers do such a variety of things that it is impossible to capture the essence of the professional experience in any one pronouncement or in a hundred examples. I do believe that we all share that occasional jolt of delight or satisfaction—as I have called it in a book title *The Existential Pleasures of Engineering*—when we perceive a truth, solve a problem, achieve a goal. And, of course, beyond one's formally defined career, an engineer will want to devote time and energy to public service. Young engineers with technical know-how and help-your-neighbor impulses are an important asset for our society. I've had the pleasure and satisfaction of serving on the boards of a school, a hospital, and a science museum, and I've returned to Thayer for activities serious as well as congenial.

Thayer School made me the engineer I am. And as we celebrate the school's 150th anniversary, I'm grateful for having been part of its history. And I'm so proud of what Thayer has recently achieved: the National Academy of Engineering's Bernard M. Gordon Prize for Innovation in Engineering and Technology Education, many accolades for its professors, and the distinction of being the first American research university to graduate more women engineers than men!

I wish for the Thayer students of today, engineers of tomorrow, lives and careers as full of satisfaction as mine has been. I know that our world will be in good hands.

OPPOSITE PAGE: COURTESY OF SAM FLORMAN

spotlights

DAVID SWANSON

A Reporter's Notebook

TOM AVRIL '89
| REPORTER, *PHILADELPHIA ENQUIRER*

Engineers can help sort truth from fiction.

Think back to a decade ago, before everyone and his grandmother were on Facebook. People used to share things with their networks of friends and family through email: funny photos, bad jokes, political screeds, news bulletins that carried the whiff of urban legend.

One day I received such an email with an especially fear-mongering tone, forwarded by an old family friend and physician who had done his undergraduate studies at Dartmouth.

"Don't freeze your plastic water bottle," the article said, or words to that effect. "This practice releases harmful dioxins into the water."

The paragraphs were written in the style of an authentic news bulletin, but no publication name was given.

I wrote back and asked my friend why he had forwarded it to dozens of acquaintances, urging them to take note of this apparent newfound health threat. Why did he think it was true?

He did not have a good answer. As near as I could tell, the reason seemed to lie in the fact that another friend had forwarded the article to him, and that it quoted someone who was purported to be on the staff of Johns Hopkins University.

The article was nonsense. Yet it had tripped up an educated person—a physician who had studied at Dartmouth as an undergrad, no less.

In today's era of hair-trigger news cycles and fake news, the problem has only gotten worse. Topics from the realm of science, medicine, and yes, engineering are especially vulnerable to misunderstanding and abuse.

No, vaccines do not cause autism. Global warming is not an environmentalist hoax. And adding more (insert food group du jour here) to your diet probably does not reduce your risk of cancer.

This is the world that Professor Horst Richter nudged me towards. I majored in engineering sciences in Hanover, and like all "engines" students of that era, I have vivid memories of Richter's information-packed, German-accented lectures on thermodynamics.

I was not an ace student of "thermo," or of engineering in general, for that matter. Understanding the concepts, sure. But putting them into practice? Solving real-world problems with partial differential equations? Not my strong point.

Once when I visited Richter's office for extra help, he remarked on the fact that I wrote for the Daily "D"—*The Dartmouth*—and offered me some career advice. Why not write about science?

He mentioned the possibility of technical writing. Maybe, I thought.

Then, during a winter term off-campus, I landed an internship in Washington at the old *MacNeil/Lehrer NewsHOUR*, and I became hooked on journalism. Today I am at the *Philadelphia Inquirer*, where I have been writing about science since 2001. At one point I covered environmental topics—energy, pollution, and the like—taking me to such varied locales as a giant pig barn and the innards of Philadelphia's aging, brick-lined sewer system.

Now I spend half my time writing about medicine, primarily on advances in cardiology, and the rest on whatever scientific topic interests me.

It is no secret that newspapers and other mainstream media outlets are on shaky financial footing these days, yet if anything, their product is more essential than ever. In a December 2016 survey by the Pew Research Center, 16 percent of adults reported sharing a story they later realized was fake. And two out of three adults agreed that fake news was a source of confusion. (Only 16 percent? And only two out of three?)

Versions of that plastic-bottle myth can still be found on the Internet all these years later. To be fair, there is indeed legitimate research on potential health effects of chemicals in certain kinds of plastic bottles. But there is a lot of junk news out there.

Dartmouth engineering graduates are in a rare position to make a difference, as Horst Richter appreciated years ago. All of us, not just the rare oddball who winds up in the field of communication.

Any good engineer or scientist has the critical-thinking skills to evaluate information, of course. But some of them may lack the ability to share their insights with others outside the technical world. I wince a little every time I see an awkward, jargon-spewing researcher depicted in pop culture, yet there is some real-life basis for these exaggerated portrayals.

At a place like Dartmouth, on the other hand, every one of us has been through a liberal-arts education that required us to speak and write effectively. So please, put those skills to good use.

Take the time to explain what you do to others. Neighbors, family members, students at a local public school, whomever. If you see an error in the media, call up the author and offer to explain.

Prepare to be patient with someone whose science education may have gotten short shrift or who got the message that science is "scary." Follow that old newspaper adage and pretend you are explaining the topic to your grandmother.

The next time your neighbor sees something like that piece on freezing plastic water bottles, maybe he or she will stop and think before deciding to pass it on.

just one question

Q. What are the most pressing problems you hope the engineering students of tomorrow will help solve?

First, anything that results in super-competitive products for global market that can be economically built domestically and that are protected by valid worldwide patents. Second, helping neuroscientists utilize computer software power to aid molecular biology in discovering protocols for treating Alzheimer's and other diseases and in support of other initiatives in bioscience.

—Tom Harriman '42 Th'43

Cybersecurity is one of the issues I think more of us citizens need to understand and protect against. I would like to have a course in that at Thayer if I were a current student.

—Bart Lombardi '52 Th'54

First and foremost, address climate change. Look into its many underlying causes and speculate on solutions: engineering, political, economic, business opportunity, religious, etc. The other side of the coin is mitigation of the effects that we know are threatening, and in some cases already here. So many mitigation measures are extremely costly. Citizens from poorer countries will attempt to move and rebuild, but how can they pay for that? In the United States, threatened towns and counties cannot afford mitigation programs, so will there be the political will to fund them from the federal level?

—F. Peter Carothers '57 Tu'60 Th'60

I think that the most pressing problem we have is developing strategies and tactics that will provide the enthusiasm among high school students for science, technology, engineering, and math offerings so that they will be prepared and interested in an engineering education.

—Harris McKee '61 Th'63

My vote would be for climate change.

—Andrew Urquhart '61 Th'64

Getting to Mars and establishing a colony there. No joke! Back when I was at Dartmouth, I clearly remember President Kennedy's speech outlining the goal to get to the moon within that decade. Even smart people thought that was an unreachable goal. I remember seeing a lot of unmanned rockets blowing up on the launching pad. Kennedy was probably the last president that I really believed in. (Maybe Trump can fill that position now.) But we made it, and with about a half year to spare, on July 20, 1969. So, Mars within my lifetime—I was born in 1942, so maybe before 2030—is not an unreasonable vision. The big challenge may not be getting there, but establishing a permanent base there.

—Ed Brazil '64 Th'65

There are three problems. First, they need to figure out the effective and affordable use of artificial intelligence (AI) in the field of education. In principle, IBM's Watson AI computer has more information, more knowledge, and more accumulated experience than the most learned professor. The second challenge is the development of electronic connections with the human nervous system. A chip implanted in the brain is used to bypass a paraplegic's spinal nerve damage to allow that person to walk. It is easy to imagine downloading information directly to the brain using implanted chip technology. There will be ethical and social challenges, but evolution is no longer just biological. Finally, the 3-D printing of human organs and body parts, using compatible stem cell technology.

—Tom Brady '66 Th'68

just one question

There are two issues indirectly related to greenhouse gases and therefore global warming: an economically viable means of storing variable renewable energy (the grid is not a battery) and addressing the spent nuclear fuel problems.

—George Elenbaas '69 Th'70 '74

There are several areas that need attention: reduce the cost of solar energy, coupled with inexpensive storage of that generated energy (including small-scale water lifting and dropping); develop micro machines to drive down the cost of wind power and low-head water flow; advance the conversion of carbon dioxide back to oxygen and burnable fuel (which has had recent breakthroughs); cut the high cost of medical and dental procedures (such as dental implants); develop plastics with two to three times the current lifespan (Bakelite was indestructible, but modern plastics fail in a few years); and create nonlethal means of stopping fleeing or threatening persons.

—Mark Totman '71 Th'72

My "career" objectives would include solutions for challenges involving water supply, water disposal, waste disposal (without wasting precious water), population control, nuclear safety, minimizing use of drugs in routine husbandry, and forcing a shift to human-powered transport.

—Peter Areson '72 Th'73, M.D.

Global warming.

—Richard Akerboom '80 Th'82 '85

Pressing problems that I expect the next generation to work on include a sustainable economy, sustainable energy, poverty (worldwide), and affordable housing.

—Kim Quirk '82 Th'83

"So many of these challenges—and their solutions—cross disciplines. This is why I have confidence in Dartmouth engineers to make substantial and urgently needed contributions."

—Alex Streeter '03 Th'04 '05

The most pressing problem engineering students of tomorrow are going to have to help solve isn't a technical one. It's a sociological one.

In one part of society we have consumers of technology who have absolutely no idea how it works. Worse, the vast majority of them are math illiterate. This would only be a minor problem were it the case that only a small fraction of the populace fits into this category. Unfortunately, this isn't so. During a recent trip to Washington, D.C., to discuss tax incentives for technology companies, I was appalled at just how many people in Congress have an understanding of science and math that matched my own at about age 10. These people are college educated and the vast majority of them have law degrees—and they're making public policy. Beyond the halls of Congress, things don't improve. There are a lot of folks out there who take the opinion, "I don't need it to do my job, and I can unpack and set up my new TV without knowing the first thing about how it works, so who cares?"

Technological and scientific ignorance being acceptable might be an arguable point were it not for three things. First, knowing the science isn't nearly as important as understanding the scientific method, which relies on a solid comprehension of causality. As we look at voting patterns and which public issues cause the most outcry today, it becomes obvious how little people comprehend when A causes B. We make broad, sweeping decisions—not just scientific ones, but also socioeconomic ones—based often not on causality but on coincidence. We also skip the last step of scientific inquiry in which we ask, "Did what we legislate actually create the result we were after?" Once, public housing projects were touted as being the solution to a wide variety of societal ills and part of a shining vision of the future. And some very decent and well-meaning people pressed for their creation. Today, "the projects" has become synonymous with poverty and crime. We're not going back and asking the dispassionate question of scientific inquiry: What in that social experiment worked and what didn't? We also don't collectively comprehend that the question is not a search for the guilty or an indictment of anyone's intelligence in articulating a policy that didn't do what was expected. Many of the best scientists have crafted experiments that did precisely what they didn't expect, and the knowledge gained by an honest logging and reduction of data made the next experiment that much better.

Second, science requires math. There's just no getting around that fact. With a great many large issues in the United States today involving numbers (a large federal debt, ongoing deficits, large numbers of social programs headed for bankruptcy, the economic consequences of tax policy and trade protectionism, etc.), we need the common language of math to be able to talk about potential solutions to problems or project tomorrow's potential outcomes that may result from today's actions. Airing a TV commercial of your political opponent pushing grandma over a cliff in her wheelchair may get you elected, but it doesn't solve anything beyond that immediate selfish concern of yours to return to power.

Third, the crafting of a system of republican government where representatives of the people are popularly elected was the work of men who were immersed as much in natural philosophy as political philosophy. Much is made of the degree to which Thomas Jefferson cribbed language from John Locke when he wrote of "life, liberty, and the pursuit of happiness." Yet we gloss over the fact that holding "truths to be self-evident" is verbiage straight out of Isaac Newton's *Principia* and the fact that Benjamin Franklin got his pre-revolutionary access to the salons of London in large part because of his ability to discuss his scientific activities. The United States and other republics modeled on it owe their existence to Enlightenment thought, which were firmly rooted in the determinism of science.

The current educational problem is a relatively simple one to fix if the will is there to do so: Hold prospective teachers to the standards of scientific knowledge that will ensure that when they go into the public school system, they will teach real science. And abolish that abomination of the modern university: the "science for non-science majors" course. It has no more place in education than "English for scientists who are allowed to remain functionally illiterate." Liberal arts include hard science. That is what by the 19th-century definition of "liberal" makes them so.

For the engineering student, all this means being an ambassador and politician. It means being articulate and non-threatening. It means being social. And it means being patient with people who may be the product of a society and an educational system that have in many ways failed us all. It's not easy (particularly the bit about being gregarious when your predisposition may be to seek out the solitude of a laboratory), but the liberal-arts-educated engineer is going to have to be able to say, gently, "Yes, Senator and Person on the Street, you do have to know this. Maybe not every detail, but enough that you're making informed decisions and enough that nobody is going to sway your opinion with fuzzy math or succeed in passing off coincidence as causality." As technology development accelerates, that's going to get harder. But if we don't go after the problem now, the future holds the prospects of making poor public policy choices, creating permanent underclasses, and sowing the seeds for some future mob burning the library of Alexandria, only on a far grander scale.

—Eric Overton '87 Th'89

The most pressing issue is waste management. There is too much waste taking up space that should be used productively instead of forcing communities to expand into nature.

—Doris H. Martínez Th'91

My fervent hope is that the engineering talent of today and tomorrow will be able to bring forth technology that addresses the perils of a changing climate. This will take many forms and will require the contributions of so many. We need economic, low-carbon energy systems for the developed and developing world. The ways in which we use energy are ripe for massive efficiency gains. As substantial climate changes are now inevitable, we will also need to develop approaches and technology to make our society, agriculture, and infrastructure more robust and resilient in the face of unpredictability and potential disaster.

So many of these challenges—and their solutions—cross disciplines. This is why I have confidence in Dartmouth engineers to make substantial and urgently needed contributions. In so doing, we are fulfilling Sylvanus Thayer's challenge "to prepare the most capable and faithful for the most responsible positions and the most difficult service."

—Alex Streeter '03 Th'04 '05

One of most pressing challenges I hope the engineering students of tomorrow help solve is how we can leave a cleaner and greener planet behind for our following generations while continuing to make giant leaps in technology. Progress in industrialization, productivity, and technology has taken an irreversible toll on our environment, atmosphere, flora, fauna, and nonrenewable resources. Climatic changes, declining forest lines, declining fauna, and increasing non-biodegradable waste are all serious issues that cannot be overlooked by the engineers of tomorrow.

—Mayank Agrawal Th'08

I think two problems will need to be faced by engineering students in cooperation with other disciplines: energy and understanding the brain. The former is a global challenge that will greatly determine what directions we move toward in the future, and the latter will be one of the greatest challenges from an interdisciplinary perspective. Both will have critical ethical dilemmas but also have incredible promise for improving the lives of many people for generations to come.

—Drew Wong '12 Th'14

The challenges: renewable energy (preferably fusion) and mental illness.

—Zachary Kratochvil '16 Th'16

obituaries

Mary Ann MacLean died August 18, 2016 in Lake Forest, Ill. after a long battle with Alzheimer's disease. With her husband, Thayer Overseer Barry MacLean '60 Th'61, she was a lead donor of Thayer's MacLean Engineering Sciences Center. She had a lifelong passion for the arts, history, and education and volunteered for countless organizations. She served on numerous boards, including the Illinois State Museum, Illinois State Board of Education, Chicago Zoological Society, Chicago Botanic Garden, the MacLean Center for Medical Ethics at the University of Chicago Medical Center, and Dartmouth's Rassias Center. In addition to her husband, she is survived by five children, including Duncan '94 Th'95 '96, Gillian '95, and Margaret '87; and 12 grandchildren.

Marian Miner Cook W'29, who endowed the Cook Engineering Design Center at Thayer School in 1979 in memory of her husband, John Brown Cook '29, died in December 2016, a few weeks shy of her 100th birthday. She was the founder and chair of the John Brown Cook Foundation (her husband, who died in 1978, was president and chairman of the board of Reliable Electric Co. in Chicago) and supported the arts and education. Marian was named a Sylvanus Thayer Fellow in 1980, received the Robert Fletcher Award in 1982, and was a Thayer Overseer from 1984 to 1996. She is survived by children Cia and Gregory '69 Th'70 and two Dartmouth granddaughters, Wallis '95 and Kirby '98.

Leonard R. Parker Sr., a well-loved fixture in the Thayer School machine shop, died September 26, 2016 in Lebanon, N.H., at age 73. He served in the U.S. Army before working for 25 years for New Jersey Machine and then Thayer. He earned an Outstanding Service Award from the school in 2003. Survivors include his wife, Bernice; two children; and eight grandchildren.

Robert Leonard Sundblad '44 Th'48 of Fort Myers, Fla., died July 20, 2016. He served in the Army during World War II and had a long career in the engineering field, including a role as technical engineer at the K-25 plant in Oak Ridge, Tenn., for the Manhattan Project. His wife, Eleanor, predeceased him in 2013. He is survived by two daughters and three grandchildren.

Edwin Lydall Quinn '54 Th'55 died October 7, 2016, in Easthampton, Mass. After graduation he served in the Army as an officer for two years, worked at Westinghouse for two years, and then became an engineer at Pratt & Whitney for more than 30 years. He served on the Easthampton town planning board and conservation preservation act committee. Predeceased by his wife, Suzanne, he is survived by four children.

Edward K. Bixby '57 Th'58 died September 6, 2016 in Edina, Minn., at age 80. Ned spent his entire career with General Mills, retiring in 1998 as the senior vice president of sales and distribution. After retirement, Ned and his wife, Marlene, became driving forces for several high-impact organizations. Through World Vision, the couple financed and maintained seven schools in central Africa that helped educate more than 7,000 young Zambians. He served on Thayer's Corporate Advisory Board from 1995 to 2002. In addition to Marlene, Ned is survived by three children and several grandchildren.

Richard "Dick" Kiphart '63, died September 10, 2016, at age 75. He graduated from Dartmouth as an engineering major, earned an MBA from Harvard, and served a stint in the U.S. Navy. He then pursued a career as an investment banker and executive at William Blair & Co. for half a century. He helped take OshKosh B'Gosh public in 1985 and famously cold-called Warren Buffett in 1997 with the idea of buying Dairy Queen, which had long ago been a Blair client. Buffet bought the company for $585 million. A key component in the Chicago startup scene, Dick launched a venture firm called KGC Capital. He had a reputation for sizing up companies quickly and deciding whether to write checks, something entrepreneurs valued almost as much as his experience and connections. He is survived by his wife, Susie; three daughters; and seven grandchildren.

Richard Couch '64 Th'65, right, and Ephraim Aniebona '64 Th'65 work on their BE project, "Decortication of Cashew Nuts."

CASHEW NUT SHELLER

>> INVENTORS:

RICHARD COUCH '64 TH'65
PROFESSOR ROBERT DEAN

THAYER SCHOOL ARCHIVES

On the second floor of Cummings Hall is a display of all the patents awarded Thayer's faculty, students and staff during the last five decades. First on the wall: U.S. Patent 3,605,843, granted to Professor Emeritus Robert Dean and Richard Couch '64 Th'65. The official paperwork doesn't describe how an explosive idea for shelling cashews was thwarted by the Cold War.

Couch, then a BE student, saw an opportunity to engineer a solution to a big problem facing a nascent African cashew industry—how to shell the cashews—while on a trip to the continent.

Shelling cashews is complicated because the nuts are in the same family as sumac and poison ivy. The oil inside the shell is toxic and will burn the skin of the workers. Moreover, shelling by hand doesn't capture the oil, a profitable commodity with a ready market in the auto industry.

Couch decided to design a machine that could shell the cashews while keeping the oil and nut apart. He returned to Dartmouth and began work on a shelling machine under Dean's tutelage.

Couch's idea: a controlled explosion. As the patent abstract explains: "The explosive opening of the nutshell results from a technique in which the nut initially is subjected to a compressed gas for a time interval during which the internal pressure of the nut is raised. The nut then is exploded rapidly, to a lower pressure which fractures the shell and separates the shell from the kernel. The nuts are isolated and exploded individually and in rapid, continuous succession. As each nut is exploded, both its kernel and shell are ejected from the machine along different trajectories and are collected and sorted separately and automatically, thus avoiding any contact between the separated shells and kernels."

"Dick ran experiments—he put nuts in a canister and found that 200 PSI worked fine," recalls Dean. The two were awarded the patent in 1971.

Their next step, building a prototype, proved insurmountable. The stumbling block wasn't technical, but simple economics. USAID, the federal agency that invests in ideas to improve the lives of the world's poorest people, initially liked their idea. Six months later a USAID official told them that their machine was a casualty of the Cold War. It turns out that the 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 Russians.

The idea was shelved.

Forty-six years after Dean and Couch were awarded their patent, the cashew shelling business is unchanged. More than 60 percent of the world's cashews are processed in India by hand, according to *The Guardian*.

"We did as much as we could, but we had no money for the project," says Dean, who along with Couch, a Thayer Overseer, went on to a successful career as an engineer-entrepreneur. "I'm pretty sure it will work."

—Lee Michaelides

Random Walk

Thayer School took advantage of Dartmouth's December break to offer five short, free, non-credit "Winterim" courses. Some students opted for Exploration with Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy, Biotechnology for Beginners, Your Research Identity, and Internet of Things. Others chose Acoustic Instrument Design, in which they built structures that will serve as musical instruments for a new work by composer Molly Herron that was commissioned by Dartmouth's Hopkins Center for the Arts. "I wanted to work with students at Thayer creating some kind of musical instrument that I could use as part of this piece," says Herron, who taught the course with Professors Vicki May and Ulrike Wegst. "These students have been so dedicated, and it's been so refreshing to be in a space where people are doing such different work but are engaged, creative, open-minded thinkers." The course was as much about material properties as about music. "This course is a really cool way to explore a lot of different materials and get a sense of them in a way that you normally wouldn't," says MacKenzie Kynoch '19. The Dartmouth community will be able to hear the results May 4 when Herron conducts her composition in GlycoFi Atrium as part of Thayer's 150th anniversary celebrations.

PHOTOGRAPH BY MAYELLEN MATSON

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150 Years of Engineering

Thayer's first dean, Professor Robert Fletcher, front left, works alongside members of the classes of 1894 and 1895 in the school's Park Street home as they mastered the engineering skills of their time. Though the scientific instruments, fashions, and student body makeup have evolved, some things never change: Thayer professors and students still work together to solve the problems of the day.

THAYER SCHOOL ARCHIVES