DARTMOUTH
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THAYER SCHOOL OF ENGINEERING

THAYER IN GREENLAND

ENGINEERING FACULTY AND STUDENTS TRAIN FUTURE CLIMATE SCIENTISTS.

inside

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From Here to Mars

No matter the path, leadership requires the problem-solving skills and ingenuity of an engineer.

LAURA RAY | INTERIM DEAN

Back in December, I had the opportunity to travel to Silicon Valley and San Francisco for Thayer's Engineering Career Trek, an annual trip that connects our current students to alumni for a first-hand look into the work at leading engineering and technology companies. Amid lab and office tours, students also had the chance to engage with Thayer alumni about how they had arrived at their career fields, which ranged from aerospace to automotive technology, from electrical to data systems and platforms. Given these diverse paths, the question most on our students' minds was: How did you get *there* from *here*?

For some, their path has always been clear. One of our alumni, Max Fagin Th'11, is a self-professed "kid" who never grew out of the astronaut phase. While at Thayer, Max and his team developed a component for the life support system in spacesuits that helps dehumidify the air that astronauts breathe in space. Through this project, Max had the opportunity to experience weightlessness for the first time, when he and his team brought the prototype to NASA for testing. Now as aerospace engineer at Made for Space, Max designs hardware and components for the International Space Station and other clients. His life's goal is to someday live on Mars.

For others like Eric Trautmann '07 Th'08 Th'09, his engineering degree was a stop on his way to his current work as a neuroscientist. As an undergraduate, Eric had helped design and build the autonomous Yeti robot that surveys Antarctic ice sheets, but this very training in electrical engineering, mechatronics, and machine learning now informs his research at Stanford, where he is developing tools that can record the simultaneous activity of thousands of neurons and vastly improve the performance of neural prosthetic devices for people with paralysis.

Another alumna, Natalie Afonina Th'16 Th'17, began her career as a chemist and found her passion for materials science while developing fuel cells for unmanned undersea vehicles for the Navy. At Thayer, she researched the microstructure of superalloys, helping develop high-temperature austenitic alloys for energy conversion applications. She now applies her engineering skills as a product manager for the Advanced Technologies Group at Uber on the team responsible for developing self-driving technologies, mapping, and vehicle safety – ultimately helping reduce accidents and congestion on the road.

From Earth to Mars, from ice sheets to brain science, from superalloys to self-driving vehicles, the message to our students was that there isn't just one path. While Thayer engineers like Max followed his passion for aerospace engineering, others like Eric and Natalie had the ability and opportunity to switch gears when they discovered a related, but different passion.

As engineers, we are trained to identify a problem, understand its root cause, and create the tools to tackle these problems head on. We are taught to value precision and details, while at the same time, understand how systems work together and what happens when parts of that system fail.

Our students are used to living at this intersection of engineering and liberal arts. Embedded in our curriculum and culture is the importance of a human-centered approach to engineering and design and the belief that our work should have an impact on the world we live in – for the better.

This is even more true when it comes to leadership. A session at a recent ASEE Conference and Exposition focused specifically on how best to teach leadership to engineering students. While leadership presents itself in many ways, for engineers who want to lead, it's not enough to simply be an expert in a field of research. True leadership also requires the ability to influence others, the ability to collaborate with people and across academic disciplines, and the initiative to "get things done."

These values, so essential to leadership, are the values Thayer students live out each day. For our engineering alumni, they embody these values as they apply their training to help solve real-world problems.

For many of our students who took part in Engineering Career Trek this past December, their next steps from Thayer to their next job, eventually to a place like Mars, may not be immediately clear. What is clear is that a Thayer engineer has the expertise and problem-solving skills, along with the drive and compassion for humanity to help solve some of the world's greatest challenges. These are exactly the kind of skills and leadership our world will always need.

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Photograph by Cameron Planck

TOP: AUSTIN LINES; LEFT JOHN SHERMAN

THE Great Hall

NEWS FROM AROUND THAYER SCHOOL

PROJECTS

Cots for Cold Seasons

THE COT PROJECT Kimberly Tan '22 and Aadhya Kocha '22 work together to build cots for a local shelter.

JUST ACROSS THE RIVER IN VERMONT, THE UPPER Valley Haven noticed a persistent problem with its Seasonal Shelter, a winter program that requires transforming one of its main gathering areas into an overnight shelter for up to 15 guests. The cots had to be set up each night, then taken down each morning so that the space could be used during the day. The cots the Haven currently uses are designed for camping, difficult to assemble, relatively uncomfortable, and break easily.

Haven staffers had already researched their options and knew the type of cot they needed—easy to store, comfortable, and durable with a simple setup. The only problem? The cots they needed didn't exist.

In came the team of Dartmouth Humanitarian Engineering (DHE) problem-solvers.

"The cot project started as a potential ENGS 21: Introduction to Engineering project that my group was considering last winter," says Nat Healy '20, co-president of the student group. "And then we thought, this would be great for DHE to run with."

DHE consists mostly of engineering majors, as well as computer science and studio art majors and undergrads who have yet to declare their majors. They all share one goal: to create engineering solutions that advance the common good. Along with Healy, students currently working on the cot project are Aadhya Kocha '22, Andres Hernandez '21, Brook Leigh '22, Dylan Cerveny '21, Garret Andreine '22, Isaac Hanover '22, Keoni Ocalvey '20, and Kimberly Tan '22.

"We quickly decided that a stackable cot would be most effective at increasing durability, minimizing set-up time, and preserving storability," says Healy. "During the summer and fall, we've been brainstorming, designing, and building with the goal of having a functioning prototype for user testing in this winter's Seasonal Shelter."

The biggest challenge was to design the joints to be durable and easy to repair.

"We used Thayer's Instron machine to test our joint designs, and I happened to be taking ENGS 33: Solid Mechanics at the time, so I was like, perfect! I know all about this stuff now!" says Healy.

"The Haven is also terrified of getting bedbugs," he says. "Our design can't use tubes or wood or have a lot of nooks and crannies. They have to be able to thoroughly wipe down the structure of the cot."

Healy continues, "There was a lot of materials science work because in order to be durable, the cot structure has to be strong but not too stiff. It has to have some give when someone moves around on it. Eventually, we found a way to simplify the design so there's no welding involved. It's all nuts, bolts, and plates using off-the-shelf standard parts. That's important, too, because if we end up going to a manufacturer to make a lot of these, simpler is cheaper.

"Around this time we had a bunch of new members join DHE and we had to get them ready and trained in the Machine Shop, which takes a lot of time. It turns out that the simplicity of our design made it the perfect project for our new recruits.

"Thayer's hands-on, experience-based learning appealed to me and was the main reason I applied to Dartmouth," says Healy. "I've always loved working on projects with others and having a tangible result for my efforts. I think DHE exemplifies Thayer's commitment to this type of learning. Every project we work on has a tangible result, both in the physical product that we build as well as the social impact that our products can achieve."

DHE delivered its first prototype to the Haven in November and hopes to complete user testing and at least one round of design iteration before the spring.

—Catharine Mayor Lamm

Q&A

Joseph Helble | Parting Words

For 13 years, the faculty, staff, and students who have passed through Thayer School of Engineering have called Joseph Helble "dean." This past October, he took on a new title—Provost Helble. Just weeks before moving down the road to his new office in Parkhurst Hall, Helble spoke with Dartmouth News. The following is an excerpt from that conversation.

How would you like the beginning of your tenure to unfold?

>> I think over the course of the first several months I'm going to be doing a lot of listening. I'll meet with as many people from as many different parts of the campus as I possibly can to understand their goals, their hopes, and their aspirations for their particular area. And to get their thoughts and creative ideas about what the administration can be doing to make Dartmouth an even more vibrant and creative and incredible place.

You've been around students here for 13 years. How would you describe them?

>> I've interacted with students who were not just engineering students but many, many students who are here at Dartmouth to study something else and will take an engineering course or two along the path to their degree. What I find over and over and over again is that they are incredibly hard-working and intellectually curious. That's one of the things that I find most inspiring about being at Dartmouth: to be surrounded by young people who are idealistic, open-minded, motivated to go out and try to change the world, and really want to draw from every aspect of this broad and rich institution. We're really privileged to work with them and I am reminded of that every day I come to campus.

As you leave the west end of campus for an office in Parkhurst, what are you most proud of having accomplished at Thayer?

>> First and foremost, I'm proud of the fact that this community has managed to accommodate increasing demand from students and incredible growth without losing the sense of community that defines the Thayer School. I'm incredibly proud of the fact that Thayer became the first major research institution in this country to award more engineering degrees to women than to men. That's something the engineering educational community has been pushing toward for decades and made incredibly small progress toward achieving. Yet, here we were able to do it in 2016.

I'm proud of the fact that this community has embraced entrepreneurship not just as a core value but recognizes that this is, in fact, what society rightly expects from engineering academic institutions—that we won't just study technology but that we will create and invent technologies that have the possibility to go out and change the world. Over 40 percent of our tenure-track faculty have started companies based on their work. I'm convinced that that is, without question, the highest level in the country.

"I'm incredibly proud of the fact that Thayer became the first major research institution in this country to award more engineering degrees to women than to men."

At Dartmouth, there is an openness to connecting with, speaking with, interacting with anyone. A great example is the partnership between athletics and engineering around the development of the Mobile Virtual Player, the MVP robotic tackling dummy. I've taken great pleasure the past couple of years in speaking to my fellow engineering deans from around the country and asking them, "How many of you can say that your students and faculty and staff have developed a technology that's actually changing the way the game, any particular game, is played?" I promise you that no other engineering dean has had a student project debut on late night television with Stephen Colbert. Of that I am absolutely certain. —*Susan J. Boutwell*

OPPOSITE PAGE: COURTESY DARTMOUTH HUMANITARIAN ENGINEERING. THIS PAGE: ROBERT GILL

AWARDS

ABET Innovation Award

THE FORMULA HYBRID COMPETITION has been awarded one of the most coveted prizes in engineering education: the ABET Innovation Award.

Launched by Thayer School in 2007, the annual Formula Hybrid Competition challenges teams of undergraduate and graduate engineering students from around the world to design and build fuel-efficient hybrid or electric-only vehicles. The competition facilitates collaboration across disciplines, with teams comprised of computer science, mechanical engineering, and electrical engineering students.

Formula Hybrid was selected "because of its broad and sustained impact in innovative energy-efficient design experiences that enhance the 21st-century skills of students in ABET-accredited programs," says Steven Cramer, chair of the ABET Innovation Award Subcommittee and vice provost for teaching and learning at the University of Wisconsin-Madison.

"We're thrilled that Formula Hybrid has been recognized for its inventive and effective approach to educating students beyond the classroom," says Douglas Fraser, senior research engineer at Thayer and founding director of Formula Hybrid, who accepted the award at the ABET gala in November. "We are also thrilled that so many students commit so much time to the competition, because it means they're engaged and learning skills they'll use for a lifetime."

For many students, Formula Hybrid is their first experience collaborating across disciplines, from computer science to mechanical and electrical engineering. As a result of the competition, a number of institutions have developed Formula-Hybrid specific curricula to encourage cross-disciplinary collaboration. The competition is part of the Society of Automotive Engineers Collegiate Design Series and is regarded as one of its most complex and dynamic.

—Callaway Zuccarello

DISTINCTION

New Endowed Chairs

IN HONOR OF DISTINGUISHED SCHOLARSHIP, TEACHING, AND service to the College, two longtime Thayer faculty—Eric Fossum and Brian Pogue—have been named to endowed professorships.

Fossum, who serves as the director of the PhD Innovation Program and as associate provost for the Office of Entrepreneurship and Technology Transfer, has been named the John H. Krehbiel Sr. Professor for Emerging Technologies. Pogue, who serves as the director of the MS and PhD programs at Thayer, has been named the MacLean Professor of Engineering.

A semiconductor device physicist and electrical engineer, Fossum is renowned for his work with solid-state image sensors and camera-on-a-chip technology that has revolutionized how the world captures images. The complementary metal oxide semiconductor (CMOS) active pixel sensor that he invented in the 1990s originally at the Jet Propulsion Laboratory is now found in nearly every camera, including billions of smartphones.

"It is wonderful to be named the next John H. Krehbiel Sr. Professor for Emerging Technologies," Fossum says. "To me, the joy of engineering is creating and inventing new technologies and then translating them from the lab to benefit society. At Thayer, we will continue to push the boundaries of sensing light and exploring new applications."

Pogue, who focuses on applications of biomedical optics, leads an interdisciplinary research team of biomedical engineers, researchers, and physicians from Thayer, Geisel School of Medicine, and the Norris Cotton Cancer Center, who are developing imaging tools that can help guide surgery and radiation therapy. Pogue and his team have helped develop a molecular tracer for a cancer cell surface receptor to guide surgical resection, now currently being tested in surgical trials. He has also helped develop an imaging camera to track and verify radiation dose delivery in real time.

"I am pleased to continue this work as the MacLean Professor of Engineering," Pogue says. "Endowments such as this bridge generations of alumni and faculty, not unlike the bridges that we try to build across faculty and students in the medical and engineering schools."

FACULTY
Brian Pogue (top) and Eric Fossum have been named to endowed professorships.

LEADERSHIP

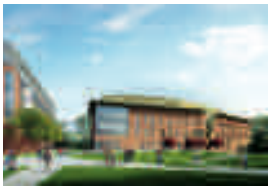
New Advisors

WILLIAM J. GRIFFITH '93 has been elected to Thayer School's Board of Advisors. Griffith is a partner at ICONIQ Capital, where he founded ICONIQ Strategic Partners, the company's growth equity investing platform focused on partnering with best in class, high-growth technology businesses. He also cofounded IPI, ICONIQ's data center real estate investment platform, and oversees ICONIQ's private equity, venture, and other direct investing activities. Griffith majored in engineering and history at Dartmouth and played football on a three-time Ivy League championship team. He also holds an MBA from the Stanford Graduate School of Business and serves on the Stanford GSB Management Board.

CHRISTINA "CHRISTY" DOWDING NICHOLAS '94 TH'95 has been elected to the Thayer School's Board of Advisors. Nicholas has been an active volunteer for the College, serving on the Thayer School Annual Fund Executive Committee, Dartmouth Centennial Circle, and the Alumni Fund Committee. While at Dartmouth, Nicholas was awarded a Luce Special Graduate Fellowship, an award aimed at encouraging promising women to pursue engineering careers, as well as a Rockefeller Fellowship for social entrepreneurship. She earned her AB from Dartmouth, her BE from Thayer, and an MBA from Harvard Business School.

New Trustee

Current Thayer board member **LIZ CAHILL LEMPRES '83 TH'84** has been elected to Dartmouth's Board of Trustees. Lempres, who has served on Thayer's Board of Advisors since 2012, is a senior partner emeritus of McKinsey & Co., where she served on the board of directors and led the Boston office and the global consumer products and private equity practices. She also serves on the boards of Axalta Coatings, Great-West Lifeco, Culligan International, MIO Partners, and the Visiting Committee of Harvard Business School. She earned her AB in engineering sciences from Dartmouth, a BE from Thayer, and an MBA from Harvard, where she was a Baker Scholar.



CONSTRUCTION TO BEGIN ON WEST END EXPANSION

Participating in a ceremonial groundbreaking recently were Terry McGuire Th'82, chair of the Thayer Board of Advisors; Christine Cook, Thayer's chief financial and administrative officer; Laura Ray, interim dean at Thayer and a professor of engineering; David Kotz, the Champion International Professor in the Department of Computer Science; Liz Cahill Lempres '83 Th'84, Dartmouth trustee and Thayer Board of Advisors member; and Provost Joseph Helble.

THIS PAGE: ELI BURAKIAN

Kudos

ELECTED **Professor Rahul Sarpeshkar** was elected fellow of the National Academy of Inventors, the highest professional distinction for academic inventors whose inventions have had significant impact on quality of life, economic development, and the welfare of society.

NAMED **Professor Petra Bonfert-Taylor** was named to the board of the International Committee for Women in Mathematics, one of the committees of the International Mathematical Union that aims to boost the impact of women in mathematics worldwide.

PUBLISHED An article by **Professor Weiyang "Fiona" Li** about how to make batteries less likely to go up in flames, "Less Fire, More Power: The Secret to Safer Lithium-Ion Batteries," appeared in *IEEE Spectrum* magazine.

HONORED **Professor Jane Hill** earned the 2018 Anton Amman Award from the International Association of Breath Research for her research on technology to diagnose infections using human breath.

NOTED Alongside inventors and renowned technology journalists, **Professor Eric Fossum** spoke on a panel discussing "Eureka: Imagining Gizmos that Will Reveal (and Rock) Your World" at Science Media Awards & Summit in the Hub (SMASH18) in Boston in September.

AWARDED Engineering major **Jack Traynor '19** earned the Class of 1948 Student-Athlete Award for outstanding performance in academics (3.7 GPA) and athletics (named to the All-Ivy League First Team).

AWARDED Engineering major **Sandile Dube '19** was recently honored by Dean of the College Kathryn Lively with the Ranny B. Cardozo Jr. 1978 Award. The award recognizes one junior each year who exemplifies leadership in his or her concern for fellow classmates and participation in campus and community activities.

AWARDED PhD candidate **Andrii Murdza Th'21** was recognized for his paper, "Hysteretic Behavior of Ice Under Cyclic Loading," from the International Association for Hydro-Environment Engineering and Research at the 2018 International Symposium on Ice.

I Want One of Those!

STUDENT PROJECT

FOG BE GONE

Safety glasses are a necessity on the construction site. They provide protection from impact, dust, and even chemical splash. But add in a bit of condensation and they become a nuisance. That's why students created Fog Be Gone, electrically heated safety glasses that prevent fogging by adjusting its temperatures when the wearer walks in from a cold, dry atmosphere to a warmer, humid one. Inventors Emma Doherty '21, Samantha Milne '19, Yumi Naruke '20, David Ringel '19, and Kevin Kenneally '18 Th'19 won the winter term Phillip R. Jackson Award for best overall performance in ENGS 21: Introduction to Engineering. Their teaching assistant was Alexa Lewis '18 Th'19.

NEW STUDENT GROUP Members of the Society for Hispanic Professional Engineers

NETWORK

Creating New Leaders

MEMBERS OF THE NEW SOCIETY FOR HISPANIC Professional Engineers (SHPE) student chapter at Dartmouth represented Thayer School for the first time at the society's 2018 national convention, held last fall in Cleveland, Ohio.

Many of the 10 students who attended were exposed to the competitive corporate world of engineering for the first time. Having prepared as a group beforehand with workshops in networking, interviewing, and resume-building, students forged connections with recruiters and employees from top companies, including Boeing, Lockheed Martin, NASA, GE, and Exxon Mobile, says Dartmouth SHPE president and cofounder Anaqhelly Cisneros '19.

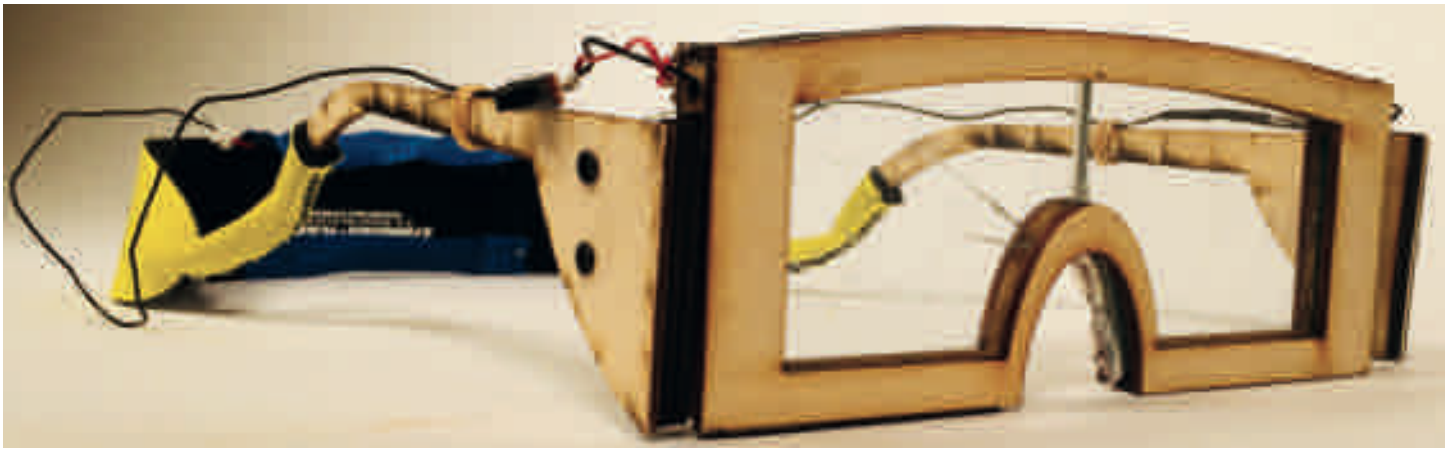
"There were a lot of Hispanic employees who are engineers and who also look like them, so I think it was important for our members to see that and to know that they can contribute to those companies in the same way," says Cisneros, who started SHPE last year with cofounder Celeste Vazquez '18 after learning about the organization through the Hispanic Scholarship Fund.

Although geared toward engineering, SHPE is open to all Hispanic and Latinx Dartmouth students in STEM fields. In addition to providing networking and job-search support, SHPE aims to help students find mentors and access resources while at Dartmouth and beyond, explains vice president David Lacroix '19.

"One of the goals that we hope to accomplish long-term is to level the playing field," says Lacroix. "A lot of the students at Dartmouth and other institutions come in knowing X, Y, and Z, but what about the students who don't come from a particular background? What SHPE hopes to do is provide resources and empower them to be the best they can be."

The students also hope SHPE can attract financial support to help fund future trips to the national convention. Additionally, the chapter intends to create an alumni board to assist the student members and executive board by offering guidance and professional contacts, says Cisneros.

"Wherever we end up going in the corporate world or for graduate school, we want to be in touch with the current executive board so that we can recruit talent from them," Cisneros says, "because we think SHPE can go a long way, as long as we maintain those connections." *—Kristen Senz*



lab report

Next-Generation Solar Power Systems

PROFESSOR JIFENG LIU AND HIS team of researchers at Thayer are working on a new type of solar absorber aimed at optimizing energy conversion efficiency, paving the way for the next generation of high efficiency solar power systems.

Liu's team—which includes research scientist Xiaoxin Wang and engineering PhD students Eldred Lee and Can Xu— will be developing a solar absorber coating that not only converts more than 95 percent of the absorbed energy into heat, but that can also endure long-term, high-temperature conditions. The U.S. Department of Energy (DOE) Solar Energy Technologies Office recently awarded Liu and his team $400,000 to advance concentrating solar-power (CSP) research and development.

"This project will make notable contributions to DOE's goal of 5¢/kWh for CSP systems by 2030," Liu says. The team will collaborate with Norwich Solar Technologies, a local high-tech company led by Troy McBride Th'01 and Joel Stettenheim Th'12, to apply the technology commercially.

CSP systems focus sunlight onto solar receivers, converting solar energy into thermal energy carried by heat transfer fluids to drive heat engines. The large-scale, cost-effective energy storage capability (for more than 10 hours) of CSP systems complements solar cell panels with on-demand electricity even without sunlight.

The solar absorber coating in CSP systems is an important component for maximizing energy absorption and minimizing thermal losses at high temperatures. Existing solar absorbers do not provide high enough efficiency or stability at 1382 degrees Fahrenheit —a service temperature required by DOE. The novel nanoparticle-pigmented solar selective absorber coating developed by Liu's group uniquely addresses this challenge, offering both ultrahigh efficiency and long-term thermodynamic stability at this extreme temperature.

—Catharine Mayor Lamm

NEW SOLAR TECHNOLOGY Thayer researchers are developing a new type of solar absorber aimed at optimizing energy conversion efficiency.

OPPOSITE PAGE: TOP, COURTESY SOCIETY FOR HISPANIC ENGINEERS; BOTTOM, "FOG BE GONE." THIS PAGE: COURTESY JIFENG LIU.

Biomaterials in Surgical Implants

Thayer faculty have teamed up with researchers at the University of New Hampshire (UNH) for a $20-million National Science Foundation-funded project to develop innovative approaches to the design and manufacturing of biomaterials in implants and tissue engineering.

The UNH-based "NH-Biomade" project is aimed at supporting the state's rapidly growing biomaterials industry through research, capacity building, education and academic-industrial partnerships.

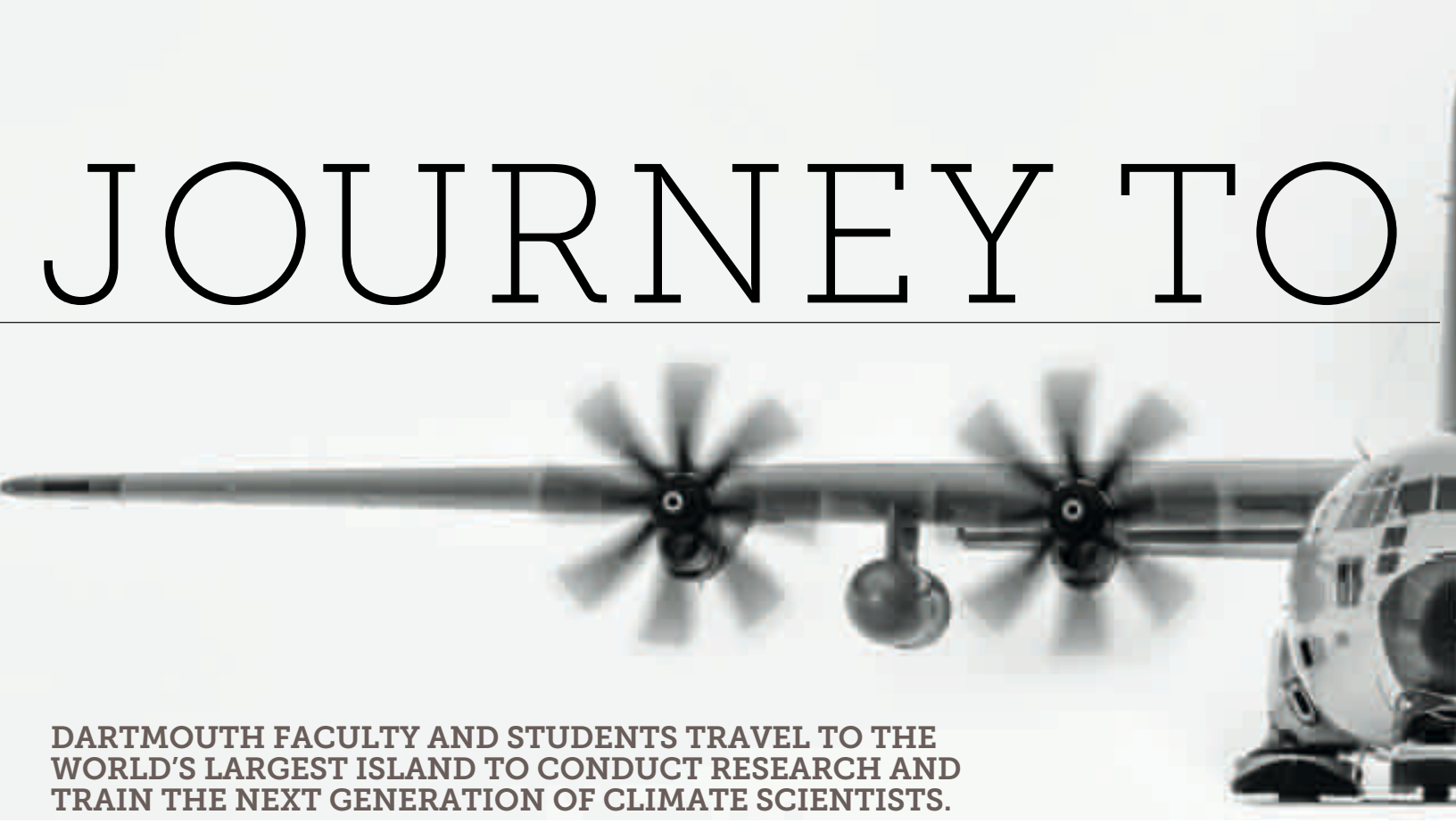
"This is a true collaboration of two institutions, where we are leveraging the resources and expertise at our respective institutions to advance research that has the potential to vastly improve a patient's quality of life," says Ian Baker, senior associate dean for academic affairs and co-principal investigator on this project.

The project will focus on the development of biomaterials that can replace parts or enhance functions within the human body, for instance composites that can replace a fractured skull, biosensors that can help better detect a body's reactions to chemicals, or microscopic polymeric scaffolds in tissue engineering to replace damaged tissues. The key, Baker says, is to better understand and develop materials that are both cost-effective and work seamlessly within the human body.

"This project represents an incredible opportunity to capitalize on the expertise of UNH and Dartmouth faculty in a way that truly benefits the entire state," said Douglas Van Citters, associate professor of engineering and a co-principal investigator on the project. "I'm excited to work with the entire team to help establish the infrastructure that will eventually help translate a broad spectrum of ideas into clinically useful products."

Along with Baker and Van Citters, Dartmouth chemistry professors Katherine Mirica and Chengfeng Kewill also co-lead or support major areas of research for this project with UNH faculty. *—Eun Lee Koh*

JOURNEY TO



DARTMOUTH FACULTY AND STUDENTS TRAVEL TO THE WORLD'S LARGEST ISLAND TO CONDUCT RESEARCH AND TRAIN THE NEXT GENERATION OF CLIMATE SCIENTISTS.

The Lockheed LC-130, a military cargo plane operated by the 109th Airlift Wing of the U.S. Air National Guard, was our ride to and from Kangerlussuaq and to the East Greenland Research Ice-core Project (EastGRIP) drilling site. The LC-130 is equipped with retractable skis that can land on snow and ice-covered runways. Inside, it was actually more comfortable than it looks. —C.P.

GREENLAND

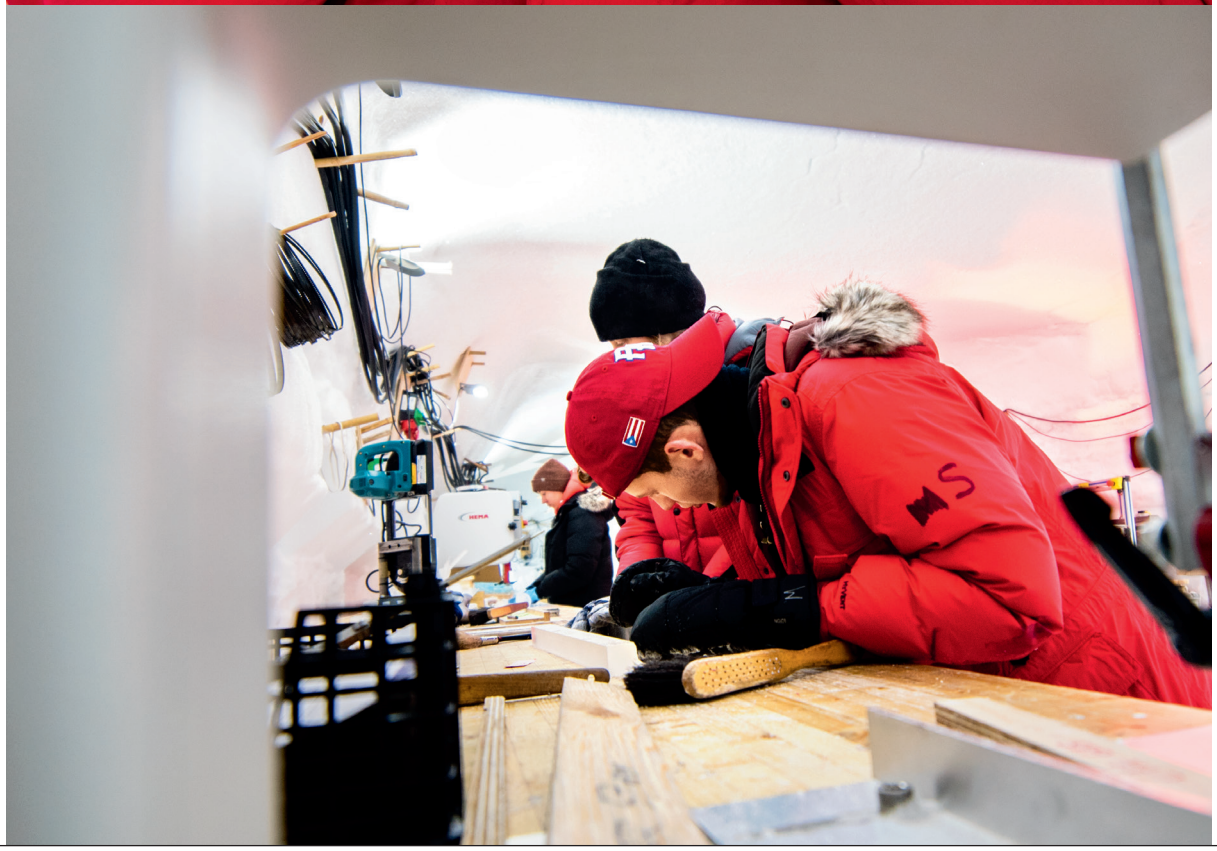
PHOTOGRAPHS BY
CAMERON PLANCK TH'20
& AUSTIN LINES TH'21

The geodesic dome at EastGRIP cradled by a sundog at 2 a.m. This far north, the sun never sets, even in the dead of night. Our home away from home, the dome was built at the North Greenland Eemian Ice Drilling camp then dragged on skis for 450 kilometers to the East-GRIP site. —A.L.

Oftentimes, birds will follow the LC-130 into camp and then lose their way home. EastGRIP scientists and researchers have built a birdhouse stocked with nuts and seeds for the adventurous feathered friends who unwittingly make it to the middle of the ice sheet. —A.L.

A student with the Joint Science Education Project (JSEP) takes a closer look at a grain of snow. —C.P.

Underneath the surface of EastGRIP is a network of tunnels that house the ice core drilling and processing equipment. Here, a JSEP student works with a scientist to section an ice core freshly extracted from about 1500 meters below the surface of the Greenland ice sheet. —C.P.



Austin Lines demonstrates to JSEP students how to use a pyranometer for measuring surface albedo, or light that is reflected off of the surface of the ice and snow. —C.P.

In our downtime, instructors indulged in mid-day yoga. —C.P.

Joshua Elliott Th'17, whose research takes him to Greenland every year, looks north as he stands on the edge of the ice sheet. —A.L.

Lake and mountainside views in Kangerlussuaq, the tiny town on the edge of the icesheet where we first landed in Greenland before heading to the EastGRIP drilling site. —C.P.

Incredible views of Kangerlussuaq from our plane. —C.P.

50 MATERIALS THAT MAKE THE WORLD

FROM CONCRETE TO CELLULOID, **PROFESSOR IAN BAKER** UNEARTHS THE HISTORY OF MATERIALS ESSENTIAL TO HUMAN DEVELOPMENT.

BY KRISTEN SENZ

PHOTOGRAPH BY JOHN SHERMAN

For his new book, *50 Materials That Make the World*, materials scientist Ian Baker traded his electron microscope for the tools of a historian, providing readers with a view of the world through the stories of the "stuff" crucial to centuries of human development.

The Thayer School engineering professor and senior associate dean for academic affairs has spent more than three decades studying the microstructures and mechanical properties of metals and ice in research efforts that have ranged from developing high-temperature metal alloys to studying the process by which snow turns to permanent ice on the Greenland ice sheet, to deepen our understanding of past climates. Baker has also studied intermetallic compounds, high-strength magnetic materials, and iron nanoparticles. His far-reaching work has led to the development of new structural materials as well as treatments for hyperthermia and cancer.

Born and educated in the United Kingdom, Baker said a BBC podcast originally sparked the idea for the book, which was published in September 2018 by Springer. Scientific but accessible to the nonscientist, *50 Materials That Make the World* offers an introduction to the broad field of materials science, with each chapter tracing the path of a particular material from discovery to prominence and discussing potential future uses.

Baker recently spoke with *Dartmouth Engineer* about his new book and the materials that have fascinated him throughout his career. The conversation has been lightly edited for length and clarity.

What was it that originally attracted you to materials science?

When I was in grammar school in the [United Kingdom]—and grammar school is from age 14 to 18—so when I was about 17 or 18, we did a new physics curriculum that had 10 modules, and one of the modules was on materials science. So I encountered it early and it really interested me. During grammar school, I was studying physics, chemistry, and math—in the United Kingdom, you tend to study only a limited number of subjects in high school—and I couldn't really decide which of those to do at university. Materials science actually was a combination of all three of those, so that's why I ended up doing materials science.

How did the idea for this book come about?

It came about in a strange way. I think the initial genesis was probably about 2010. I listened to a BBC podcast by Neil McGregor, who's the director of the British Museum, called *A History of the World in 100 Objects*, in which he talks about objects from the museum. It's a really great series, because he doesn't just talk about the object; he talks about the history all around it. So that gave me the idea to start thinking about materials and the history around them. Then there was a book by a professor at Cornell named Steven Sass, who's now retired, called *The Substance of Civilization*, which was about how materials had evolved throughout history. That was interesting and got me thinking about doing a book. There were a couple of other books that also helped inspire the content and tone and got me thinking about this kind of project.

Then, in December 2014, I was one of the organizers of a symposium at the Materials Research Society meeting in Boston. Springer, the publisher, contacted me and asked me if I'd like to write a book on intermetallic compounds, because that was the symposium I was organizing. I thought about that for about 3 milliseconds and said, 'No, not really.' I figured it would be a lot of work and maybe about three people would read the book. So I said, how about I write you a book proposal on something else, and they said fine. I wrote the proposal and the working title was, *50 Materials That Make the World*.

Was it challenging as a scientist to write a book aimed primarily at nonscientists?

The only other time I've ever written anything like this was back in 1991. I wrote an article for *New Scientist*, a British publication. I sent off my copy to the publisher and it came back with red all over it; probably every other word they put a pen through. I realized how difficult it was to write something like this, because whenever you define something, as a scientist, you use other scientific terms to define scientific terms. Here, I tried to avoid doing that and put things in more straightforward terms—not dumbing it down, but making it accessible. It's exact, but it doesn't get hung up on too many details.

How did you choose the materials to include in the book?

My initial process was to send a note to all of my colleagues at the engineering school here, asking them to name what they thought were the 10 most important materials. I didn't tell them why I was asking. Some of them gave me materials such as steel and aluminum and some of them reframed the question and gave me 10 classes of materials. They gave me about 15 or 20 materials total and then I chose others.

I included some materials that aren't used very much now but were important at one time. One example of that is gutta percha, which comes from a tree and is sort of like latex, except it's harder and it's a thermoplastic—you can heat it up and reform it. When it was first used in the 1850s, it had a huge impact: It was used to coat undersea cables and make golf balls and had a whole bunch of other applications. Now, the only real use is to fill in your root canal, if you have to have one.

Another example is celluloid, which was invented because someone wanted to replace ivory in billiard table balls, and someone came up with celluloid, which didn't actually fulfill that purpose at all. But it did spawn the movie industry. They use celluloid to make film and photographs. Celluloid stopped being used for that purpose around 1949, because it's actually quite flammable, almost explosive in some situations, and it degrades, so other stuff was used after that. Now, celluloid is used only for a few things, such as ping pong balls.

How many of the materials in the book are naturally occurring vs. manmade?

That's a good question. I cannot give you a simple answer. It's an interesting question because you could have something that is naturally occurring but you make it yourself most of the time. For example, graphite is naturally occurring material. You can go mine graphite to put lead in your pencil, but when you make graphite fibers, which are used in tennis rackets or squash rackets and a whole bunch of other things, you make them from a polymer using various heat treatments. It's similar to natural graphite, but it's made in a completely different way and has different properties because of the way it's made. Similarly, rubber is a natural material, but when you use rubber, you normally do cross-linking of the polymer chains, which changes its properties quite a bit.

Silver, gold, and platinum are naturally occurring materials, which you can just dig out of the ground and they're used that way. And clay, of course, is a natural material, but you don't just use it as clay; you normally bake it or do something to it. Steel is iron, but you've done a lot to it to get steel, and it's not like iron at all.

MATERIAL FACTS

A shopping bag. A jet engine. A billiard ball. Have you ever wondered what materials are used to make the things you encounter every day? Here are 10 quick facts from *50 Materials That Make the World.*

ACRYLONITRILE BUTADIENE STYRENE plastic is the most popular engineering polymer, used in camera bodies, keyboards, and many other products.

BAKELITE (phenolformaldehyde), the world's first thermosetting polymer, replaced ivory in billiard balls and is now used in bowling balls. Bakelite kitchenware and jewelry have become collectors' items.

Found in roads, bridges, buildings, and more, CONCRETE is the most ubiquitous material on Earth. It is used in larger quantities than the combined weight of all metals used in a year.

The metallic compound GALLIUM ARSENIDE is used to make laser pointers, CD and DVD players, and barcode readers.

Single crystals of NICKEL-BASED SUPERALLOY are used to make the turbine blades in most jet engines due to their resistance to chemical degradation and high temperatures.

PLATINUM can withstand even higher temperatures—its melting point 1,772 degrees Celsius. Uses include spark plugs, optical fibers, pacemakers, and jewelry.

First synthesized in 1898, POLYETHYLENE is used in plastic shopping bags, milk jugs, tubing, furniture, and other products. Caterpillars that eat polyethylene could help mitigate pollution from these plastics.

Unsuccessful as a replacement for ivory in billiard balls, CELLULOID instead gave rise to the film industry and is now used in guitar picks and ping pong balls.

Nine-tenths of the world's RARE EARTH MAGNETS, which are used in wind turbines, electric car engines, computer hard drives, microphones, headphones, generators, sensors, MRI machines, and other applications, are mined and produced in China.

NITINOL, a common "shape memory" alloy, is used in arterial stents and eyeglass frames, among other applications. The market for nitinol was expected to top $8 billion by 2018.

In doing the research for the book, what did you discover that you didn't know before?

I think most materials scientists know about the properties of the materials, but they often don't know a great deal about the history or how they were discovered and came into use.

Some of the most interesting things to me had to do with materials that I don't really work with, such as wood and concrete. When I started researching wood, I found that there's this stuff now called engineered wood. It's sort of like plywood, but it's bigger slices and the wood is deliberately put in different orientations so that the grain is at 90 degrees in each consecutive layer. They are now building quite a few buildings out of this engineered wood, such as small skyscrapers. They can make fairly tall buildings without a lot of the heavy equipment that is used for steel buildings, because the wood is not as heavy. You can make the wood more fireproof by putting layers of concrete on it as well.

In concrete, I learned that people are now trying to incorporate bacteria into concrete. So, if you get a crack in the concrete, the bacteria there would interact with the carbon and oxygen in the atmosphere to create a compound that can actually glue the concrete back to together and heal the cracks.

Can you describe the connection between the properties of a material on the micro level and the way it behaves on the macro level?

What happens on the microscopic level completely controls what happens on the macroscopic level, for the most part. My main area of expertise is microstructural characterization, and a key part of that is electron microscopy. Nearly all of my projects use electron microscopy and some of them use X-ray techniques as well. Understanding what the microstructure looks like is really key to understanding the behavior on the larger scale.

A lot of what material scientists do is try to understand the microstructure and come up with models of how that microstructure affects the properties of the material, be they magnetic or mechanical or electronic properties. Once we can understand the microstructure and how it influences the properties of the material, then we can actually do things to change it to make it even better.

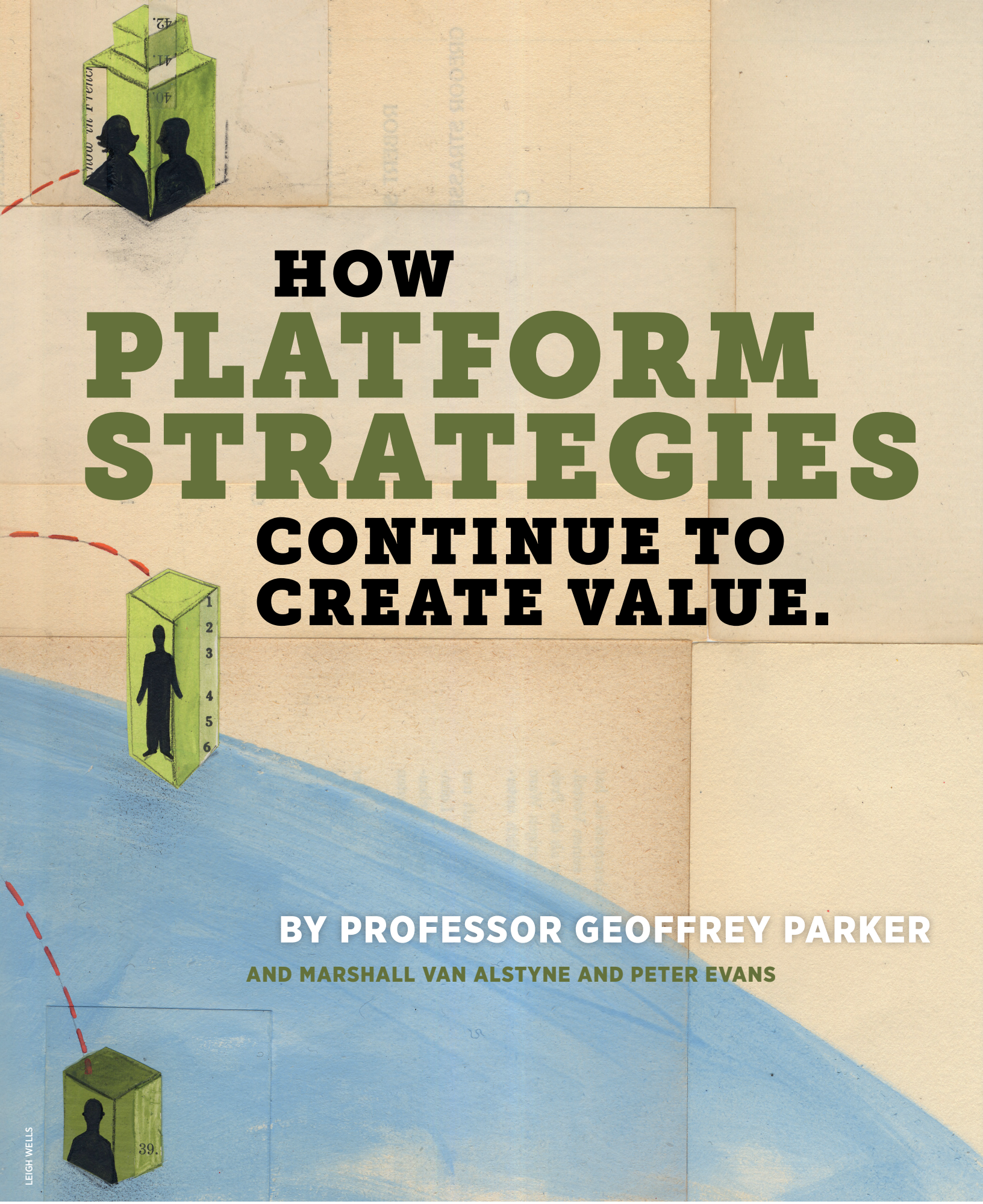
What is a material that you think is going to become more prominent in our daily lives?

Graphite composites are sure to become more prominent. Up until recently, all jetliners—the bodies and the wings and everything—were made out of aluminum alloys. With the latest planes, they're making them out of composites instead. They can be lighter and they can be less costly to construct, because you can make them all in one big piece. The Boeing 787 Dreamliner was really the first one of those. It might be that cars start to be made out of graphite composites as well. They are expensive materials, but if you can get the manufacturing costs down, maybe that can offset some of the price of the materials.

How should people approach the materials in the book?

I put the materials in alphabetical order purely for organization, but you should just delve into a particular material you find to be of interest. Maybe you'll find out a little bit about the history that you didn't know.

KRISTEN SENZ *is a freelance writer and editor.*

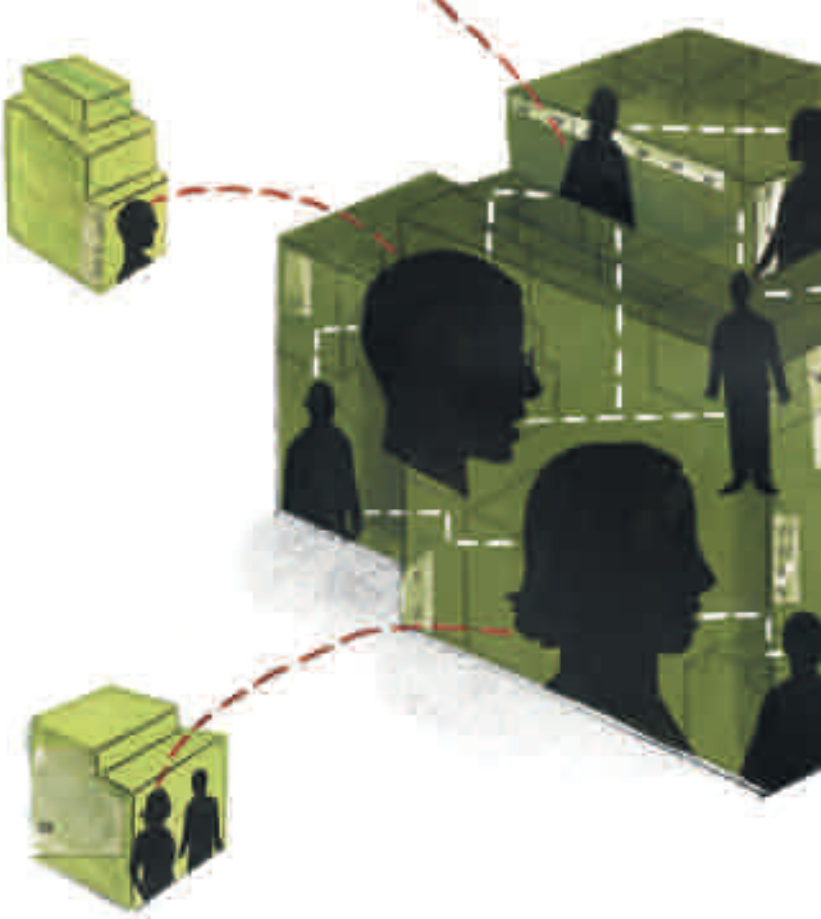


HOW PLATFORM STRATEGIES CONTINUE TO CREATE VALUE.

BY PROFESSOR GEOFFREY PARKER

AND MARSHALL VAN ALSTYNE AND PETER EVANS

LEIGH WELLS



PLATFORMS WERE ONCE considered small and even quirky additions to business strategy. This is no longer the case: Now, more than ever, platform-centered markets are booming, and business-to-business and business-to-consumer platforms, such as Amazon and Facebook, have become household names. Meanwhile, incumbent companies are racing to catch the wave. In 2018, companies deploying platform business models continue to surprise and challenge conventional approaches to creating value.

Platform companies have also been among the first to recognize and harness data-centric strategies, and many have moved to the forefront of a wide range of disruptive technologies, from cloud computing to Internet of Things. In the process, platform companies have become powerful engines of innovation that play an increasingly integral part in economies throughout the world.

There is a tremendous need to understand the economic, policy, and management sides of platforms and to learn from visionaries on the leading edge, such as Airbnb, Uber, and Topcoder. The journeys shared by the companies at the 2018 MIT Platform Strategy Summit—where more than 300 leading executives, entrepreneurs, technologists, and visionaries gathered to offer insight, share experiences, and envision a way forward—illustrate several key principles that represent the locus and control of platform value today.

1. TECHNOLOGY, SCALE, AND SMART RISK MANAGEMENT

Executives building and operating platforms pointed to the interplay between technology, scale, and smart risk management. Michael Morris, the CEO of Topcoder, which provides an on-demand global network of designers and technologists to small businesses, observed that to reduce transaction costs and grow network effects, companies must manage risk. Intelligently absorbing risk helps pull new transactions onto the platform and grows the enterprise.

For MuleSoft, a provider of API services, the transition from manual to self-service options reduced friction and accelerated employee onboarding times from weeks to minutes. MuleSoft's chief technology officer Uri Sarid said, "There has to be value in the platform, and self-service reduces friction in setup. Service in seconds is digital; service in days is not."

There are numerous and varying implications for emerging technologies. Eamonn Maguire, global lead in financial services at KPMG, led a discussion with Gerhard Lohmann of CFO Reinsurance, Jalak Jobanputra of FuturePerfect Ventures, and Kiran Nagaraj of KPMG about blockchain technologies and where they might also contribute to reducing friction across platforms. Naturally, the answer was "it depends." Some argued that blockchain still cannot match current transactional means of processing international payments. Others pointed to the significant gains that could be made in deploying blockchain to improve the efficiency, security, and transparency of areas like insurance, which are notorious for complex, siloed, paper-based processes.

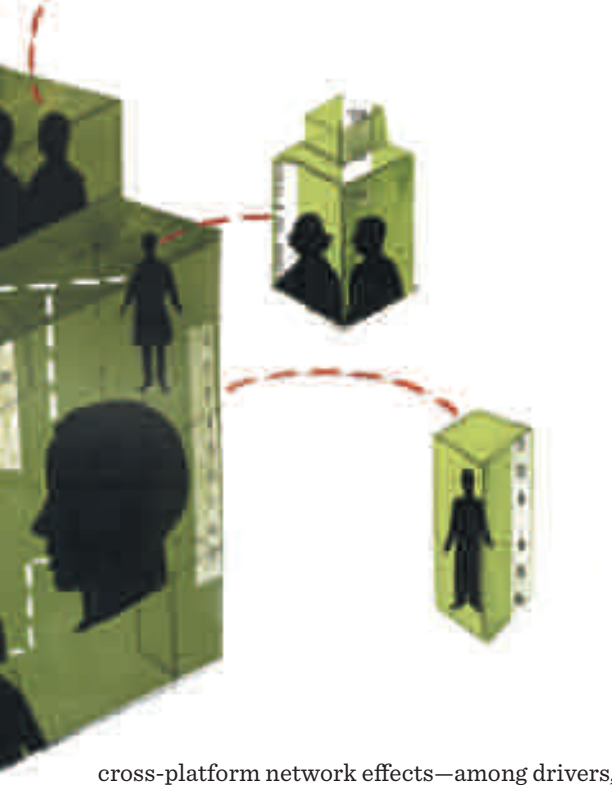
2. THE POWER OF SPECIALIZATION AND ADVANCED DECISION ENGINES

As platforms mature, they often become more complex and more specialized. This creates new management challenges and the need for more sophisticated decision engines to harness value.

PLATFORMS MAY BE DATA-RICH, BUT THE VALUE OF THIS BOUNTY CANNOT BE HARNESSED WITHOUT INVESTMENT IN SKILLS DEVELOPMENT, INFRASTRUCTURE, AND TOOLS.

Uber provides a case in point. Irfan Ganchi and Ahmad Anvari, Uber's top product management executives, pointed out that Uber now does 5 million forecasts every minute to balance supply and demand. But forecasts are not enough: The company also has had to develop sophisticated incentives to act on these estimates.

The company deploys dynamic pricing as one lever for minute-by-minute matching of riders and drivers. Over longer intervals by week, month, and quarter, it uses incentives such as guaranteed surge and marketing and various customer relationship management strategies. As the company has moved into food delivery with its Uber Eats service, forecasting and incentives should advance



cross-platform network effects—among drivers, couriers, restaurants, riders, and eaters. While Uber has particular challenges associated with being hyper-local, the company's experience illustrates the heavy investments that platforms are making into advanced decision engines.

3. DATA-DRIVEN, AI-SAVVY PLATFORM TALENT

Many companies have built data analytics teams. However, Airbnb's leadership team is taking things a step further. As head economist Peter Coles explained, the company believes data is so strategically important to its success that it is building an internal data university for its employees, now numbering more than 3,000. The vision is to empower every employee at Airbnb to make data-informed decisions by providing data education that scales by roles and teams across the entire organization.

Realizing this vision requires investment in training as well as in tools and company-wide data infrastructure. This points to the fact that platforms may be data-rich, but the value of this bounty cannot be harnessed without dedicated investment in skills development across the organization and supporting infrastructure and tools.

Rapid innovation around AI will further challenge companies to embrace data-driven business innovation and new skills development. This was the central theme of the panel chaired by Mona Vernon, chief technology officer at Thomson Reuters Labs. As Michael Palumbo, the technical product manager of Rolls-Royce's R2 Data Labs, said, the "people who can cleanly identify problems and next steps" will be in high demand as jobs evolve in an era of AI. In a cautionary note, Ian Myers, CEO of NewsPicks, pointed out that platforms themselves can introduce bias, as content recommendation engines are designed to give users more of what they have already consumed—demonstrating some limits of technology that companies should consider.

The power of the platform to create value can also be seen by helping companies discover new revenue streams. The most common secondary data use today centers around advertising, but we expect many more uses as data rights are worked out and markets in data develop. The potential for both healthcare delivery and development was discussed by Alice Raia, vice president of digital presence technologies for Kaiser Permanente, and Valérie Abrell Duong, vice president of information technology and solutions for Sanofi. Thomas Friese, vice president of Siemens Healthineers Digital Ecosystem Platform, described how external parties seek access to their image database in order to develop new services.

4. BUILDING VALUE THROUGH DIVERSITY

Productivity is one measure of value—but not the only one. Diversity has also shown to be a driver of value for organizations, and there is growing evidence that diverse teams are sharper and more creative than homogeneous teams. Yet, the tech sector is an area that often lags significantly. For example, tech employs half as many African-American and Hispanic workers compared with the rest of the private sector. Can a platform help?

Rodney Sampson, the cofounder of Opportunity Hub, believes it can. He and his team are drawing on platform principles to connect demographic groups that are underutilized and underrepresented in the tech community with companies that are looking for talent. As part of its strategy to expand supply, Opportunity Hub has inked a partnership with the Flatiron School, a coding bootcamp recently acquired by WeWork. In addition to programming and data analytic skills development, the "inclusive ecosystem," Sampson explains, also provides unique networking opportunities (such as a scholarship to attend the South by Southwest conference), startup resources, workspaces, and access to funding programs.

5. TACKLING EVER MORE FRAGMENTED MARKETS

Fragmented markets have been longstanding hunting grounds for platform business models. This continues to be the case in ever more complicated and splintered markets, such as music.

In examining the intersection of music and platforms, Nathan Hanks pointed out that major brands spend more than $20 billion annually, but music currently captures only $2 billion because of the splintered nature of the market. Music Audience Exchange, which Hanks founded, helps to flip the model where the brand makes a promotional piece for the artist, which is then matched, leveraging music metadata collected by the platform to audiences across multiple media channels from TV to streaming services. This is possible in part because platforms separate access from ownership, as Joe Belliotti, founder of Noisegate, noted.

Platform innovation strategies can also serve investors. Nick Terzo highlighted how Royalty Exchange is building music rights in ways to make them more accessible to a range of institutional investors. Fabrice Sergent noted that, despite the extreme fragmentation of the live music market, Bandsintown now has 38 million registered fans and 430,000 artists since it was founded in 2007.

In short, the adoption of platforms continues to transform industries and create new value where it did not exist before.

This article originally appeared in MIT Sloan Management Review. *Thayer School professor Geoffrey Parker is the director of the master's of engineering management program. Parker wrote* Platform Revolution: How Networked Markets Are Transforming the Economy—and How to Make Them Work for You *(W.W. Norton & Co., 2016) with Marshall Van Alstyne, a professor of business and the chair of the Boston University Information Systems Department. Peter Evans is a principal in the KPMG Innovation & Enterprise Solutions group. The authored co-chaired the 2018 MIT Platform Strategy Summit.*

Alumni News

FROM AROUND THE WORLD

spotlights

Liz Gerber '98

A decade after **Liz Gerber '98** founded Design for America (DFA), the national network of students, mentors, and community leaders has earned the Cooper Hewitt, Smithsonian Design Museum's National Design Award for corporate and institutional achievement. The prestigious award—which has previously been given to Apple, TED, and Etsy—recognizes the group's focus on using human-centered design to address complex, real-world problems. Based at Northwestern, where Gerber is an associate professor of design, DFA is a national network of interdisciplinary undergraduate teams trained to go into a community, identify a social problem, and design and implement solutions. Now composed of 38 universities and more than 1,200 student members, DFA students tackle more than 150 projects each year. "In 1961 the Peace Corps mobilized youth to support economic and social development. In 1989 Teach for America encouraged a new generation of teachers," Gerber said in her acceptance speech. "Today we have a thriving design corps that is changing higher education, industries, and our communities." At DFA, Gerber encourages students to tackle challenges outside their campus and comfort zone. "DFA doesn't give students problems to solve; it guides them to walk around their local community to find problems they believe are meaningful, such as literacy and obesity." One of DFA's first social innovation projects looked at hospital-acquired infections. After studying hospital design and practices, the team found that providers did not wash their hands enough, in part because sinks were not located near patients. The DFA team designed a portable hand sanitation device that clipped to the provider's clothing for easy access and tracking—and boosted hand hygiene by 64 percent. "Her work is centered on scaling educational innovations that will help create a generation of young people with the knowledge, skills, and creative confidence to address complex problems facing the planet," says Professor Peter Robbie, who has known Gerber since she was a student taking design courses at Thayer. "She is a rock star in the field of creative engineering design education."

GERBER'S 4 ESSENTIAL MINDSETS TO DESIGN THINKING

1. Work together. "Important problems worth solving are often situated in complex systems that involve many stakeholders."

2. Build to learn, not to impress. "We learn more when we focus on what is possible rather than be preoccupied with appearing to have all of the answers."

3. Take many paths. "When we try out different ideas, we more quickly learn what works and what doesn't work. When we commit to a single idea, learning takes longer."

4. Embrace change. "Question the status quo and regularly take risks to make the change happen."

Harris B. McKee '61 Th'63 grew up a "farm boy" in Iowa and attended a one-room schoolhouse during his elementary years. His original plan? Follow in his family's footsteps and attend Iowa State. But his course changed when Dartmouth's then-football coach spotted his talent on the field and recruited him to play for the Ivy League. He set out to Hanover and the former "farm boy" from Iowa went onto play during Dartmouth's 1958 championship-winning football season, major in engineering sciences, and eventually deliver the valedictory address to his graduating class. This fall, McKee was honored as one of three recipients of the Dartmouth Alumni Award for his decades of service to the College and for his extensive career. In receiving the award, McKee said, "Dartmouth turned my life into what it's been. Being a volunteer for Dartmouth was a way that I could give something back. That's really all there is to it."

A little more than a year ago, **Sean Casten Th'98**, who earned his master's in engineering management (MEM) from Thayer, announced he was running for U.S. Congress. This past November, Casten, a Democrat from Illinois' 6th district, won his congressional seat. His term began in January. As Casten launched his campaign last year, he spoke to *Dartmouth Engineer* for the Fall 2017 issue about the value of a scientific approach to governing: "Scientists and engineers are trained to look at big, diverse sets of data, identify a problem, hone in on the root cause, and solve it. We don't waste a lot of time talking about 'alternative facts' or worrying about the


Harris McKee '61 Th'63 with Alumni Council President Adrienne "Tee" Lotson '82

On the Job

JED YEISER TH'10 | SKI DESIGNER

"I want to make skis that let me and my friends push limits."
—JED YEISER TH'10

Yeiser draws on his background as a skier—he started racing competitively at age 10—to design and test two product lines for Seattle-based K2 Sports. He's designed about 250,000 pairs of skis currently on the slopes—with a new line on the way.

How does your background as an athlete factor into your design process?
I grew up skiing, and a lifetime spent racing proved enormously valuable when I started at K2. A huge part of my job is testing product and identifying small variations. My time racing makes me far more sensitive to small differences in ski performance than I would be otherwise. The first skis I worked on were focused on carving and "race-inspired" performance. Designing them was much easier as I had a very clear understanding of how the skis should feel on snow.

How do you juggle various product lines?
I've always worked in the ski design department, which is responsible for all engineering on K2 and LINE skis. If you walk into a shop today and find a LINE, I designed it. From a brand identity standpoint, K2 and LINE are very distinct, and we take that same approach to product design and technology. We've started to use some of the same design tools—notably, a large Excel program I designed to model ski flex and sidecut—but if an idea or technology starts with one brand, it stays there.

Where do you find inspiration?
Ideas for new product tend to come about fairly organically. We're all skiers in the office, and at the end of the day, we want to make skis that we want to use. Before I set pen to paper, we make a pretty detailed product brief that describes the customer for a specific ski, the most important performance attributes, any constraints and cost for the product. Skiing is inspiration in and of itself. The deeper I get into ski design, the better I understand the interplay between the mechanics of a ski itself and how that translates into on-snow feel. From a technical side, there are countless ways to improve processes, analyze product more efficiently and streamline manufacturing. Yes, I design skis, but I'm also working on better modeling strategies, production processes and machinery, material evaluation and qualification, and brand strategies—it's that variety that enables me to keep learning and keeps the job stimulating. On the horizon, we'll be releasing a new line of men's and women's skis that I've spent the last three years dreaming of and the last 20 months designing.

—Interview by Theresa D'Orsi

OPPOSITE PAGE: TOP LEFT, LISA BETH ANDERSON; BOTTOM LEFT, JEFF WOODWARD. THIS PAGE: COURTESY JED YEISER.

Kevin Rebenius Th'99 has launched new core-scanning tech.

political fallout. To the contrary: We pride ourselves on being the first to identify and correct problems with a flawed paradigm. … If we were using facts and data to inform our policy discussions, we would be having a much different conversation."

A century after it first flew, the No. 191 "Tommy" rag-and-wood biplane took off again in Ithaca, New York. It was the culmination of a lofty effort by Dr. **William Thibault '64**, son **Bill '94 Th'95 Tu'01**, daughter-in-law **Melissa '94 'Th'95 Th'96 DMS'00**, and the Ithaca Aviation Heritage Foundation. One of 13 Thomas-Morse S-4Bs known to exist, Thibault's Tommy is the only one in flying condition anywhere in the world. The single-seat trainer was part of a batch ordered up by the Army Signal Corps to prepare American pilots for fighting in the skies over Europe in World War I. Tommys that survived the war in decent condition went to civilian flight schools, barnstorming daredevils, and film production companies. Thibault donated his plane to the Ithaca club in 2013, when a complete ground-up restoration—and in some cases, reconstruction—began. The team soon discovered the airplane was a mash-up, a rare S-4B fuselage adorned with scavenged parts from other models. Fortunately, another Tommy was housed a few hours' drive away at the Old Rhinebeck Aerodrome and the team was allowed to examine the plane. During the seven-year effort, volunteers dismantled the body, wings, and engine; reverse-engineered fittings for the motor; and stretched new fabric over the frame. Nearby, Borg-Warner opened its doors at the facility where the planes were originally produced so the Tommy team could use the original tools to replicate a complete set of upper and lower wings. "You demonstrated you would do exactly what I had always wanted to do with the plane," Thibault told the Tommy volunteers, "which was to restore the aircraft to its original configuration."

From her office in Reston, Va., **Abigail Davidson '05 Th'06 Th'07** is working on a giant leap for mankind: launching AI into the cosmos. As CEO of Cubic Aerospace, Davidson leads a 10-person team developing computational power for large satellite providers Lockheed Martin and Northrop Grumman as well as the U.S. Air Force. One major project is a radiation-tolerant payload processing computer that adapts a terrestrial system-on-a-chip for use in a space environment. "By putting massive amounts of computational power in space, a user can process data onboard at the point of collection," she says. "This allows users to get close to real-time answers instead of porting the data down the ground and processing it there, which can introduce significant time delays and valuable data loss." Davidson is also excited at the potential of machine learning and AI algorithms: "Spacecraft could then find things we don't even know to look for," she says. "Imagine a pattern-recognition algorithm operating in real-time onboard a spacecraft that collects cosmic background radiation data, or a machine-learning algorithm running on data used to predict weather patterns." NASA is interested in using Davidson's processor to analyze gamma rays. "The missions we support have pretty significant potential to impact our lives," says Davidson. "I try to remember that when dealing with all of the little things we need to do to get there."

▲Hans Albee '03 Th'04 oversees the construction of an 883-kilowatt solar photovoltaic system.

Energy-storage ideas power the enthusiasm **Hans Albee '03 Th'04** brings to the office each day. As an engineer with renewable energy provider ReVision Energy—which has installed five photovoltaic projects at Dartmouth and has 15 more on the drawing board—he has played a crucial role in making the firm a leader in this rapidly growing sector. "I've led ReVision's entrance into energy storage with innovative products such as the Tesla PowerWall and Maine-based Pika Energy Island systems," he says. "Energy storage is a crucial part of widespread electrification and displacement of fossil fuels with renewables." Albee's trajectory has mirrored the growth at ReVision, from 19 employees when he started in 2007, to more than 250 now. He began by installing solar hot water and solar photovoltaic systems, then moved to sales and system design, and is currently overseeing commercial project management and engineering and design in the Liberty, Maine, office. "Solar energy development is growing so quickly that the size of our projects grows substantially each year," he says. "I enjoy working on these larger and larger projects because they not only displace a lot of carbon dioxide pollution, each project also brings fresh challenges and opportunities for creative problem-solving." He credits his Thayer degree with honing his problem-solving abilities on a team. "Those skills have translated directly to my work in solar energy," he says. "In a small way, I feel that I'm fulfilling Sylvanus Thayer's directive to 'prepare the most capable and faithful for the most responsible positions and the most difficult service' by working to advance solar energy development."

Joe Brown '00 is tapping into some tiny tools with big potential applications. "I'm building a group centered on microdevices and nanomaterials," says the assistant professor of mechanical engineering at the University of Hawaii at Manoa (Honolulu). "My students are doing cool stuff; I'm looking forward to seeing if we can eventually focus these projects into accomplishments such as papers, patents, and startups." He sees opportunities for water-based, energy-harvesting devices for powering consumer electronics with motion, 3D-printed optics, and low-profile, chip-integrated sensors for hearing aids, noise cancellation, and portable electronics systems. "I'm trying to bring an entrepreneurial mindset to be adaptable to the people and needs around me, rather than to force my plans forward in a straight line," he says. "This is particularly important in Hawaii, where things seem to get done by 'planting seeds' and helping things grow, rather than by walking in a linear path to a goal." He says the social science classes he took at Dartmouth help him think through group interactions. "I'm trying to build a team with a range of skills and foci and an ability to learn from each other," he says.

Drawing on medical radiol-

Alison Andrews Reyes '94 has built and run tech companies for more than 20 years.

ogy research, **Kevin Rebenius Th'99** helps geologists drill down through a wealth of data. Orexplore, the company he founded in 2010, has developed a novel X-ray technology that allows miners and mineral explorers to scan through rock samples to extract structural and elemental data—on-site and in a matter of minutes, rather than the six weeks it can take laboratory geochemical analysis. The cost is about $100 per meter of drill core. "The scanning tool can be used in both green-field exploration or in mine exploration, but we focus on the mines as they scan continuously and are less sensitive to changes in the market," says Rebenius, who returned to Sweden to complete his master's in mechanical engineering and later earned an MBA from Stockholm University. He spent three years assembling a team and developing the technology before landing his first investor, Australian drilling company Swick Mining Services. The process helped him identify two key components to startup success: "Persistence—I never give up—and being fortunate enough to find the right people," he says. Orexplore has launched in Australia, with plans to enter the American and Canadian markets next. "People are a bit overwhelmed with the wealth of information, and I think the next horizon would be to apply AI on the data to allow the system to automatically identify interesting geological commonalities and patterns," he says. "This would be of great value to the geologist, whose time is very limited." Rebenius also anticipates using the technology in down-the-hole surveying. "The rationale is that with faster and cheaper percussion drilling, the mineral analysis could be done directly when the hole has been drilled. I also envision that in-depth analysis can be applied for mineral sorting."

Alison Andrews Reyes '94 is turning her startup savvy to a tech venture fund. After 23 years working in startups, the engineering sciences major is now a general partner at early-stage technology venture fund 1843 Capital. "We advocate for gender equity in founding teams, not as a nice to have, but as a success indicator." She would know: Recent firms she founded include Dezignable, a tech company that connects clients with an army of professional designers and socially responsible products, and cybersecurity firm Vigilant Inc., which Reyes grew into a 65-person organization before selling it to Deloitte. Her ingredients for a successful startup: timing, adaptability, passion, emotional intelligence, and luck. "Having run the gauntlet at five startups, I know a combination of clear vision and adaptability get you started, but it's the passion and emotional intelligence that keep you going when the inevitable big crises occur," she says. "I also can't overstate how much timing and luck play a factor. We all want to believe that it's raw skill or expertise that makes our startups successful, but right time, right place can be just as significant." Her background also makes her sensitive to the gaps in support for women: Female founders make up nearly 20 percent of all startups, yet receive less than 3 percent of funding. In her role at 1843 Capital (1843capital.com) in Greenwich, Conn., Reyes hopes to change the statistics *and* capitalize on outsized returns. "We invest in deep tech sectors, such as analytics, AI, and cybersecurity as well as what we call 'silver tech,' " says Reyes, pointing to opportunities to improve the lives of the aging. "Seventy percent of the wealth in the United States is held by people age 50 or older, and we are all living longer. The rise of voice recognition, self-driving technology, robotics, and more will create new applications that will allow us to age better and live independently for longer while reducing healthcare costs."

OPPOSITE PAGE: TOP, COURTESY KEVIN REBENIUS; BOTTOM, COURTESY HANS ALBEE. THIS PAGE: COURTESY ALISON ANDREWS REYES.

just one question

Q. If you could re-experience one moment from your time at Thayer School, what would that be?

Discovering that pure compressive load on the standard test cylinder of concrete causes tension failure. I was just to trying learn about strength of materials and stress analysis (just do the components)!

—Tom Harriman '42 Th'43

When in a mechanical engineering class, I was designing a gear and thinking maybe I didn't want to be an engineer. I was rushing through my education as a Navy V-12 student. I didn't become an engineer, but found that I gained analytical skills that served me well throughout life. I am 92 and the go-to guy in my family regarding computer technology. If I had been in a more leisurely educational environment, I think I would have found myself in electrical and finally computer technology.

—Lawrence Goodman '47 Th'47

My senior thesis was on ionospheric radio propagation. The fun part of that activity was stringing up a 150-foot rhombic antenna on a nearby mountain with help from my professor and assistants to receive a signal from Collins Radio in Cedar Rapids, Iowa. Later, when I was in the U.S. Army, I was assigned to the Signal Corps to work on tropospheric propagation studies. In the Signal Corps, they needed only short-distance communications on the battlefield (tropospheric bounce is fine). I then worked as a business executive with IBM for 35 years, mostly in the United States, but the last five years prior to retiring were in London and Paris. Now, I am just relaxing.

—Bart Lombardi '52 Th'54

I would have prevented **Larry Freier '55 Th'58** from joining the U.S. Marines. If he were with us in 1956, Thayer School would definitely have won the 1956 intramural softball championship game against Beta. (The Brooklyn Dodgers had wanted to sign him out of high school.) I was captain of our softball team, and we had the captain of the varsity football team, **Lou Turner '55 Th'56**, as our pitcher. We lost only by one run! Larry Freier could have made the difference.

—Norman Fine '55 Th'56

George Taylor's moot court in his engineering law course. I don't remember the issue, but Professor Taylor was the judge. I learned how to do case law research, some tort law, and very good contract law. The course was way ahead of others in MBA law class years later. I proofed all the problems in his text, *Managerial and Engineering Economy*, before it was published. It was the most valuable course of a lifetime.

—Tom Jester '63 Th'64

ENGS 22: Systems in 1963 would be worth re-living. It was the first time I took a mathematical model and turned it into a working artifact—an air-bearing seismograph. Interactions between math, or other abstractions, and working solutions would prove to be a very important part of my career.

—Mark Samuel Tuttle '65, Th'66

I would love to re-experience my time making a Stirling engine in the machine shop under the direction of Fred Schleipman and the other machinists. It was fun, I learned something about fabrication, and, most important, I learned that the workers on the shop floor know things that I don't.

—L. Scott Magelssen '75 Th'76

Working in the machine shop with Roger Howe and Vince Cheney.

—Glenn Grube '82 Th'83

"I would go back to the times I spent with my other MEM friends working and hanging out at the MEM space! I currently work as a construction and maintenance coordinator for BP in New York City."

—Karen Uchiyama Th'17

Hands down, the career-formative experience that is priceless: First day of ENGS 64: Engineering Electromagnetics with Professor David Stratton.

—Dave Rausen '90 Th'92

The design challenge to build a chair out of polypropylene. The hands-on collaboration with my classmates brought us together in an engaging way. That experience encapsulated what made my time at Thayer so special: the bonds we made over the exchange of ideas and the collaboration with my fellow students and the faculty in pursuit of our common goals.

—Malik Mamdani Th'92

The first time I drove the ElecTruck around the Green in 1994. Our BE project team—**Peter Barrette '94 Th'94 Th'95, David Cramer '93 Th'94, Owen Donnelley '93 Th'94**, and **Brian Hannon '94 Th'94**—had worked steadily throughout fall term and most of winter term to design, find parts, and convert an old Chevy S10 pickup truck from gasoline to electric "fuel" for use by the Hanover Police parking enforcement officers. Motor and gas tank out; electric motor and batteries in (plus many other components and details)! The icy day finally came when all systems were a go, and we started it up (noiselessly). After taking five minutes to fix an initial glitch—the accelerator potentiometer was wired in backwards—we drove it onto the streets of Hanover and around the Green. What an exhilarating victory lap! I currently work with OverDrive Fuel Cell Engineering Inc. in Vancouver, British Columbia, Canada. We provide engineering services in the area of fuel cells, helping customers bring their fuel cell products to market. We have a particular focus on fuel cells for vehicles with electric drive trains. My work at Thayer School on both ElecTruck and the solar race car helped get me started in this field!

—Laura Iwan '93 Th'94

I'd go back and re-live my time in the machine shop, working on the lathe or the welding machine, fabricating my Stirling engine. I loved the hands-on work with metal, which put into context how industrial parts were made—either by hand in the early automotive days or by modern computer-aided design. The experience especially resonated because of the two guys in overalls who supervised the shop. They reminded me of NPR's *Car Talk* guys "Click and Clack." They were funny, patient, helpful—and hilarious. It was always fun and collegial to be down in the shop, working with them and laughing.

—Erica McLoughlin '96

One of my favorite moments was the final testing of our water tower project for ENGS 51: Solid Mechanics. Usually people built a bridge out of balsa wood, but the year I took it we built a water tower. I teamed up with one of my best friends, **Michael Chong '97**, and together we came up with an excellent design, optimized it analytically, and then built it very carefully. The day of testing came, and we were so excited! Even my history-major girlfriend, **Marlene Sheehan '98**, came to witness the test. (We're married 18 years now, and have three kids.) When our turn came, our tower did really well—and surpassed the capacity of the testing machine! So, we had to continue the test in a lab in the basement, where eventually our water tower did break. It was a great moment, after a lot of work. I would love experiencing that moment again!

—Andres Dandler '97 Th'98 Th'99

I had a fantastic year at Thayer School as an exchange student from the Royal Institute of Technology in Stockholm, Sweden. The most prominent Dartmouth experience was being part of the Formula SAE team and having the honor of being one of the race car drivers. The project forced us all to get theory to work in practice. This was very educational, at least to me, as the Swedish school system in those days was very focused on theory. I remember bringing a mechanical drawing to the workshop, thinking I had come up with the perfect solution. One of the guys in the workshop looked at my drawing and just sighed, then explained why it would never work in practice. It was an eye-opener, and it changed my way of thinking. It taught me to pay much more attention to best practices and to listen to the experience of these "elders" who had pretty much seen it all.

—Kevin Rebenius Th'99

Firing up my Stirling engine! The culmination of designing, machining, hand-crafting, and doing performance calculations into a physical form that still sits on my desk brought a tangible feeling of accomplishment.

—Brian Nickerson '00

I would love to go back to the machine shop and build the Stirling engine. It was a nightmare then—but in hindsight, it was fun!

—Afua Djimi Th'06

I had hiked up Mount Cardigan on my own in the middle of the night with a laptop and small radio antenna. It was a cold and still night and the stars were extremely clear. At the prearranged time, the rest of my research group launched a high-altitude balloon from Hanover on a test flight into the stratosphere. I was the downrange spotter; my job was to track its descent and see where it landed. Just by pressing a button on my laptop, I was able to turn the balloon's optical beacon on and off 70,000 feet above me. Standing alone on that peak, it felt and looked like I was turning a star on and off. The project was for a research program called ALTAIR with Professor Yorke Brown in the physics department. [He went on to publish the research paper, "ALTAIR: Precision Calibration via Low-Cost Artificial Light Sources Above the Atmosphere," at the 2013 American Astronomical Society meeting.] The payload the

balloon was carrying was one that I built in Thayer's machine shop, and I pulled in a lot of Thayer skills from Machine Learning, Fluid Mechanics, and Intermediate Fluid Mechanics to design it.

—Max Fagin Th'11

We built an autonomous sailboat for Professor Laura Ray in ENGS 147: Mechatronics. We were testing the sailboat on Occom Pond and demonstrating it to Professor Ray. The controls had some bugs and we kept losing control of the sailboat. I spent a few hours in a canoe on Occom Pond chasing after the sailboat, with Professor Ray cheering us from the shore while we worked out the bugs.

—Peter Ankeny '12 Th'12 Th'14

I loved being a Thayer tour guide and I have a fond memory of taking a class of local middle-school boys on a tour, and watching them squirm and delight at the fake poop I handed them. (It was leftovers from my ENGS 89/90: Engineering Design Methodology project! Our 89 was quite the talk of the town for a while, thanks to its unusual nature—we even had cultured dog poop in the cold storage lab at one point!) It would be nice to experience their joy again! We created a few practical stops for them during the tour: A couple of professors ran some activities, another guide ran a little activity, and then I took them to the biotech lab and made them play with the fake poop. (We had to buy 30 pounds of it, as I recall, because that was the smallest quantity we could buy of the good stuff, the *real* industry-grade fake poop. It had to be shipped in from Canada. We tried making many types of fake poop ourselves, but we couldn't get the right consistency—google 'Bristol Stool Scale'!) I always tried to emphasize the liberal arts nature of our engineering education: how we still took a normal courseload outside the major, how the major itself was interdisciplinary, how we all had friends outside Thayer. The students seemed to be really intrigued by that. I remember coining and orating the phrase—"To design for a better humanity, you need to understand the *humanities*!"—with a grand flourish.

—Sharang Biswas '12 Th'13

May 29, 2012: The ENGS 146 Wiggle Car Race! There's was so much hard work leading up to it—it felt like such an accomplishment just getting to the start line. It was exciting, it was silly, and it was intense! Many great relationships were built in that class (Professor Diamond did a wonderful job) and it was such a great Thayer event. The slalom course through the hallways was fun to navigate, and there was an awesome turnout from the rest of the Thayer community. It was a wonderful celebration.

—Robert Mercurio '12 Th'13

It would have to be the final presentation my ENGS 89/90 team gave to our sponsors for their automotive capacitor redesign. We had been working hard for six months and, as we were presenting our work and results, the final test that would validate our work was being completed by one of the company's senior engineers. He walked back in and stood at the back of the conference room during the middle of our presentation. At the climax of our talk, we invited him to share his results (hoping they weren't too bad). He stunned us all by saying the capacitor we designed performed significantly better in electrical tests than the one they had been developing and used substantially fewer and less-expensive materials, stirring excitement for his team and a sigh of relief for ours.

—Drew Wong '12 Th'14

Moosilauke! I loved the amazing food (tomato soup and bread), cozy lodge, and gorgeous hike!

—Gabrielle DaGama Th'15

It would be when we set up an obstacle course in the Great Hall and raced our RC robots for Professor Sol Diamond's class. That was cool.

—Evan Landau '15

The day of graduation. That was the best day in my life at Dartmouth.

—Xiaobai Yu Th'16

My favorite singular experience was probably going to Dartmouth-Hitchcock Medical Center with Professor Sol Diamond's ENGS 170: Neuroengineering class to take MRIs of our brains. In that class, I also got to try on an EEG cap and watch my response in real time when another classmate tried to spook me from behind!

—Mackenzie Carlson '17

I would go back to the times I spent with my other MEM friends working and hanging out at the MEM space! I currently work as a construction and maintenance coordinator for BP in New York City.

—Karen Uchiyama Th'17

My first late night in Couch Lab, which occurred during my sophomore fall. My ENGS 21: Introduction to Engineering group and I were finally starting to make headway on our project, and we were excited about getting our prototype working. Surrounded by hardworking and enthusiastic students, it was the first time I really felt at home in Thayer and part of the engineering community. Our project was to increase the stability of longboard skateboards at high speeds, targeting the trucks that connect the wheels to the board. We initially designed an electro-mechanical solution for our problem that would tighten and loosen the trucks on the go. It was a cool idea, but became increasingly complicated and out of scope for a term-long project. It "clicked" for the team when we created a highly simplified mechanical design that would still solve our problem—allowing users to tighten and loosen the trucks by hand on the go—and could be developed within our timeframe.

—Katie Flattum '18 Th'18

It would be when my ENGS 146: Computer-Aided Mechanical Engineering Design group finished assembling our omni-directional, zero-turn-radius vehicle. It was late at night, and it had been a difficult process with many sleepless and near-sleepless nights, but getting on and riding it when it was finished made every second worth it.

—John Leahy Th'18

"The Wiggle Car Race was exciting, it was silly, and it was intense!"

—Robert Mercurio (standing, seventh from left) and classmates in "Computer-Aided Mechanical Design" created, built, and relay-raced Wiggle Cars around the halls of Thayer School.

Photo by Douglas Fraser

OPPOSITE PAGE: COURTESY KAREN UCHIYAMA.

thayer notes

| 1940s |

Jim Rudolph '47 Th'48: Since graduating from Thayer in 1948, I made my career as an international art dealer, working with museums, galleries, artists, and collectors all over the world. Thirty-four years ago, HarperCollins published my book, *Make Your Own Working Paper Clock*, which includes160 pieces that you glue together to produce a wall clock that functions perfectly, goes "tick-tock," and can be adjusted to go faster or slower. It has never been out of print and has sold almost 300,000 copies. The back story: When I was a graduate student at the Sorbonne, I wandered into a used bookstore one day to find a copy of a book called *Paper Clock*. I bought it and spent the next two weeks building the clock. I thought it was the most spectacular gift I had ever seen. I returned to the store to buy one for everyone I knew. The owner explained that it was now out of print, but he had the last three copies. I bought all three immediately. I kept them all—until 20 years later, I read in *The New York Times* a book review about a cut-up-and-paste book called *Build Your Own Empire State Building*. I figured if they could do that on a project that just entailed gluing a few paper boxes together, somebody ought to see my clock book. That's how it became a book in this country. I wasn't nearly smart enough to have invented the clock, but I was just smart enough to have recognized the book's potential. Harper & Row spent many months hiring patent attorneys and trademark experts in France to ensure we weren't infringing on the inventor's rights. When nothing showed up, I said to Harper that there's one sure way to find out if the creator is still alive: Publish the book. And they did.

| 1950s |

Ron Read '57 Th'58: I had the honor of being invited to teach a three-day technical management leadership class at the NASA Jet Propulsion Laboratory (JPL) in Pasadena, Calif., last May. We had scientists and engineers from two JPL space programs attend. One group is working on the Wide Field InfraRed Space Telescope, scheduled to launch in 2024. It will have a field of view 100 times greater than the Hubble Telescope and will measure light from more than a billion galaxies. The other is the Exoplanet Exploration Program (an exoplanet is any planet that does not orbit Earth's sun). The program goal is to search more than 40 billion Earth-sized planets orbiting the habitable zone of sun-like stars within the Milky Way galaxy for signs of oxygen and water. This is pretty exciting science, and it was great fun to work with and learn about their projects. Needless to say, they were a very high-powered and motivated group of engineers!

| 1960s |

Mark Samuel Tuttle '65, Th'66: I am involved in startups that usually have to do with data in healthcare—at the rate of about one per quarter. I get to learn something new from each one. I'm also working on my own software development, with the very pretentious name, Re-inventing Statistics Assuming Unbounded Computing Resources. I also mentor wannabe data scientists from Dartmouth and elsewhere.

| 1970s |

Bob Jackson '75: I am now officially retired from both my Navy and civilian careers, happily living in San Diego with my wife of 30 years, Bobbi. Several years ago, I retired from the Navy as a captain in the Civil Engineer Corps, where my responsibilities peaked as the commodore of the First Naval Construction Regiment, responsible for all Pacific-based Seabees (approximately 4,000 Seabees and 23 units) during Operation Iraqi Freedom. On the civilian side, I retired from Sempra Energy as the general manager and director of engineering and construction, with the construction of the $1.8-billion Sunrise Powerlink 230kV-500kV transmission line—the largest project for which I was given responsibility. Now, I am having lots of fun with my three young grandkids, with a fourth on the way. My five boys are doing well, some of whom are in San Diego and some in Illinois. My oldest made a radical career change out of engineering and construction management to law enforcement and is now a sergeant with the Illinois State Police. It has been several years since I have been back to Hanover. I probably would not recognize it with all the new construction. I am shooting for 2025 to attend our 50th reunion. It is hard to come to grips with the reality that so much time has elapsed since my undergraduate days!

| 1990s |

Malik Mamdani Th'92: Since graduating from Thayer, I have started my own software and analytics companies. Most recently, I launched a data-and-analytics service offering at Armeta Analytics (armeta.com) to help retailers and product companies make data-driven decisions. When I'm not running my business or running our three kids to their activities, we're in hot pursuit of the best tacos and gelato in town.

| 2000s |

Brian Mason '03 Th'04 Th'05: The Masons are staying plenty active in California. The family works hard during the week, and we do our best to play hard during the weekend. I am still at the wearable breast pump startup Willow Pump (and was excited to host Thayer Trek students in December). **Jocelyn '05** is teaching Spanish, and Lynn, 7, is in first-grade Spanish immersion at the local elementary school. Peter, 4, and Andrew, 1, never stop moving, and the entire family loves to do LEGOS, wrestle, and draw. Just this last weekend, we built a "cottage" in the backyard with a converted sandbox and some old grapevine stakes, with Peter being the "boss man." We look forward to the rain soon to quench the earth and fires, slow things down, and give us some powder up in Tahoe. Miss you, Thayer!

| 2010s |

Max Fagin Th'11: I'm still working at Made In Space (madeinspace.us), where I like knowing that what I'm doing is helping humanity become an interplanetary species. There, I have two mottoes on my desk. One is the standard engineering mantra, "What have you forgotten?" The other is a modified version of the quote from NASA's flight director Gene Kranz: "Tough and competent, and with proper deference to those who are more so than you."

Sharang Biswas '12 Th'13: My role-playing game, Feast, won another award this summer. It was named "Most Innovative Game" at the Indi Game Developer Network's Groundbreaker Awards. [Read more about this project in the Fall 2017 issue of *Dartmouth Engineer*.] My game Verdure was part of the *Rules to Play By* exhibition in St. Louis, Mo., also this summer. And, in one of my proudest moments, I got to teach a class at Dartmouth! Professor Mary Flanagan invited me to give a guest lecture for her game design class—the very class I took with her my freshman year! The icing on the cake was a student who emailed me after the class telling me how much they enjoyed it! I also recently finished teaching my first full, university-level course, Art and Interactivity: A Call and Response, to second-year photography MFA students at the International Center of Photography. I still love collaborating with other alums. **Max Seidman '12** and I were commissioned to design one of the game modules for "Save the Munba," a piece of immersive and interactive theater that showed in Boston this fall. I also worked with **Nick O'Leary '14** and **Rebecca Drapkin '13** on a performance game about cyberpunk-esque hackers that uses dancing as a game mechanic, performed at the NEON show in Brooklyn in November.

Drew Wong '12 Th'14: I'm currently finishing up my PhD in applied physics at the Harvard John A. Paulson School of Engineering and Applied Sciences and am looking around for what comes next, including possibly starting up a

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battery company through my research.

Evan Landau '15: This August, I began an industrial design MFA at Parsons School of Design in New York City. My interest in the field was definitely set into motion by Professor Peter Robbie. So far, I've created an urban compost tumbler and an ad-hoc disaster relief solution for homeless individuals and their pets in the city. The urban compost tumbler (dubbed "Tabletop Tumbler") is a compact receptacle for city dwellers that helps them compost and sustainably contain food waste without odor or mess. The inspiration came from two independent research initiatives I took part in this summer interviewing homeless individuals for two nonprofits. The found-materials schematics for a dog shelter crate was part of a larger system design of using public indoor spaces for temporary pet-owner shelters during states of emergency due to natural disaster. I am now working on a coffee machine for an I.D. competition hosted by the Philadelphia Museum of Design & Dieter Rams. (I have lots more images and products at.evantlandau.com.)

The human-centered design principles I learned at Thayer loudly echoed in my career throughout the past three-plus years. My time working as a strategic consultant and qualitative researcher at my previous job and most recently in research projects on homelessness has given me a valuable level of insight into how people think and behave that can't be taught in a textbook. Living in New York City is a great source of inspiration for design. In a city with so many people up to *something*, and not a whole lot of space, on almost every block you can find some sort of makeshift solution or compensatory behavior. My favorite is when people co-opt the city's infrastructure to turn public domain into private amenity. This might be using a pizza box as a clipboard, making a perch for people-watching out of a building's stand pipe, or setting up the lamppost municipal boxes as mini galleries for street art. I've seen that there is definitely an art to industrial design, but the end result is not a piece of art; it's something that must serve a real purpose to a human being. It's sometimes easy to lose sight of that, and to me, doing a "good job" refers to producing something that others can appreciate and build upon.

George Boateng '16 Th'17: I started my PhD at ETH Zurich, Switzerland, in July and I'm working on a project on emotion recognition to be used in couples' management of diabetes. Also, my nonprofit successfully ran the fifth edition of our summer program, Project iSWEST. [Read more about this project in the Spring 2018 issue of *Dartmouth Engineer*.] We had some interesting projects by the students, and one of the participants is actually a Dartmouth '22 who is interested in computer science and engineering. And I finished a fellowship piloting my nonprofit's new program, SuaCode, to teach students to code using their smartphones.

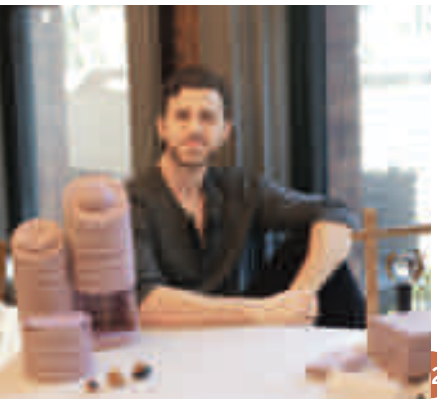
Mackenzie Carlson '17: I just started my PhD in bioengineering at Stanford this fall, after taking a gap year to work in an MRI lab at the University of Virginia. There, I worked in the hyper-polarized gas lab, where I used polarizing machines to get xenon gas, which basically allowed us to take pictures of people's lungs when they inhaled the gas and held their breath. For my PhD, I'm focusing on MRI, and there are lots of areas to specialize in even within just MRI. My program has students rotate—spend one academic term in a different lab each term of our first year, so I'll get to try out three labs this year—so I'm not sure what, exactly, my focus will be beyond that. It will likely be hardware (gradient/shim array) prototyping for high-magnetic fields (6 to 7 tesla) with applications to brain imaging.

Johnny Sigman Th'17: After getting my PhD at Thayer in 2017, I took a postdoctoral researcher position with Lawrence Carin's machine learning/AI group at Duke University. My project is building automatic detection of threats in carry-on luggage at airport checkpoints using deep neural networks. This product will go live this summer and be in airports nationwide soon. I'm leading a team made of myself and two graduate students, and we collaborate with the two companies that make X-ray scanners at airport security checkpoints. Duke is the lead on the project, and our role is to develop and advise all aspects of machine learning and neural networks. Our algorithms learn from labeled X-rays (knives, guns, and other prohibited items), and then detect and show the location of any threats in your luggage when you pass through a checkpoint.

Thomas Cornew '18 Th'18: I recently started a company with **Samwel Bahebe '18** and my brother, **Eduard Cornew '18**. Since artisanal or small-scale gold mining (ASGM) was legalized in Tanzania in 2010, Sam knew that he wanted to get involved. As the sector developed, he began to notice the growing health impacts that mercury processing was having on the mining communities. By the time Sam made it to Dartmouth, he knew that he wanted to help foster both the economic development and the long-term sustainability of the growing ASGM sector. Sam recruited me to develop the tech—and it quickly became clear that the opportunity was much larger than the Band-Aid solution we had begun developing in Thayer's machine shop. We had set out to mitigate the adverse effects of mercury processing via a mercury containment and recapture device; now we were going to address the lack of processing infrastructure and efficient distribution in Tanzania's ASGM sector. We are currently growing our distribution capacities, acting as a broker/dealer for mines, buying gold at above local-market prices, and selling to high-tech precious metals refineries in Dallas, Texas.

Once we have built out our distribution channel, we will begin constructing clean processing facilities in the mining communities we operate. We will use techniques that rely on sodium cyanide and activated carbon to extract the gold from the ore. This technology is not new but is expensive to install, and is the reason that Tanzanian natives have been relying on harmful and inefficient mercury. Thayer helped a great deal in my holistic understanding of systems and how to integrate discrete systems into novel solutions. For example, we are going to develop photovoltaic systems to meet the energy demands of our processing facilities. We intend to overbuild our solar capacity so that we can service the energy needs of neighboring communities in rural Tanzania. I have opened discussions with a clean energy company in Jordan to size the system and optimize

OPPOSITE PAGE: COURTESY JOHNNY SIGMAN. THIS PAGE: LEFT, COURTESY EVAN LANDAU; RIGHT, COURTESY MACKENZIE CARLSON.



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Gallery

1. Johnny Sigman Th'17 is on a Duke University team working to enhance airport screening technology.
2. As he pursues an MFA in industrial design, Evan Landau '15 says he is drawing on human-centered design principles he learned at Thayer.
3. Mackenzie Carlson '17 used polarizing machines during her work in an MRI lab.

thayer notes

various components to work well for our specific application.

Thanks to Thayer's expansive curriculum, I have the necessary experience in both mechanical and electrical engineering to design the mechanical layout, the material flow paths of the processing facility itself, and the electrical system required to run it. The market is enormous. In Tanzania—where we plan on buildin our proof-of-concept plant in 2019—there are around 1.5 million small-scale miners we could partner with. This represents a significant portion of the estimated 10 to 15 million ASGM miners around the world. We want to empower the Tanzanian people to make better use of the opportunities and resources available to them. If our model is successful in Tanzania, we have dreams of expanding to neighboring African countries and South and Central America.

Katie Flattum '18 Th'18: After graduating from Dartmouth and Thayer in June, I've been working for Amazon in Santa Barbara, Calif. I'm a knowledge engineer on the Alexa team, working to expand Alexa's knowledge base using structured data and natural language understanding.

John Leahy Th'18: I am currently working part-time for a biotechnology company called Boca Scientific while I look for a full-time position that can start a career I am passionate about.

obits

Robert E. Field '43 Tu'47 died June 23, 2018, at Dartmouth-Hitchcock Medical Center (DHMC). Bob's Dartmouth career was interrupted by WW II. He joined the U.S. Navy and was deployed as commander of a Navy yard patrol boat set to defend San Diego harbor against potential enemy submarines, then as second in command of the *USS Yarnall* destroyer. After returning to Hanover to earn his degrees from the College and Tuck, Bob began a 32-year career as a certified public accountant with Price Waterhouse & Co. In 1960, he became a partner. A recipient of the Dartmouth Alumni Award, Bob served the College as a member of the Dartmouth board of trustees, the Thayer and Tuck boards of advisors, and the DHMC board of trustees. Bob was predeceased by his wife, Pauline, in 1998. He is survived by children Bob Jr., Kathleen, and Peter; six grandchildren; and five great-grandchildren.

John B. Helsell '46 Th'50 died May 16, 2018, on his farm on Orcas Island, Wash. Jack spent summers at Four Winds Camp on Orcas Island and began a lifelong fascination with the design and maintenance of everything, from boats to machinery. At Dartmouth, his studies were interrupted by WW II, during which he served as an infantryman in Europe until the end of the war. After earning his master's in mechanical engineering from Thayer, Jack worked as an engineer at Pacific Car and Foundry in Seattle, Wash. In 1967, Jack and his wife, Jan, opened Camp Nor'Wester and developed big-boat sailing and mountaineering programs. Jack is survived by Jan, his wife of 66 years; children Mary Jane, Susan, and Ellen; and six grandchildren.

Albert G. Wilson Jr. Th'46 '47 of Braintree, Mass., died April 8, 2018. He was a member of the Navy V-12 program, and served during WWII. He earned his degree in civil engineering at Thayer and graduated Phi Beta Kappa. He went on to earn a master's in civil engineering from Case Institute of Technology, then began a long career as a civil engineer with various Boston engineering companies. He was also a well-known professor in civil engineering in the night school program at Northeastern University for more than 55 years. He was predeceased by his wife, Mildred. He is survived by his children David, Gerard, John, Karen, Mark, and Patricia; 14 grandchildren; and 11 great-grandchildren.

William R. Davis '49 Tu'50 Th'50 of Bloomfield, Conn., died April 19, 2018. In 1943, he volunteered as an aviation cadet in the Navy and served as a fighter pilot until WWII ended. He then entered Dartmouth, where he was active in the Tabard and Sigma Chi fraternities and earned his MS at Thayer School. His 33-year career at the Stanley Works in New Britain, Conn., included positions in the steel strapping division, as manager of research in the magic door division, and then in research and development, securing many patents for the company. He also acted as the company's expert litigation witness. He served the College as Thayer Annual Fund volunteer and class agent. He is survived by his wife of 67 years, Lenore; children Jeffrey, Katherine, and William; nine grandchildren; and five great-grandchildren.

Herman F. Woerner '52, a longtime resident of the Boston area, died in Naples, Fla., on January 9, 2018. At Dartmouth, Herm was an architecture major and a member of Gamma Delta Chi, the Dartmouth Outing Club, and the Dartmouth Players. Following Dartmouth, Herm earned a master's in architecture from the MIT School of Architecture and Planning in 1955. He then served four years in the U.S. Navy Civil Engineer Corps before embarking on a successful career in architecture. He worked on many projects, both in the United States and Europe, and he was especially proud of his effort in designing the Murdough Center as part of the Tuck-Thayer complex in the early 1970s. His wife, Katherine, predeceased him.

John H. Cogswell '55 Th'56 passed away on June 1, 2018, in Needham, Mass. He majored in engineering and was a member of Alpha Theta fraternity, Green Key Society, Army ROTC, the radio station, and the Athletic Council. Jack earned an MS in civil engineering from Thayer and served eight years in the Army as an intelligence officer before starting a 34-year career with the New England Telephone Co. He rose to the position of secretary and treasurer. For Dartmouth, Jack was a class agent for the Thayer Annual Fund, Alumni Fund volunteer, and a member of the class executive committee. Jack was predeceased by his wife of 59 years, Patricia. He is survived by daughters Julie and Catherine and grandchildren Jacob, Isaac, and Kiernan.

James H. Lothrop '57 Tu'58 Th'58 of Loveland, Ohio, passed away on May 24, 2018. A Tuck-Thayer double major in engineering and business, he was a brother and president of Phi Delta Theta and a member of the Interfraternity Council and Green Key Society. He served on the College Athletic Council and as football manager, was active in intramural athletics, and was in the Army ROTC, where he was on the drill team. He had a long career at Procter & Gamble, including international assignments as employee relations manager in Germany and personnel manager in Canada before returning to the head office in Cincinnati, where he was division personnel manager international. He served Dartmouth as Alumni Fund volunteer, class agent, and fraternity agent. He is survived by Ginny, his wife of 60 years; children Donald, David, Randall, and Linda; and many grandchildren.

Robert E. Prasch '57 Th'59 of Grand Isle, Vt., died on March 22, 2018. At Dartmouth, he was a member of Delta Kappa Epsilon, the Dartmouth Outing Club, and Army ROTC. Bob had a long career as a consulting engineer. He spent nearly half of his mid-career years overseas with resident assignments in Kenya, Egypt, Portugal, Malawi, and Bangladesh. In the early 1980s, he worked in Chicago as deputy project manager for the O'Hare Airport expansion program. His hobbies were rural land improvement and skiing. Bob is survived by his wife, Carolyn, and daughter Sandra. Son Robert predeceased him.

Herbert A. Grant Jr. '59 Tu'60 Th'60 of Scottsdale, Ariz., died on July 5, 2017. He completed the 3/2 program with Thayer and Tuck schools, and in 1960 he received his M.S. in engineering and business administration. He was in Navy ROTC during his college years, and served as a Marine Corps officer before he joined the Kingston-Warren Corp., a family-owned metal-fabricating firm in Newfield, N.H. He eventually became CEO. He served as president of the Dartmouth Club of the Seacoast Region. In 1987, Herb sold the Kingston-Warren Corp. and moved to Scottsdale. He is survived by his wife, Robin, and several children and grandchildren.

Brian F. Walsh '65 Th'66 of Hanover, NH, died on July 3, 2018, during a bicycle ride along the New Hampshire seacoast. At Dartmouth, he was an All-American lacrosse goalie and a member of Psi Upsilon fraternity. After graduating from Thayer, Brian earned an MS at Columbia. He was an entrepreneur and founding CEO of three technology start-ups: Creare Innovations; Creonics, a

robotics company; and Spectra Inc., a breakthrough ink-jet printer technology company now known as FujiFilm Dimatix. He served the town of Hanover on the board of selectmen for 15 years, and was involved in moving then-Mary Hitchcock Memorial Hospital to the current Dartmouth-Hitchcock Medical Center site and creating a rowing dock on the Connecticut River to accommodate Upper Valley crew teams. He is survived by his wife, Linda, and children Amy, Emily, Leila, Michael, and Gretchen.

Richard K. Wells '66 Th'67 died January 18, 2018, at his home in New York City. At Dartmouth, he was a member of Alpha Theta/Theta Chi fraternities and earned degrees from Thayer School, MIT, and Harvard Business School. Richard served as the founding president of NorthEast Regional Computing Program from 1967 to 1971, where he gained a reputation for revolutionizing computer network technology between universities in the Northeast. He later worked in venture capital at JPMorgan, following a passion for the oil and gas industry, and later owned Computer Help in N.Y.C. He was a member of the First Monday Harvard Businessmen's Club. He is survived by sister Carolyn (Wells) Furbish and his former spouse Patricia Goodlet Wells.

Ronald B. Shores Jr. '76 Tu'78 Th'82 died in Denver, Colo., February 15, 2018, after a brief illness. At Dartmouth, he majored in engineering sciences and mathematics and earned his MBA and ME. Ron joined Fischer Imaging, eventually leading the X-ray imaging electrical engineering group at its Denver headquarters. In 1987, he formed Creos with **Carter Yates '74 Th'76** to develop innovative power sources for CT imaging. Creos became publicly traded, and Ron served as U.S. division president. He then went on to consult for medical technology companies and created control systems to improve product performance via sophisticated mathematical models. Ron was well versed in many engineering disciplines and held several patents. At the time of his death, Ron was a volunteer with the College's Career Network. He is survived by his sister, Betty Anne.

THIS PAGE: DARTMOUTH COLLEGE ARCHIVES.

| in memorium |

PROFESSOR JAMES BROWNING '44 TH'45
— 1922-2018 —

Inventor Browning lit up the lab with advances in plasma torch technology.

When Browning died this fall at the age of 96, he had more than 100 patents to his name. His favorite inventions had a few things in common: "They all made a lot of heat, sparks, and noise—particularly noise," recalls colleague Dick Couch '64 Th'65.

Browning—a pioneer in the invention of plasma torches—died October 8, 2018, in Lebanon, N.H.

He was exposed to science at an early age through the family business, which did custom tooling for the maritime industry. After earning his ME from Stanford University, Browning returned to Hanover to teach mechanical engineering at Thayer School from 1949 to 1966. In the school's laboratory, he began experimenting with rocket propulsion, mixing oxygen with kerosene, gasoline, and propane gases. It was an extension of gasoline cutting torches that his father had helped develop.

"That's how he got into all this, he saw it as finishing his father's legacy," says Browning's son, Jim.

In the 1950s, Browning gained a reputation as Hanover's fire bug for his work with plasma torches that produced flames twice as hot as the sun's surface. Passing nitrogen or hydrogen through a high-intensity electric arc, the torch cut metal like butter. He enlisted Merle Thorpe '51 Th'53 to cofound Thermal Dynamics Corp. in 1958 to manufacture the device. The company went on to build equipment to test the heat shield on the *Mercury* rocket capsule for re-entry into the atmosphere. A decade later, Browning sold his shares in the company—which by then had 51 employees and annual sales of more than $1 million—to hone a new kind of high-velocity oxygen fuel (HVOF) technology.

In his remote laboratory in Enfield, N.H., Browning continued to perfect his plasma torch technology, applying it to everything from cutting rock at quarries to drilling through the Ross Ice Shelf in the Antarctica. Dubbed "Thermoblast," his high-temperature rocket drill pierced the 1,400-foot-thick ice shelf so scientists could study aquatic life in the water underneath. It took Browning nine hours to drill—but years to develop. He began a series of experiments in 1962 "to gain a better understanding of the principles governing the 'cutting' action of jet flames and to evaluate burning designs already available," as he reported in a paper, "Use of Internal Burners for Working Permafrost and Ice" at the 1963 Permafrost International Conference.

"He was a terrifically gifted inventor. Up until near the end of his life he was still inventing," says Couch, who cofounded Hanover-based plasma- and laser-cutting equipment company Hypertherm.

At a recent conference in Germany, Browning was honored posthumously as the "Father of HVOF" technology, which remains widely used in manufacturing and research, according to Professor Emeritus Horst Richter, who used to attend the conference with Browning. "He asked me quite a few years back if I could help with the theoretical understanding of the HVOF process, which he invented. This resulted in a long-time interaction with Jim, many visits to his laboratory in Enfield, and wonderful technical discussions."

"At 85-plus years old, he was still inspiring our most seasoned engineers to think about things differently," says Hypertherm's Jack Lee Tu'04. "A visit with Jim provided equal parts amazement and terror. The things he was doing with standard pipes drilled to optimize gas flow were amazing, but the combustible nature of the gases he was using and his management of them was also sometimes a bit terrifying."

Browning is survived by his wife of 69 years, Lucille; children Jim, William, and Joel; and two grandchildren. *—Theresa D'Orsi*

Inventions

ENGINEERING A BETTER E.R.

>> INVENTORS: PROFESSORS VIKRANT VAZE, RYAN HALTER, AND JONATHAN ELLIOT

The problem is easy to describe. "Emergency providers don't currently have a good way to predict which patients will remain stable and which will go into shock," explains Dr. Norman Paradis, an emergency physician at Dartmouth Hitchcock Medical Center (DHMC) and a professor of emergency medicine at the Geisel School of Medicine at Dartmouth. The solution requires the collaboration between doctors and engineers.

In October, a team from DHMC and Thayer School were granted $3 million from the U.S. Department of Defense (DoD) to develop what principal investigator Paradis describes as "a noninvasive system that gives an accurate and early alarm that a patient has begun to deteriorate."

Pentagon interest in the system began in 2007 with an email from Baghdad by battlefield doctors. "There are three groups of casualties," they wrote, "the ones who are really sick and (almost) everyone knows it; the ones who have minimal injuries and will live almost regardless of what we do; those who look like they aren't too bad but then deteriorate. We are most interested in identifying group three."

"DoD put out a request for applications that was literally a description of what we wanted to do," says Paradis. "We had this idea and filed patents."

Professor Vikrant Vaze leads Thayer's team that will make this new system happen. Professor Ryan Halter is the electrical bioimpedance specialist. Professor Jonathan Elliot handles optical sensing. Vaze is an expert in machine learning, healthcare analytics, and healthcare systems modeling.

"Machine learning is gigantic and the most worrisome of the three technoglies vital to the project because it hasn't been all that successful so far in biomedical," said Paradis. "Fortunately, Vikrant Vaze not only knows how to do this, but he also knows how to think critically about it."

Don't expect new gizmos to come out of Thayer's labs. The needed technology already exists.

"The novelty isn't the individual components, but the way the components are hooked together and how the information coming from those components is used," says Vaze. "What will make this system unique will be its ability to compile measurements from multiple points in the patient's body and then make a meaningful prediction.

"We are at the very early stage of this," says Vaze. "The DoD research that we are conducting is more to support the science behind the device than to construct the device itself. If we can validate these ideas, we'll be in a place where we can say 'we can do this' and go ahead and build the device. If I were to guess, we might have something in two to four years. In the meantime, there is a lot of testing and a lot of research."

Dr. Paradis sees the grant as the first step on a path toward a new line of medical devices, and foresees the use of this system in civilian hospitals to monitor victims of car crashes and other traumatic injuries."The long-term dream, if we develop a methodology for these developing technologies, is applying them in cardiogenic shock and sepsis shock," says Paradis. *—Lee Michaelides*

MARCO DI LAURO/GETTY IMAGES; INSET: THAYER SCHOOL OF ENGINEERING

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I'm an Engineer and a Drummer

"I grew up in a Christian family and when we went to church, I would always pay attention to the drummer. My freshman year in high school I got the chance to sit in front of a drum kit for the first time and soon became the church drummer. When I got to college, I joined the Barbary Coast Jazz Ensemble, and that's where I really developed my abilities. I think engineering and drumming are similar in that they both require creativity and improvisation. I take it as a partnership. I have math and science courses that are logical and have direct paths to solutions, versus music, which is more abstract and more artistic. Having the ability to develop those two sides of my personality works hand in hand. They work together to make me a better person."

—Moises Silva '16 Th'16

WATCH SILVA AND OTHER STUDENTS IN THAYER'S "I'M AN ENGINEER AND..." VIDEO SERIES AT YOUTUBE.COM/THAYERSCHOOL.

Random Walk

Faced with the prospect of losing the outdoor activity permit for the Homecoming bonfire due to ongoing safety issues, Dartmouth turned to engineering professor Doug Van Citters '99 Th'03 Th'06 to increase the event's predictability. The most important task: provide quantitative assurances that a new bonfire design would improve upon prior builds. "The re-engineered structure had to not only be appropriate for students to build while retaining its majesty," says Van Citters, "but also fall in a more predictable fashion, despite nature's unpredictability."

Thanks in large part to Van Citters' extensive use of engineering modeling techniques and slow-motion experimental analyses, town officials were sufficiently reassured and the looming specter of a denied permit was avoided.

"Dartmouth is full of people who love this place more than rational thought would permit, and I'm proud to be one of them. Homecoming is bigger than any one experience, and this tradition is an example of building community without ever having to say that this is the purpose. Also, nobody can beat me at Jenga anymore."

PHOTOGRAPH COURTESY OF DOUG VAN CITTERS