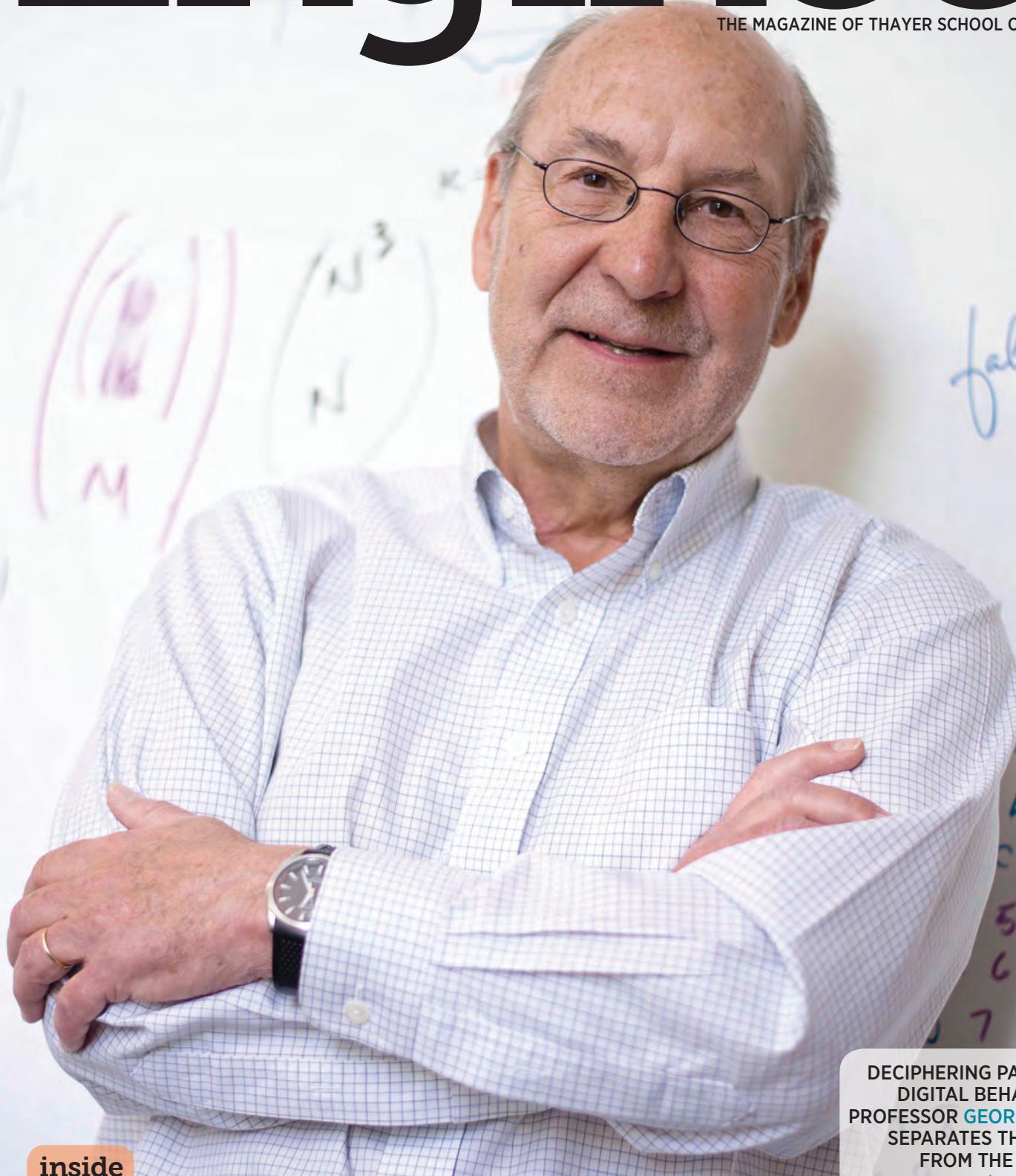


DARTMOUTH Engineer

FALL 2014

THE MAGAZINE OF THAYER SCHOOL OF ENGINEERING



inside

DECIPHERING PATTERNS IN
DIGITAL BEHAVIORS,
PROFESSOR GEORGE CYBENKO
SEPARATES THE GOOD
FROM THE BAD.

M.E.M. TURNS 25

TRAY BIEN

ALUMNI NEWS

HACKING THE HACKERS

Editor
Karen Endicott

Design
Wendy McMillan

Senior Editor
Kathryn LoConte Lapierre

Alumni News Editor
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Joseph J. Helble (ex officio), Ian Baker, Harold Frost, Elsa Garmire, Karl Griswold, Marcia Craig Jacobs, Peter Robbie '69, Holly Wilkinson

Contact Us
Office of Communications
Thayer School of Engineering
14 Engineering Drive
Hanover, NH 03755

dartmouth.engineer@dartmouth.edu
Tel. 603.646.3521 Fax: 603.646.9133

Dartmouth Engineer Online
dartmouthengineer.com

Thayer School Website
engineering.dartmouth.edu

Report Address Changes
engineering.alumni.records@
dartmouth.edu

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Designing Our Future

JOSEPH J. HELBLE | DEAN

AS THE 2013–14 ACADEMIC YEAR, WITH ITS RECORD NUMBER of engineering A.B. degree recipients, drew to a close in June, planning began for the next phase in Thayer's history. With Cummings Hall and MacLean Engineering Sciences Center at capacity, engineering enrollments at record levels and continuing to rise, and ambitious plans on the table for an expanded role for engineering at Dartmouth, it was time to explore the feasibility of adding a new Thayer building to the west end of the Dartmouth campus.

Wilson Architects, a Boston-based firm with a long history of architectural design of university engineering and science facilities, was selected in June as our partner in a six-month basis-of-design study that is now fully underway. Working with Wilson and Dartmouth's Office of Campus Planning and Facilities is a steering committee chaired by Senior Associate Dean Ian Baker and including faculty, staff, student, and alumni/Board of Overseers members.* Their charge is simple, but the challenge is not: to understand our vision for an expanded Thayer (including a significantly larger faculty), gather input from the Thayer community, and envision the space that will be needed to support that vision when it is fully realized a decade from now. And they have been asked to do all of this while preserving the interdisciplinary character of the school and maintaining the sense of community, shared purpose, and mission that have defined Dartmouth engineering for nearly 150 years.

To gather the input of the Thayer community, steering committee members have met with focus groups of faculty and staff, conducted electronic surveys of staff and current students, solicited suggestions through an old-fashioned suggestion box located in the GlycoFi Atrium, surveyed three recent classes of alumni, held a Friday afternoon design charrette run by students for students, and solicited input from the Board of Overseers during its October meeting. These conversations elicited many ideas—for open-concept laboratories, design studios, classrooms (with a great deal of conversation about what “classroom” will even mean in a decade or two), conference rooms, common spaces, social spaces, green space, open space, light, food, coffee, and of course, parking. Given our desire—our requirement—that any new building be intimately connected with the current Thayer campus yet preserve the flowing architecture of Cummings and MacLean, we are focusing on options to the south, south-east, and west of our current buildings as we explore feasibility over the next several months.

By mid-winter, when the basis-of-design study is completed, we will have renderings that show in more vivid detail the potential location and scope of our new building. Final architectural design and start of construction will, of course, depend upon progress in fundraising, but our ambition is to have a clear path identified by our 150th anniversary just a few short years from now. Stay tuned!

* Steering Committee Members:

Ian Baker, Professor and Senior Associate Dean; Mary Kay Brown, Instructor, Bioengineering Laboratories; Richard Couch '64 Th'65, Cofounder of Hypertherm, Thayer Overseer; Christopher Levey, Professor and Director of Instructional Laboratories; Lawrence McKinnon, Executive Officer and CFO; Scott Snyder '00, Ph.D. student; Holly Wilkinson, Assistant Dean for Academic and Student Affairs; Lisa Hogarty, Vice President, Dartmouth Campus Planning and Facilities; and John Scherding, architect and Dartmouth Director of Campus Design and Construction.



"It's almost too obvious. People just overlook and accept the standard tray that has been around for a long time," says Krystyna Miles '16, right, with Tray Bien cofounder Shinri Kamei '16. **Page 18**

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Hacking the Hackers

Deciphering patterns in digital behaviors, Professor George Cybenko separates the good from the bad.

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Mastering Engineering Management

At 25, Thayer's award-winning M.E.M. program comes of age.

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Tray Bien

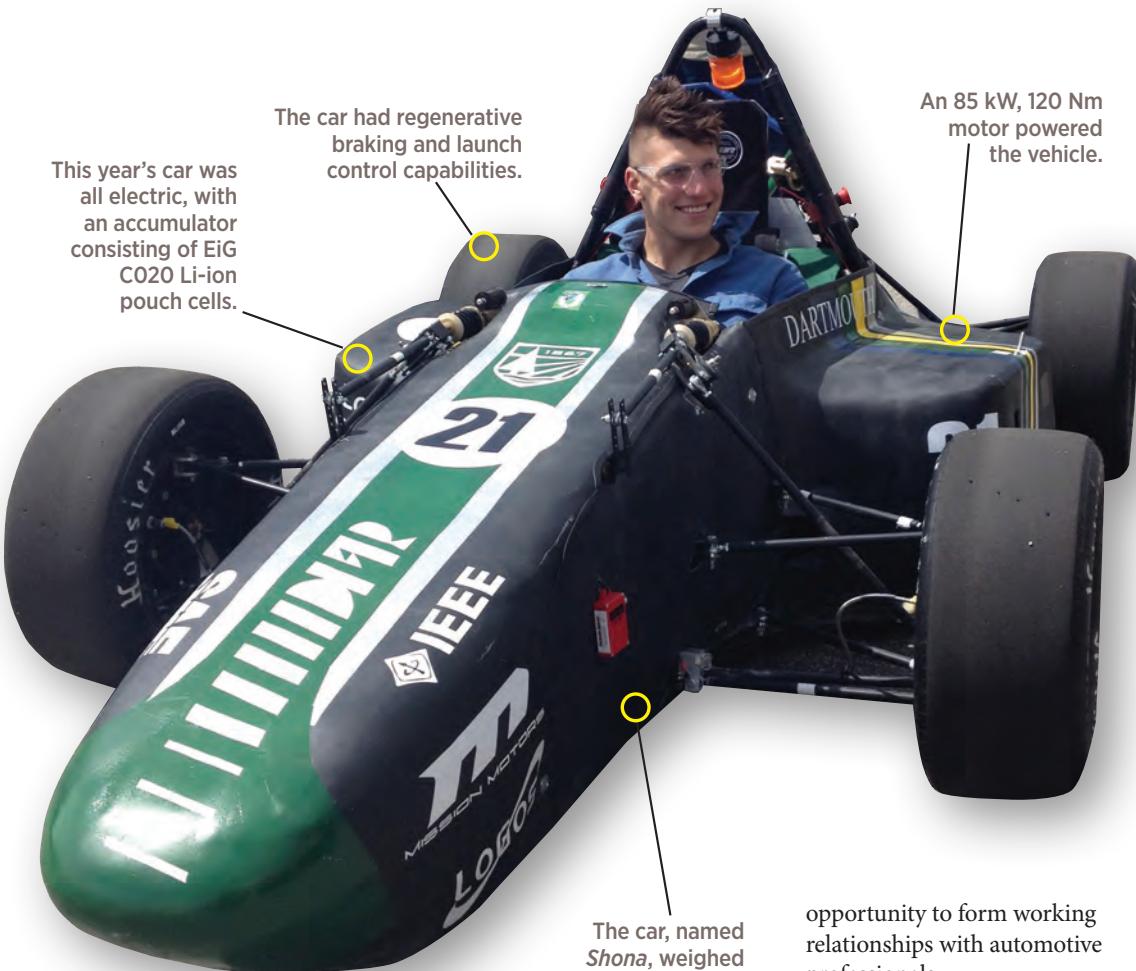
An enterprising student team brings an introductory class project to market.

BY KIMBERLY SWICK SLOVER

THE Great Hall



NEWS FROM AROUND THAYER SCHOOL



This year's car was all electric, with an accumulator consisting of EiG C020 Li-ion pouch cells.

very helpful," says student Mike Spinelli from Carnegie Mellon University. Mentors aided students in everything from technical questions to helping teams acquire the right parts for their vehicles.

Another new aspect of the competition is a focus on project management rather than marketing in design presentations. Complementing technical competencies, the presentations require students to demonstrate their communication and team management skills and their understanding of financial, ethical, societal, and global issues.

"Making the change from a marketing event to a project management presentation makes clear sense. These skills are essential to every engineer's career," says Formula Hybrid coordinating manager Amy Keeler. "The opportunity to guide students through this process is a chance that Formula Hybrid organizers embrace."

The event brought teams together from across the globe, including newcomers Nitte Meenakshi Institute of Technology and RV College of Engineering from Bangalore, India; Atilim University from Ankara, Turkey; the University of Waterloo from Ontario, Canada; Ferris State University from Big Rapids, Mich.; and the University of Akron from Akron, Ohio.

"The mentor program connects industry and the universities to help the students with their design process and project management and also helps to give the students a better understanding of what the competition is like and what to expect," says GM's Scott Lananna '08 Th'09.

"The best part of being a mentor is that we've been able to go and visit the teams and get to know them personally," says GM's Nathalie Capati.

"We didn't have any connections with suppliers from our school, so the mentors were

COMPETITION

New Roads at Formula Hybrid

ENGINES REVVED, DRILLS WHINED, AND sparks flew in the garages at the eighth annual Thayer-founded and -hosted Formula Hybrid Competition held at the New Hampshire Motor Speedway in Loudon in early May.

Along with the usual rigorous rules and regulations, this year's event introduced a few new cogs in the Formula Hybrid machine, one of which is the mentor program, which affords students the

opportunity to form working relationships with automotive professionals.

ALL SYSTEMS GO
Arthur Bledsoe '14 headed strategic marketing and public relations for the electric vehicle Dartmouth Formula Racing entered in the Thayer-hosted Formula Hybrid Competition.



CURRICULUM

Human-Centered Design Minor

STUDENTS WHO WANT TO learn a process of innovation for addressing human needs have a new curricular option: a minor in human-centered design.

The six-course minor combines Thayer engineering and design-thinking courses with a wide range of cultural, behavioral, and artistic offerings in anthropology, sociology, geography, psychology, computer science, public policy, film studies, and studio art.

According to Professor Peter Robbie, who teaches design courses at Thayer and led the development of the new minor, studying human interactions with products is essential for successful design. “If you observe the points at which people get frustrated or where things become disconnected, those then become points where you can innovate and improve,” he says.

The minor will prepare students for the problem-solving challenges they’ll face in industry and other professional settings, Robbie says.

“Students who become really good at design become experts at a process that they can apply to anything, from designing medical devices to improving the lives of infants in their car seats,” he says. “The same process can be applied, no matter what the problem is.”

—Kathryn LoConte Lapierre

Q&A



“We know so little about the microbes that run our daily lives.”

Professor Jane Hill

>> **JANE HILL** joined the faculty as an associate professor last year.

What sparked your interest in chemical and environmental engineering?

In high school I enjoyed all my subjects and had an aptitude for chemistry and mathematics. In college and after participating in summer co-op experiences with Unilever and the Colonial Sugar Refinery company, I discovered my interests lay in applications in the biological and environmental areas. After my chemical engineering degree I worked on a master’s with an environmental technology and management emphasis. As a graduate student at Yale, I immersed myself in the chemistry and biology of microorganisms, which have remained my passion ever since.

How did that lead to work on infectious diseases?

I have always been fascinated by biology and microorganisms, particularly. We know so little about the microbes that run our daily lives, such as those in the gut that regulate our immune system to those that threaten our very existence, like Ebola. It is exciting for me to get up each day and, with my great team, apply what we know about microorganisms, analytical chemistry, and humans to the infectious disease diagnostics topic.

What would you like your research to achieve?

Our overarching goal is to identify robust biomarkers that allow for a rapid, non-invasive, sensitive, and accurate detection of infectious diseases. As we make progress, this will lead to improved healthcare for all.

What do you enjoy most about your students?

They are smart, motivated, and curious. How can that be anything but fun!

What do you like doing aside from engineering?

Skijoring, hiking, tennis, making and playing music, reading and writing fiction, gardening, making bad art, and traveling to experience new cultures and see lovely vistas.

Kudos

AWARDED Professor Eric R.

Fossum has earned the 2014 Camera Origination and Imaging Medal Award from the Society of Motion Picture and Television Engineers for his invention and promotion of CMOS active pixel sensor technology, which he developed while working at NASA’s Jet Propulsion Laboratory. His technology is now ubiquitous in motion picture and television cameras, cell phones, and numerous other applications.

WON Professor Paul Meaney and

Adjunct Professor John Weaver won the American Association of Physicists in Medicine’s Moses and Sylvia Greenfield Award for the best paper published in Medical Physics in 2013, “Integration of microwave tomography with magnetic resonance for improved breast imaging.”

NAMED Thayer Dean Joseph J.

Helble has been named to the newly created New Hampshire Task Force on Science, Technology, Engineering, and Math (STEM) Education. The 14-member task force will recommend ways to modernize STEM education.

AWARDED Engineering major Morgan Curtis ’14

earned the 2014 Dartmouth Sustainability Student Award in May. An alumna of Dartmouth’s Big Green Bus, Curtis leads Dartmouth’s fossil fuel divestment campaign and manages the Office of Sustainability’s EcoReps program for first-year students. Studio art and engineering lecturer **Jack Wilson**, who works on the \$300 House project in Haiti, won the Sustainability Award for faculty.

FEATURED Professor Solomon

Diamond ’97 Th’98 was profiled in a feature on “20 under 40” in the September issue of the American Society for Engineering Education’s magazine, *Prism*. Diamond was cited for taking “hands-on learning to new levels”—including having students make and race diwheel vehicles in his ENGS 146: Computer-Aided Mechanical Engineering Design course and inviting students to dine and conduct energy audits at his net-zero house.



I Want One of Those!

STUDENT PROJECT

READY SET STEADY ▼

Hate restaurant tables that wobble? A student-designed device attaches to such tables to keep them steady. Viewing a potential market of more than 20 million unstable tables, Isabella Caruso '17, Kahil D'Souza '17, Daniel Jackson '17, Katelyn Jones '17, and Mariko Whitenack '17 are pursuing patent protection for their product—which is why we can't show you their prototype. The group won Spring Term's Phillip R. Jackson Prize for outstanding performance in ENGS 21: Introduction to Engineering. Their teaching assistant was Brenden Hedblom Th'14.

STUDENT PROJECT

SEMI-AUTOMATIC THERMOS CLEANER

More people might use a thermos rather than disposable hot-drink cups if cleaning a thermos was quick and easy. So reasoned the student team that created a thermos-cleaning device that is convenient, efficient, uses less water and energy than washing by hand or dishwasher—and could help cut down on the 7,000 disposable hot-drink cups Dartmouth alone discards every day. Team members Theodore Burt (dual degree), Tom Cheng '15, Prajan Divakar '16, Zachary Kratochvil '16, and Sarah Hammer '15 won Winter Term's Phillip R. Jackson Prize for outstanding performance in ENGS 21: Introduction to Engineering. Their teaching assistant was Nina Frankel '13 Th'14.



Left to right, Katelyn Jones, Daniel Jackson, Kahil D'Souza, and Isabella Caruso, all '17s.



OUTREACH

Design It! Build It!

THAYER'S SECOND ANNUAL DESIGN IT! BUILD IT! summer workshop gave 37 high school juniors and seniors an intensive two-week introduction to the creativity—and fun—of engineering.

Led by Professor Vicki May, the workshop took students through the hands-on process of designing and fabricating underwater robots, guitars, waterproof headphones, guitar pedals, iPod amplifiers, synthesizers, model rockets, and longboards.

"We want our students to gain a better understanding of engineering, to see how multi-dimensional it is," says May. "Many high school students think engineering is just building bridges or airplanes. I want to show them it's much broader than that."

A team of Thayer professors, grad students, and undergraduates taught the students a variety of engineering skills, including design thinking, spatial reasoning, and computer-aided design, and introduced them to topics such as frequency and vibration, beam bending, and optics. Studying wind and solar energy, the high school students designed wind turbine blades with a pitch and shape that would produce the maximum amount of electricity and tested solar energy panels to find out which panel design produced the most electricity. Thayer students showed them the machines and tools of the Machine Shop and helped them print out gliders and 3-D glasses.

Shifting gears, students also got an unusual inside look at the college application process. Dartmouth's Associate Director of Admissions, Adria Belin, let them read actual applications from past years and evaluate which applicants should be accepted, rejected, or waitlisted. The goal: to help the students strengthen their own college applications.

The workshop culminated with students testing their completed projects and giving presentations to their parents about how much they learned.

"Since starting this workshop, I've realized that engineering is much more than numbers—there's a lot of creative sides to it," says Megan Morris of Chicago, Ill. "Touring all the awesome labs here got me interested in studying biomedical engineering."

"I was afraid of engineering when I first came to this camp," admits Brittney Antous of Newtown, Conn. "I didn't think I could tackle it. But the teachers here really broke everything down so that we could understand it. I now might want to major in electrical engineering in college."

—Alex Arcone

investiture



David Kelley

Class of 2014

THAYER'S GRADUATING CLASS was honored at Investiture, held June 7 at the Hopkins Center. Presiding over the presentation of hoods, caps, and awards to 173 recipients of B.E. and graduate degrees, Dean Joseph J. Helble noted that at Commencement the next day, 103 engineering sciences majors—the largest class in Thayer history—would also receive their A.B. degrees.

The annual Robert Fletcher Award, named for Thayer's first dean and recognizing distinguished achievement and service in the highest tradition of the school, was presented to Stanford Professor David Kelley, founder and chairman of the design firm IDEO and founder of Stanford University's Hasso Plattner Institute of Design.

Kelley focused his speech on empathy. Calling engineering "a team sport," he said, "To build great stuff today, we really have to collaborate with people, especially people we want to use the things that we come up with."

A Stanford student project was among his examples. "A bunch of Stanford students went to India and found that a million-plus babies were dying because they couldn't maintain their birth weight, and so we got into designing incubators. The problem was the incubators were in the hospital, and that's not where the babies were. The babies were out in the villages. And so the students ended up inventing something that looks more like a sleeping bag with a paraffin liner that you can

heat up. But the students would go out in the field, and the bags just weren't working. They couldn't understand why they weren't working. And so they had to get into the homes and really try to understand the people, the mothers, who were using them. And what they found is that the mothers in their culture had learned that Western medicine was so powerful that even though the instructions said to warm the incubator up to 98.6, they were warming it up to 70 because of the power of Western medicine. So the students had to change the thermometer from saying in degrees to 'not OK' to 'OK,' so you heated it up to the point that you get to OK, and this would be 98.6. It solved the problem, but they never would have gotten that if they hadn't built empathy for the people they were trying to help."

Kelley advised: "Wear your empathy as a badge of honor. It will allow you to do your best work, as a caring engineer known today and forever for developing meaningful solutions to today's most important challenges, as someone who has the confidence and know-how to look someone in the eye and say: 'I understand what you need, and I think I can help.'"

Helble told graduates, "Our Board of Overseers Chair, Terry McGuire Th'82, often speaks of 'lives touched' as a measure of worth of an engineering program." Citing various ways the class touched lives—from building bioenergy systems in Tanzania to developing new drugs to combat methicillin-resistant *Staphylococcus aureus* infection—Helble said, "To you our students, who have left your mark on us, your faculty and staff, I say thank you. And to your family and friends, gathered here today, I again say thank you for lending us this extraordinary group of talented individuals for this too-brief period of time."

Kudos

NAMED Engineering student **Rachel Glikin '17** has been named a 2014-15 N.H./Vt. Albert Schweizer Fellow. She will help interest children ages 6 to 9 in engineering and science by running a Junior FIRST LEGO League in Norwich, Vt.

NAMED Engineering major **Sarah Hammer '15** has been named a 2014 Goldwater Scholar. Hammer, who has taken part in Dartmouth's Women in Science Project and researched cellulose biofuels in the lab of **Professor Lee Lynd Th'84**, intends to pursue a Ph.D. in chemical engineering.

EARNED Engineering grad students **Alden Adolph '11, Fioleda Prifti, and Molly Grear '11** have earned National Science Foundation graduate research fellowships for 2014. Each will receive three years of support from NSF, including a \$32,000 annual stipend and a \$12,000 cost-of-education allowance, as they continue their research.

EARNED Engineering students **James Kennedy '14 and Albert Kim '14** have earned fellowships that will support their research in environmental engineering and biomaterials. Kennedy was awarded the Bengt Sonnerup Fellowship and will work with **Professor Mark Borsuk** to investigate technologies that thermally decompose cellulosic biomass with a goal of producing energy. Kim was awarded the Mazilu Engineering Research Fellowship and will work with **Professor Ulrike Wegst** to improve hyperthermia cancer treatment.

NAMED Skipper **Deirdre Lambert '15** has been named the Quantum Women's Sailor of the Year for the second straight year after leading the Dartmouth women's sailing team to its second consecutive win in the Sperry Top-Sider National Championship in May. "It's great. I couldn't imagine this happening again," says the biomedical engineering major, who learned to sail in Maine.

research



PROJECTS

How Good is Well Water?

DARTMOUTH RECEIVED A \$93,000 GRANT TO

determine what proportion of households with private wells in New Hampshire test their drinking water and what factors keep some households from testing more often. "We want to learn how to empower well-water users with the tools and information they need to keep their drinking water safe for themselves and their families," says project leader and Dartmouth engineering Professor Mark Borsuk.

Close to 40 percent of New Hampshire's 1.3 million people use private wells for drinking water. Currently 95 percent of new wells are drilled into bedrock, since outmoded dug wells were ripe for runoff contamination. But drilling deep comes at a price. Water that has been soaking in bedrock contains elements that naturally occur in the Earth's crust, including contaminants such as arsenic and radon.

Approximately one in five of New Hampshire's wells contain unsafe levels of arsenic, which, even at low doses, has been associated with skin, bladder, and lung cancers and other harmful health effects.

A U.S. Geological Survey study released in June estimates that nearly 50,000 people in southeastern New Hampshire could be drinking water with elevated levels of arsenic.

"There's no visual cue in their water, there's no immediate health impact. So people may have lived with arsenic in their water for years and years and not had any problem," says Borsuk.

"We will use the findings of our survey to identify the major factors contributing to water testing and treatment as well as to identify specific subpopulations at risk. These will be used to design initiatives to improve well-water testing and treatment," says Borsuk.

In July researchers gathered and analyzed the results to help design cost-effective, targeted initiatives to help well-using residents protect their drinking water. During the stages of

analysis, Borsuk's team determined that the possible presence of arsenic was a specific concern for 73 percent of respondents. The team also determined that only about half of the respondents who treat their water with the intent to remove arsenic actually have treatment systems that are effective.

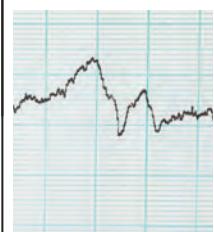
"There are many problems for which technical solutions exist, but which are not being solved because, for one reason or another, people don't adopt the available technologies," Borsuk says. "One line of my research is concerned with understanding these barriers to adoption and how to overcome them, either through improved design or through policy interventions."

The next steps, Borsuk says, are to compare statewide estimates of testing and treatment rates to other available sources of information, including anecdotal information from labs and published results from other states, evaluate the stated motivations or barriers to testing and treatment for the identified target populations, further examine the types of water treatment systems being used, and ultimately design intervention strategies to overcome identified barriers to testing and treatment.

—Kathryn LoConte Lapierre

RESEARCH DESIGN

The engineering student group of Siddharth Agrawal '14, Arlinda Rezhdó Th'14, and Xiaotian Wu '14, advised by Professor Alexander Hartov Th'88, won the 2014 Northeast Bioengineering Conference Undergraduate Design Competition in April. For their ENGS 89/90 project—"Multilayered Phantom for Electrical Impedance Measurements of a Fetal Heartbeat"—they developed a physical model of the human womb and fetus for use in researching ways to monitor fetal heart rate.





Modeling Airline Travel and Delays

NEED SOMETHING TO READ THE NEXT time you're stuck at an airport? Pick up "Modeling Passenger Travel and Delays in the National Air Transportation System," a study recently published by Thayer engineering Professor Vikrant Vaze, Cynthia Barnhart of MIT, and Douglas Fearing of the University of Texas at Austin in the journal *Operations Research*.

Unlike previous studies that only examined flight-centric measures of delays, Vaze's research also analyzed delays that passengers encountered because of missed connections or flight cancellations. Using data from 2007, the last boom year for air travel, Vaze and his colleagues developed a model for estimating historical passenger travel and extended a previously developed method for estimating passenger delays.

"The results from the study can be used to motivate policy and investment decisions for the National Air Transportation System," says Vaze. "We expect our passenger-centric approach to be applied in additional contexts where previously only flight information has been available."

Analyzing a complicated network in which even minor delays can cause a ripple effect of missed connections and further delays, Vaze and his colleagues found that:

- The ratio of average passenger delay to average flight delay was highest for regional carriers and lowest for low-cost carriers, owing primarily to cancellation rates and connecting passenger percentages.

- Newark, Chicago O'Hare, New York LaGuardia, Washington Dulles, New York Kennedy, and Philadelphia had the longest average connecting passenger delays, the longest average delays for departing flights, and the greatest number of departure cancellations.

- Atlanta, Chicago O'Hare, and Dallas/Fort Worth, the top three transfer airports, accounted for 40 percent of missed domestic connections and contributed to more than 43 percent of all delays for connecting passengers.

- In the evening, the average passenger delay was 92.3 percent greater and the average flight delay 90.5 percent greater than in the morning.

- Passenger delays in summer and winter were 56 percent higher than for the rest of the year. June was the worst month.

- On nonstop flights, passenger delay depended on the ease of rebooking and was lower on routes with at least 10 daily flights per carrier.

- Mondays and Saturdays had the lowest ratio of average passenger delay to average flight delay. Those days had a higher percentage of morning passengers and a lower percentage of canceled flights than other days.

- Southwest Airlines has the lowest average passenger delay—nearly 55 percent lower than its competitors—even though its average flight delay was only 36.3 percent lower than other airlines. Southwest experienced fewer flight cancellations and missed connections than other airlines.

Vaze and his colleagues plan to further analyze flight and passenger data to better understand how airline network structures and scheduling decisions impact passengers and how policy changes could affect airlines and passengers.

—Kirsten Mabry

lab reports

Ash from Forest Fires Melts Ice in Greenland

Global warming isn't the only contributor to the melting of the Greenland ice sheet. A Dartmouth-led study links large-scale surface melting in 1889 and 2012 to rising temperatures and ash from Northern Hemisphere forest fires.

Dartmouth engineers supervised by Professor Mary Albert, co-author of the study and director of the U.S. Ice Drilling Program Office, analyzed six Greenland shallow ice cores.

"The widespread melting of the Greenland ice sheet required the combination of a lowered snow albedo from ash and unusually warm temperatures to push the ice sheet over the threshold," says Thayer Ph.D. graduate Kaitlin Keegan Th'14, the study's lead author.

With the ash-filled snow reflecting less light than pure snow, melting increases. Researchers project that by the end of the century, the Greenland ice sheet may experience large-scale melts nearly annually.

Microplastics Accumulate in Arctic Sea Ice

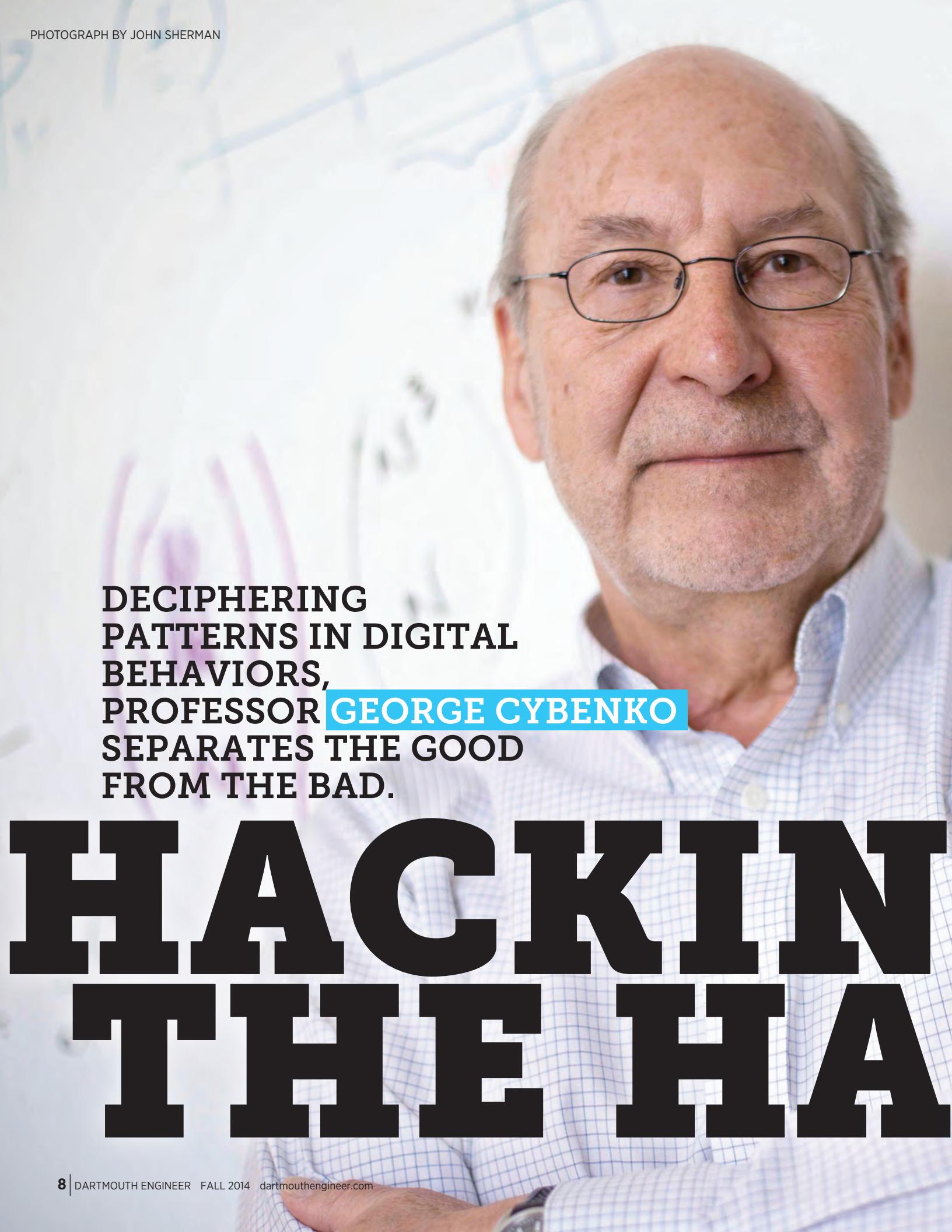
When Professor Rachel Obbard Th'06 melted Arctic sea ice to count microscopic algae beneath the surface, she found something more than she was looking for: tiny pieces of plastic.

Estimating that there were as few as 38 and as many as several hundred pieces of microplastic particles per cubic meter, she says, "It was such a surprise to me to find them in such a remote region. These particles have come a long way."

Obbard and her colleagues gathered four ice cores during Arctic expeditions in 2005 and 2010. The researchers melted portions of the cores, filtered the water, and placed the sediments under a microscope. Using an infrared spectrometer, they determined the chemistry of the particles, which included rayon, polyester, nylon, polypropylene, acrylic, and polyethylene.

As global warming melts Arctic ice, "there will be microplastic particles dumped back into the Arctic Ocean that have been entrapped in ice for several years," Obbard says.

"I was really shocked and saddened," she says. "I guess I, like most people, still consider the Arctic to be a pristine and remote area, and clearly our pollution has reached even it."



DECIPHERING
PATTERNS IN DIGITAL
BEHAVIORS,
PROFESSOR **GEORGE CYBENKO**
SEPARATES THE GOOD
FROM THE BAD.

HACKIN THE HA

G C K E R S

A close-up photograph of a person's hand holding a pen over a sheet of graph paper. The hand is wearing a light-colored, long-sleeved shirt. On the graph paper, there are several handwritten blue letters and numbers: 'false' on the left, 'a', 'b', 'c', 'd', 'e' at the top right, 'o' in the center, and '1', '2', '3', '4', '5', '6', '7', '8', '9' along the right edge. There are also some faint, illegible markings and arrows.

IMAGINE A HOUSE.

You put a motion sensor at the doorway and scatter several others around the hallways and stairwells. Then you sit back and watch as they light up in a pattern. It's easy enough in this imaginary house to determine when an intruder enters and exactly where he or she goes inside the building.

Now, however, imagine several people enter and exit the house at different times and take different routes through the halls and rooms. Based on the pattern of sensors, could you tell how many people arrived and where each one went? Now imagine hundreds of people enter and exit over the course of the day—and one of them is an intruder who has set out to rob the place. Can you tell which one he is?

These are the kinds of questions that preoccupy George Cybenko, Dorothy and Walter Gramm Professor of Engineering at Thayer School, and have informed decades of his research into signal processing. "If I see a sequence of events associated with different behaviors, can I associate those events with the right behaviors?" he says, drawing out the thought experiment. "Based on where the sensors are and how fast people typically walk, can I take all these reports and say with high probability that this is the track of one person?"

That may seem like a simple task, but the answer to the problem has implications in areas as disparate as cybersecurity, stock-market fraud, and counterterrorism. During the past 30 years, Cybenko has become one of the preeminent experts in finding patterns in the vast amounts of data that accumulate every time we enter a keystroke on our browser or make a transaction with a credit card. Most of the time such "behaviors," as Cybenko calls them, are benign. But some behaviors, both online and in the physical world, are dangerous—a hacker trying to gain access to a company database, say, or a drug cartel trying to cross an international border.

Law enforcement must struggle to identify those bad behaviors before they are too late. Making matters more difficult, says Cybenko, at the same time that one person is acting, another person is often reacting, competing against each other in a high-stakes game of hide-and-seek. "I may have some confidential information on my computer, and I am competing with a hacker who is trying to gain access to that information," he says. "He's developing techniques to gain access, and I am trying to develop techniques to prevent him."

BY MICHAEL BLANDING

I'D LIKE TO SEE A MORE COHERENT BODY OF KNOWLEDGE AROUND BEHAVIOR MODELING

In that environment, it's not individual actions but the dynamic patterns of behavior that must be identified in order to protect the system. The question is, with billions of bytes of data flying back and forth around the world, how can you separate the bad behaviors from the good ones?

That is just the kind of complex web that Cybenko has spent his career patiently and methodically finding ways to unravel. Eugene Santos, a professor of engineering at Thayer School who frequently collaborates with Cybenko, first discovered him 25 years ago, when, as a grad student, he read a seminal paper Cybenko published about the nature of neural networks. Computer scientists had been using these networks—which mimic the structure of the brain—to solve complex problems, but largely without understanding how they worked. Cybenko's paper not only provided the mathematical underpinning of neural networks but also showed what they could do.

"He showed mathematically what people didn't know—that a neural network could learn any mathematical function," says Santos. "Before then, they were successful, but more of a black box. He managed to ground them in a theory people could build from."

Santos contacted Cybenko about the paper and received a friendly note of encouragement that has stayed with him ever since. Now that Santos works closely with him, those initial impressions have only been confirmed. "I don't want to use this word—but I can't find another one—he is one of the nicest people in the world," says Santos. "He is thoughtful, he is sociable, and he is also very approachable for someone of his stature. When he is in a group of people he is almost like a gravity wall—people flock to him."

"He is one of the most relaxed people I know," says Vincent Berk, a former Thayer professor who continues to collaborate with Cybenko. "I always joke that if he was any more relaxed, he would slip into a coma. It takes a lot to rile him." At the same time, Berk has counted on that calm demeanor to elegantly get to the source of problems.

"He sets a problem, then takes stabs at it from three or four different viewpoints. Then he goes away and comes back with the math to explain it," Berk says. "Too many scientists, when asked to boil an egg, will study the laws of thermodynamics and whether it's a gas stove or an electric stove or what kind of metal the pan is. He has a way of figuring out what part of the problems are worth the thinking time and what parts can be ignored or dealt with early."

In research funded by the Department of Justice, for example, Cybenko and Santos investigated how criminal gangs might be transporting drugs across international borders—what routes they might take and why, and how they might respond to actions of the border patrol in real time. "His simple intuition was to capture things in terms of different costs—of transporting something on a certain route, or if military was operating in an area, or if citizens of a city were leaning toward them—but being able to capture those costs in a structured way," says Santos. "He took something very chaotic and trial-and-error and made it methodical again."

Cybenko grew up in Toronto, where he was interested in math from an early age. He received his B.A. from the University of Toronto and his Ph.D. in applied mathematics from Princeton. One of his first forays into analyzing patterns in data focused on tracking aircraft on a radar screen. We are all familiar with the "blips" that appear onscreen to designate an object—however, those blips aren't as straight-

forward as they seem. "You have to be able to tell which is a plane, which is a helicopter, which is a bird, and which is just noise. If I have 20 aircraft, I have to know which is which," Cybenko says.

By using the knowledge about how fast airplanes can fly and how quickly they can speed up or turn, he was able to construct a mathematical algorithm to separate out which blip belonged to which plane. "The radar returns are constrained by the kinematics of aircraft behaviors, and in a sense those constraints are an important part of doing the processing," he says.

When he started applying the same techniques to computer security, however, the constraints weren't as immediately identifiable. Unlike airplanes, which follow set rules of behavior in how they are able to move, human beings have no such limits on their behavior. Cybenko began looking for patterns of expected behavior. "It's not just the individual events that are meaningful, but it's the sequence of events tied together that are interesting. A failed login attempt is pretty common; people forget their passwords all the time. But let's say there is a sequence of failed logins, followed by a successful login, followed by opening files. That's a lot more suspicious," says Cybenko.

Using the house analogy, it is as if in 99 out of 100 times, the sensor in the front hallway was tripped 10 seconds after the sensor at the front door—and then in one case, the sensor in a side hallway was tripped instead. Similarly, Cybenko looked for expected actions that differed depending on the category of behavior being tracked, and then identified suspicious behavior outside of those actions. "The normal constraint on opening a web browser is that you have to be logged into a computer before you can open a browser window. So if you see a browser window open but there is no login associated with it, then that is a strange behavior."

Arriving at Thayer School in 1992, Cybenko helped disseminate his ideas through the Dartmouth-based Institute for Information Infrastructure Protection (I3P), a consortium of 28 universities and other institutions that promotes greater cybersecurity. At the same time, he began working with other professors at Dartmouth to explore new forms of computer attacks that were just beginning to appear.

Dartmouth computer science Professor Paul Thompson describes a project they worked on 10 years ago funded by the Department of Justice that looked at cases in which people published fake press releases about companies online in order to manipulate their stock prices. "As a mathematician, he was interested in looking at irregular fluctuations in the stock market that might indicate something was manipulating the price," says Thompson. "I have a background in computational linguistics, and was interested in looking at deception in language." Together, they wrote a paper in 2003 that coined the term "cognitive hacking" to describe the phenomenon. "By manipulating information, hackers can alter our perceptions of reality in subtle ways—without launching a virus or a network

THAT IS TRULY CROSS-DISCIPLINARY.



worm,” Cybenko told a reporter at the time. Of course, now, when fake emails and other “phishing” attempts are commonplace, such manipulations are regular occurrences. At the time, however, the concept was groundbreaking, defining a burgeoning new threat.

“When George sees something and moves into a field, he is usually way ahead of the curve—he sees something that really changes the direction of things,” notes Santos.

That could certainly be said about Cybenko’s latest breakthroughs in analyzing patterns in data. During the past decade, he and colleagues at Dartmouth, including Berk and Santos, developed the analysis techniques into a paradigm called Process Query Systems (PQS), which includes both an algorithm to identify anomalies in data and a software framework in which to store them. Their progress, however, hit a major limitation. The analysis required knowing the expected pattern of behavior—as determined by experts or longtime observers of a field—and then detecting behaviors that deviate from that normal pattern.

But what happens when you don’t know what’s normal? That’s the question Cybenko has been tackling more recently—using processing techniques in order to actually learn behaviors. “If I am given a collection of data, how can I create a model of behavior?” he asks. Humans are good at learning models of behavior intuitively. That’s what enables a 4-year-old to catch a ball by observing the arc and trajectory of the ball and modifying behavior to meet it, without knowing a lick of calculus. People playing rock-paper-scissors or watching an opponent bluff at poker are similarly recognizing patterns. How we do that is another matter. In fact, we know surprisingly little about how the brain processes that information to learn behaviors.

Developing an entirely new kind of algorithm, Cybenko has recently begun teaching computers to learn to identify anomalies in patterns, even when the computers don’t know initially what the pattern should look like. In one recent experiment that picked up from prior research about traders gaming the stock market, he and Ph.D. graduate David Twardowski Th’11 analyzed suspicious behavior in the NASDAQ stock exchange, which processes millions of orders—80 percent of which are anonymous—to buy and sell every day. By analyzing the patterns of when stock was bought and sold, however, Cybenko and Twardowski were able to identify suspicious patterns, tracing the pattern to one particular trader. In other words, they effectively de-anonymized the data.

Such techniques could have applications in a wide variety of contexts, including identifying credit card fraud. We’ve all had the experience of getting a call from our credit card company about a purchase that falls outside of our normal purchasing patterns—but currently credit companies are very unsophisticated in how they determine those patterns. “What is normal for me is different than what is

normal for you,” says Cybenko. “For every individual you have to build a specific model, so you have to automate it in some way.”

The question is: How does the company avoid “false positives” that would lead it to flag legitimate purchases. “If they called you every time you tried to buy lunch, they’d catch all the fraud, but you’d change credit cards pretty quickly,” says Cybenko. If computers could learn patterns of purchasing based on each individual customer, they could better identify fraudulent purchases or identify theft before it was too late.

Cybenko has become increasingly interested in finding applications such as this for his work. With Berk, he recently cofounded a company called FlowTraq, which uses proprietary algorithms to analyze the network traffic of firms in order to create a “behavioral fingerprint” that can then be used to identify any potential security breaches. Berk left Dartmouth in 2012 to become CEO of the new company, which counts major Fortune 500 companies and several cloud-computing service providers among its clients. While Cybenko isn’t involved in the operation of the company, he says he is excited to see his ideas applied in commercial settings.

“Academic journals are graveyards for ideas,” Cybenko says, despite having served as editor-in-chief of several journals for the Institute of Electrical and Electronics Engineers (IEEE). “People have written papers about thousands of good ideas in the field of cybersecurity, but unless a Microsoft or Symantec picks them up and makes a product out it, your idea will remain a paper.”

Cybenko realized he needed to take action. “For most of my career it was good enough to develop good ideas and hope the world was a better place because I wrote it down and published it,” says Cybenko. “Now I would like to see if some of the more recent ideas will gain traction out in the world.”

Along with continuing to explore computer behavioral learning, Cybenko also hopes to spur more collaboration between researchers studying behaviors in the engineering realm and others studying them in the social sciences, such as behavioral psychology and behavioral economics. “You can go through the literature and find 23 different definitions for ‘behavior’ ” says Cybenko. “In the next five to 10 years, I’d like to see a more coherent body of knowledge around behavior modeling that is truly cross-disciplinary.”

For better or for worse, more and more of our behaviors are being tracked and collated—whether it’s our activity on social media sites or information captured by the GPS on our phones. While that information has obvious marketing potential, Cybenko would like to see it analyzed as well for what it might tell us about the daily patterns of people in society, and how we might better design our environment to improve life.

“My background is in hard-core signal processing and computer engineering, but it’s become obvious to me that for many of the systems we are building, the human user and social aspects of those systems are really critical,” says Cybenko. “The technology behind Twitter is pretty simple, but the phenomenon of Twitter—how it’s being used and how it will evolve and develop—is pretty complicated. Being able to incorporate the human as part of the engineering system will be even more important as we move ahead.”

MICHAEL BLANDING is an award-winning investigative journalist. His most recent book is *The Map Thief*.



MASTERING ENGINEERING MANAGEMENT

BY ANNA FIORENTINO

AT 25, THAYER'S
AWARD-WINNING
M.E.M. PROGRAM
COMES OF AGE.

IN 1989 Shailesh Chandra Th'91 enrolled as one of four students in Dartmouth's inaugural Master of Engineering Management (M.E.M.) class with a plan to bring his engineering know-how to a technical management role within a business environment. Did he ever.

"The payoff has been very rewarding in the sense that I have undertaken many roles in different organizations that are both within and outside the engineering function," says Chandra, now senior director of strategy and transformation at Cisco Systems. "After graduating from the first M.E.M. class, I remember I had to explain to recruiting organizations what it meant to have an 'engineering degree with significant graduate-level business work.' I still recall them asking, 'We are looking for chemical engineers, so why do you want to talk to us?'"

As the program celebrates its 25th anniversary, many more people understand the value of M.E.M. graduates. From its early days educating a handful of Dartmouth's continuing students, the program has achieved an international student body, enviable placement statistics, and top accolades.

Most recently, the National Academy of Engineering applauded the M.E.M. program by honoring M.E.M. founder and Thayer Dean Emeritus Charles Hutchinson and long-

M.E.M. DIRECTORS
From left, Professor Benoit Cushman-Roisin, Professor Edward March, and Ross Gortner Th'03 '04.

time M.E.M. director Robert Graves with the Bernard M. Gordon Prize for Innovation in Engineering and Technology Education.

Achieving a record-high enrollment of 50, the 15-month professional degree program divides students' time between Thayer and Tuck School of Business. The M.E.M. provides students with a valuable toolkit: advanced knowledge of an engineering specialty, technical management skills, understanding of the design process and its relationship to commercializing new products, and well-developed communication skills.

With a background in engineering and management pillars, such as accounting and marketing, M.E.M. students are equipped to rise in industry. "Graduates of this program are the first to get jobs, they have good starting salaries and are well thought of by people who hire them," says Hutchinson.

Within just three months of graduating, 95 percent of M.E.M. students now land jobs at leading companies in big data and business strategy analyst roles and in technology and healthcare consulting at companies such as Goldman Sachs, Eaton Corp., and Biogen Idec. A large number of M.E.M. alumni take an entrepreneurial path during their careers: 43 percent of surveyed M.E.M. graduates 15 years out have started at least one company.

"Alumni are out in career positions and beginning to reach levels where they are more successful than we ever imagined," says Graves, Thayer's John H. Krehbiel Sr. Professor for Emerging Technologies, Emeritus.

M.E.M.s demonstrate the power of having the analytical tools of an engineer and the ability to effectively navigate their way through the business world. "They can communicate highly technical information not only to fellow engineers but to non-technical individuals across the entire organization," says M.E.M. graduate Ross Gortner Th'03 '04, associate director of the M.E.M. program since 2007. "They can solve differential equations and then can sit down with the chief marketing officer and explain how that equation affects the brand strategy of the organization."

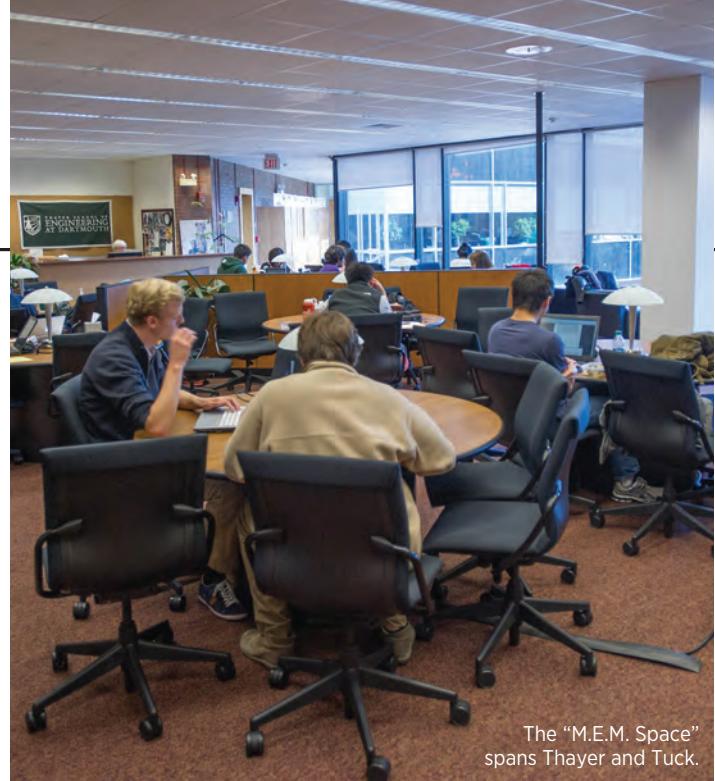
A NEW MODEL

"Every failure is an orphan and every success has at least 10 people who claim they started it," says Hutchinson. But most will credit Hutchinson first for the M.E.M. program.

When Hutchinson became dean of Thayer School in 1984, the Board of Overseers asked him to launch a program similar to the Tuck-Thayer program, offered from 1942 to 1962, in which students attended Dartmouth for three years and then Thayer and Tuck for two more years. "A huge amount of nostalgia existed around that program," says Hutchinson. He just had to look around him to realize the Tuck-Thayer program graduates were among the most successful of Thayer alumni.

Hutchinson convened an exploratory committee, chaired by Thayer adjunct professor and Tuck Nathaniel Leverone Professor of Management Kenneth Baker. The committee, which included former associate dean and current MacLean Professor of Engineering Daniel Lynch, Dan Dimancescu '64, and the late Thayer Professor Caroline Henderson, developed a management curriculum, including courses in corporate finance, organizational behavior, and marketing, and arranged for Tuck faculty to teach them.

"We were looking to give engineering students a sense of what happens in the real world of business," says Hutchinson. "They didn't know how companies worked."



The "M.E.M. Space" spans Thayer and Tuck.

The resulting professional management track—with students receiving a Master of Engineering (M.E.) degree—was launched in 1989. Baker, who became program director, selected the first class of four students. Renamed the Master of Engineering Management program (and M.E.M. degree) in 1997, the program helped pave the way for a new type of manager with both business and technical skills.

"The M.E.M. was really the first of its kind to extract the best aspect from each school and put them together into one coherent, deliberate program," says Gortner. "The program envisioned a more dynamic engineer who could take on leadership roles quickly."

The first duplication of Thayer's M.E.M. program took place at Duke University in 1997, when Duke engineering Professor F. Hadley Cocks modeled a new program on the Thayer M.E.M. studies his son, Elijah Cocks '97 Th'97 '98, had pursued.

Consultations between Duke and Thayer proved mutually beneficial. "I went down to do a big presentation on the M.E.M. for faculty at Duke," recalls Hutchinson. "I learned about their program and was impressed. They even had a piece we didn't have." That piece was Duke's law school, with its expertise on legal matters relevant to business. Contracts, intellectual property rights, and other legal issues were incorporated into Thayer's M.E.M. curriculum. Today ENGM 188: Law, Technology, and Entrepreneurship, taught by Vermont Law School Professor and Thayer Adjunct Professor Oliver Goodenough, is one of the most popular M.E.M. courses.

GROWING STRONG

The M.E.M. program got a major boost when Professor Robert Graves was recruited from Rensselaer Polytechnic Institute in 2003 to co-direct the M.E.M. program with Tuck's Kenneth Baker. Graves threw himself into advocacy for M.E.M. training. "He was able to grow the program and cement its interaction with the outside world," says Hutchinson.

One of Graves' tactics was to benchmark and compare the growing number of M.E.M. programs in the nation. He and his colleagues visited various schools. "After the fourth one of these visits, we realized we all share things in common even though we were competing," says Graves. "We agreed that the M.E.M. skill set wasn't as well known as it could be or should be." Graves convened a new group, the M.E.M. Programs

PROFESSOR ROBERT GRAVES



After 11 years co-directing Thayer's M.E.M. program, Robert Graves, Thayer's Krehbiel Professor of Emerging Technologies, Emeritus and an adjunct professor at Tuck School of Business, retired at the end of Spring Term. Graves, an expert in industrial engineering and operations research who previously taught at Georgia Tech, the University of Massachusetts at Amherst, and Rensselaer Polytechnic Institute, answered our questions about his time in Hanover.

What initially drew you to Dartmouth?

The educational philosophy at Dartmouth of strong respect for and trust in its faculty to pursue their work in teaching and research as talented professionals was attractive to me. In addition, the Thayer School approach to project-based, hands-on coursework was an excellent fit with my views and experience in engineering education.

Why are you such a strong advocate for the M.E.M. degree in general and Thayer's M.E.M. program in particular?

My work with industry and government agencies convinced me that there is a great need for significant improvement in our country's competitiveness in the world. One way to support this is to pursue research in materials, devices, and other areas of technology. But these efforts are necessary while not always sufficient. For example, new devices need to be brought into use and demonstrated to be more effective or less costly in the marketplace; it is the technology managers, product managers, and technology leaders who do this, and it requires distinctly different talents from those of researchers. M.E.M.s are a perfect fit for these roles. Similarly, the processes or operations of many of our companies and agencies may be in need of improvements in efficiencies and performance as compared with those of competitors in the world where labor is less costly. Innovations in these processes and their implementation also require the kind of skills that M.E.M.s have.

Thayer's M.E.M. program is a high-quality program. In the last decade, it has grown in student numbers, strengthened its curriculum, and widened its reach globally. It is well respected in the world and its alums have proven their success year after year in securing positions and growing their careers.

What's ahead for you?

I am working on a project for Thayer that involves developing a prototype of a public forum of chief technology officers and vice presidents of technology addressing the strategic significance of finding and keeping high-quality technical talent for technology firms and technological competitiveness. I am also writing a textbook on technology assessment with Professor March to be used in our ENGM 178: Technology Assessment course and perhaps at other places.

What will you miss most about Thayer?

Colleagues and friends in Thayer and Tuck and the M.E.M. students and alums. It has been a steady inspiration for me to see them prepare for and then grow in their careers with success.

Consortium (MEMPC), to share best practices and strategies for making the M.E.M. better known in the business world. MEMPC members Dartmouth, Duke, Northwestern, Stanford, Cornell, MIT, and the University of Southern California now meet regularly to raise awareness of what M.E.M. graduates can offer industry.

Graves also increased interest in Thayer's M.E.M. program. He grew the M.E.M. alumni network through annual events in Boston and New York. Working to attract more students who hadn't gone to Dartmouth as undergraduates, he and his team doubled M.E.M. enrollments.

Revamping Thayer's M.E.M. curriculum, Graves introduced new courses, including ENGG 177: Decision-Making Under Risk and Uncertainty, ENGM 186: Technology Project Management, and ENGM 188: Law, Technology, and Entrepreneurship. In a major change, M.E.M. students no longer took Thayer's two-term ENGS 190/290 engineering design sequence (now called ENGS 89/90) because it overlapped with coursework students from other institutions had already completed. Right away the percentage of external students in the program increased. Today only 15 percent of M.E.M. students hold a B.E. from Thayer, and international students, mostly from China and India, comprise 50 percent of the M.E.M. student body.

Graves initiated a new challenge for M.E.M. students—ENGM 178: Technology Assessment. The course requires teams of students to analyze emerging technologies for both technical and commercial viability. Teams choose from problems such as how to do away with pinprick blood monitoring for diabetics, how to use spinal implants instead of bone fusion, and how to increase crop yields while using environmentally sustainable agricultural methods.

"It's a different way for engineers, who are used to finding one correct answer in science and math, to think. In management there are multiple correct answers, and it's a matter of considering what is the best," says engineering adjunct Professor Edward March, who has taught ENGM 178 and is now interim co-director of the M.E.M. program.

Students also complete ENGG 390, a summer-long internship in a wide range of companies. "Talk about desirability—these companies have an M.E.M. intern over the summer to get good work done well," says Graves. Some 45 percent of students receive an employment offer from the company at which they intern, and of those students, 25 to 35 percent accept.

According to Graves, the number of companies seeking M.E.M. interns has increased, mainly due to efforts of the M.E.M. Corporate Collaboration Council (CCC), a group of alumni and friends dedicated to opening doors for M.E.M. students. "The council cultivated contacts for students, giving them a sounding board in the corporate world," he says.

CCC Chair John Fletcher, CEO of the strategy consulting firm Fletcher Spaght, regularly employs M.E.M. graduates. "Our first-choice source of new hires is Dartmouth's M.E.M. program," he says. "We find the M.E.M. graduates have the ideal mix of engineering and business capabilities and additional work experience from their internship, thus they are better prepared for our consulting business than undergraduates or other M.E.M.s typically are."

CCC members now offer students lectures on topics ranging from leadership to finance and work with M.E.M. faculty and staff to improve program recruitment, admissions, and structure. Each CCC member also takes on three student mentees, offering them industry

M.E.M. ALUMNI REFLECT ON THEIR EXPERIENCES.

perspectives, and helping place them after graduation.

"I've really enjoyed the opportunity to be a mentor to current students and then keep in touch with them over the years," says CCC member Dana Haffner Guernsey '06 Th'08, director of corporate development at Ambri, a startup company that is working to commercialize an innovative energy storage technology known as the Liquid Metal Battery. "One of the key pillars of the M.E.M. program is its tie to the business community, and I feel that it is important for alumni to help provide that voice."

FILLING TODAY'S NEEDS

Reflecting growing areas of student interest and corporate need, the M.E.M. program now offers students the option of focusing their studies on healthcare systems, energy and environment, manufacturing and operations, entrepreneurship, or management of design.

"The M.E.M. program is more relevant to engineers in today's society than probably ever because innovation and entrepreneurship, which are all around us, require skills at the intersection of technology and business," says Professor Benoit Cushman-Roisin, interim co-director of the M.E.M. program. "We now live in a world that is crucially dependent on technology."

"Every company—and I mean every company—is now directly connected to technology," says Gortner. "When M.E.M. students tell me they want to get into marketing, it's not the Don Draper marketing of the 1960s that they are talking about. They are referring to big data and data mining and extracting analytical insights."

Today some 70 M.E.M. programs are producing graduates ready to fill industry needs. Prepped to step into middle management roles and rise quickly to senior positions, today's Thayer M.E.M.s typically see starting salaries that are \$10,000 higher than average B.E. salaries.

Since its beginning, the M.E.M. program has sent 648 graduates into the business world. Many, including Jessica Tice Pray Th'02, associate director of program management at Genzyme, and Ariel Diaz '02 Th'04, who founded the online educational resource Boundless, regularly come back to Thayer to share their knowledge and advice with students and fellow alumni.

The successes are points of pride for Graves as he leaves the M.E.M. leadership.

"At my age I can look back at having raised three of my own children and helped them through career development and see that a student may have the skills but not the confidence yet. That is something they cultivate in the M.E.M. program," says Graves. "To see young alumni coming back to events year after year and the amazing grace they now exhibit as middle managers and so forth, to see them giving advice to other alumni still trying to find their way, is heartwarming."

And from the program's first class, CCC member Shailesh Chandra is one of them.

"I have had the good fortune and benefit of the mentoring I received from the professors in the program that I wouldn't have gotten with just an engineering-focused course of study," says Chandra. "Now, by mentoring the M.E.M. students, I can pay back in a small way the benefit I received."

1. SHAILESH CHANDRA TH'91

Senior Director of Strategy and Transformation, Cisco Systems; Member, M.E.M. Corporate Collaboration Council

Being part of the first program, back when it was just a master's in engineering degree with a specialization in management, was a little bit chaotic in the sense that we did not have precedents about what the electives and M.B.A. courses would be like. I remember discussing a case study in a marketing class on crisis management. It was interesting to observe the number of varying opinions and options of how to handle the situation. It taught me that there is always at least one other point of view to any situation and the value of considering that view.

The most valuable skill provided by the program was introducing and making students familiar with the language of business—from asset management to zero-based budgeting—that allows the M.E.M. graduate to rapidly integrate into the business work environment.

2. SEAN CASTEN TH'98

President and CEO, Recycled Energy Development; Member, M.E.M. Corporate Collaboration Council

I knew I wanted to combine engineering and business after earning an undergraduate degree in biochemistry followed by years of post-undergrad cancer research.

During my internship, which involved helping a biotech startup scale up their technology, I inadvertently mis-transcribed a number in a presentation I gave—I was off by an order of magnitude. The senior vice president of production immediately said, "That's the great thing about academia: Units don't matter." It was way better to learn that lesson in a safe environment than in front of an employer post-graduation when the personal stakes were higher. And it's a line I find myself consistently using on smart new hires to keep their own hubris in check.

Sometimes my job is technical, sometimes it's financial, sometimes it's legal, and sometimes it's managerial. But it's a rare day that I don't find myself drawing on something I learned in Professor Richter's thermodynamic class or Professor Joyce's organizational behavior class.

ANNA FIORENTINO is senior writer at Dartmouth Engineer.



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3. MARC FENIGSTEIN '01 TH'03

CEO and Cofounder, BRD Motorcycles

My situation was a little unique in that I had started a company with a Tuck student, Ned Coletta Tu'03. The M.E.M. program gave me an opportunity to work more closely with him, utilizing the engineering and advisory resources of both Thayer and Tuck, while filling in some significant and directly relevant knowledge gaps in my engineering and business expertise. It was perfect for my admittedly unusual needs.

What Thayer and the M.E.M. do best, and what has been most valuable to me, is working on open-ended problems, with no one best approach or methodology, that require multidisciplinary thinking and teams. The M.E.M. and Thayer are fantastic pools of talent for a startup like ours. It is very difficult to find engineers with intellectual breadth and curiosity, multidisciplinary experience, and the ability to work in ambiguous environments on these problems. Thayer produces exactly that.

4. JESSICA TICE PRAY TH'02

**Associate Director, Program Management,
Genzyme**

In my senior year at the University of Rochester, where I did a degree in chemical engineering, I decided I didn't want to just do engineering. I wanted to have a broader perspective and focus more on the business aspect as well. That's what drew me to the M.E.M. degree as a hybrid marrying the technical piece with the business aspect.

I liked that there was a lot of group work. It was very helpful to learn how to work in teams to achieve a common goal. Throughout my career, the teamwork aspect has been helpful. Even if you're not working as part of a team within a company, you're still always going to be working with a number of different functions. Being able to have cross-functional interactions and being able to work with different team members who have different personalities and ways of going about things has been very helpful.

The M.E.M. teaches you to think from a technical and a business perspective. Even if you're working on a project in industry that's very technical, being able to see from a holistic perspective how things fit together is very valuable.

5. DANA HAFFNER GUERNSEY '06 TH'08

Director of Corporate Development, Ambri;

Member, M.E.M. Corporate Collaboration Council

I loved the idea of learning how to apply the technical knowledge from my engineering classes to solving real business and societal challenges. It's one thing to do a problem set or a lab assignment, but another to learn how to apply those problem-solving skills to commercialize a product or solve a real customer dilemma.

To be a great engineer it's critical to be a good listener, communicator, and problem solver. I think the M.E.M. degree can help further this part of your education, in addition to learning how to apply technical knowledge in a business setting.

6. HAIFENG SHEN

M.E.M. Student

I have a background in engineering and want to learn more about business and management. I knew about this program three years ago. I got to know a Thayer alum, Li Jincheng Th'12, who was a graduate of my undergrad school, Shanghai Xi'an Jiaotong University. He told me about the M.E.M. and from that time it was my dream program.

The M.E.M. program is composed of students from everywhere. There are a lot of students from America, China, India, and every place. People hang out together for dinner and lunch and people are doing work in the M.E.M. Space at Thayer, and the atmosphere among the students is really good. People try to get to know people from different countries. We have fun together. It's a good preparation for us for our future careers.

I really liked the technology assessment class. We had to pick a topic and do research with teammates. The teammates are selected according to our choices of topics, so we work with people who share an interest. My topic was water purification technology. We had three people on the team: one from China, one from Mexico, and one from America. We had different geographical knowledge, so it was really interesting for us to discuss where the technology should be implemented and what the technology should be for the place we picked. The project helped me to build my confidence. One teammate was from Princeton and the other from Dartmouth. We worked together and did a good job, and it gave me confidence that I could do well at Dartmouth and discuss things well with native speakers.

I love the program. It's even greater than my expectations.



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AN ENTERPRISING STUDENT TEAM BRINGS AN INTRODUCTORY CLASS PROJECT TO MARKET.

BY KIMBERLY SWICK SLOVER



IN BUSINESS

Shinri Kamei '16, left, and Krystyna Miles '16 describe themselves as accidental entrepreneurs.

PHOTOGRAPH BY JOHN SHERMAN



S

ome problems are so common that people barely notice them or assume that if a viable solution existed, it would have been discovered long ago.

Last fall a team of four engineering students took 10 weeks in the incubator of their ENGS 21: Introduction to Engineering class to identify and create a solution for one such problem: the high incidence of injuries and accidents related to awkward serving trays in restaurants. Less than a year later, two of the team members transformed their class project into a new business, Tray Bien LLC, to bring their product—an ergonomic serving tray—to market.

Class of 2016 students Shinri Kamei, Carly Kuperschmid, Krystyna Miles, and Yvette Zou teamed up to tackle Professor Ulrike Wegst's ENGS 21 theme of inventing solutions for mobility and portability challenges. In need of an accessible testing ground, the group took a fresh look at serving trays in local restaurants.

"We observed the standard serving tray was begging for improvement," Miles says. "In the first week we met a waitress who told us she and many of her coworkers suffered from severe tendonitis and 'were just waiting for carpal tunnel.' We focused on human-centered design and were in constant dialogue with Hanover restaurants to test and receive feedback on our concepts. After several messy prototypes, we felt we had designed the ultimate improved ergonomic serving tray."

Constructed of sturdy, lightweight bamboo, their tray prototype featured slots to slide in stemware, holes to secure glasses, room for plates, and two rectangular openings with fist grips to accommodate different arm lengths and put the server's wrist in a stable, comfortable position.

Why had no one thought of this before?

"It's almost too obvious. I think people just overlook and accept the standard tray that has been around for a long time," Miles says. "For centuries!" Kamei adds.

The Tray Bien team realized its prototype might have a life beyond the classroom at the ENGS 21 final product demonstration, where they received overwhelmingly enthusiastic responses from the College community and advice from Professor Wegst and others to "get patenting this *right now*."

The students, who won Thayer's Phillip R. Jackson Prize for outstanding performance in ENGS 21, immediately began the patent process. They officially filed a provisional utility patent for their product in February 2014.

While Kuperschmid and Zou moved on to other academic priorities after the class, Kamei and Miles had become passionate about their product's potential to improve the health and working conditions of food servers. Their research revealed that the food-service industry—the second largest employment group in the United States—bears huge financial losses and reputational damage from accidents caused by heavy, unstable trays. Astonishingly, no viable alternatives to the old standard are available on the commercial market. Kamei and Miles registered Tray Bien as



WE FOCUSED ON HUMAN-CENTERED DESIGN AND WERE IN CONSTANT DIALOGUE WITH RESTAURANTS TO TEST AND RECEIVE FEEDBACK.



a limited-liability company in New Hampshire in March 2014.

"We decided to take it forward as a business venture because so many people loved our product and recommended we take it to the next level," Kamei says.

Wegst introduced Miles and Kamei to Gregg Fairbrothers '76, founding director of the Dartmouth Entrepreneurial Network (DEN), to seek advice on launching the venture. Fairbrothers gave them his book, *From Idea to Success*, and connected them to Tuck School of Business resources, DEN student and alumni mentors, and to Kevin McClamroch, vice president of sales at Adams-Burch, a major distributor in the food-service industry.

"Their product had merit; it's more functional, stable, and ergonomic than traditional serving trays, and meets an industry need," McClamroch says. "We talked through the cost the market would bear for the product and how they plan to take it to market. They had a good concept but lacked a good deal of market feedback."

Their conversation coincided with an upcoming Adams-Burch trade show in the mid-Atlantic region in March 2014 that would attract thousands of buyers in their target market, from restaurants to caterers and casinos. "I invited them to set up a booth, show their concepts, and get real-world feedback to see if theirs was a real-world venture with legs to go forward," McClamroch adds.

Kamei and Miles returned to Thayer's machine shop with instructor and mentor Charles "Chip" Brettell to build new iterations of their tray, and also designed a logo, business cards, and marketing materials. They finished Fairbrothers' guide to entrepreneurship on the plane to Washington, D.C., for the trade show.

"Our tactic going in was to approach every person who walked by our booth and ask them, 'Can we tell you about our trays?' Some people were initially, understandably, unenthused, but we told them our story—that we were engineering students from Dartmouth College—and demonstrated our tray anyway," Kamei says. "By the end of our pitch, nine of 10 customers requested more information or placed an order."

What happened at the trade show surprised McClamroch, a 20-year industry veteran.

"Shinri and Krystyna took my suggestions to a whole new level. They moved their booth to the edge of the aisle and stood *in the aisle* so that it wasn't possible for customers to pass by without engaging one of them," McClamroch says, laughing. "I was able to use them as a great example of enthusiasm and engagement for the rest of our suppliers."

Tray Bien became the talk of the two-day trade show. The students came away with confidence, actionable ideas for product enhancements, interested investors and manufacturers, six supply companies that wanted to license their product, and more than 2,000 orders from customers for products that didn't exist yet.

With the next challenge—the annual Dartmouth Ventures entrepreneurship contest—just weeks away, the students threw themselves into preparations. Fairbrothers, Justin Leon Tu'15, and alumni mentors Catalina Gorla '09 and Bill Nisen '73 coached them through dry runs of their presentation and offered invaluable tactical advice and support.

"Krystyna and Shinri, in typical Dartmouth form, were learning machines, using every piece of feedback as an opportunity to grow," says Gorla, founder of DEN's Ohio chapter. "I have never met two undergraduates more receptive to feedback."

Competing against more than 100 companies, including 26 DEN regional teams, Kamei and Miles sailed to the last round. In their final presentation to 300 people, they radiated enthusiasm, poise, and passion. Twice the audience interrupted their presentation with applause. The Tray Bien team emerged with the First Place Prize, the People's Choice Award, and a total of \$29,000 to take their product to market.

In the waning days of spring semester, Kamei and Miles arrived in the Couch Project Lab at 8 a.m. to discuss their journey and critical next steps. They smiled and seemed upbeat, their scratchy voices the only sign of fatigue or stress.

They described themselves as "accidental entrepreneurs" ascending a steep learning curve with phenomenal support from Thayer, Tuck, DEN, and others.

Miles says that starting a company has been the most exciting, re-



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warding, and meaningful journey of her life—and also the most time-consuming and challenging. “Passion is the key to being a successful entrepreneur,” she says. “If money is the only incentive, I don’t think it’s the best driving force to get you through the hard parts. Success for us is getting our trays to our end-users and improving their daily lives, whatever it takes. We’re not defining success by financial metrics.”

The power of the team—and surrounding themselves with people they trust—has been critical for Kamei and Miles. They say they’ve learned firsthand how vital communication skills are for conveying ideas effectively and interacting with all types of people. And they agree that juggling academic and co-curricular responsibilities with the insatiable demands of building a business is hard.

“The most important thing we’ve learned is that we absolutely love doing this,” says Kamei. “There are truly amazing resources at Dartmouth. Everyone wants to help and is excited about experiential education. We’ve found it’s the best way to learn.”

Kamei and Miles say they also learned to listen to customers, who insisted on dishwasher-safe trays. The partners let go of beautiful bamboo in favor of a phenolic composite board—a more resilient material that maintains the wood aesthetic—for their final products.

The Tray Bien team spent much of Sophomore Summer refining materials, finalizing manufacturing and distribution contracts with their attorneys, pushing forward on a non-provisional patent, and edging closer to getting their first products to their first customers. With their distributor, Adams-Burch, serving the mid-Atlantic region—a good test market—and linked to a large network of regional distributors, Kamei and Miles are already preparing for the possibility that Tray Bien could move into the national market.

But mainly they’re keeping their minds on the work at hand.

Calling Kamei and herself “playful partners,” Miles says they’re “excited to be right here, right now. There are so many exciting entrepreneurial initiatives happening on campus now. We’re so grateful to be involved.”

KIMBERLY SWICK SLOVER is a freelance writer based in New Hampshire.

Tray Bien LLC is the latest company that began with an ENGS 21: Introduction to Engineering project. Here are the others.

Osmonics

In 1963, when ENGS 21 students Dean Spatz ’66 Th’67 and Chris Miller ’66 Th’67 were given a jar of brackish water and told to find a way to make it potable, they came up with a prototype for a reverse osmosis purification system. They ramped up their undergraduate project into graduate-level research. In 1969 Spatz cofounded the reverse osmosis company Osmonics with longtime Thayer Overseer Ralph E. Crump. Their first machine was sold to the Mayo Clinic for kidney dialysis. The second went to a car wash for a rinse-water system. The company grew into a world leader in reverse osmosis filtration. In 2003 General Electric bought Osmonics for \$275 million.

Aqua Design

Founded in 1983, the desalination company Aqua Design was an extension of a 1963 ENGS 21 project with Professor Paul Shannon and a reverse osmosis graduate research project that Spatz and Miller conducted under the guidance of Dean Myron Tribus. Aqua Design engineered, manufactured, constructed, owned, and operated seawater reverse osmosis desalination plants supplying water to governments and resorts mainly in the Caribbean. The company reduced energy consumption for the main desalination process to less than 9 kilowatt-hours per thousand gallons by reusing the hydraulic energy in the waste brine by means of dynamic pressure exchange systems. Sold to Ionics in 1996, the company is now part of General Electric.

Gyrobike

Six years after Hannah Murnen ’06 Th’07, Augusta Niles ’07, Nathan Sigworth ’07, and Debbie Sperling ’06 Th’07 tackled the eternal problem of learning to ride a bike, their solution, the stabilizing Gyrobike wheel, went on the market. The inventors and Errik Anderson ’00 Tu’07 formed a company, GPSS, LLC, which developed the intellectual property, filed the original patent, created prototypes, and wrote a business case. Under the business leadership of Daniella Reichstetter Tu’07, thousands of children’s Gyrobike wheels were sold directly to customers and through various retailers. In 2013 the inventors sold the technology’s rights and patents to U.K.-based entrepreneur Robert Bodill, whose renamed product, Jyrobike, is available for purchase at jyrobike.com.

Spiral-E Solutions, LLC

The company, founded in 2011, features a vacuum suction tissue-stabilizing device designed to prevent tissue damage during endoscopic surgery. The device was invented in ENGS 21 by Alison Stace-Naughton ’11 Th’13, Ihab Basri ’13, Brenna Gibbons ’12, and Ph.D. candidate Scott Snyder ’00 Th’01. All cofounded Spiral-E Solutions, LLC, and serve on its board. Stace-Naughton is the company’s manager.

FROM ENGS 21 TO INDUSTRY

Alumni News

FROM AROUND THE WORLD

spotlights

Cristina DeVito '01 Th'02



After studying mechanical engineering at Thayer, attending Harvard Business School, and working in investment banking and private equity for a few years, **Cristina DeVito '01**

Th'02 returned to her home state of New Jersey to join Tough Mudder, a series of hardcore obstacle races designed by British Special Forces and scheduled around the world. DeVito first came on as chief strategy officer, but soon had the opportunity to tailor a series to women. Mudderella debuted in Pennsylvania last fall, and this year expects to welcome 60,000 participants to seven U.S.

events and one U.K. event. "Mudderella is a brand that encourages women (and men) to define what being strong means to you and to own it—to believe that 'can't' doesn't exist," DeVito told *The Huffington Post* in July. "I myself have run in many obstacle mud runs over the past few years and saw first-hand how motivating and inspirational it can be to set a goal and achieve something that you didn't think was possible." A typical event offers a dozen obstacles—everything from Dirty Downward Dog, a challenge that gets participants to assume yoga-friendly

positions to move across a muddy trench, to Hat Trick, where contestants jump off a trampoline onto a cargo net and then slide into water—on a 5- to 7-mile course. "Mud is a great equalizer," DeVito says. "The obstacles are team-based so you do them with your partner, you do them with your team, but they're also meant to be fun." DeVito says she was drawn to the math and problem-solving aspects of engineering, but soon realized she also enjoyed working with people and making deals. "I had always enjoyed working with small, growing companies and brands, so making the switch to starting a new brand from scratch was an incredible opportunity for me," she says.

John Lamppa Th'11 is serving up science with a good dose of gastronomy in the Boston area this year. The senior director of research and development at WikiFoods uses biotechnology and food science to pair ice cream, cheese, cocktails, and even soups with nutritional and tasty packaging to form bite-sized portions that can be held without melting. The products, known as WikiPearls, are encapsulated in a membrane similar to the skin of fruit. WikiFoods technology—cited among the 32 innovations that will change tomorrow by *The New York Times Magazine*—involved engineering a protective, cell-like membrane from a combination of electrostatically charged food, biopolymer, and ion particles. WikiFoods recently partnered with Stonyfield Yogurt to introduce frozen yogurt pearls in four Whole Foods markets in the Boston area during the spring—and plans to expand to 50 stores in Massachusetts by the end of the year. Water is the next frontier: "We've had multiple leaders in the beverage industry reach out to discuss options for replacing or reducing plastic packaging," Lamppa says. "Currently we have multiple

biodegradable and edible materials in development that range from flexible fruit-like skins to much more rigid structures like egg shells." His lab, based in Cambridge, Mass., is associated with the Paris-based Le Laboratoire, a creative extension of the company that explores new ways to consume and experience food. Visitors there can sample, notebooks in hand, everything from cocktails to gazpacho to Black Forest cake. U.S.-based culinary adventurers will have the opportunity to try some of these experiments firsthand when Cafe ArtScience opens at 650 Kendall Square in Cambridge later this year. "Consumer feedback will be a huge benefit for us. The ability to engage customers on a day-to-day basis and learn what people like and dislike and what product attributes they would like to see in future is invaluable," he says. "It's really getting back to how WikiFoods was started: the idea of community and a project that everyone contributes to, like a wiki."

"Doctors today have more and more tools to fight cancer, but fighting cancer is a race," **Sean Hogan '88**, vice president of healthcare at IBM, wrote in a *Forbes* opinion piece in March. He sees genomic medicine as the lifesaving solution. "One of the greatest advances since scientists first mapped the human genome a decade ago is that cancer treatment can be tailored based on DNA data," he says. Oncologists can analyze full DNA sequencing and find the mutations in cells that caused the cancer, then prescribe drugs to target that mutation, hoping to halt the molecular action causing cells to replicate uncontrollably. But this highly personalized care is expensive and time-consuming and available to too few patients. Hogan says cognitive computing systems—such as those he works with at IBM—can provide physicians at the point of care with the right information at the

Success Story

SEAN BYRNES '00 | COFOUNDER, FLURRY

right time. "The New York Genome Center recently selected IBM Watson to help make sophisticated genomic analysis a standard part of care, starting with brain cancer," he says. "Until now, we lacked the powerful analytical tools capable of making sense of vast amounts of genetic information, which is the big-data challenge of human biology."

Greg Chittim '01 Th'02 '03 has earned a 2014–15 Dartmouth Young Alumni Distinguished Service Award for his extensive volunteer involvement at the College. An engineering sciences major modified with computer science, he was a member of Sigma Phi Epsilon, helped reconstitute the Dartmouth Society of Engineers (DSE), was active in the Student Assembly and Habitat for Humanity, and was a teaching assistant in computer engineering classes for Professor Linda Wilson. As a graduate student in the M.E.M. program, he served as president of DSE. He has also served the College on the Alumni Council and the M.E.M. Corporate Collaboration Council. He is currently the senior director for strategic marketing at Arcadia Healthcare Solutions, a healthcare analytics and services firm outside of Boston.

Charles Queenan Jr. '52 Tu'53 Th'53 recently received two awards. Citing his long and distinguished legal career and dedication to public service, *The American Lawyer* magazine presented him with its 2014 Lifetime Achievement Award. Saint Vincent College honored him with an honorary doctor of laws degree at its May commencement in recognition of his lifetime of contributions to the legal profession, his community, and the firm he headed from 1976 to 1990. Queenan served as chair and senior counsel at Kirkpatrick & Lockhart, now K&L Gates, a global law firm with more than 2,000 attorneys across the world representing leading global corporations as well as public sector entities, educational institutions, and philanthropic organizations. "For more than five decades, yours has been the voice of leadership in a multitude of venues in the public and private sectors of western Pennsylvania," the degree citation states. Queenan has spearheaded many corporate, charitable, and civic endeavors, serving as director of Allegheny Ludlum Corp., Allegheny Teledyne Corp., Teledyne Technologies Inc., and Allegheny Technologies

Nine years ago engineering major Sean Byrnes '00 cofounded with Daniel Scholnick '00 and Gabriel Vanrenen '03 the mobile ad-tech firm Flurry, which Yahoo bought for \$300 million in July. Now he's advising and investing in the San Francisco Bay Area as well as blogging on building companies at *Sean On Startups* (seanonstartups.co). Here he shares what he's learned so far.

What was the great challenge to starting Flurry?

Overcoming adversity. When you are starting a company you are, by definition, starting with nothing. Your competition always has more resources, people, and capital, and you need to find ways to succeed when all the odds are against you. The defining characteristic of successful entrepreneurs I know is not intelligence or charisma but simple perseverance. It is the people who don't give up in the face of certain failure that are able to build successful companies.

What was the key ingredient that enabled you to grow?

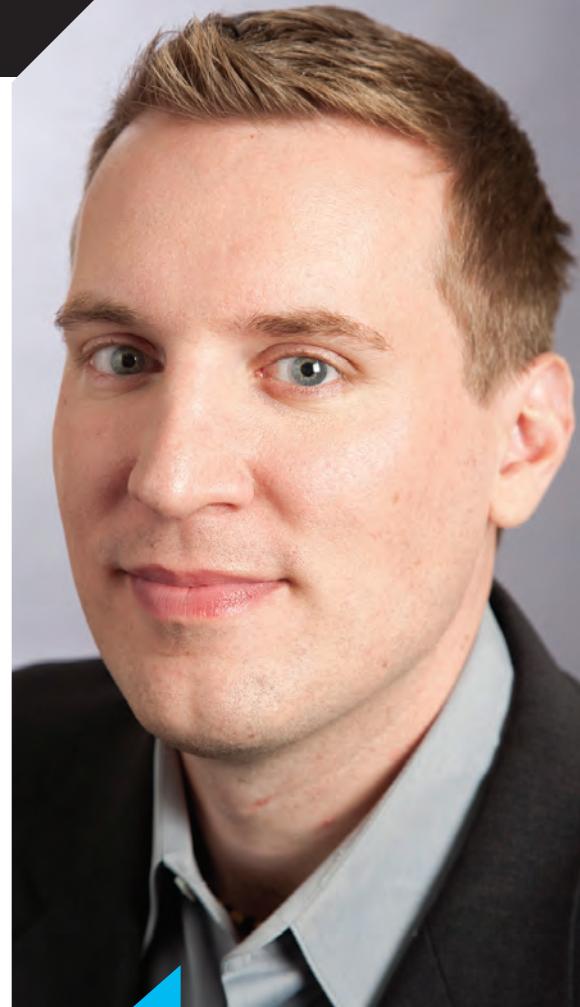
I think that everything starts with the people. Having a great team is the most important building block of any company, as it gives you the flexibility to learn from the market and adjust your business. (Our first few employees were Karl Harris '00 and Dave Latham '01, who helped build the company into the success it is today.) So much of building a company is adapting to what you learn, especially in the case of Flurry, where the mobile market was literally growing up around us. It is also true that without having picked a market like mobile, Flurry would not have had a chance to grow as fast as it did, regardless of the team. So, in the end, it was the people and the opportunity together.

How do you encourage the innovation necessary to stay on top of the field?

I always assume that anything and everything can be improved. If you assume that you can always improve, you never get comfortable with the status quo, and you always seek to reinvent yourself in better ways. That is critical for a high-growth, high-tech company because the market and state-of-the-art technologies are constantly changing.

What elements of a startup do you enjoy most?

The best part of starting a company is how many different skills and new talents you learn along the way. One thing I always enjoyed at



The defining characteristic of successful entrepreneurs I know is not intelligence or charisma but simple perseverance."

—SEAN BYRNES '00

Dartmouth was the diversity of classes I was able to take and the amazing variety of things I was able to learn. That drive to learn many new things and challenge myself differently every day was what led me to want to start Flurry—and what will lead me to start more companies in the future.

What's next for you?

I'm currently taking some time off to decompress from the pressure of building Flurry and to spend time with my new daughter. Eventually, I'd like to start another company, as there are many interesting problems to be solved. In the meantime I am investing, advising, and mentoring a lot of great new startups that are in the early days of their journeys. I'm happy to say that some of them were founded by fellow Dartmouth alums.

spotlights



Charles Queenan Jr. '52 Tu'53 Th'53

Inc. He has also served as chair of the board of directors of the Allegheny Conference on Community Development, co-chair of the Pittsburgh Cultural Trust, chair of the audit committee for the board of Pittsburgh Life Sciences Greenhouse, and chair of the board of trustees of Carnegie Mellon University, where he endowed a chair of psychology.

Counterfeit medicine frequently kills by robbing patients of the real drugs they need. And some counterfeits contain a small amount of active ingredient—not enough to cure an illness, but enough to promote resistance that renders even the real medicine powerless. “That might be the most deadly effect of all,” Tina Rosenberg reported in a June opinion piece in *The New York Times*, “The Fight Against Fake Drugs.” She pointed to an authentication solution developed by **Ashifi Gogo Th'09**. Sproxil, the company he founded, makes labels with unique scratch-off ID numbers that its clients affix to blister packs inside each box of medicine. Purchasers text the ID to a number on the box, and instantly get a text back saying whether the medicine is real. Today Sproxil works in Ghana, Kenya, Nigeria, and India and is expanding into Latin America and farther into Asia. It is the biggest company in the mobile verification business, with more than 9 million verifications so

far. But progress comes slowly. “The phone companies advertise very fast network speeds on their TV spots but they have molasses-grade administration,” Gogo says. “It can take a year for them to provide lifesaving service to their own customers.”

As Bloomberg Businessweek reported in June, **Dax Kepshire Th'06** may have accidentally stumbled upon a solution to the biggest challenge for renewable energy: how to store it. Kepshire and **Ben Bollinger '04 Th'04** formed SustainX in 2007 (with former Thayer **Dean Charles Hutchinson**) after sketching out plans for a water-cooled air-compression system for renewable energy while pursuing their Ph.D.s at Thayer. As they tweaked the design—adding anticorrosive and disinfectant chemicals to the water to reduce wear on machinery and kill bacteria—the mixture foamed. That foam, Kepshire discovered, helped prevent the wide temperature swings that waste a lot of energy in traditional compressed-air facilities. Injecting it into the air being compressed helps keep the temperature almost stable (at about 122°F) as the foam absorbs excess heat. The big test is on the horizon, as SustainX is finalizing partnerships in the United States, China, Japan, and South Korea to build its first commercial installations, which Kepshire says can produce about 1.5 megawatts of electricity. And he'll keep tweaking the foam formula. “We're reengineering and fine-tuning it,” says Kepshire, a vice president and general manager at the Seabrook, N.H.-based firm. “It's our secret sauce.”

Three Dartmouth engineers—**Scott Sandell '86, Hurst Lin Th'88**, and **Terry McGuire Th'82**—made the 2014 “Midas List” of people *Forbes* considers the best venture capitalists in the world. Sandell, a general partner at New Enterprise Associates and former Microsoft product manager, comes in at No. 10. He posted big wins with enterprise software firm Workday and Nicira (sold in 2012 for \$1.26 billion) and was a lead investor in Playdom, which sold to Disney in 2010 for \$563 million. The Portola

Valley, Calif., resident told *Forbes* you never can tell when you're going to meet a great entrepreneur: “I met Daphne Koller when our families got together for lunch at my house. She told me what she was doing in her lab at Stanford, and we funded Coursera less than a month later.”

Lin, No. 54, cofounded DCM China in 2006 after cofounding and serving as chief operating officer at SINA Corp., a leading Chinese Internet company. Lin invests primarily in consumer Internet for DCM, including Vipshop, Tuniu, Linkinrich and the recently public 58.com, which now has a market cap of \$4 billion. A Brooklyn native, Lin lives in Beijing, where he is active in the country's alumni communities for his alma maters, Dartmouth and Stanford.

McGuire, No. 91, has been an early-stage investor for more than a quarter century, 18 years of that career at Polaris, the firm he cofounded. A life sciences expert, McGuire led Polaris' investment in Acceleron Pharma, Ironwood Pharmaceuticals, and Adimab; McGuire is on the board of all three, as well as at least 10 other private companies in his portfolio. Career highs include Akamai and Cubist Pharmaceuticals. McGuire started three companies in his career: Inspire Pharmaceuticals, Advanced Inhalation Research, and MicroCHIPS, a company working on programmable drugs delivered via microchip implanted under the

skin. The Weston, Mass., resident is chairman of the Board of Overseers at Thayer School and is the chairman emeritus of the National Venture Capital Association. McGuire says his biggest accomplishment, however, will be in mentoring the firm's junior partners to eventually eclipse his own success.

Max Fagin Th'11 is one step closer to claiming a one-way ticket to Mars. “What I want to do is spend as much of my life as possible on Mars, opening it to humanity, making use of the resources and opportunities that are present on a planet that has never been touched by humanity,” he told Fox Business' *Money* in June. Fagin is one of 700 candidates—culled from 200,000 applicants—competing to join the permanent settlement that the nonprofit Mars One hopes to establish on the red planet by 2024. Fagin worked this past summer for Made in Space, helping to identify items that could be built by the 3D printer the company sent to the International Space Station this fall. Fagin is midway through a two-year master's program in aerospace engineering at Purdue, researching entry, descent, and landing systems for Martian spacecraft. If he can't catch a ride with Mars One, Fagin will seek other options. “There are always other ways to get to Mars,” he says, citing spacecraft designer SpaceX, where he's working this fall during a break from school.

return • reminisce • reunite



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just one question

Q.

What was your greatest experience at Thayer?

My greatest experience, strangely enough, was testing the compressive strength of concrete in the big machine on a cylinder of concrete that I had mixed. In a beautiful conical fracture, it failed in shear! I have thought of this many times and used it to show beginners the wonders of stress analysis, which I have practiced for 73 years. On a personal note, I remember all the happy comrades-in-arms times with **Nate Ward '43 Th'43**, **Bill Knoff '42 Th'43**, "Black Jim" O'Mara '42 Th'43, and all the rest. Much later in life this aeronautical and electronics engineer, practicing civil yet, looked to our favorite professor, **Brownie [Ed Brown]**—then boss of the Hanover Water Co.—for critiques on getting a practically vertical tail-pipe, sucking a nearly horizontal lake drain, to pull its full head with its discharge end submerged in a catch basin without having been purged of its air first. "Unlikely," was the prognosis. But after rumbling and belching for a couple of minutes, it ran right on the numbers for a full pipe! (This was to keep a lake level in a severe rainstorm and prevent it from flooding newly built PGA golf greens worth \$70,000 apiece.)

—**Tom Harriman '42 Th'43**

We were detailing a steel truss bridge—ink on velum—in one of the structures class labs, showing each rivet head. **Professor John Minnich '29** looked over my shoulder and gave me the finest piece of advice I have ever received: "Johnston, don't ever try to make your living on a drawing board." And I never did—not one line, ink or otherwise! At a reunion many years later, I reminded John of that one, and thanked him heartily as we both enjoyed a good laugh.

—**Hal Johnston '47**

It was the teaching fellowship granted me by **Dean Bill Kimball**, which involved spreading my graduate year across two years while I put in time

conducting lab sessions and correcting students' papers. This provided a special education for me, and getting to know that marvelous group—the Thayer School faculty—through faculty meetings and other contacts, was a great experience.

—**Foxy Parker '48 Th'49**

My greatest memory at Thayer was **George Taylor**, who taught "Engineering Law" and what we used to call time and motion study. Great man.

—**Prentiss Carnell '56 Tu'57 Th'57**

I did my master's thesis on the properties of a multi-stage amplifier, using, of course, vacuum tubes. Each early evening I would get it tuned, connect instrumentation, and begin my testing. Suddenly, all instruments would go off scale. I would re-tune everything and again begin testing, when suddenly the instruments would go back to almost zero. After some very frustrating times and getting nowhere on my thesis, I called up to our graduate assistant. He said he would be down to see me shortly, after he completed his call to a buddy in Africa and turned off his short-wave radio. And then I knew the source of all my problems! I got a C+ on my thesis, a charitable grade considering the limited value of my work.

—**Porter Kier '56 Th'57**

When I was in my graduate program as a Tuck-Thayer student I had an idea that I might improve the efficiency of jet engines. I took the idea to thermodynamics **Professor Jim Browning** to see what he thought of it. His first response was something like, "Well, that won't work because..." followed by a long pause, then, "let's take a closer look." Finally he acknowledged that he was not sure my idea wouldn't work and that it was deserving of further study. Ultimately, he suggested I take it on as a project, for one hour credit, and he would be my tutor, if we could get the dean to



"Getting to know Fred Schleipman, who ran the machine shop, hearing his stories about building helicopters for WW II."

—**PETER MILLS '77**

agree. Fortunately, the dean agreed and I benefited greatly from my many hours of one-on-one discussions with one of the great thermodynamics minds of the time. Professor Browning would review my progress, suggest areas for future examination, and critique my thought processes. Our conversations often would go well beyond the project itself, and they contributed immeasurably not only to my specific education in jet engine cycle analysis but to engineering problem-solving in general. As a consequence of our work together, Jim eventually offered me a job helping him develop the world's first plasma jet cutting tool while I was still a student. The Upper Valley remains a central player in the entire plasma jet industry.

—**Emerson Houck '56 Tu'58 Th'58**

My greatest experience was a class in contract law taught by **George A. Taylor**. He started out on the first day by saying he did not care whether we learned much contract law. The important thing was the process of problem solving, and the approach worked for law cases as well as engineering problems and life in general. He wrote down on one small blackboard what he wanted us to get out of

the course, and said if we learned to apply those principles, he and we, as students, had done our job. He told us to spend all of our time identifying the critical issue on which everything hinges. He said this is the hardest part, because there is a lot of chaff. Once we had defined that, he said, we were to list the facts that relate to that critical issue and then list the laws (legal or engineering) that apply to those facts and the issue. Meld those facts against the laws (rules), and we would come out with an answer. I have used that approach for problems ever since.

—**Bob Woolman '57 Th'58**

I was just starting my crossover year in Thayer's 3-2 program when the former Soviet Union launched *Sputnik 1* on October 4, 1957. Thayer's **Professor Huntington Woodman Curtis** was asked by Air Force Cambridge Research Center (AFCRC) to be a part of a hastily constructed tracking network to track Soviet earth satellites. There would be three network stations in New England: the AFCRC itself, the University of New Hampshire, and Thayer School. Hunt Curtis was a scientist, an engineer, a radio amateur, a former Army Signal corpsman, an enthusiastic and inspiring

just one question

teacher, and certainly a man of action and initiative. He agreed immediately, with approval from **Dean Bill Kimball** and the College. The objective was to determine the exact times of the satellite's closest approach to each of these three listening stations in order to refine the AFCRC's information on the satellite's orbital characteristics. The elegant engineering solution was to determine those times by observing and analyzing the Doppler shift in carrier frequency as the satellite moved past each station. All the equipment had to be existing lab apparatus, configured to perform this never-before-accomplished task. Professor Curtis asked me to become a research assistant and help him build Thayer's station and put it in operation as quickly as possible. The deal included a salary and an agreement to complete my final year at Thayer during the two-year span of the assistantship. I saw electrical engineering fundamentals being put to work on a very important Cold War project as I operated the listening station, eventually tracking a variety of U.S. and Soviet satellites, all on different frequencies and all with different orbital characteristics. The resulting experience was a completely unexpected, valuable, and much-appreciated part of my education at Thayer.

—**Frederick Hart Jr. '58 Th'60**

George Taylor was a professor of industrial engineering. He taught us time and motion, more than we ever wanted to know about therbligs, etc. His mantra was, "There's always a better way." My classmates and I laughed about it among ourselves, but it stuck with me and informed my approach throughout my career and my life outside of work. It has to do with never being entirely satisfied with the status quo—being alert to opportunities to improve both personally and professionally. I never used a therblig, but I always remembered to look optimistically for a better way, thanks to Professor Taylor.

—**Ray Becker '59 Tu'60 Th'60**

It was peaceful. And it was an important time in my life to be surrounded by peaceful things.

—**Arthur Pritchard '60 Tu'61 Th'61**

Two experiences at Thayer made major differences in my life. The first was my introduction to computers

in my senior year. We had access to a Royal McBee LGP-30. Our programming was terribly tedious; we had to keep track of every location used by either our program or any piece of data. We used a punched paper tape to program the computer, which meant that if we found an error, we had to recreate the entire tape. When we later used punched cards to program other computers, we were elated to be able to make corrections by simply replacing, adding, or removing a card. This early exposure to computers provided a lifelong interest in computers. The second experience was becoming **Professor Bob Dean's** graduate assistant and project engineer in the plasma lab, where we studied anode behavior in arc jets. That opportunity provided a way to create technical papers as well as develop familiarity through the use of many research tools. The responsibility that I was given gave me the confidence for many later endeavors. In addition, Professor Dean's mentoring gave me the impetus to pursue a Ph.D. in mechanical engineering at Stanford, a path that I would not have taken otherwise. I was fortunate to spend about 10 years in the aerospace industry with NASA and McDonnell Douglas; 10 years in snack food engineering, manufacturing, and research with Frito-Lay; three years in food equipment manufacturing back in Iowa, where both my wife and I had grown up; five and a half years in the printing business in Minnesota; and two years in consumer capital good with Sunbeam Outdoor products. Each of these industries gave me a challenge of learning new technologies and in each change I was able to use some of my engineering talents and experience as a bridge. In all of these transitions, the Thayer School and Stanford experiences provided me with the interest and ability to understand new technologies and make a contribution.

—**Harris McKee '61 Th'63**

Dean Myron Tribus. He pioneered the statistics of thermodynamics, probably the hardest course I took at Dartmouth. A very dynamic man. Shook things up. Came to Washington, D.C., and did the same thing. Worked with **John Kemeny**, who was president at the time, to create the math center. Dartmouth needs more like those two.

—**Don Jansky '62 Th'63**

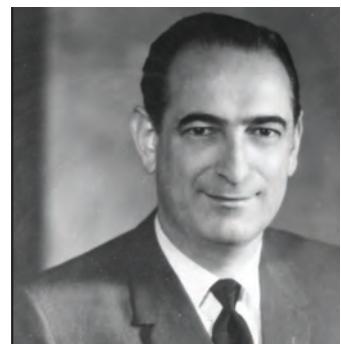
Learning and engineering with electricity. That got me my first job engineering new TV sets for RCA in Indianapolis and then two years later moving onto Cummins Engines in Columbus, Ind., and being an application engineer for diesel engineering applications. It was all a great adventure and great fun. Most importantly, it instilled in me the engineering problem-solving method, which has been my go-to process for every problem in my career and life.

—**Sandy Duncan '63**

My greatest experience at Thayer school was the ES 21: Introduction to Engineering course I took with 10 other students in fall 1963. Our advisor professor was **Paul Shannon** and we had to come up with a product to help people who had brackish water get good water at a reasonable cost. We decided to use a brand-new technology, reverse osmosis, invented by Dr. S. Sourirajan in 1959. We came up with a system to provide five gallons of de-mineralized water to a homeowner each day. We did this in the 10 weeks of the course. All 11 students were actively involved and helped in the planning and production. Then we presented our prototype to the judges in early December 1963. I believe there were five groups of students—or "companies"—and the competition was fierce but friendly. I still have my lab notebook used to take minutes of our weekly meetings and the various technical ideas, "inventions," we worked on. We contacted outside companies by phone and learned a lot about how to interface with design engineers and sales and application engineers. This experience helped us recognize the importance of the courses we would take in the future, which gave us the tools to design and manufacture new products. Many of us ran businesses after graduating from Thayer. In 1969 I started Osmonics Inc. in Minnetonka, Minn., and built it to \$210 million sales listed on the New York Stock Exchange and 1,500 employees when, in 2003, General Electric bought it to be their water equipment platform. At the time we were the most vertically integrated reverse osmosis and filtration company in the world.

—**Dean Spatz '66 Th'67**

The last term of my fifth year, a



"Dean Myron Tribus. He pioneered the statistics of thermodynamics, probably the hardest course I took at Dartmouth."

—**DON JANSKY '62 TH'63**

friend and I took a two-person seminar from **Professor Paul Queneau**, a "grand old man" of metals smelting, refining, etc. The class was quite intense and we worked hard at it, but were rewarded when Paul arranged a first-class tour of International Nickel's huge Sudbury, Ontario, complex. A great teacher and a great learning experience.

—**Mike Onderick '73 Th'74**

Getting to know **Fred Schleipman**, who ran the machine shop, hearing his stories about building helicopters for the WW II war effort, making a Stirling-cycle engine for my thermodynamics class, and using the milling machine to make moulding for a grandmother clock I designed and built for my parents as a graduation present.

—**Peter Mills '77**

My greatest experience at Thayer was taking ES 21 during my sophomore fall quarter in 1977. It got me hooked on engineering, and more important, it introduced me to one of the most amazing people it has been my privilege to know: **Fred Schleipman** of the Thayer machine shop—master machinist, gentle genius, wise and encouraging mentor. He continues to inspire and encourage me!

—**Alison Andrews Vogel '80**

The one that stood out most was the original solar car project. Looking

back after more than a quarter century of a professional engineering career that's had me in the thick of several startup companies (one of which went public, one of which was acquired, two of which imploded spectacularly, and one of which I'm still working at), I'm struck by how many similarities there were between that original adventure, where Dartmouth and Thayer School went to the races for the first time, and a few young companies I could name. They all started with a great idea, high hopes, enthusiasm, a blank sheet of paper, a staggering amount of naivety, and an overall management structure completely incapable of running the effort coherently. That's what startups are all about, and in a microcosmic sense, Thayer's first effort ever to get to the Tour de Sol was no different. In the end, the car itself was disqualified due to mechanical failure quite early in the race. With two and a half decades of being a practicing engineer, I can clearly spot the two critical flaws in the design of that drive system, into which I'd poured my heart and soul. And I can say with confidence: If you gave me about a month today, I could put the whole thing back on the road in perfect order, never to have another hiccup.

All things considered, it probably matters a whole lot less whether the 1988 Solarmobile won the Tour de Sol as where the people who built it ended up later. And herein lies the virtue of being able to say with a clear conscience that, ultimately, it wasn't exactly a startup venture to make investors money as much as it was an educational proving ground for the people involved. In that the Solarmobile succeeded far beyond anybody's wildest hopes.

—Eric Overton '87 Th'89

I only spent one year at Dartmouth after graduating from Smith College to pursue my B.E. at Thayer back in 1989. I was not very familiar with the Apple network on campus, so my computing experience was limited to accessing the campus-wide Unix network via VT100 terminals, and I remember connecting my own terminal to the network from my off-campus apartment. I was taking a course in numerical analysis taught by math **Professor Thomas Kurtz**, whose assignments were based on programs installed on

the Apple computers. I should have figured out how to use the Apple computers and programs to answer the homework assignments like everyone else, but I didn't. Instead, I programmed most of the algorithms in C on Unix. A great experience that comes to mind is the handful of after-class teacher sessions with Professor Kurtz, who took the time out of his busy schedule to help me debug my code. The kindness extended by Professor Kurtz is worth mentioning and I am grateful.

—Merilyn Chesler Th'89

My greatest experience at Thayer was **Professor Horst Richter**. I had a non-traditional college experience, as I joined the U.S. Army after high school. I started Dartmouth and then Thayer already married and expecting my first child. I was asked by the registrar: "I don't know how you got into this school, and I don't think you will succeed, but what do you want to do?" I told her, "Engineering."

Horst Richter gave me some nuggets that I have always carried with me: "If you always want a job, work in the energy industry." I have worked in the oil field my entire professional career, and am now the director of engineering research and development at Noble Drilling Services Inc. in Sugar Land, Tex. I have always had a job and have never been in fear of not having one.

He also asked: "What is conserved?" There have been countless times that I thought of this quote in my career. It has always guided me to think about things from that light. It works for many areas, even outside technical engineering.

I think of Professor Richter often.
—Dave Dartford '91 Th'92

I had a very special experience during my B.E. year at Thayer. In the spring of 1992, **Professor Kennedy** helped me set up an exchange program at the Asian Institute of Technology (AIT). Located just outside of Bangkok, AIT is an engineering graduate school that attracts students from all over Asia. I believe I was the only American at the school and one of only a handful of Westerners there. My three professors were British, Japanese, and Thai. My friends were from Japan, Vietnam, Bangladesh, and Thailand. It was an incredibly rich cultural experience that I will



was in 2000, when I took ENGS 21—the classic course that every engineer talks about. It was my initiation into the human-centered design process, iterative design, and fantastic team collaboration with **Julie (Kowalsky) Bradley '03, Bill Shields '03, and Aaron Goss '03 Th'04**. And now, 14 years later, I continue to strengthen my muscles in the design process through the host of projects on my plate at IDEO.

—Brian Mason '03 Th'05

"Our favorite professor, Brownie [Ed Brown]."

—TOM HARRIMAN '42 TH'43

never forget. I am thankful that the Thayer curriculum was flexible enough to give me that opportunity.

—Jim Meneely '91 Th'92

I had a lot of great experiences in the halls of Thayer, but none better than ENGS 21: Introduction to Engineering. At the time it was the first class in the engineering major, and I had no idea what to expect on the first day of class. The open format of the class was amazing: We were challenged to find a problem and build a solution—as simple as that. We had no formal engineering training so we had to use whatever we knew to build something as best as we could and compete against the rest of the class, which was doing the same. What my team achieved in that class, and the resourcefulness we found along the way, have always stayed with me and motivate me even today.

—Sean Byrnes '00

ENGS 21. Great class.

—Sujan Patel '01

I think it has to be my first and last team project at Thayer. My project was co-co-co-co-captaining (there were six of us) the Dartmouth Formula Racing team. It was a thrill to be building something from scratch with a real-world deadline. We traveled to Michigan and to the United Kingdom to race the car. Traveling with friends and classmates and rallying around a common mission was a gift, challenge, and a lot of goofy fun. My other great experience

My greatest experience occurred after I graduated (for the third time) in 2005. My master's thesis had been the design and control of a multi-panel solar power system for an autonomous rover. The rover, called *Cool Robot*, was designed for fieldwork in Antarctica. In the summer of 2005, one month after graduation and two weeks after getting married, I (along with **Dr. Jim Lever** from CRREL) took the rover to Greenland for field trials. We were stationed at Summit Camp, a small scientific outpost near the geographic center of the icecap, 10,000-feet above sea level. I was responsible for not only the power system, but also for getting the motor control, autonomous navigation, and communications working reliably. It was three challenging weeks of debugging, experiments, data collection, and occasional successes. By the end of the trip we had succeeded in demonstrating the basic functionality of the rover, and along the way developed a respectable pile of burnt-out parts, discarded and rewritten code, and head-slapping "duh" moments.

—Alex Streeter '03 Th'05

My best experience in Thayer was ENGS 130: "Mechanical Behavior of Materials." **Professor Erland M. Schulson** is an extraordinary teacher, and I learned a lot from his class. Now I am also a professor, teaching the same course for graduate students in Central South University in Changsha, China. I use the same teaching method and similar content in my class. I like Professor Schulson very much.

—Min Song Th'05

My most memorable experience was traveling the United States and the world with Dartmouth Formula Racing. Best education I ever received.

—Colin Ulen Th'05

just one question



"1988 Solarmobile. It wasn't exactly a startup venture to make investors money as much as it was an educational proving ground for the people involved."

—ERIC OVERTON '87 TH'89

Friday beers on the roof after slogging through a problem set all day.

—Andrew Argeski '06

Dartmouth Formula Racing.

—Brad Fierstein '06

One of my favorite experiences at Thayer was beating the Tuck students in competitions. Through the M.E.M. curriculum we were often matched against the Tuck students, and more often than not we Thayer "kids"—with our unkempt look and grease-stained hands (straight from the machine shop or some lab)—would beat our fresh-from-the-corporate-world counterparts. We learned a lot from them, and I think they learned from us as well. It is the blending of both worlds that make the Thayer experience, specifically the M.E.M. degree, so valuable.

—Daniel Tootoo '06

My experience was a mix of involvement with Thayer, Tuck School of Business, and Dartmouth's department of computer science. The open environment at Thayer encouraged participation in multiple disciplines. Since I was accepted for an M.E.M. and an M.S. in computer science, I approached the two schools and was provided an option to participate in a dual-degree program, which was great. The willingness and ability of the schools to allow a candidate to tailor his learning experience had a very positive impact on me. The Thayer and Dartmouth experience

was an intellectually stimulating and enriching environment created by intense involvement through courses, projects, study groups, guest sessions, on-campus jobs, and community activities.

—Himanshu Chhabra Th'07

Having 200-plus middle-schoolers from all over New Hampshire and Vermont invade Thayer School for a day to show off their Mindstorms robots in the annual Dartmouth LEGO League Regional Tournament! (And, as the tournament director and host, getting to dress up as a giant LEGO!)

—Caitlin Johnson '10

Product design with Professors Robbie and Collier!

—Nathalie Rivest '10

Floating in zero gravity while testing our ENGS 89/90 design project onboard NASA's Weightless Wonder! (Thayer made an "I'm an Engineer and..." video about it: youtube.com/watch?v=opTvZOQe0es.) The project was the capstone engineering experience for Sean Currey '11, Broghan Cully '11, Mike Kellar, and me. We were building a dehumidifier for the next generation of crewed spacecraft. When you are in a closed volume such as a spacecraft, the water vapor that you exhale doesn't have anywhere to go. All spacecraft that carry people have to have a system to remove that water from the air, and recycle it for drinking or washing. This is especially hard to do in mi-

crogravity, since there is no buoyancy to separate the water from the air. On the space station right now, they spin the air through a centrifuge to separate air from the water. For our ENGS 89/90 project, we built a working prototype of a device that would serve the same function without a centrifuge. It sucks the water right out of the air with a specially treated block of graphite that absorbs water like a sponge. To really prove it would work, we needed to fly it in a microgravity environment. So we flew it with the 2010 NASA Microgravity University flight campaign.

—Max Fagin Th'11

Working in Professor Karl Griswold's lab as an undergrad and being included in the journal *Protein Engineering Design & Selection* with the paper "Design and analysis of immune-evasive enzymes for ADEPT therapy."

—Christabell Makokha '11

One time Matt Dahlhausen '11 organized a game of capture the flag that was played throughout the inside of Thayer School our senior year. It was a great study break.

—Garrett Simpson '11

ENGS 21, where I founded a company: Spiral-E Solutions! Second best experience was ENGS 89/90, where my team won \$25,000 from the National Institutes of Health for our fecal transplant project. I loved the project-based courses.

—Alison Stace-Naughton '11

Learning that our 89/90 project earned the special Faculty Award for Service to Humanity during Investiture. The previous few nights, I had been talking with our team leader about who we thought was going to win the various Thayer awards. "Of course we're not going to win," one of our teammates said, "there are so many excellent projects!" Our team leader remained confident: "We have a chance!" During the ceremony, when Dean Helble intoned my name (I was first alphabetically), I turned to see the open-mouthed expression on my first teammate: She was stunned. On our way to the stage, I whispered to our team leader, "You totally called it!" Her reply was her characteristic enigmatic smile and a barely audible, "I know, right?"

—Sharang Biswas '12

Four experiences leapt to mind: my ENGS 31: Digital Electronics project with Professor Eric Hansen, running Dartmouth Humanitarian Engineering's hydropower project, running Tau Beta Pi, and my ENGS 89/90 project. I chose a pretty complex ENGS 31 project, but Professor Hansen was encouraging. I'm super proud of what I built and still have the circuit diagram up in my room. DHE's hydropower project was intimidating. I was 21 and responsible for seven other students' health and safety for two months in rural Africa, \$20,000, and the largest infrastructure project in a village of 7,000. But assistant dean Carrie Fraser '87,

Professor Charles Sullivan, Professor Doug Van Citters '99 Th'03, and the team were phenomenal to work with. I tried to leverage Tau Beta Pi to support freshmen engineers and failed. But admitting I'd tried hard and failed was good for me. In ENGS 89/90 half of our project was to prove the project was possible. I got valuable experience that landed me my current job as a data scientist at Automatic, a startup using data to model driver behavior, provide more information about a car's health, and model road networks to detect dangerous road segments. All these experiences had one thing in common: I was given responsibility beyond what I'd earned, but there was a great support system when I needed help.

—Ted Sumers '12

First was my independent investigation into the "Structural Analysis of Earth-bag Systems," with Professor Vicki May as my advisor. My research project stemmed from Dartmouth's \$300 House initiative, and I received the Dean of Faculty research grant to pursue fulltime research during summer term. My work culminated in an honors thesis and led to my current research on sustainable and resilient infrastructure. Second was the opportunity to be a teaching assistant at the Thayer machine shop for four years. I learned more about industrial engineering and manufacturing processes under the guidance of Kevin Baron and the machine shop crew than I learned from any engineering course. These experiences were an invaluable part of my life at Dartmouth, and I am indebted to the people at Thayer for making my four years in Hanover truly unforgettable.

—Awais Malik '13 Th'13

Expertise

GABE FARKAS TH'02 | DIRECTOR OF BASKETBALL ANALYTICS, SAN ANTONIO SPURS

WITH HIS FIVE-FOOT, NINE-INCH stature, Gabe Farkas Th'02 knew that his future wasn't as a power forward in the NBA.

But a decade ago, he saw an opportunity to enter the hoops world. As baseball's stats-based "sabermetrics" movement was in full swing, one was developing in the basketball community on a much smaller scale.

"I had stumbled across the APBR [Association for Professional Basketball Research]," recalls Farkas.

"There was barely a website at the time. It was just an e-mail list of like 75 people. There were discussions you could participate in. It got me thinking more and more about how to combine my two loves: basketball and math."

Ten years later, Farkas, a Master of Engineering Management (M.E.M.) graduate, has found the ideal way to mix those two passions. As director of basketball analytics for the San Antonio Spurs, Farkas spends his days aiding one of the NBA's most successful organizations on all fronts—from preparing for the June draft to breaking down lineups for the team's next opponent to simply aiding someone with creating an Excel document.

On a daily basis, Farkas says, his work breaks down into three categories. First is his work for the front office, which is focused on player acquisitions. Farkas and his analytics staff provide information to help the team's decisionmakers in their evaluation process when trying to improve their roster, such as what trade possibilities may exist and who could be scouted further. Second, there's his work to support the coaching staff. Farkas and his staff aid with game preparation by analyzing potential lineups, i.e., what player combinations perform best for a given opponent. Last, there's a purely technical side to his day—from database maintenance to explaining different types of technology the team may be utilizing.

When it comes to working with analytics, Farkas—who works from his Durham, N.C., home—says that the numbers are ineffective unless they can be communicated properly.

"One of the biggest challenges is communication," says Farkas, adding that analytics is just a "small piece of the pie" in the grand scheme of the day-to-day operations of an organization. "Even if you have the best formula, it is ineffective if you can't explain it to the coaching staff or the scouts."

Basketball has seen a rather impressive statistical revolution in less than a decade. Since the days when Farkas was trading e-mails with stats enthusiasts, the majority of NBA teams have developed in-house analysts—though San Antonio was certainly on the cutting edge when it came to the infusion of APBR metrics into daily operations. In the coming years, the basketball analytics world looks to continue its rapid expansion. Just last season, the NBA introduced into every arena cutting-edge SportVu cameras that track myriad statistics, from the speed a player is moving to how well he performs at a certain spot on the floor.

Considering the impact that analytics can have in areas such as roster management and game decisions, its surge in popularity is not surprising. "I think analytics have grown in popularity because it can give you a competitive advantage if you do it well," says Farkas. "Games are decided often by a point or two, which can come down to an inch or two. Every little bit helps. There's a book by Jonah Keri, *The Extra 2%*, which talks about how the Tampa Bay Rays made little adjustments here and there that helped them create additional wins. The same concept applies here."

Ending up in the NBA didn't happen overnight for Farkas. In fact, he thought that he'd continue in the pharma industry, either as a researcher or a statistician. But working in basketball was something that always called out to him. And six years ago, he decided that he just had to make a play for it.

In the spring of 2007, Farkas went to the inaugural MIT Sloan Sports Analytics Conference in hopes of making a connection in the pro hoops world. That weekend he'd finally meet those other analytics gurus he'd been e-mailing with for years.

Ultimately, Farkas was introduced to Sam Presti, who was then assistant general manager for the Spurs. They'd exchange contact information and trade e-mails about their thoughts on statistics, topics such as why it's more efficient to measure performance per minute as opposed to per game. After he didn't hear from Presti—who is now general manager of the Oklahoma City Thunder—Farkas began to give up hope.

But one morning, he got the message that would change everything.

"My phone kept vibrating at like 4 in the morning, and my wife just thought that it was



"There's no reason why I shouldn't wake up every day with a big smile."

—GABE FARKAS TH'02

one of my friends," remembers Farkas. "[Presti] had sent me a text that was like 1,000 characters and it said to call him as soon as I could. It was the steps to start working on a project as a consultant."

At the same time he took the consulting role, Farkas took a job with Quintiles, a clinical research company that works for biotech and pharma companies throughout the globe. But his role with the Spurs would eventually evolve from a consulting gig into the full-time position he holds today. It's a job that suits Farkas perfectly. According to Farkas, who followed his M.E.M. with a master's in statistics at Columbia, his time in the M.E.M. program was invaluable, with classes at both Thayer and Tuck having rounded out his education. In fact, he says, he still consults materials from his classes to help him with his day job.

Making that fateful trip to Boston was certainly a gamble for Farkas. But he's reminded each morning why it was worth it.

"There's no reason why I shouldn't wake up every day with a big smile," says Farkas. "I've been able to take my two biggest loves—besides family, of course—and use them in a way that is actionable."

—Andrew Clark

thayer notes

1950s

John Kennedy '53 Th'54: The major recent activity in engineering that I have been involved with is Junior Solar Sprints (JSS). I prepared an exhibit on JSS earlier this summer at the Hopkins Center, where there were several other Thayer alumni displays as well. I have been assisting the students from Kelly Middle School and Teacher's Memorial Middle School, both of Norwich, Conn., in participating in the Norwich JSS program by teaching them the scientific and engineering principles involved in model solar car design as well as helping them fine-tune their cars for maximum performance. JSS is a U.S. Army Educational Outreach Program for middle school students.

1960s

Fred Mansfield '69: I went to Stanford in 1969 on a fellowship from Fairchild Camera and Instruments and finished the program for a master's in electrical engineering. I then worked on the San Francisco peninsula for three years at a series of jobs focused on design of digital controllers for analog systems and mechanical processes. At the end of that time (even before microprocessors would have made me obsolete), I reckoned that my half-life as a designer was less than 10 years, so I went to Harvard Medical School and became an orthopedic spine surgeon. I loved designing digital controllers, but I love being a surgeon as well.

1970s

Steve Askey '76 Th'77: I'm now semi-retired. I bought a house in Florida and rotate back to Houston two weeks on and two weeks off. I'm a contractor at BHP Billiton in Houston, an international exploration and production company. I'm in a global role as quality assurance engineer for "smart tools," such as electric line logging, measurement and logging while drilling, and any other equipment making sophisticated measurements down-hole as part of the drilling and completion operations. I continue to travel globally as needed, which is getting old, like me!

Will Fraizer '78: In March 2014 I started a new work assignment as Gorgon commissioning and startup (CSU) technical manager. I am continuing with Chevron's large grassroots liquefied natural gas (LNG) projects that are being built in western Australia. However, I've moved from the Wheatstone Project back to the Gorgon Project. The Gorgon Project involves developing two major offshore natural gas fields off the northwest coast of Australia, through a subsea production system, with pipelines transporting the produced hydrocarbons to Barrow Island, where a three-train LNG plant is being completed. I worked on the Gorgon Project previously, during the concept selection and early engineering stage, when I was living in Perth, Australia, a few years ago. My new position involves managing the engineering function during the commissioning, startup, and initial operation of the Gorgon facilities as well as leading the CSU technical team, a group with more than 20 engineering and coordinator positions.

1990s

Ed Evans '91: I am an associate professor of chemical and biomolecular engineering at the University of Akron in Ohio, working on several material systems, most of which fall into the category of ceramics, ceramic coatings, and ceramic composites. We are currently focused on carbon/carbon and metal oxide composites for high-temperature applications.

2000s

Alex Streeter '03 Th'05: For the past five years I have been working at DEKA Research and Development Corp.—FIRST Robotics founder Dean Kamen's company—in Manchester, N.H. For most of that time I have been a junior systems engineer for the Luke Project: a Defense Advanced Research Projects Agency-funded program to develop a revolutionary prosthetic arm. Our arm has been used by dozens of amputees. Our third-generation design, which has many features never seen in a prosthesis, recently received FDA approval. We are working hard to bring

it to market for amputees—both veteran and civilian—who need it.

Daniel Hassouni '05 Th'05: I got married to **Sarah Isbey '08** in May. Among several Dartmouth grooms-men were two fellow engineers, **Matt Guernsey '05** and **Colin Murray '04 Th'05**. Sarah moved to Denver to begin her medical residency in pediatrics. I have continued working for DC Energy in the D.C. metro area, but will head to Denver soon. I hope to stay involved in the energy sector.

Colin Ulen Th'05: My wife, Melissa, and I spent a wonderful week with 60 of our closest friends and family getting married outside Lucca, Italy, in an old country villa. We returned to Boston to sell our condo and buy a great house in Cambridge, Mass., to start our life together. I've recently been promoted to director of engineering, hardware, for Alarm.com, a company I joined as employee No. 18 and engineer No. 3 that has since grown to more than 300 employees. We are the largest provider of connected home awareness and security over cellular and are starting a huge international push that is keeping me plenty busy.

Himanshu Chhabra Th'07: I have kept to M.E.M.'s theme of being cross-disciplinary and rather broad. I'm currently work for the consulting wing (sales and services) of an engineering and electronics conglomerate and am involved with software and process platforms aimed at facilitating engineering and discrete manufacturing, primarily for industrial, power, automotive, aerospace and defense, marine, electronics, and healthcare sectors. My role involves business consulting, process consulting, product consulting, and technical delivery. I live with my spouse, a Dartmouth Medical School alum, and two kids in MetroWest (Boston suburbs).

Akash Shah Th'08: I'm working as project manager with Thermax, an Indian efficient power conversion company focused in energy, environmental, and water solutions. My projects are steam generators for refineries and chemical and fertilizer plants. My role involves managing the project from receipt of order till final commissioning and handing over. My M.E.M. coursework has helped me a

lot in understanding project finances and execution. I have also been able to improve my project execution and decision making by analyzing different options in an effective manner.

Christopher Koppel '09: I just completed four years of service with the Army and I am back in engineering. I took a supervisor role in Abiomed's mechanical engineering department in Danvers, Mass. I also married **Carolyn (Rippe) Koppel '10** in July.

2010s

Jan Gromadzki '10 Th'11: I've been working at UGE, a cleantech company based in New York City that provides distributed wind and solar renewable energy solutions for leading global enterprise customers. UGE was founded only six years ago but has already installed solutions in more than 90 countries. The company is young and dynamic, made up of professionals who are truly passionate about making the world a better place and empowering people with clean energy solutions. In many ways, it reminds me a lot of Thayer, and I love it. I have had the opportunity to take part in many facets of the engineering team's endeavors: cutting-edge development on vertical-axis wind turbine technology, designing integrated off-grid lighting and electric vehicle charging solutions, and traveling internationally to manage first-time installations for high-profile clients. During the past year, I have been leading the engineering efforts in pioneering the development of a cost-effective, reliable, and sustainable off-grid streetlighting platform powered by the wind and sun. We've achieved a solution that's 50-percent cheaper and five times as reliable as your conventional grid-tied streetlight. We've already rolled out several successful projects and are in the process of scaling the technology to a global level. The success has also led to several speaking opportunities, including one at the World Summit for Small Wind in Germany, and being selected to teach a course on off-grid street-lighting at Lightfair International in Las Vegas, one of the world's largest lighting trade shows.

Nathalie Rivest '10: I'm living in

D.C. and working as an operations business analyst for McKinsey & Co.

Caitlin Johnson '10: After three years at Navigant, I left my job in energy consulting to pursue my lifelong dream of becoming a high school physics teacher! I just began a one-year master's program at Boston University and am loving it so far.

Christabell Makokha '11: I moved back to my home country, Kenya, and work with Dalberg, a strategy consulting firm that specializes in global development. I recently hiked Mount Kilimanjaro, the highest in Africa, with three other Dartmouth alumni.

Julianne Scheiman '11: I am a mission integrator at SpaceX, Elon Musk's private spaceflight company. I'm responsible for ensuring our payload is well integrated with the rocket (I make sure we don't break the satellite, like shake or bake it too much) and we're meeting our customer's needs. I'm also responsible from a project management perspective for a launch, ensuring we're meeting our aggressive schedules. And I'm responsible for our customer relations and am their main point of contact. I work on NASA science satellite missions, whether it's managing a mission we already have on contract or working with the government to win new business. It's a fun time to be in the launch business, especially at SpaceX. I'm loving my job and my return to out-of-this-world pursuits.

Garrett Simpson '11: This past summer I, along with two group members, built a web app to help people keep track of what their elected representatives were doing in Congress (floating-chamber-2899.herokuapp.com.) This was for the final project of a four-week intensive Ruby/Rails bootcamp through iXperience in Cape Town, South Africa. The source code can be found at github.com/discotroll65/mouse_hunter. The second half of iXperience is a four-week internship with a local rails shop in Cape Town. I've been interning at Siyelo, getting more experience with Rails, jQuery, and test-driven development. Between January 2012 and June 2014—after graduating with a degree in mechanical engineering in 2011—I bounced between New Delhi, N.Y.C., and Mumbai, working at PharmaSecure, a venture-backed U.S. startup that operates in India.

Tim Vanderet '11: I just finished my second year at Amazon working as a product design engineer.

So far I have worked on the Kindle Fire HD 8.9-inch and the Kindle Fire HDX 7-inch. I've been working as the product design lead on a confidential project that is set to release by the end of the year. I've been enjoying my job and all of the challenges it brings. The work requires frequent travel; I have flown to China 15-plus times. While I miss my time at Thayer, the transition to a career has been very exciting.

Sharang Biswas '12: I'm pursuing a master's at the Interactive Telecommunications Program at Tisch School of the Arts at NYU, where I'm combining my artistic, scientific, and design skills into a number of different projects. Recently I performed a piece titled *Transparency*—"an improvised live-drawing and storytelling performance featuring true anecdotes from the lives of the performers, told in a stream-of-consciousness style"—at the Museum of the Moving Image in Queens along with partner Clio Davis. I also showed an experimental play called *Treason* at the Brick Theater in Brooklyn. Along with three other teammates, I'd been developing the piece since December, with help from the Tisch Graduate Student Organization interdepartmental grant that we'd won. *Treason* is an espionage-themed, multimedia, interactive experience with improvisational performances, role-playing games, and audience participation. I'm not in engineering, but I'm definitely applying the design and technology skills I gained at Thayer!

Wiley Dunlap-Shohl '12: I started a Ph.D. at Duke University, where I will focus on the development of novel photovoltaic materials and devices.

Awais Malik '13 Th'13: I am pursuing a Ph.D. in civil engineering at NYU.

Joe Zabinski Th'13: Since graduating from Thayer with my M.E.M., I spent some time working in the energy industry in the Boston area. I'm now starting a Ph.D. in operations management at UNC Chapel Hill's Kenan-Flagler Business School, where I'll focus on how energy production and consumption affect business operations.

obituaries

Obituaries for the following alumni are online at dartmouththengineer.com:

Hamilton "Ham" Chase '47 Th'49
John Edward Joyce Jr. '47 Th'49
Paul J. Barnico '49 Th'51
Robert E. Fiertz '51 Th'52
Louis Charles Semprebon Th'61
Aaron D. Powers '93



on the job

1. Sharang Biswas '12 is developing artistic pieces while pursuing a master's degree at the Interactive Telecommunications Program at Tisch School of the Arts at NYU.

2. Jan Gromadzki '10 Th'11 was involved in a renewable energy installation in Bangalore, India, through his work with cleantech company UGE.

3. Alex Streeter '03 Th'05 works at DEKA Research and Development Corp. as a junior systems engineer on the Luke Project, a Defense Advanced Research Projects Agency-funded program developing a revolutionary prosthetic arm.

Inventions

ELECTRIC LIGHT

>> INVENTOR:

MOSES FARMER, CLASS OF 1844

Had Thayer School been around when Moses Farmer, Class of 1844, was a Dartmouth student, the prolific inventor surely would have been one of the school's most celebrated alumni.

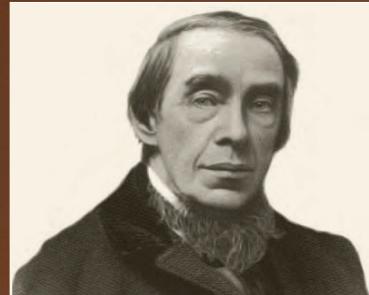
Farmer's inventions include the electric fire alarm and the electric trolley. His enduring legacy, however, is the work he did with electric lighting. In 1859, decades before Thomas Edison electrified the nation, Farmer had electric lights in his Salem, Mass., home.

Moreover, it was Farmer who inadvertently inspired Edison's successful experiments with the light bulb. Edison had dabbled with electric lights for years without success and had pretty much given up—until he visited Farmer's lab in 1878.

"I believe I can beat you making the electric light," Edison told his host.

The tour had been a revelation. "I saw for the first time everything in practical operation. I saw the thing had not gone so far...that I had a chance," Edison wrote.

The two inventors took different approaches. Farmer, a member of the Spiritualist Church who believed that his talents were gifts from God and should not be commercialized, had factories in mind when he experimented with lighting systems. He



built massive arc lights powered by an on-site dynamo that illuminated thousands of square feet of manufacturing space. Edison, who calculated the moneymaking potential of what he invented, devised a profitable system by thinking small. He imagined an electric system in which a homeowner could turn on a single light powered by metered electricity from a centralized power plant. When Edison restarted his experiments using a new self-exciting dynamo invented and built by Farmer, venture capitalists took notice.

Although Moses Farmer pioneered many electrical applications, he is largely unknown today because he routinely plunged ahead with new technologies rather than perfecting saleable products. He never got rich, though he made some money selling his patents to the likes of Westinghouse and Edison. Farmer died at the 1893 Chicago World's Fair preparing his inventions for exhibition. In 2006 he was a posthumous inductee into the National Inventors Hall of Fame.

—Lee Michaelides





Random Walk

For six weeks in June and July, Dartmouth hosted 25 young African fellows as part of President Obama's Young African Leaders Initiative (YALI) Washington Fellowship program. The group of rising stars came to Dartmouth for advanced training in business, entrepreneurship, civic leadership, public management, and a two-week design-thinking workshop at Thayer with Professor Peter Robbie. YALI participant Chedi Festo Ngulu, who is from Tanzania and founded MegaMark Communications, said, "What really made me apply for YALI is the speech that President Obama did in Johannesburg. It was such a powerful, moving, and on-point speech. What stood out was the faith that Africa, if empowered, if given a chance, has the opportunity to build itself. I was like, this is not something that I'm going to miss." The design thinking segment stood out for Ngulu. "This design thinking was a reflection of the entire process. It goes back to thinking about: What is a problem? How do you approach it? How do you think non-linearly instead of the linear process that we are so intuitively used to. It showed me the gaps that we miss, and how I can go back and do things better than the way we used to do," he said. "I'll tell you what Africa needs now. It's not that we don't have educated people. We need the out-of-the box thinking to look at our problems and say, 'Why do we keep doing the same approaches and failing?' It's about approaching things differently so we can have different outcomes."

PHOTOGRAPH BY KATHRYN LOCONTE LAPIERRE

THAYER SCHOOL OF ENGINEERING
DARTMOUTH COLLEGE
14 ENGINEERING DRIVE
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