DARTMOUTH Engineer

WINTER 2016

THAYER SCHOOL OF ENGINEERING

MEET MVP

THE STUDENT-CREATED MOBILE VIRTUAL PLAYER SIMULATES TACKLING TO REDUCE THE RISK OF CONCUSSIONS ON THE GRIDIRON.

inside

NEW STUDY ABROAD PROGRAM • DECODING THE IMMUNE SYSTEM • ALUMNI PATENTS

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Commitment and Creativity

JOSEPH J. HELBLE | DEAN

LATE ONE AFTERNOON, EARLY IN MY FIRST YEAR AT Dartmouth, I was walking outside Cummings Hall while the MacLean Engineering Sciences Center was under construction. Parts of the Cummings lawn were surrounded by fencing, and construction materials and debris were scattered about. A student I had met once or twice before fell in alongside me, and as I said hello, I gestured to it all—the fence, the covered lawn, the construction materials, and the noise—and asked her what she thought. I was asking about this disruption to her daily routine, to the daily routine of all of our students—something I think about a lot these days as we approach a major expansion of Thayer's faculty, programs, and facilities. Her answer, which I have never forgotten, made it clear that she saw things differently: "I find them inspiring."

By "them," of course, she meant the words of Sylvanus Thayer, literally carved in stone on the side of Cummings (and now MacLean) and visible through the clutter of that day: "To prepare the most capable and faithful for the most responsible positions and the most difficult service."

Responsibility. Service to society. An embracing of the most difficult challenges. These are usually not the first words that come to mind when one describes an engineering school, but these are the words that have guided the Thayer School for nearly 150 years—words that this Thayer community continues to hold as central to our purpose.

Today another word also comes immediately to mind when I think about the Thayer community: creativity. Our faculty, students, and alumni exercise extraordinary creativity in devising novel solutions to address fundamental human needs. My firm belief is that this creativity stems naturally from the commitment General Thayer's words instill in us: the commitment to see beyond the immediate, to embrace the world's needs as our own, and to use our skills, our knowledge, and our insights to improve the human condition.

When I look around the Thayer School of Engineering today, I see this outward-focused creativity embodied in all that we do. It is abundantly evident in our students, in their capstone design projects, which address immediate real-world challenges, or in our ENGS 21: Introduction to Engineering projects, which focus on a different open-ended societal challenge each term. It is evident in the work of our faculty, from our youngest colleagues, such as Margie Ackerman, developing vaccines to address devastating disease, or Jifeng Liu, developing novel solar materials to capture light more efficiently, to more senior colleagues such as Eric Fossum, developing new ways to sense and image where there is almost no light. And it is so clearly evident in the accomplishments of our alumni, with countless innovators, inventors, and entrepreneurs among those who have called Thayer School "home."

Creativity abounds today in every corner of this School. I have no doubt that General Thayer would be proud.

"For six months an experimental motorcycle shared the large frame lab with Dartmouth Formula Racing and turned a lot of heads," says Professor Douglas Van Citters. Page 15

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Left to right, David Drennan Th'09, Adam Danaher Th'09, Laura Weyl Th'08, and Kyle Lobisser Th'09 developed a speed-controlled pivot-lock mechanism to prevent a three-wheeled motorcycle from overturning.

PHOTOGRAPH BY JOHN SHERMAN

COVER: Left to right, Noah Glennon Th'14 '15, Andrew Smist '13 Th'14, Elliot Kastner '13 Th'14 '15, advisor John Currier '79 Th'81, and Quinn Connell '13 Th'14. Photograph by John Sherman.

BACK COVER: Scanning electron microscope view of a biomaterial scaffold. Image by PhD candidate Fioleda Prifti Kesseli.

THE Great Hall

NEWS FROM AROUND THAYER SCHOOL

CITY SCAPE Thayer students will be able to explore Copenhagen while studying at the Technical University of Denmark.

CURRICULUM

Danish Foreign Exchange Program

THAYER WILL LAUNCH A NEW FOREIGN exchange program for undergraduates at the Technical University of Denmark (DTU) in the fall of 2016 and is considering adding a fourth program in Melbourne, Australia, in 2017. Thayer currently runs exchange programs for engineering majors with Chulalongkorn University in Bangkok, Thailand, and the Chinese University of Hong Kong and a program for BE students with the Helmut Schmidt University in Hamburg, Germany.

"One of the reasons we pursued new exchange programs is that we've had more of demand than we've had space available," says Assistant Dean for Academic and Student Affairs Holly Wilkinson, who oversees Thayer's international programs with Professor Benoit Cushman-Roisin. Says Wilkinson, "We had an overwhelming interest in starting an exchange program in Western Europe." Of the 22 students who attended Thayer's study abroad information session during Fall Term, she reports, 18 students already indicated they'd like to attend DTU, which offers a wide range of engineering disciplines—including sustainability, a popular area of study among Thayer students.

The new program will also build another kind of international experience: bringing several Danish students a year to Thayer.

—Anna Fiorentino

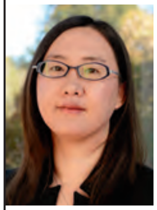
NEW OVERSEERS

Catherine Sellman '93 has joined Thayer's Board of Overseers. She is founder and portfolio manager of Aperimus Capital in Marina Del Rey, Calif. After a career in environmental engineering, she began her investment career in 2000 at Barrington Partners in Santa Monica, Calif. In 2005 she joined Atlas Capital, based in Dallas, Tex. She founded Aperimus in 2008. She holds an AB in engineering sciences from Dartmouth and an MBA from the Anderson School of Business at UCLA, where she guest lectures on finan e and accounting.

Andrew K. Silvernail '94 has joined Thayer's Board of Overseers. He is chairman and CFO of IDEX Corp. Previously he held senior leadership roles at Rexnord Industries, Newell Rubbermaid and Danaher Corp. He began his career as an equity research associate for Fidelity Investments. He is a director of Stryker Corp. and MacLean-Fogg Co. and a trustee for the Manufacturers Alliance for Productivity and Innovation. He holds an AB in government from Dartmouth and an MBA from Harvard Business School.

NEW FACULTY

Amro Farid has joined Thayer as a tenure-track assistant professor. For the past fi e years, he taught at the Masdar Institute of Science and Technology in Abu Dhabi. He holds BS and MS degrees in mechanical engineering from MIT and a PhD from the University of Cambridge. His research focuses on the application of control, automation, and information technologies to intelligent energy systems.



Fiona Li has joined Thayer as a tenure-track assistant professor. She holds BS and MS degrees in chemistry from Nankai University in China and earned her PhD in biomedical engineering from Washington University. Her research focuses on energy materials, including battery technologies.

Geoff ey Luke has joined Thayer as a tenure-track assistant professor. He holds a bachelor's degree in computer engineering and mathematics and an MS in electrical engineering from the University of Wyoming and a PhD in electrical engineering from the University of Texas at Austin. His research focuses on biomolecular imaging.

Geoff Parker will join Thayer in June as a tenured full professor and director of the Master of Engineering Management program. Parker, who holds a bachelor's degree from Princeton and a PhD from the MIT Sloan School, currently teaches at the School of Business at Tulane University.

Q&A

Professor Rahul Sarpeshkar

Rahul Sarpeshkar joined Thayer this year as a tenured full professor. He is also a professor in Dartmouth's physics department and in Geisel School of Medicine's microbiology and immunology department and physiology and neurobiology department. He is the inaugural holder of the Thomas E. Kurtz Chair in Dartmouth's new Neukom Cluster in Computational Science, which will explore the computational and engineering principles of intelligence.

Sarpeshkar earned undergraduate degrees in electrical engineering and physics from MIT and a PhD in computation and neural systems from the California Institute of Technology. Prior to coming to Dartmouth he taught at MIT's Department of Electrical Engineering and Computer Science.

>> What drew you to Thayer School?

I liked the fact that Thayer is one unified and interdisciplinary school of engineering with superb faculty. I believe that the future of engineering will again be what its past was: a truly integrated renaissance art form. Dean Helble was open and encouraging of my desire to have appointments in schools outside engineering and to build bridges between engineering and these schools, which I found to be very refreshing and enlightened.

Is there a common thread to your various areas of expertise and affiliation?

Everything I am interested in or do ties back to the unifying and universal language of analog circuits and analog computation: analog circuits within atoms or molecules (quantum computing/biochemistry), analog circuits of molecules within living cells (synthetic biology), or analog circuits of transistors within supercomputing chips or within medical devices (bioengineering).

What are your current research priorities?

I am focused on applying analog circuits and analog computation to various medical applications, as well as advancing the fundamental science of biological circuit design, which is in its very early stages.

Is there a major challenge you are trying to solve?

The core challenge in all of the problems that I work on is about computing efficiently and robustly with noisy and unreliable parts. The solution to this challenge requires sophisticated feedback loops and error correction as well as collective analog and mixed-signal computation that artfully exploits physics and chemistry to compute. Nature has already solved this challenge, and we need to learn from her.

What courses are you most looking forward to teaching?

I am excited about originating a course that will unify electronic and biological circuit design through common fundamental physical laws of thermodynamics. I'd like to show students how they can design experimental circuits with transistors that are almost identical to those that they build with DNA-protein molecules in actual living cells.

Is there anything else you'd like to add?

I enjoy the friendly, supportive, and highly collegial atmosphere at Thayer, which is amazing at all levels. The beautiful countryside constantly connects me with nature and is calming. My family and I are very happy to be here!

"I believe that the future of engineering will again be what its past was: a truly integrated renaissance art form."

OPPOSITE PAGE: LEFT, IBRAHIM50/CREATIVE COMMONS. CENTER, TOP TO BOTTOM: COURTESY OF CATHERINE SELLMAN, COURTESY OF ANDREW SILVERNAIL. RIGHT, TOP TO BOTTOM: COURTESY OF AMRO FARID, KATHRYN LAPIERRE, KAREN ENDICOTT, COURTESY OF GEOFF PARKER. THIS PAGE: KAREN ENDICOTT

Kudos

SELECTED Sherman Fairchild Professor of Engineering **Ian Baker** has been selected as a 2015 Fellow by the American Association for the Advancement of Science, the world's largest general scientifi society and the publisher of the journal *Science*. Baker is cited "for distinguished contributions to fundamental understanding of structure-property relationships in materials, particularly high-temperature austenitic alloys, ice sheet fabric formation, and nanoparticle development for cancer treatment."

ON DISPLAY **Professor Eric Fossum's** CMOS image sensor is on display at the Smithsonian National Museum of American History's *Inventing in America* exhibition. The CMOS image sensor, part of virtually all cell phone cameras, shares the stage with such other innovations as the fi st Apple computer, the telegraph, the telephone, and the incandescent lamp. The display continues through 2020.

AWARDED **Professor Jifeng Liu** and his research team have received a U.S. Department of Energy SunShot Initiative award for a lower-cost, effici t alternative to conventional solar-panel construction. A novel metal nanostructure and ceramic matrix developed by Liu's team provides optimal spectral selectivity and long-term antioxidation protection without the need for costly vacuum deposition. Liu and his team will collaborate with Norwich Technologies, led by **Troy McBride Th'01**, to scale up the technology.

RAISED Biotech startup Alector, cofounded by **Professor Tillman Gerngross**, raised $32 million for early-stage work in harnessing the immune system to fig t neurodegenerative diseases such as Alzheimer's. According to Alector.com, the "strategy is to effici tly generate and validate antibody drugs that engage key disease-altering, genetically-validated neuro-immune targets. Alector's approach is enabled by a strategic alliance with Adimab, the technology leader in the discovery of fully human antibodies and bispecifics" Adimab was also cofounded by Gerngross.

OUTREACH As 2015–16 Schweitzer Fellows, engineering students **Madeleine Yi '18** and **Juergen Buchsteiner '18** are helping elementary students in Norwich, Vt., explore engineering through Junior FIRST LEGO League.

I Want One of Those!

Left to right, William Romness '18, Brett Seeley-Hacker '18, Christopher Vale '18, Trammell Saltzgaber '18, and Andrew Werchniak '18 display the BivyPac.

STUDENT PROJECT

THE BIVYPAC

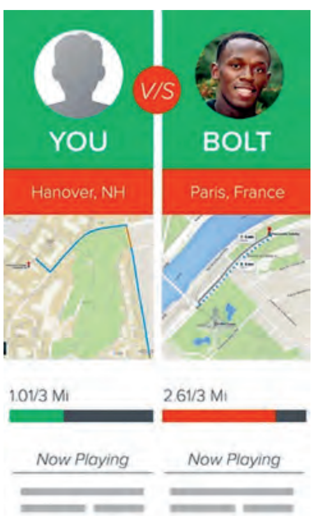
Backpackers, backcountry skiers, and alpine climbers take note: portable shelters just got trimmer. Part bivy sack and part backpack, the BivyPac weighs a feathery 16 ounces—half the heft of a normal bivy sack—yet holds as much gear as a standard packpack. The BivyPac's inventors, William Romness '18, Brett Seeley-Hacker '18, Trammell Saltzgaber '18, Christopher Vale '18, and Andrew Werchniak '18, have filed for patent protection. They also won the Phillip R. Jackson Prize for outstanding performance in ENGS 21: Introduction to Engineering. Their teaching assistant was Prajan Divakar '16, who is now a PhD student at Thayer.

Great Idea

STUDENT PROJECT

APP: BANDRUNNER

Imagine a competitive running IOS/Android app that allows two or more users to connect their smartphones and compete with one another in real-time. MEM student Qurat Rafiq and three Dartmouth computer science grad students created the app, which won second place in the Dartmouth Entrepreneurial Network's Pitch competition in November. "The idea of BandRunner started with Hack Dartmouth II, in which our team won the first prize as well as the sponsor prize by Microsoft for using their product, the Microsoft Band," says Rafiq. The running app may have legs. "The team will definitely take it forward and are in talks with Microsoft, who is very interested to see it in the app store some day and succeed," she says.



Hilary Johnson '15 leads a design workshop in Ghana.

OUTREACH

Teaching Human-Centered Design in Ghana

HILARY JOHNSON '15 AND GURKARAN SINGH '15 FOUND a new application for critical thinking and problem-solving skills: promoting peace.

Johnson, an engineering graduate who is now a design fellow at Thayer, and Singh, who majored in economics modified with engineering and minored in human-centered design, taught human-centered design to high school girls in Accra, Ghana. "Girls around the world experience violence because of not being able to educate themselves and because of early marriage. Educating and empowering these young women leads to peaceful and sustainable communities," says Johnson.

The project was spearheaded by Regina Agyare, a Ghanaian who participated in the 2014 Young African Leaders Initiative (YALI) program at Dartmouth, where she learned human-centered design from Professor Peter Robbie '79. After YALI, Agyare sought Dartmouth students to teach in the Tech Needs Girls mentoring program she started.

Enter Johnson and Singh, both of whom had built strong foundations in human-centered design through ENGS 12: Design Thinking and ENGS 75: Product Design. Spending three weeks in Accra, they ran after-school workshops that immersed 32 girls in empathizing with users, identifying problems, mapping resources, and prototyping.

"Our task was to help the girls unlearn the notion that asking questions is bad and unlock the creative confidence that they already had," says Singh. "We cheered on their failures, just as much as their successes."

The experiential learning clicked for their students. "They were ingenious and clever with milk cartons, with scraps fabric that they'd gotten from a seamstress down the street, with pieces of twine that they had found. They built prototypes addressing needs," says Johnson. "That was a really magical moment for us and for the girls because they realized that they were actually rich with resources all around them that they could use to create real change."

Johnson and Singh also taught interviewing skills, introducing the girls to the "five whys" technique: asking "why" five times to elicit a series of answers that point to the core of a situation. The following day a student named Patience described using the five whys to discover that a girl she met on the street was an orphan who needed help. "Patience talked to her pastor and found the girl a space at the orphanage—found her a place to live, an education, and regular food. And it was just because she simply decided to stop and ask a random girl on the side of the road 'why?' " says Johnson. "That was a stunning moment for us—realizing how compassionate and easy it is to create change when you're willing to step outside of your box and comfort zone."

—Kathryn Lapierre

Investiture speaker Steven Chu

OPPOSTIE PAGE: LEFT, KATHRYN LAPIERRE; CENTER, COURTESY OF BAND RUNNER GROUP; RIGHT, COURTESY OF HILARY JOHNSON. THIS PAGE: MARK WASHBURN

Class of 2015

THAYER'S GRADUATING CLASS was honored at Investiture, held June 13 at the Hopkins Center, with Dean Joseph J. Helble presiding over the presentation of hoods, caps, and awards to 153 recipients of BE and graduate 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 former U.S. Secretary of Energy Steven Chu, Professor of Physics and Molecular & Cellular Physiology at Stanford and co-recipient of the 1997 Nobel Prize.

"I love being a scientist. I love being a professor," Chu told the audience. "Why was I willing to take on the directorship of the Lawrence Berkeley National Laboratory and the role of secretary of energy?"

The answer, he said, was easy: "I, as a citizen, was increasingly concerned about climate change and felt that science, engineering, technology, and innovation were going to be the key ingredients to get us to a path of sustainability." He related how at the Lawrence Berkeley Lab he thought, "Maybe I can convince some really outstanding scientists and engineers to get excited about this." Later, as Secretary of Energy, he launched the Advanced Research Projects Agency-Energy (ARPA-E) to inspire big thinking. "We started this with the idea that we didn't want to fund incremental work. We wanted to fund things that could be transformational. That means instead of funding singles, we wanted to fund game-changing home runs. But we knew that if you swing for the fences, you're going to strike out more. We fully expected that 90 percent of the projects would fail. We value your brave attempt."

To the students he said, "You have the opportunity to go out there and make the world a better place and help save the world because many of your skills will be needed for sustainability and climate change." And he urged them to think big. "You should go out there and take risks and don't be afraid of failing. If you're going to fail, fail fast and move on," he said.

"When you look back when you're old and gray like me and you see what you've been and the choices you've made, you want to be in a position where you say: I like the choices I made, I was willing to take risks, and you were willing to do things that you felt were meaningful and can really help the world as well as you and your family."

ENGINEERING GRADUATES

12
Doctor of Philosophy

8
Master of Science

51
Master of Engineering Management

82
Bachelor of Engineering

77
Bachelor of Arts in Engineering Sciences

Kudos

AWARDED The National Institutes of Health awarded $1.4 in funding to DoseOptics, a company founded by **Professors Brian Pogue** and **Scott Davis** that has developed an imaging technology for real-time visualization of radiation therapy as it is administered to cancer patients. Pogue and Davis will conduct clinical trials at Dartmouth-Hitchcock Medical Center.

NOTED An engineered variant of the antibacterial enzyme lysostaphin—developed by **Professor Karl Griswold** and his team—may treat methicillin-resistant Staphylococcus aureus (MRSA) infections more effectively than a non-engineered version. The "engineered enzyme holds promise for inciting a less-severe immune response when treating MRSA infections," according to *Chemical & Engineering News*.

CITED Research conducted by **Professor Vikrant Vaze** was cited by a recent National Science Foundation report on how operations research (OR) can help address the nation's "grand challenges" in engineering. "Overall, OR models help in understanding human decision-making and in creating incentives for the individuals to take actions that will benefi them and the society at the same time," Vaze says. His latest research, conducted with MIT, looks at flig t delays caused by the U.S. Department of Transportation's 2010 Tarmac Delay Rule, which was designed to protect passengers from sitting on the tarmac for more than three hours. He and his colleagues found that the rule did reduce long tarmac delays but increased flig t cancellations, which in turn added to passenger delays. Vaze and his colleagues recommend upping the tarmac time limit to 3.5 hours, only applying the rule to flig ts scheduled to depart before 5 p.m., and redefi -ing tarmac time limit to refer to when a plane returns to a gate rather than when passengers deplane. The research appears in *Transportation Research Part A: Policy and Practice*, Volume 83.

NOTED Engineering major **Catherine Berghuis '16** is leading Dartmouth's varsity women's hockey team this season as captain. As of the end of fall term, the forward had already played 103 career games.

lab reports

FIELDWORK

Of Ice and Satellites

ICE EXAMINERS In trying to explain the apparent decline in the reflectivity of ice in northern Greenland, Polashenski, left, and Thayer PhD candidate Carolyn Stwertka, right, analyzed dozens of snow-pit samples.

FOR MILLENNIA, GREENLAND'S ICE SHEET REFLECTED sunlight back into space, but satellite measurements in recent years suggest the bright surface is darkening, causing solar heat to be absorbed and surface melting to accelerate. Some studies suggest this "dirty ice" or "dark snow" is caused by fallout from fossil fuel pollution and forest fires. But, according to a study led by Thayer adjunct professor Chris Polashenski '07 Th'07 '11, a research geophysicist at the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory in Hanover, degrading satellite sensors, not soot or dust, account for the apparent decline in reflectivity of inland ice across northern Greenland. The study, published in *Geophysical Research Letters*, suggests the ice sheet hasn't lost as much reflectivity as previously thought, and that black carbon and dust concentrations haven't increased significantly and are thus not responsible for darkening on the upper ice sheet.

Observations suggest the Greenland Ice Sheet's albedo—its ability to reflect the sun's energy back into the atmosphere—has declined considerably since 2001 due to black carbon and dust from increased industrialization and forest fires across the northern hemisphere. The apparent decline is greatest around the ice sheet's edges, but it also is occurring in the high elevation interior known as the dry snow zone, where the reflectivity is effectively reset each winter by new snowfall.

In trying to explain the apparent decline in reflectivity, Polashenski and his colleagues analyzed dozens of snow-pit samples from the 2012–2014 snowfalls across northern Greenland and compared them with samples from earlier years. The results showed no significant change in the quantity of black carbon deposited for the past 60 years or the quantity and mineralogical makeup of dust compared to the last 12,000 years, meaning that deposition of these light-absorbing impurities is not a primary cause of reflectivity reduction or surface melting in the dry snow zone. Algae growth, which darkens ice, also was ruled out as a factor. The findings suggest that the apparent decline in the dry snow zone's reflectivity is attributable to degradation of sensors in the aging NASA satellites that track land, ocean, and atmospheric features.

The study's findings don't apply to the ice sheet's lower elevations, where surface melting, soot and dust result in more pronounced declines in reflectivity and where warmer temperatures may promote algae growth that further erodes reflectivity.

—John Cramer

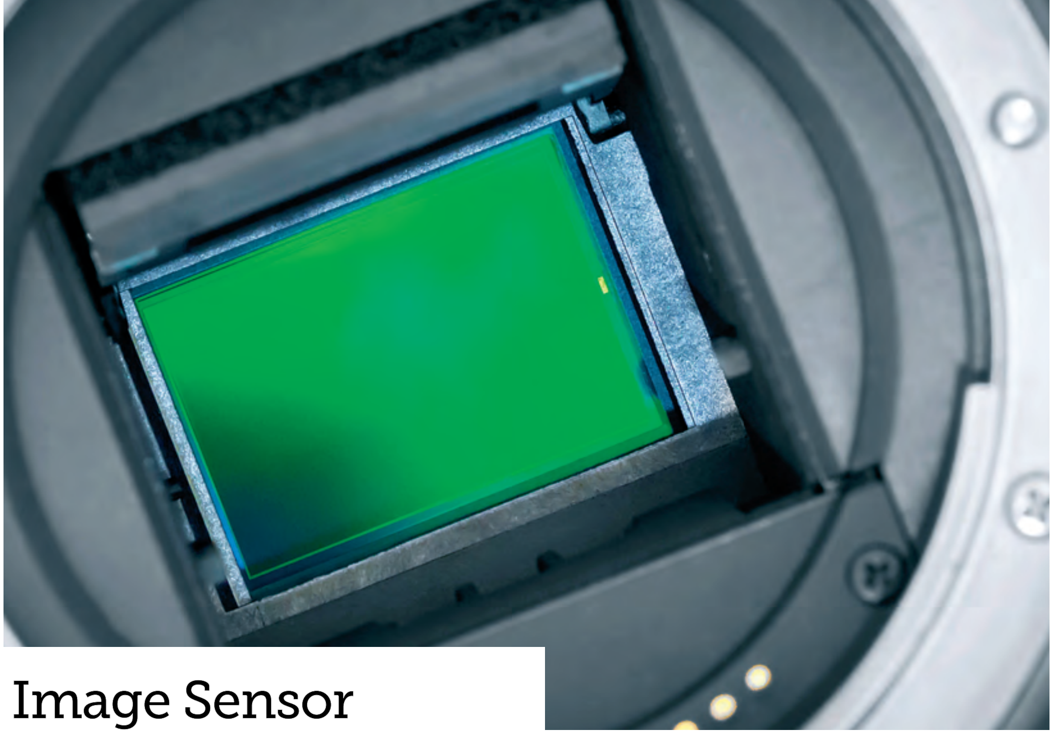


Image Sensor Breakthrough

IN A BREAKTHROUGH THAT MAY USHER IN the next generation of light-sensing technology with potential applications in scientific research and cell phone photography, Professor Eric Fossum and Thayer PhD candidate Jiaju Ma have developed a revolutionary Quantum Image Sensor (QIS) that can sense and count a single electron.

Fossum, inventor of the CMOS image sensor that is in billions of cell phone cameras, and Ma have worked together on the project for more than three years and shared authorship of a June 2015 paper on their invention, published in *IEEE Electron Device Letters*.

Their new sensor has the capability to significantly enhance low-light sensitivity. This is particularly important in applications such as "security cameras, astronomy, or life science imaging—like seeing how cells react under a microscope—where there's only just a few photons," says Fossum.

"When we build an image sensor, we build a chip that is sensitive to these photons. We were able to build a new kind of pixel with a sensitivity so high we could see one electron above all the background noise," he says.

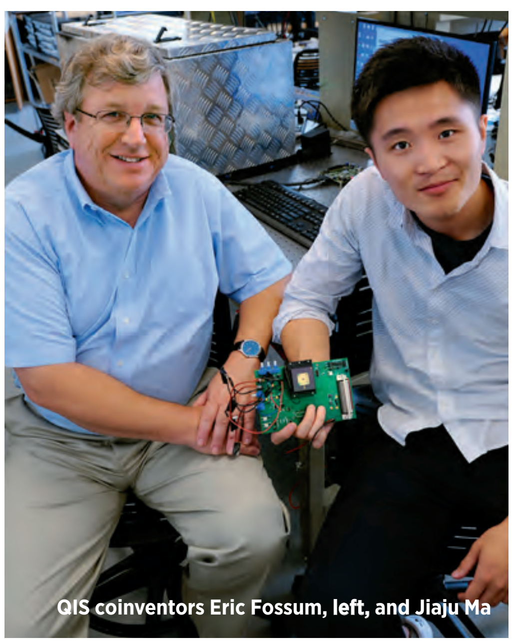
The new pixels are considerably smaller than regular pixels since they are designed to sense only one photon, but many more are placed on the sensor to capture the same amount of total photons from the image. "We'd like to have 1 billion pixels on the sensor, and we'll still keep the sensor the same size," says Ma.

These new pixels are able to sense and count a single electron without resorting to extreme measures, such as cooling the sensor to minus 60°C and/or avalanche multiplication. "Avalanche multiplication may be thought of as an electrically induced chain reaction, but the strong electric fields necessary lead to reliability issues, and it is difficult to make small pixels," says Fossum.

Fossum and Ma have kept industry in mind as they solved the QIS's technical challenges. "We deliberately wanted to invent it in a way that is almost completely compatible with today's CMOS image sensor technology so it's easy for industry to adopt it," says Fossum.

The QIS project has been funded by the Silicon Valley company Rambus Inc., where Ma has served as an intern during the past two years. "A company representative offered some extraordinarily high praise for him," says Fossum, "calling him a 'superstar intern.' We hope to continue our collaborations with Rambus in the future."

—Joseph Blumberg



QIS coinventors Eric Fossum, left, and Jiaju Ma

Imaging Chemo's Effectiveness

PROFESSORS SHUDONG JIANG, Brian Pogue, and Keith Paulsen are using an imaging technique called diffuse optical spectroscopic tomography (DOST) to enable quick assessment of breast tumor response to neoadjuvant chemotherapy given to patients to shrink tumors and reduce metastasis prior to surgery.

By measuring tumor hemoglobin and oxygen saturation levels—indicators of the presence of tiny blood vessels that cancer tumors need in order to grow—DOST can reveal whether the tumor is responding to chemotherapy. Knowing that a tumor is not responding could spare women from further chemotherapy and wasting months before moving on to surgery or other treatments.

"Today's standard cancer imaging techniques—MRI, mammography, and ultrasound—are based on tumor volume, which can require at least three months of treatment," says Jiang. "With DOST we are able to capture physiological variations in the tumor after only one treatment and potentially even before neoadjuvant chemotherapy treatment begins. This provides doctors with the information needed to better manage patient care at an early stage."

Jiang, Pogue, Paulsen and their team have used DOST to evaluate 19 patients at Dartmouth-Hitchcock Medical Center before, during, and after neoadjuvant chemo treatment. The imaging technique is noninvasive, does not use ionizing radiation, and does not involve costly instrumentation. The team is working on developing a portable and compact DOST system for use in clinical settings large and small.

OPPOSITE PAGE: LAUREN FARNSWORTH. THIS PAGE: TOP: BIGSTOCK. BOTTOM: KAREN ENDICOTT

Collaboration By Design

ENGS 89/90, THAYER'S CAPSTONE BACHELOR OF ENGINEERING PROJECT SEQUENCE, GIVES STUDENTS A FINAL TEAM-BASED, REAL-WORLD PROFESSIONAL EXPERIENCE IN ENGINEERING ANALYSIS, DESIGN, AND DEVELOPMENT.

THE FOLLOWING PAGES PRESENT A FEW OF OUR 89/90 PROJECT FAVES.

PHOTOGRAPH BY JOHN SHERMAN

ENGS 89/90

Students created the Mobile Virtual Player to simulate tackling and reduce injury risks for athletes.

Tackling Concussions

BY MICHAEL BLANDING

The sun is setting on Memorial Field, filling the sky with wispy pink clouds as the stadium lights cut through the twilight. As the football players take the field, dance music blares at top volume from speakers set up on the sidelines, pumping up the players before the fi al game of the season—a high-stakes championship bout against Princeton.

One player stays behind, pacing restlessly back and forth on the running track, before being called in for a drill. At last, he zips onto the field and takes up a position facing a line of hefty linebackers. The whistle blows and the fi st player barrels down the field, hitting him with a loud crack and dropping him to the grass. In a second, he's standing again, popping up like a Weeble and doing a theatrical little spin before facing down the next player in line.

Every year, emergency rooms treat 175,000 sports-related concussions in the United States, with the highest percentage from football. Research has shown that high school and college players suffer more concussions in practice than in games. Yet, this player seems unharmed by the hit. That's because "he" is actually a Mobile Virtual Player (MVP), a remote-control tackling dummy created by a group of Thayer students to simulate tackling without putting a real person at risk.

The device started its life as a Bachelor of Engineering capstone project in the fall of 2013 and has since appeared on CNN and NPR, as well as being featured on the *Late Show with Stephen Colbert*—where the host, comically dressed in helmet and pads over his suit, performed his own tackle of the five-foot-tall dummy. Inquiries have started coming in from NFL, college, and high school teams eager to use the equipment in their own practices to cut down on player injuries. "We defi itely saw the potential for this, and hoped it would take off," says Quinn Connell '13 Th'14, one of the students behind the project. "But I don't think anyone was expecting how quickly it would move forward."

Calling the plays on the field today is Dartmouth Coach Eugene "Buddy" Teevens '79, who has been a crusader for reducing injuries at practice—going so far as to ban full-contact practices back in 2010. Three years ago he was talking with his classmate John Currier '79 Th'81, a Thayer research engineer, about mechanical ways the team might simulate tackling. "We decided the most effective way would be to take it to the Thayer School and position it as a capstone project," says Currier, who reached out to Elliot Kastner '13 Th'14 '15, an engineering student and Dartmouth football player. He was enthusiastic about taking it on. "For the majority of my life, football and engineering have been living in separate worlds," says Kastner, clutching the MVP's remote control on the sidelines. "Now I got to see them come together."

Joined by Connell and fellow students Andrew Smist '13 Th'14 and

MOST VALUABLE PROJECT
Clockwise from left, Noah Glennon Th'14 '15, Andrew Smist '13 Th'14, Elliot Kastner '13 Th'14 '15, and Quinn Connell '13 Th'14 are taking their Mobile Virtual Player to market.

"IT WAS AN AMAZING EXPERIENCE," SAYS ELLIOT KASTNER, LEFT, OF APPEARING ON THE *LATE SHOW*, WHERE HE BANTERED WITH STEPHEN COLBERT, RIGHT, ALONG WITH BUDDY TEEVENS, CENTER. QUINN CONNELL PILOTED THE MVP ACROSS THE FLOOR OF THE ED SULLIVAN THEATER AS COLBERT DOVE IN FOR THE TAKEDOWN.

Noah Glennon Th'14 '15, the group blue-skied possibilities, considering all of the ways they could create something that would give players the experience of tackling while keeping them safe from injury—including drones, helicopters, and even using animals. "Should it float? Should it fly? Should it be shot out of something? We considered all of the possibilities," says Kastner.

Finally, they settled on taking the classic football tackling dummy—but updating it to make it mobile. As they started researching, they found that the football dummy had been invented in 1936 and hadn't been updated much since. The students interviewed players and coaches to fi ure out what they might be looking for, deciding on a humanoid form so players could practice proper form, leading with the shoulder rather than the helmet. They had players test different materials for tackling, zeroing in on a fi m foam for the base and a softer moldable foam, surrounded by a vinyl cover, for the top.

Early on, the students decided the dummy would need to be self-righting, preferably within two seconds of being tackled, in order to maximize the number of drills in practice. That presented particular design problems. "The whole balance of the weight was a big issue," says Smist. "We wanted to have enough weight in the bottom so it could stand up on its own and have enough weight in the top so they weren't flying through it."

The electronics they initially used in the drivetrain turned out to be too complex, constantly malfunctioning due to the repeated hits the MVP suffered. "It was defi itely a delicate balance of trying to fi d that performance we wanted and still making it robust enough to be repeatedly tackled," says Connell, adding, "How many engineering projects do people work on where the end goal is to make something that can be beat up?"

Kastner estimated that over three years of practices, the MVP would take 6,000 tackles. "My computer couldn't take 6,000 tackles," he says. Adding to the difficulty, the dummy had to be cheap enough that it could be mass-manufactured and affordable to college and high school teams working within limited budgets. "We could build a $10 million anatomic robot, but that wouldn't be that useful," says Kastner.

Currier was advising the project in a hands-off manner, letting students create their own design—and make their own mistakes. "There was one time when an early prototype was running around, and there was a fair amount of smoke coming out of it," he laughs. "They were really persistent in coming up with something that would work." By graduation in the spring of 2014, the team had completed a design and a number of elements but still didn't have a fully functioning prototype. Kastner and Connell decided to continue working on the project, spending the summer of 2015 in Hanover working on the project in space at Thayer, repeatedly iterating different ideas. At one point, they were trying to engineer a new motor for the drivetrain, and unable to fi d anything that would work. In one of those "aha!" moments, says Connell, "we looked at the drill we were using to put things together. In a half an hour we were using the drill, and it worked."

They ended up with a device that, for all of its bulk, is surprisingly agile. After the fi st tackle this afternoon, another linebacker charges ahead for his own takedown. But as he barrels down the field, the MVP skirts away from the attack, outrunning the player, who hits the turf empty-handed. The MVP does an extra spin, as if to drive home its victory.

One player who didn't miss his tackle with the MVP was Madison Hughes '14, who played rugby with Connell at Dartmouth before going on to captain the U.S. Olympic rugby team. Running into Connell and Kastner one day as they were testing their prototype, he made a short video of himself tackling the dummy and posted it online. Within 48 hours, the video had one million views, and suddenly the students' phones started ringing with media who wanted to interview the inventors and coaches who wanted to buy an MVP.

"It was an amazing experience," says Kastner of appearing on the *Late Show*, where he bantered with Colbert along with Teevens and watched Connell pilot the MVP across the floor of the Ed Sullivan Theater as Colbert dove in for the takedown. All the media attention, however, suddenly meant that the students couldn't continue to tweak the device in private. "The publicity has really put the pressure on us to get it out to the market fi st," says Kastner.

The four students worked on a business plan with Tuck MBA student Alex Jenny '10 Tu'16, a former Dartmouth quarterback, and gained advice from the Dartmouth Entrepreneurial Network. Then Teevens, Kastner, and Connell formed a company, Mobile Virtual Player LLC, to take the project forward.

Asked if he thinks the MVP will make him rich, Kastner answers with the diplomacy of a winning quarterback after a game, saying, "Protecting players is the most important thing."

In the meantime, the now-former students are refi ing their prototype. They showed it at the American Football Coaches Association convention in January, and they hope that beta versions of the MVP will hit the field for testing by other teams in the spring. They are also looking further ahead. Mobile Virtual Player LLC sponsored two new 89/90 teams this year to help develop the next generation of the robot. Advancements could include attachments for use in other drills—for example, a hoop that a quarterback could use to practice throwing—and more sophisticated electronics that would make the MVP self-driving. "Right now, it is remote control, but we are working on making it programmable," says Glennon. "Eventually, a team of four or five of them could all be programmed to run a certain drill together."

Sometime in the future, a team of MVPs may be able to play a football game by themselves. Until then, they'll have to content themselves with keeping their flesh-and-blood teammates free from injuries.

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

THIS PAGE: COURTESY OF THE LATE SHOW WITH STEPHEN COLBERT. OPPOSITE PAGE: COURTESY OF SAFAPANI

ENGS 89/90

Getting the Arsenic Out

Students pitch—and work to perfect—a prototype for removing arsenic from drinking water.

BY KIMBERLY SWICK SLOVER

With two minutes to make their pitch, two engineering majors stepped on stage to do what entrepreneurs and engineers do best: identify a problem and offer an effective solution. “Every day, 140 million people drink arsenic-poisoned water,” said Meili Eubank ’15.

As an image of a Nepali villager’s scarred, discolored hands—visible signs of arsenic poisoning—flashed on a large screen behind her, Eubank explained how the disease causes cancer and birth defects. Noting that just 20 percent of household wells in Nepal are equipped with water-filtration systems and that many of these have either failed or been rejected by villagers, she described current solutions as “difficult to maintain and lacking durability—in short, ineffective.”

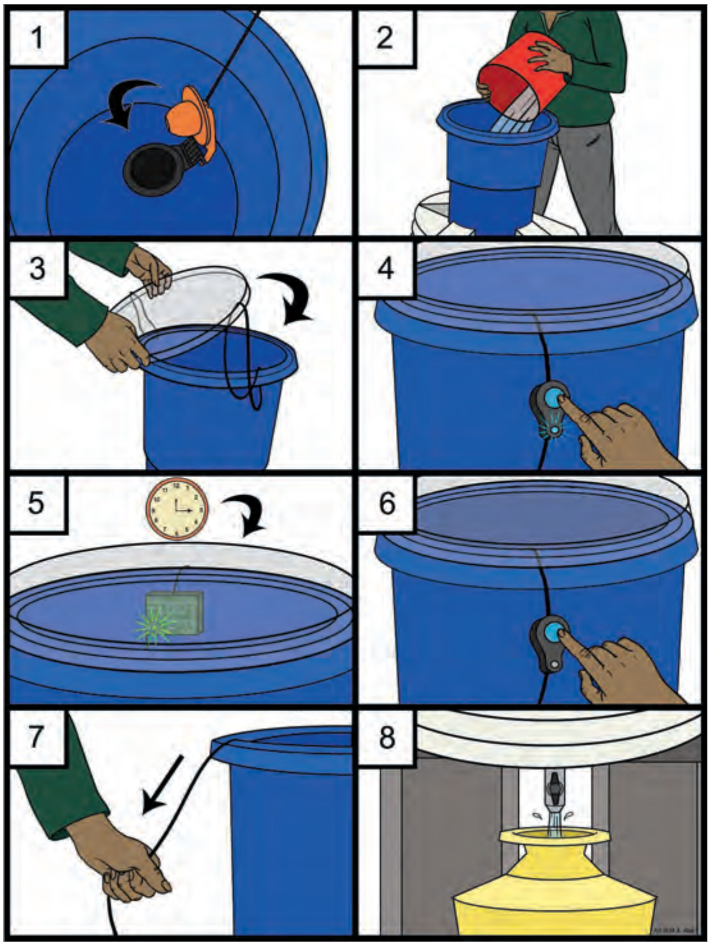
Teammate Shannon Carman ’17 then spoke about SafaPani, a low-cost, reliable, easy-to-use water filtration system developed by Thayer students. “It’s a simple household solution to a complex global problem,” Carman said in closing.

That two-minute overview—and the team’s use of electrocoagulation to remove arsenic from residential wells—won top honors last winter in “The Pitch,” an annual entrepreneurship competition sponsored by Dartmouth’s Digital Arts Leadership and Innovation Lab and the Dartmouth Entrepreneurial Network. SafaPani, which means “clean water” in Nepalese, came away with funding and development support. The hope, according to Carman, is that the win—along with recent support from Dartmouth’s Class of 1980—will help the project gain the credibility and visibility it needs to become a viable business.

THE PROJECT BEGAN IN 2008, WHEN DAVID SOWERWINE, cofounder of the VillageTech Solutions (VTS), approached Thayer School for help in creating an effective, affordable, and reliable solution for removing arsenic from residential drinking water. Arsenic contamination affects about 1 million villagers in rural Nepal, 80 to 90 million in Bangladesh, and tens of millions more people in Afghanistan, Bengal, China, and India, where water drains from the Himalayan Mountains.

“It’s a big problem that hasn’t gone away. No one has come up with an alternative solution that works, and governments are trying to ignore it,” says Sowerwine, whose VillageTech Solutions colleagues includes Thayer Overseer Edward “Skip” Stritter ’68. “It’s fantastic that Dartmouth teams have been hammering away at this project, year after year.”

The Thayer students’ filtration system consists of a nested two-bucket system that houses iron electrodes, an electronic controller, a common flush valve, a diffusion plate, and a layer of sand. In the process of electrocoagulation, iron electrodes in the fi st bucket are powered by batteries to inject iron into raw water over a 30-minute period, forming insoluble ferric hydroxides through electrochemical oxidation. Arsenic coagulates around these ferric hydroxides to form clumps of arsenic-ferric precipitates. After the half-hour waiting period, the user releases the water into the second bucket, which contains a layer of sand to catch the clumps. Clean water then percolates down to the collection vessel.



The fi st version of the system, created by Lindsay Holiday ’07 Th’09, Dana Leland ’09, and Philip Wagner ’09 as their capstone Bachelor of Engineering (BE) project, won the National Inventors Hall of Fames’ 2009 Collegiate Inventors Competition. Since then, three more BE teams have furthered the technology for their ENGS 89/90 project work.

“These systems have chemistry, electronics, mechanical design, and fluid flow—most everything any engineering class ever had to work on,” Sowerwine says.

The SafaPani group emerged in 2013, after Nepali citizen and Thayer

LINDSAY HOLIDAY '07 TH'09 AND DANA LELAND '09 DEMONSTRATE THE FIRST ARSENIC REMOVAL SYSTEM THAT STUDENTS CREATED IN 2009 AS THEIR CAPSTONE DESIGN PROJECT. "ARSENIC IS ALWAYS GOING TO BE A PROBLEM UNTIL THERE IS A COMPREHENSIVE SOLUTION TO IT" SAYS SAFAPANI'S CARMAN. "WE HAVE A REALLY GREAT, ENTHUSIASTIC TEAM WITH LOTS OF ENERGY AND IDEAS THAT NO ONE PERSON COULD EVER COME UP WITH ON THEIR OWN."

PhD candidate Aditya Mahara approached Dartmouth Humanitarian Engineering (DHE) and offered to lend his expertise to any engineering project willing to address rural health issues in his homeland. With the ENGS 89/90 water filtration system in the late stages of development, DHE created SafaPani to provide organizational structure for the technology, with Mahara and Eubank as its first project leaders.

With DHE support, Mahara, Eubank, and Chad Piersma '13 Th'15, a member of the 2013–14 ENGS 89/90 team, traveled to the Nawalparasi region of western Nepal in 2014 to conduct research and make connections with villagers and potential NGO partners. In the six villages where they tested residential tube wells, the students discovered that arsenic levels were 25 times higher than the World Health Organization safety standard. In five of the six villages, local residents identified arsenic poisoning as their biggest health issue. The students also met with water and health experts to discuss the chronic failures of filtration systems in the region and to strategize about how to meet the need for more effective technologies.

Sowerwine, a chemical engineer who advises both the ENGS 89/90 and SafaPani club students, considers electrocoagulation to be the best current technology for resolving the persistent problem of arsenic poisoning at the residential level in Nepal. "With electrocoagulation, we feel confident that if there's a reliable flow of electricity, it's going to throw off a certain amount of iron that will do something predictable—take the arsenic level down below 10 parts per billion—and make the water safe to drink," he says. "If the electricity isn't working, people will know when the system isn't working. That's our insight."

SAFAPANI HAS ATTRACTED A DIVERSE TEAM OF ENGINEERING students, as well as biochemistry, biology, chemistry, economics, environmental studies, geography, and government majors. The club has one team focused on technology development and another on everything else—research and data collection, the economics of the filter, outreach, and building partnerships with NGOs, manufacturers, and distributors.

Although administrators, faculty, and partners are involved in advising and oversight, SafaPani is driven by students. "We're transitioning from students to real-world engineers and thinkers, so it's students who run the meetings, and ultimately, it's students who make the final call," says Eubank.

Still, faculty input is welcome. For example, technology team members Eldred Lee '16 and Collin McKinney '18 met weekly with Professor Ryan Halter Th'06 last winter in the context of an independent study course, ENGS 87: Engineering Investigations, to discuss experimental protocols and results. "I was able to provide this team with laboratory equipment and support in obtaining sufficient training to conduct experiments with arsenic," says Halter.

Halter also advised the 2014–15 team of ENGS 89/90 students—Scott Hansen Th'15, Stephen Jenkins Th'15, Jamie Potter Th'15, and Julia Zaskorski Th'15—as they worked on the arsenic filtration system. "This team developed by far the most refined version of the prototype," Halter says.

Closing in on what they thought was close to a final product, the 2014–15 team and SafaPani students sent three sets of equipment to VTS for testing. Unfortunately, the testing revealed persistent problems.

"While the results initially seemed discouraging, the team was able to pick out specific ways the tests could be improved to yield better results," says Carman, who stepped into SafaPani's leadership role following Eubank's graduation. "Our main objective is to strive for consistency across all the prototypes and then evaluate whether additional features, such as a stirring mechanism, should be added to improve the effectiveness."

In another kind of setback, this year's ENGS 89/90 class didn't field a team focused on the arsenic filter.

But SafaPani has emerged with an energetic plan to move the project forward. The SafaPani team has recruited new members and has begun planning another DHE trip to Nepal to test prototypes in the field, gather user feedback, and engage its NGO partners.

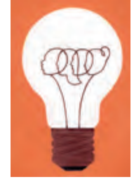
"Arsenic is always going to be a problem until there is a comprehensive solution to it. We've invested so much time, and there is absolutely a commitment to the project," Carman says. "We have a really great, enthusiastic team with lots of energy and ideas that no one person could ever come up with on their own. It will be cool to see how impactful we can be."

That's a pitch that appeals to Sowerwine. He remains optimistic that the work of the ENGS 89/90 and SafaPani students will come to market and benefit the people of Nepal and other areas affected by arsenic contamination.

"Helping to make the world a better place isn't quick or easy," Sowerwine says. "I appreciate the energy and expertise that Dartmouth students have devoted to this project and the people who will benefit. It continues to be a privilege for us to work with these talented students."

KIMBERLY SWICK SLOVER is a writer based in Wilmot, New Hampshire.

THIS PAGE: DOUGLAS FRASER. OPPOSITE PAGE CLOCKWISE FROM LEFT, JOHN SHERMAN, COURTESY OF NASA, COURTESY OF AUDIO-VISUAL SOLUTION TEAM, JON GUERRETTE, COURTESY OF EXPANDABLE HYDROGEL TEAM, DOUGLAS FRASER



Capstone Standouts

ENGS 89/90

Professor Douglas Van Citters '99 Th'03 Th'06 tells why these ENGS 89/90 projects are his faves.

DEVELOPMENT OF A SMART DEEP BRAIN STIMULATOR

"This project was groundbreaking in that the students developed a closed-loop feedback system for deep brain stimulation," says Van Citters. "Entire laboratories around the country were devoted to this, and the team of three students successfully implemented a system in rats in only six months." Developed by the 2007-08 team of Christina Behrend '07 Th'08, Shiraz Cassim '07 Th'08, and Matthew Pallone '07, the project won the 2008 Dartmouth Society of Engineers Prize. "We implemented Christina Behrend's ideas, and the collaboration was incredibly useful to me and to her—she is now an MD/PhD student in a lab at Duke doing DBS-related work," says the project sponsor, Geisel School of Medicine Professor Dr. James Leiter '75 DMS'79.

SPEED CONTROLLED PIVOT LOCK FOR TILTING THREE-WHEELED VEHICLE

Adam Danaher Th'09, David Drennan Th'09, Kyle Lobisser Th'09, and Laura Weyl Th'08 developed a speed-controlled pivot-lock mechanism to prevent a three-wheeled motorcycle from falling over when it comes to a stop. According to Van Citters, "For six months an experimental motorcycle shared the large frame lab with Dartmouth Formula Racing and turned a lot of heads." The design also earned the team the Dartmouth Society of Engineers Prize at Investiture in 2008. Project sponsor and Tilting Motor Works CEO Bob Mighell '85, who rides a modifie version of the three-wheeler, says, "It was very helpful for us to take the initial concept and create a prototype." The bike can be ordered at tiltingmotorworks.com.

POROUS MEDIA CONDENSING HEAT EXCHANGER FOR SPACE VEHICLES

NASA needs a reliable life support system that can function for up to two years for its anticipated long-duration missions to Mars in the near future. One of the greatest challenges has been condensing water in microgravity. Working with project sponsor NASA Glenn Research Center, Sean Currey '11 Th'11, Broghan Cully '11 Th'11, Michael Kellar Th'11, and Max Fagin Th'11 developed a working prototype to regulate the humidity of a simulated spacecraft interior. "Perhaps most memorably," says Van Citters, "this project fle in microgravity aboard the 'Vomit Comet' to demonstrate its utility in a reduced gravity environment." While aboard the NASA plane flyin parabolic maneuvers to achieve zero-gravity conditions, the student team gathered data from the prototype to send on to NASA for further review.

AN AUDIO-VISUAL SOLUTION FOR EVERY SCHOOL

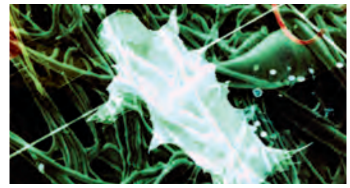
The team of Alyssa Belisle Th'12, Rachelle Morris '12 Th'12, Roja Nunna Th'12, and Peter Williams Th'12 used cultural anthropology and design thinking to develop an inexpensive, integrated computer-projector system that can access the Internet and run off a battery. "This project was among the best examples of engineering for a full system," says Van Citters. "The team developed a

self-contained device that was culturally appropriate, scalable, and modifiabl to meet the needs of any rural community in any developing nation." The team's design, called Looma, became the proof-of-concept for project sponsor VillageTech Solutions (VTS). "The collaboration with Dartmouth has been crucial for the success of Looma continuously during the intervening four years," says Edward "Skip" Stritter '68 of VTS, who worked with students to develop and test prototypes in rural schools in Nepal. "We are about to ship version two to Nepal," he says.

WATER RECOVERY FROM DIESEL GENERATOR EXHAUST

Conor Galligan '11 Th'12, Merritt Jenkins '10 Th'12, and Eric Packer '12 Th'12 designed a novel solution to the challenge of reliably providing water to soldiers in the fiel . "The technology is now patent pending," says Van Citters, "and can be quite useful for remote operating sites where transportation of water can be either expensive or dangerous." Water is condensed using a combination of absorption refrigeration and ambient air heat exchange and is subsequently fil ered in preparation for use. This system, designed for sponsor Logos Technologies, could potentially serve as an on-site water source that reduces the need for water delivery via convoy, saving the military millions of dollars each year.

BIORESORBABLE SURGICAL SPONGE



"Mix a chemist, a biologist, and an economist and you get a completely marketable surgical sponge that can be retained after surgery and disappear harmlessly," says Van Citters. Surgical sponges are frequently misplaced during surgery, and the solution—developed by Devon Anderson '10, Jon Guerrette Th'10 '15, Nate Niparko '09 Th'10—involved a fib ous mat of bioresorbable oxidized cellulose and oxidized alginate. Although the product has not yet been approved for use in humans by the FDA, "we still see the project as useful," says sponsor Dr. Vince Watts with the VA Medical Center in White River Junction, Vt. "We are interested in investing in long-range solutions, and remain optimistic that projects like this will eventually take hold and realize their potential benefit ." The project was a 2010 Collegiate Inventors Competition award winner.

EXPANDABLE HYDROGEL SPHERE FOR ORBITAL IMPLANTATION

Elizabeth Chang Th'12, Amanda Christian Th'12, and Christopher Ng Th'12 developed an $8 medical device to help children born without eyes in India. "This is a fin example of technology used to solve a problem in a developing nation," says Van Citters, who accompanied the students when they went to Madurai, India to present their solution in person to project sponsor Aurolab. Their hydrogel implant, which featured expansion properties that match those of a natural human eye, was a finalis in the Collegiate Inventors Competition.

CRACKING THE IMMUNE SYSTEM CODE

DECODER
Margaret Ackerman wants to know how vaccine components educate the immune system.

PHOTOGRAPHS BY JOHN SHERMAN

AS SHE TRIES TO ASSESS IMMUNE RESPONSES TO HIV VACCINES, PROFESSOR MARGARET ACKERMAN IS WORKING TOWARD A GRAND UNIFIED THEORY OF ANTIBODY ACTIVITY.

BY MICHAEL BLANDING

Inside each of our bodies is an arsenal of defenders just waiting for the right attacker to show up. Our front-line troops are legions of T cells, white blood cells on patrol looking for cells that are infected with foreign pathogens, binding to them, and killing them. Behind the lines, other blood cells called B cells produce antibodies, proteins that bind to foreign invaders and either neutralize them or act as a beacon to recruit other immune cells to come and attack.

Our bodies have millions of these B cells, each producing its own unique antibodies, which together are capable of recognizing any infection we might encounter. "Protein engineers would call this a library," says Margaret Ackerman, an assistant professor of engineering at Thayer. "Any time you are infected, your immune system samples thousands of different antibody proteins and identifies those that bind best to the target pathogen."

While the body is capable of doing this by itself in response to most infections, scientists have found a way to jumpstart the process with vaccines to help the body sort through its own vast libraries in order to produce the right antibodies to fi ht off invaders it has yet to see. That's done by using a weakened, inactive, or dead form of a pathogen or sometimes by using unique protein components, or antigens, from pathogens. "By exposing your T cells and B cells to weak, dead, or component antigens of a pathogen, they can learn to recognize a real infection," says Ackerman. Once exposed, the body maintains populations of T cells and antibodies, each with specific orders to seek out and destroy a specific virus or bacteria.

The system works incredibly well—until it doesn't. While most foreign invaders spur this natural response in the body, some diseases fail to muster the right troops in our bloodstream. In the cases of flu and malaria, for example, the pathogens are so variable, with so many unique strains, that the body can't know in advance what will hit it—or in the case of flu, an annual vaccine is needed to help battle each year's particular strain.

Then there are other diseases, like HIV, the virus that causes AIDS, that just seem to thwart the body's natural immune response. For reasons scientists don't completely understand, the body's white blood cells seem helpless in the face of HIV's attack, failing to generate the right T cells and antibodies to effectively target the disease. And if the body can't do it on its own, that makes traditional ways of developing immunity through vaccination more problematic.

"If your immune system can't naturally induce a protective response, then building a vaccine to do so is a fundamentally more challenging goal," says Ackerman, who has dedicated her lab to achieving exactly that goal. In combination with a team of collaborators, her research group's secret weapon is a unique platform to evaluate antibodies in much greater detail than has been possible previously, which is then coupled to complex computer algorithms to determine how best to make vaccines better.

"It's sort of looking under the hood of your immune system," Ackerman says. "We are looking at the thousands of different variants of antibodies your B cells have produced in response to vaccination and weeding through that data to learn the features of potent immune responses in order make better vaccines." Using these techniques, her research may contribute in the not-too-distant future to one of the holy grails in modern medicine—a vaccine that could provide immunity against HIV.

Ackerman was trained as a protein engineer at the Massachusetts Institute of Technology in Dane Wittrup's lab in the departments of chemical engineering and biological engineering. There she learned to evolve antibodies in the lab to change or enhance their function. "It's just crazy cool to evolve a protein in a test tube and to make a new molecule that can do something that doesn't exist in nature," she says, "or take a natural protein and make it ten times or a thousand times or a million times more effective."

As intriguing at that sounds, that type of engineering is actually quite routine. ("Undergrads do this," Ackerman says.) But it's one thing to develop an antibody in a lab; it's another to create one in the human body. "How can you get people with different immune systems and different antibody libraries to each mount a response that is protective?" she asks.

That's even trickier in cases like HIV, where the body has such a limited capacity to do that on its own. The HIV-positive subjects who have developed protective antibodies have tended to do so over long periods of time after being exposed to different strains of the virus. Those antibodies belong to a class called broadly neutralizing antibodies, which work by binding to the HIV virus and rendering it inactive. But candidate vaccines have not been able to induce the immune system to robustly generate those types of antibodies.

In fact, only four vaccines have ever been tested in large-scale human efficacy trials to see if they can drive development of antibodies or T cells that will make vaccinated subjects immune to HIV. Of those four vaccine trials, two appeared harmful to patients, one had no effect, and one was marginally effective. In that last case, however, the vaccine, called RV 144, seemed to function in a surprising way.

Ackerman was a postdoc at the Ragon Institute of Massachusetts General Hospital, MIT, and Harvard researching the immune response to HIV when she heard the results of the RV 144 vaccine trial. Carried out in Thailand, the trial involved more than 16,000 people who were given the vaccine or a placebo and then monitored for HIV infection. The vaccine, consisting of an inert form of a bird virus engineered to express several HIV genes followed by a mix of two HIV protein antigens, was controversial at the time, criticized for the amount of time and money spent on such an experimental treatment. "Prominent scientists wrote a letter to *Science* questioning whether the study was a waste of resources," Ackerman recalls.

It was a surprise, then, when results released in September 2009 showed that the vaccine provided 60 percent protection against the disease after a year and 30 percent after two years. When blood samples were tested for the presence of several common antibody types, however, the broadly neutralizing antibodies weren't among them. "Scientists thought we knew how a vaccine was going to work. It was either going to induce broadly neutralizing antibodies or a really potent T-cell response," says Ackerman. "This vaccine appeared to work, but it didn't do either of those things very well. So the question was, what did it do?"

One clue was the presence of different types of antibodies in people who were protected compared to those who weren't. These so-called binding antibodies can attach themselves to a specific site on a pathogen and act as a molecular beacon that recruits other immune cells to eliminate pathogens from the body. Some of these cells, such as neutrophils, can trap pathogens, while others "eat" the infected cells or circulating virus. In other cases, the antibodies initiate a chain reaction known as a complement cascade, which punches holes in infected cells, killing them.

The possible activities of these binding antibodies are complex. Each antibody possesses a unique means to recognize the pathogen and a unique ability to summon innate immune effector cell power. Collectively, these antibodies program pathogen recognition and provide instructions about what should be done with the tagged cell or virus.

These instructions can have a wide range of possible outcomes. "There are order-of-magnitude differences in how antibodies recruit different innate immune cells," says Ackerman.

In the Thai trial, however, researchers performed a restricted analysis of correlates of infection risk, limiting both the information they could obtain about what was going on after exposure to the virus and their ability to solve the riddle of how these antibodies might provide protection from the disease.

In the research she began at Ragon, Ackerman has taken the exact opposite approach. "We said we are going to measure as many different things as we possibly can, and then we are going to use data-driven discovery," she says. "When you limit the questions you ask, you limit the answers you can get. Instead of pre-ordaining our measurements, we'll let the analytical models tell us which of those measurements or which combinations of measurements are associated with protection."

With her postdoc advisor, Galit Alter, Ackerman developed a set of procedures that would analyze antibodies in incredible detail. (While there hasn't been another large-scale efficacy trial since the Thai trial, multiple HIV vaccines tested in monkeys or humans have generated a range of antibody responses.) Alter and Ackerman's tests would not only examine pathogen recognition and inactivation, but also more globally evaluate the types and activities of the antibodies, including which immune cells they recruited and how they affected the pathogen.

Such cell-based assays, however, are still difficult and time-consuming, requiring a large number of human immune cells to test, and therefore limiting the number of antibodies Alter and Ackerman could test. After coming to Dartmouth in 2011, Ackerman called on her molecular engineering background to create faster and more efficient means of analyzing antibody responses. "I wanted to step away from more complex assays and enable better understanding at the molecular level of how the antibody binds to viral antigens and how the innate immune system recognized the antibody," she says.

Using a boxy, plastic instrument vaguely reminiscent of an all-in-one printer or a Star Wars droid, researchers in Ackerman's lab test antibodies for their ability to recognize up to 500 different variants of viral proteins in a single assay. They do this by attaching each protein to a tiny bead called a microsphere, which fluoresces a different color and intensity when a laser is shined across it. When the beads are incubated with samples from vaccine recipients, each of the antibodies in the sample can bind to its respective protein target, and another fluorescent measurement can be made to determine how prevalent each antibody specificity is and how well each antibody type interacts with the various antibody receptors expressed on innate immune cells. "Instead of just saying how many antibodies are there and what they recognize, we look at how well those pathogen-specific antibodies interact with the innate immune antibody receptors," Ackerman says. That information, in turn, can offer clues about how effective antibodies are in recruiting immune cells to attack the virus.

WE SAID WE ARE GOING TO MEASURE AS MANY DIFFERENT THINGS AS WE POSSIBLY CAN, AND THEN WE ARE GOING TO USE DATA-DRIVEN DISCOVERY.

Unlike the kind of assays used in the Thai trial, which looked at a handful of different antibody types, this multiplexed assay can generate a tremendous amount of data about the wide variety of different antibodies active in a single sample. “For any one of those serum samples, we might have a thousand different characteristics about the pathogen-specific antibodies that are present,” says Ackerman. “It’s much more data than has been typically generated for evaluating vaccines.”

In order to make sense of all of that information, Ackerman runs the data through machine learning software that can help make broad predictions. “Just like Amazon learns from other people’s choices or Netfli learns from other people’s viewing habits to make suggestions for you, we weed through our thousands of data points and see how well the data we collected can predict or differentiate between subjects that were protected versus those that were not,” she says.

That level of prediction is key, says computational biologist Chris Bailey-Kellogg, a Dartmouth computer science professor who collaborates with Ackerman to analyze the data. “One way she is changing the field is not just to say what’s different, but also to make predictions about what is going to happen,” he says. “If Netfli only told you are different from someone else, that’s not as useful as telling you what movie you might like.”

Even the same vaccine antigens can produce dramatically different results depending on how they are administered to patients (for example, intravenously or nasally), how often they are given, and what kind of other chemicals, called adjuvants, are added to boost their effectiveness. By feeding all of this data into their computational models, Ackerman and her collaborators can better predict the ideal combination of factors that will cause a vaccine to work at its best. They are then able to go back to scientists testing vaccines and give them valuable predictions with which to tweak their next vaccine. “It’s not just trial and error anymore,” says Bailey-Kellogg. “You are not just trying a vaccine and seeing if it worked. You can see what vaccine is working and why.”

Ackerman and her collaborators recently looked at a National Institutes of Health (NIH) study of nearly 100 monkeys, one of the largest non-human primate vaccine studies ever done. “When you have this many animals, and this many outcomes, you have to sift through the data to fi ure out what’s important,” says study leader Mario Roederer, a senior investigator at NIH’s Vaccine Research Center. “There are a ton of different ways of modifying the vaccine, and they generate different qualities of the antibodies,” he says. “What her work does is identify what flavor of antibody we want to develop and which vaccine is much more likely to develop that antibody.”

Not only is Ackerman able to do this with individual vaccine trials, but because she and her collaborators are testing multiple vaccines from different studies, they are also able to pool data to synthesize results to look for patterns of effectiveness. So far, many of the analyses her lab has made seem to bear out the Thai trial fi dings—that the key to protection may not be a broadly neutralizing antibody but, rather, a combination of binding antibodies sending signals to the immune cells. “It really is a swarm of antibodies working in concert,” she says.

While the samples Ackerman’s lab has been able to study so far come from small-scale human and non-human primate trials, she is looking forward to the next efficacy trial currently underway in South Africa, which will use a variation of the same vaccine used in the Thai trial, RV 144, modified for strains of the virus prevalent in Africa. “The entire HIV research community is keen to see if the vaccine will protect in another subject population,” says Ackerman. She hopes that when results are released in two years, she will be able to analyze samples to examine exactly what type of antibodies the vaccine induced—whether it proves effective or not.

More than that, however, Ackerman hopes her research can ultimately help unlock the secrets of exactly how antibodies function in all of their complexity. “We want to have a grand unified theory of antibody activity,” she says, “so we can say, if you want an antibody that is really great at recruiting a neutrophil, it should have this type of profile, or if you want an antibody that initiates the complement cascade really well, you want that type of antibody.” Having that kind of information could help crack the immune system code, allowing scientists to create vaccines to fi ht not only HIV, but potentially a large number of other diseases, including influenza, malaria, and even cancer.

Beyond this understanding, immunologists would like to do more than see the effect of their candidate vaccines on B cells in terms of the antibodies they produce. They want to know the details of how this process takes place. “It’s sort of the black box of immunology,” says Ackerman. “When we evaluate a vaccine, we know what we are injecting and we know something about the antibody or T-cell responses raised in subjects, but we’d also like to know how exactly the vaccine components educated the immune system to produce which types of responses.”

Call it designer vaccine development. “By understanding exactly how vaccines function,” Ackerman says, “we can better understand how to engineer them to allow our bodies to do the work fi hting off the diseases they can’t combat well enough on their own.”

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

Alumni News

FROM AROUND THE WORLD

spotlights


J. Andrew McAllister '87

As one of five members on the California Energy Commission, **J. Andrew McAllister '87** is tackling clean-energy issues that could provide a roadmap for national and global policies. Appointed in 2012 to serve on the state's primary energy policy and planning agency, he is using law, policy, and large-scale investment to push for better energy performance of buildings, decarbonization of the electric grid, and large-scale electrification of the transportation fleet. "I occupy the economist seat at the commission, though truth be told, I draw primarily on my engineering and policy backgrounds to develop creative and effective pathways toward a resilient, low-carbon energy future," says McAllister from his Sacramento office. He has more than 20 years of experience in energy management, efficiency, and renewable generation. Before joining the commission, he worked at the California Center for Sustainable Energy and with NRECA International Ltd. in the electric sectors of countries in Central and South America, Southeast Asia, and Africa. "The distributed energy world is upon us and presents huge opportunities for new systems and technologies for efficiency, demand response, energy storage, smart analytics, innovative financing, and clean generation at every scale—all of which make my job consistently exhilarating," he says.

Jonas Åkermark Th'01 has helped develop *Seagas*, the first liquefied natural gas (LNG) fueling vessel in the world. Owned by AGA Gas AB, the leading gas company in northern Europe, *Seagas* is currently serving the *MS Viking Grace*, the world's first LNG-powered passenger vessel, with about 50 tons of LNG every morning when it docks in Stockholm. "So far, *Seagas* has conducted about 800 fueling operations to the *Viking Grace*," says Åkermark, AGA's LNG sales and business development manager. The *Seagas* is filled by three LNG trucks per day at its port in Loudden, Sweden, and then travels to Stockholm to meet the *Viking Grace* for a one-hour ship-to-ship fueling process that is a new way of bunkering fuel. "This extremely fast process is like a maritime Formula 1 pit stop," says Åkermark. "It's a unique and customized solution." (You can watch him explain it at youtube.com/watch?v=R8dLYOZfPKY.) LNG is natural gas that has been rendered liquid by cooling it to –160° C. This decreases the volume of the gas by a factor of 600, making it a highly energy-efficient way to transport the gas. "Natural gas is a mixture of hydrocarbons that consists of about 90 percent methane," Åkermark says. "By choosing natural gas to power your fleet at sea or on land, you reduce carbon dioxide emissions by about 25 percent and nitrous oxide by about 90 percent, while aerosols and sulfur are reduced by nearly 100 percent." His greatest challenge in executing the project? "It was the first LNG fueling vessel in the world—thus, nothing to compare with! It was a great engineering development project." He's now turning his efforts to developing the LNG market.

Desktop Genetics in Cambridge, England, wants to revolutionize the way that genetic researchers work. To that end, CEO and cofounder **Riley Doyle Th'08** has raised $2.15 million to further develop the firm's DESKGEN genome editing software platform, which allows researchers to design and perform genome editing experiments in virtually any cell line or species. Along with some investment in sales and marketing, this latest cash injection will be used to launch a custom sgRNA library design service for users engaged in functional genomics, target identification, and validation. "To date, the DESKGEN platform has enabled over 4,000 gene editing experiments and assisted thousands of users in designing and accessing the best reagents for their research," says Doyle.

Last fall **Jason Fortier '94 Th'95**, director of research and development at Covidien, and five team members won the 2015 Medtronic Technical Contributor of the Year Award. Medtronic, one of the world's largest makers of medical devices, purchased surgical supplier Covidien for $42.9 billion. Fortier and his team won a "Rising Technology" award for the Veriset hemostatic patch, which was launched in Europe last year. His wife, **Michelle Moore Fortier '94 Th'95**, reported in November that they were about to leave their hometown of Concord, Mass., for Dubai, "as Jason is training surgeons from Asia, the Middle East, and Africa on how to use the Veriset patch."

Bruce Curran '73 Th'82 has been inducted as a fellow in the American College of Radiology. He is an associate professor of radiation oncology at Virginia Commonwealth University in Richmond, Va., and chief of radiation oncology physics at H.H. McGuire VA Medical Center in Richmond. His research interests include the application and improvement of computer systems in radiation oncology, in-

On the Job

KEIRA PENG TH'11 | FOUNDER WELOVE

"I had few dating experiences and, frankly, didn't know how, especially in America." —KEIRA PENG TH'11

OPPOSITE PAGE: COURTESY OF J. ANDREW MCALLISTER. THIS PAGE: HEIDI ROLAND

After earning her MEM from Thayer, Keira Peng worked with large databases, most recently to optimize fraud-detection strategies for health insurer Cigna. While researching the impact of stress on employees there, she examined the stress she felt from expectations to start a family. So began the Philadelphia resident's foray into online dating.

What prompted you to form your dating consultancy, WeLove?
Once I got over my own fear of dating, mastered online dating, and actually started having fun with it, I realized it was a challenge for many Asian immigrant women. Many of them need someone to hold their hands to navigate something that's way outside of their comfort zone—where they know very little, where they need a lot of practice, where they can make mistakes and fail! I realized this was my true path of service, and WeLove was born.

What makes your service unique?
We coach Asian professional women to become their own matchmakers. Our clients not only get better responses from quality men online, they also have a much lower tolerance for men who treat them poorly or in a stereotypical way. Perhaps for the first time in their lives, they also start to define their own vision of happiness and follow their own paths to freedom and love.

What skills are essential for a successful entrepreneur?
Leadership. At Thayer I learned that sometimes leadership is a burden people take on to do things that may not be glamorous but necessary. Since I started my own business, I've gotten to know another facet of leadership: having the courage to advocate for what you believe can really improve people's lives. Another skill is empathy: being able to put yourself in the other person's shoes and grasp many different perspectives.

How do you use the Lean Six Sigma (LSS) methodology to optimize online dating?
Wherever there is waste, redundancy, and overwhelmingness, LSS can be applied to get better results with less time. While at Dartmouth, I was introduced to the LSS methodology by Professor Ron Lasky and worked with him on helping Dartmouth-Hitchcock schedule 25 percent more MRI scans. We often talk about LSS as if it's a sacred business practice, but it really can be applied anywhere, including your personal life. By cleaning up in-boxes, streamlining contact lists, and following optimized screening schedules, we help our clients get at least one date a week with a high-quality candidate while investing as little as 30 minutes a day. We've been told by clients that just the calming feeling of being in control and the sheer amount of stress we've helped them reduce is worth thousands of dollars, not to mention the higher-quality dating experience.

—Theresa D'Orsi

spotlights

Jonas Åkermark Th'01

cluding imaging and dose calculation algorithms, and the development of standards for information exchange.

Doug Madory Th'06 is one of the nation's "most renowned private-sector experts on the structure of the Internet," according to *Business Insider* magazine, which profiled him last summer. As the director of Internet analysis at the New Hampshire-based company Dyn, Madory has helped turn the firm into a leading resource for observers, companies, and journalists tracking global Internet traffic. He was a major source in a series on online gambling that *The New York Times* ran last fall, beginning with the story, "Cash Drops and Keystrokes: The Dark Reality of Sports Betting and Daily Fantasy Games." In late 2014 he broke news of the Internet outage in North Korea, following President Barack Obama's statement that Pyongyang had been responsible for the December 2014 cyberattack on Sony. He has mapped out the Iraqi Internet's dependence on Kurdish providers and assessed the effect of the recent Nepal earthquake on the country's Internet access. Madory began learning about computer networking while serving in the U.S. Air Force after studying computer engineering at the University of Virginia. Computer networking "is kind of a neat trick," he told *Business Insider*. "And Internet-based communication is one of the defining aspects of the present state of human civilization."

Michael R. Walsh '77 Th'78 '91, a research mechanical engineer at the Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, has been promoted to the highest rung on the U.S. Army Engineer Research and Development Center (ERDC) career ladder. During his 29 years at CRREL he has worked in Greenland, Antarctica, and Alaska on diverse projects, including the structural analysis of icecap radar stations, development of a towed snowplow, tunneling at the South Pole, military energetics, and environmental cleanup. As co-chair of a research task group within NATO on the characterization, fate, and transport of munitions related contamination, Walsh is recognized in the international community in the field of munitions impacts on military ranges. He is the inventor or coinventor of eight U.S., Swedish, and Canadian patents.

Michael R. Walsh '77 Th'78 '91

"Playing golf is a critical piece in understanding how design changes will impact the performance of the ball."

—MIKE MADSON '05 TH'06

THIS PAGE, LEFT TO RIGHT, COURTESY OF JONAS ÅKERMARK, CRREL, MIKE MADSON.

On the Job

MIKE MADSON '05 TH'06 | DIMPLE DESIGNER

As senior product development engineer for Brockton, Mass.-based Acushnet Co., Mike Madson is responsible for designing dimple patterns for Titleist golf balls. He also develops computer models for predicting trajectories and is involved in analyzing and interpreting data related to golf ball design.

How do you approach the design process?
Designs can be as simple as arranging circles on a sphere using solid modeling programs or as complicated as writing optimization algorithms that organize points in space based on a given set of constraints. We spend a lot of time developing methods for creating dimple patterns or designing the dimple shapes themselves. Those various designs and methods are at the heart of our aerodynamic patents, and I am very involved in developing new ideas and building our patent portfolio. One example of an aerodynamic improvement would be a pattern providing increased distance. However, we also strive for improvement in less-obvious areas, such as optimizing the trajectory for our target golfer or improving the aerodynamic consistency.

Explain the role of dimples.
Essentially, the dimples on the ball reduce the drag and increase the lift. This keeps the ball in the air longer and significantly increases the distance the ball can travel. Acushnet was ahead of other golf ball manufacturers when we developed the 392-dimple icosahedron pattern in the 1970s. That was a significant breakthrough and was used on our golf balls in some form through 2010. In 2011 our premium golf balls—Pro V1 and Pro V1x—changed dimple patterns because we found something better, using a spherical tiling method I helped develop. Now all Titleist golf balls use dimple patterns designed with the spherical tiling method.

What does your testing facility look like?
We have state-of-the-art testing facilities. We test every piece of the golf ball indoors and outside. We test with amateurs, tour players, and robots.

How have you developed your knowledge of aerodynamics?
Golf ball aerodynamics isn't something you learn in the classroom. What Thayer did was instill in me a passion for engineering and a desire to solve problems and learn new things. Professor Lasky's engineering statistics course inspired me, and I went on to get a master's in applied statistics while working for Acushnet.

How have your experiences on the golf course informed your designs?
I started playing golf my senior year and loved it. I play golf—just not very well. Playing golf is a critical piece in understanding how design changes will impact the performance of the ball. It is all part of understanding what players of various skill levels need to help their own game.

—Theresa D'Orsi

just one question

Q. Do you hold any patents?

Lots of patents, but all expired: skid landing gear for helicopters, design of a high-altitude helicopter, true airspeed for re-entry vehicle, Mosaic macrofont for video monitor display. The helicopter skid landing gear was patented around 1950. My title was assistant chief engineer of the Bell Helicopter Group, following service for three years as a project engineer of the Model 47, the first helicopter in the world to be certified for commercial production. Hiller Helicopter presented a competition in 1948, and I worked to design significant enhancements, including the skid landing gear. The improvements reduced weight and costs, and this version became known as Model 47G. It defeated the competition for many years. Helicopters until that point were equipped with wheels with pneumatic tires and pneumo-hydraulic struts to handle the energy of hard landings. Yet helicopters are needed in rough country work, where wheels face the serious hazard of sinking into the earth, causing upset when contacting the earth at even slow speed. We demonstrated, in landing with forward speed on soft earth and boulder-strewn streambeds, that skids provide a safe landing. The novelty for patenting included the use of aluminum cross tubes in place of pneumohydraulic struts to absorb the energy in contact. The cross tubes provided a convenient support for accessory equipment, such as Stokes litters, crop-dusting hoppers, water tanks for firefighting, and grenade launchers. All other helicopter producers utilizing skid landing gear were required to pay Bell a hefty royalty, which was unusual for the industry association overseeing such matters.

—Tom Harriman '42 Th'43

I invented a product that, although it has never been available commercially, did win a prize of great repute. In 1938 the Disney Co. started to publish *Mickey Mouse Magazine*, and my parents presented me with a subscription. In one of the early issues the editors held a contest—prizes were offered for the most imaginative "useless inventions." I entered the contest and was declared a winner, my entry being "Eye-glasses without lenses—for people with perfect eyesight." I don't recall if I won first prize, but I was pleased with my award, a Mickey Mouse sweatshirt. If I had kept a copy of the magazine—I see on eBay that they sell for as much as $165. If I had kept the sweatshirt—oh, certainly priceless.

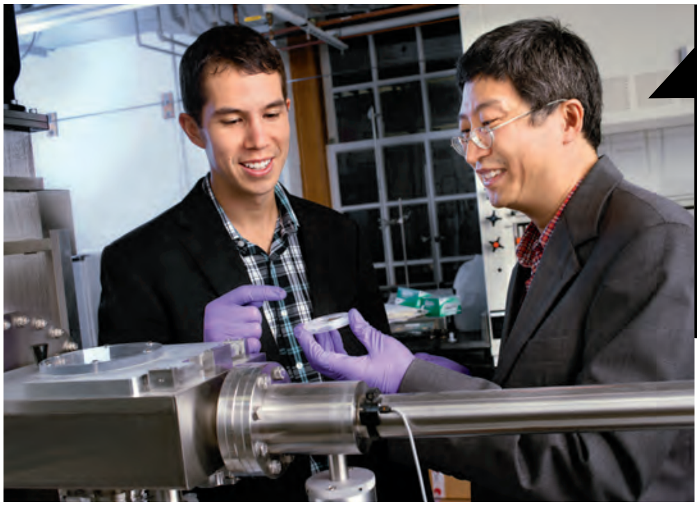
—Sam Florman '46 Th'46

I co-own one patent with General Dynamics on an airborne noise reduction device used on the *USS Nautilus* in the 1950s.

—John Kennedy '53 Th'54

I hold about 140 patents having to do with optics, cameras, and digital printers, mostly at Polaroid. I worked there from 1962 until 2001, and many of the products I worked on are still available at antique and second-hand stores. Polaroid cameras and film are considered obsolete, but there is still a market for them and many folks think that instant pictures are magical. Polaroid went bankrupt in 2001 and under new management stopped making film in 2008. Austrian investor Florian Kaps bought the Polaroid film plant in Enschede, the Netherlands, and with the help of 10 ex-Polaroid film engineers started making film again. Much of the extremely complex chemistry had to be re-invented. They now buy old cameras (and sold 30,000 of them last year) and sell the film online.

just one question



"Professor Jifeng Liu and I are working on a method to make metal-rich metal oxide thin films to improve light trapping in devices such as solar cells ."

—Drew Wong '12 Th'14

I once worked on a quirky Polaroid camera project in 1972 called the Big Shot, designed to take only great portrait pictures. It became Andy Warhol's favorite camera, which he used to help create his artwork. There is now a store in Australia called the Big Shot. The owner buys up old Big Shots, fixes them up, and sells them to Polaroid enthusiasts. He contacted me last year because he saw my name on patents connected with this camera. I was extremely surprised that it is still used after all these years and has a large fan base. The camera now uses a Fuji Instant Film pack and makes quite nice portrait pictures.

—Bruce Johnson '61 Th'62

When I worked for Texas Instruments I got my first patent on a sequential logic programmable logic array in metal-oxide semiconductor technology. My next patent came when I worked for Sperry Rand Research Center. My patent was on a block-oriented random-access memory in metal-nitride-oxide semiconductor technology (using a gate made from nitride and oxide).

—Dick Spencer '61, Th'62

I hold one patent on a chemical toilet designed for use in the 1960s in remote camps in the Antarctic. I bet no one can top that for novelty!

I was an NROTC student at Dartmouth, with a one-year deferment of active duty to get an ME at Thayer. My advisor, the late Ed Brown, suggested I study cold weather sanitation issues for a master's thesis. I discovered that a lot of work on the subject was being done by the Navy, which provided logistics support and infrastructure for the National Science Foundation scientific work in Operation Deep Freeze (U.S. operations in Antarctica). When it came time to go on active duty, I arranged to be assigned to the Naval Civil Engineering Lab in California, which was doing the cold weather sanitation research. A major issue was maintenance on the toilets they were using, complex electromechanical fluid moving systems adapted from airplane toilets. With a 10,000-mile supply chain that only operated six to eight months out of the year, access to spare parts was a big problem. I had to come up with something simple—as few moving parts as possible and limited maintenance and spare parts issues. The result was successfully tested at a Navy base and shortly thereafter, my two years were up and I left the Navy and the project died. The main reason is that the international scientific community decided that for environmental and safety reasons, human waste would no longer be disposed of on the Antarctic continent and it would all be shipped out to New Zealand for treatment and disposal. That set in motion a new approach to management of all kinds of waste, which had previously been just an afterthought.

Having a patent was a very big plus when I looked for my first job.

—Neil Drobny '62 Th'64

I hold four patents. Three are for wireless broadband local area networks. One, used by AT&T, is for "flip-chip" mounting of semiconductors (transistors) on interconnection substrates. I founded a radio-frequency integrated circuit (IC) business in 1994 called Endwave. We designed high-power millimeter wave circuits based in gallium arsenide (GaAs). Unfortunately, other than being a transistor, GaAs is a terrible material for other circuit elements. In order to improve the performance of the circuit, we patterned the IC on silicon and flipped the GaAs transistors into the circuit. My flip-chip patent is the basis for this circuit attachment technique. The major use of our circuits was in wireless, high-speed, broadband communications gear (think microwave radios). Three of my patents were various configurations of this wireless network. We worked with all the major wireless equipment providers of the day: Nokia, Siemens, Ericsson, AT&T, Nortel.

—Ed Keible '65 Th'66

As a research scientist for Xerox I was privileged to work in many areas: optics, computer hardware and software, font design, etc. I hold nine patents: 6714694, "Method for sliding window image processing of associative operators"; 6625306, "Color gamut mapping"; 5557720, "Method of determining whether a document tree is weakly valid"; 4724467, "Light blocking stop for electro-optic line printers"; 4633505, "Character compression encoding for electronic printer and facsimile"; 4483596, "Interface suppression apparatus and method for a linear modulator"; 4405956, "Tracking apparatus for read/write head"; 4355860, "Double pass scanning system"; 4100408, "Signal generator for raster type scanners." Patent 4355860 is a design patent for a laser printer optical system that Xerox sold in its 8000 line of office products. I was a research scientist working on developing software modeling of optical systems. I wrote a ray-tracing program that also did tolerance analysis. This analysis shows the performance of the optical system if the components are misadjusted or have slight errors in manufacture. We were using laser beams that do not propagate quite like light rays, so the modeling had to take this into account. Xerox launched a laser printer product with this design.

I believe that it is my strength in mathematics that allowed me to see and comprehend the essence of what was happening and is a common thread in many of these patents. I recommend that students master mathematics, physics, and engineering principles, as the current technologies may not be around in the future, but the basic mathematics, physics, and engineering will.

—Sidney Marshall '65 Th'72

I founded Plastic Technologies Inc. (PTI) 30 years ago and am very proud of the contributions that we continue to make to the world of plastics. We are a technology development company that specializes in plastic packaging, but our patent portfolio includes platform technologies that are useful in a broad range of plastic processing and product applications. Perhaps our most successful patented technology is a small-particle, food-grade packaging pellet (known as LNO), which led to the founding of a second PTI company, Phoenix Technologies Intl., the leading supplier of food-grade recycled polyethylene terephthalate (PET) to the industry and to Coca-Cola and Colgate Palmolive.

—Tom Brady '66 Th'68

I have no patents or inventions that were commercialized. However, I did invent (along with a couple of sailors who worked for me) a far superior way to take photographs through a submarine periscope, which was fairly quickly made obsolete when they started building cameras and video cameras directly into the periscope. Now the whole crew can see what the periscope sees via digital high-definition technology.

Forty-five years ago, I was a naval

officer serving on the *USS Scamp* and responsible for photography. We developed a way to use the periscope as the lens of a single-lens reflex camera instead of using a camera with a lens to shoot a photo through the periscope's optics. It had better light utilization and the system could be lowered down the periscope's well if necessary, which meant it was faster and safer to use. You can make your own guesses as to what we were taking pictures of. Attached is an unclassified example. [See photo below.]

—Clint Harris '69 Th'70

I am inventor or coinventor on 26 patents issued between 1976 and today. The more recent and most valuable ones relate to chlorine dioxide and a new product that allows chlorine dioxide to be shipped and stored commercially for the first time. Older patents, which have mostly been allowed to lapse or have expired, are on various technologies ranging from cryogenic freezers to gas-flow control systems to quality-control techniques for blow-molding plastics to gas atmospheres for transporting vegetables, and many others. My earlier patents were generated over 25 years while I was working for Air Products and Chemicals Inc. There, I had roles ranging from development engineer to director of applied research and development and business area manager for a $250-million business. My more recent patents (related to chlorine dioxide) were produced while I was working for startup company CDG. I was president and CEO of CDG for the first eight years. I left to found other companies and follow a career in consulting. Recently I returned to CDG as an advisor. I have some patent applications that have not yet been granted or denied that resulted from work I did for Quantum Confined Ltd., where I worked as president.

—Tom McWhorter '69 Th'70

I applied for a patent in the United Kingdom with two coinventors for "Methods and apparatus for making measurements on fluids produced from underground formations." It was an electric wireline-conveyed combination electric submersible pump and production logging tool to test multi-zone, low-pressure completed reservoirs. The patent was never granted because a search by the patent office showed someone had a blanket patent on anything having to do with measurements downhole, etc. We did, however, cobble together a working prototype that was able to do what we expected.

—Steve Askey '76 Th'77

I have two patents. I was coinventor of a server enclosure assigned to SnowShore Networks: "Electronics enclosure," D465,465. I was also inventor of a key holder assigned to Illinois Tool Works, "Selectively mountable article holding fastener," 4,397,438. Neither was a great commercial success, but I was pleasantly surprised recently in the hardware store in Shelter Island, N.Y., to find an adhesive-backed cord routing clip that I designed at Illinois Tool Works in the early 1980s still being sold. Thirty-plus years isn't a bad run!

—Mike Chapman '76 Th'77

I am listed as an inventor on two patents for work I did for IBM as a contractor supporting the speech recognition research team. IBM places a high value on patents, encourages PhD researchers and support staff to propose patent ideas, and retains control of the resulting patents. I worked on "System and method for control of lights, signals, alarms using sound detection." I also worked on "Natural language interaction with large databases."

—Bill Ablondi '77 Th'80

I spent more than 32 years at IBM developing electronic design automation tools, primarily for logic synthesis, static timing analysis, clock tree synthesis, power analysis, and design optimization. IBM encourages employees to disclose potentially patentable ideas, and I did so frequently from 1985 until I retired in 2014. As a result, I am sole inventor or coinventor of 98 issued U.S. patents, and I believe I have 19 other U.S. patent applications pending. All of these were assigned to IBM. Many of the timing analysis-related patents were the foundation for IBM's EinsTimer incremental timing analyzer, which was used by IBM application-specific integrated circuit customers until the business was sold to GlobalFoundries last July. They are also in use through cross license by Synopsys in its PrimeTime static timing analyzer, which is probably the most widely used tool of that sort in the industry. Other patents were used in IBM's physical design automation tool for logical/physical design automation, its ClockDesigner clock tree synthesis tool, and its EinsPower power analysis tool. I also served as a member and chair of IBM's invention disclosure review board for Economic Development Administration inventions.

—David Hathaway '78 Th'80

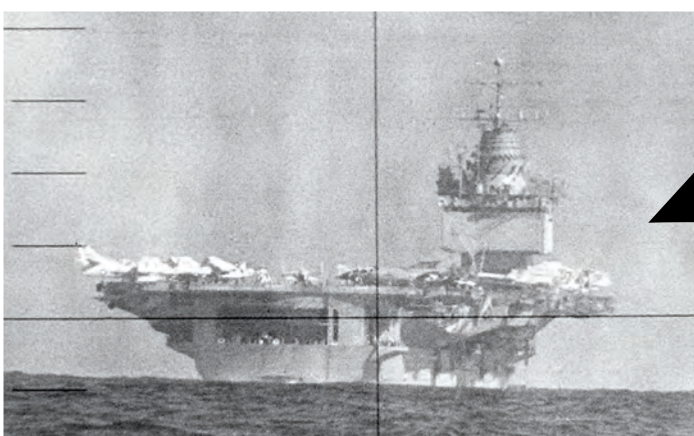
My awarded U.S. patents and patents pending: "Methods and apparatus for simulating risk tolerance and associated adversary costs in a distributed business process," 8,862,454; "Method for differentiating duplicate or similarly named disjoint localities within a state or other principal geographic unit of interest," 7,831,382; "Map database having vectors for determining destinations, and vector determination method," 8,655,590; "Locality indexes and method for indexing localities," filed; "Map database having address points for determining destinations," filed; "System and method for differentiating duplicate addresses in a locality," filed.

Within the boring title "Locality indexes and method for indexing localities" is a lifesaving invention I developed while director of geo-coding technologies and services at TomTom. There are four different "2 Adams St." locations in Boston. When asked, mapping software will either simply pick one answer or will return all four distinguished by either zip code or county name, which are not useful to most travelers in the United States. The essence of this patent is that it allows mapping software to distinguish duplicate addresses by the smallest containing unique known area. So when asked for "2 Adams St." in Boston, the user will see the address by area, such as "2 Adams St., Charlestown, MA." This simple association prevents ambulances from being sent to the right address in the wrong town. It also prevents people using navigation devices from mistakenly doing the same.

—Michael Geilich '79 Th'82

I received one U.S. patent, 4,406,606, for "Apparatus for producing soil building blocks." The idea resulted from my BE thesis for Dart-Ram, a compressed-earth block-making machine that I developed under the direction of Professor Francis Kennedy. After I graduated, Prof. Kennedy had two students in later years do further development of the machine. The machine was tested in Guatemala in 1984 by Habitat for Humanity and was used to build four houses there. Issues with maintainability have limited its commercial adoption.

—Harry Sangree '79 Th'80

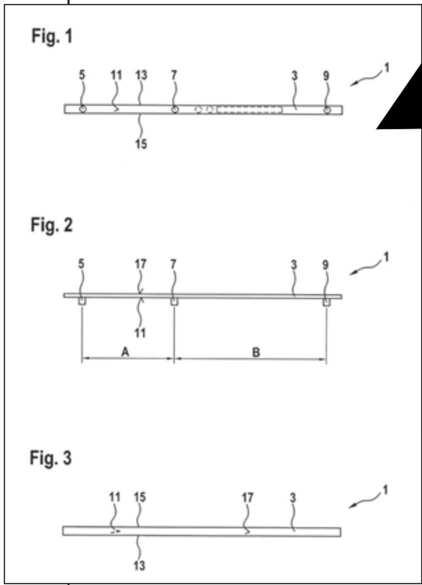


"I did invent a far superior way to take photographs from a submarine which was quickly made obsolete when cameras were built directly into periscopes ."

—Clint Harris '69 Th'70

OPPOSITE PAGE: JOHN SHERMAN. THIS PAGE: COURTESY OF CLINT HARRIS

just one question



"My design for a plastic clip used in the auto industry eliminates the tolerances between clips—and therefore the risk of excess material that could be damaged during installation—by simply combining several clips into one."

—Matt Wallach Th'09

I hold two patents: "On-chip test circuit for evaluating an on-chip signal using an external test signal," 6163862; and "Fault identification by voltage potential signature," 6252417. Both are incorporated into IBM chips.

—Ted Cooley '82 Th'88

I hold no patents, but in 1988 I worked on a project with DuPont to build a prototype of a laser imager for medical images that went on to become a DuPont product.

—Steve Shustack '84 Th'87

I hold only two patents, neither of which became a commercial product. One (5,831,736) is for making an image of a microscopic surface. The other (7,444,014) is to collect a microscopic image with high resolution and long depth of focus.

—José Angel Conchello Th'85

I have 15 U.S. patents and two patents pending. They deal with a variety of technologies, including a surgical tool for microperforation of bone and ligament tissue during knee ligament surgery, a rehabilitation tool for increasing bone density and ligament strength, protective equipment for preventing fractures (focused on preventing wrist fractures in snowboarding), methods and systems for monitoring head impacts in sports (multiple patents), methods and systems for monitoring physiological parameters of sports participants (multiple patents), methods and systems for providing dynamic perturbations to individuals to prevent falls in the elderly and prevent injuries in athletes, materials and system for attenuating impact energy (multiple patents). Several products are on the market either by my company, Simbex, or its partners.

The patents include "Instrument and Method For Surgical Stimulation of Connective Tissue," 5,961,535; "Vibrational Stimulator," 6,620,117; "System and Method for Measuring the Linear and Rotational Acceleration of a Body Part," 6,826,509; "Power Management of a System for Measuring the Acceleration of a Body Part," 7,526,389; "Dynamic Body Protector," 7,837,640; "Fall Prevention Training System Using a Dynamic Perturbation Platform," 7,980,856; "Measuring Acceleration of a Body Part," filed; "System and Method for Monitoring a Physiological Parameter of Persons Engaged in Physical Activity," filed; "Training System and Method Using a Dynamic Perturbation Platform, Continuation of U.S. Patent 7,980,856," 8,246,354; "Impact Energy Attenuation System," 8,524,388; "System and Method for Evaluating and Providing Treatment to Sports Participants," 8,548,768; "System and Method for Measuring the Linear and Rotational Acceleration of a Body Part, Continuation of U.S. Patent 6,826,509," 8,554,509; "Training System and Method Using a Dynamic Perturbation Platform, Continuation-in-Part of U.S. Patent 7,980,856," 8,622,747; "System for Monitoring a Physiological Parameter of Players Engaged in a Sporting Activity," 8,797,165; "Material for Attenuating Impact Energy System, Continuation-in-Part of U.S. Patent 8,524,388," 8,986,798; "Impact Energy Attenuation Module, Continuation-in-Part of U.S. Patent 8,524,388," 9,023,441; "Impact Energy Attenuation System, Continuation of U.S. Patent 8,524,388," 9,034,441.

—Rick Greenwald Th'88

I have one U.S. patent, "Carbon management for sourcing and logistics," 8,346,595, issued in 2013. I was working at IBM as a senior management consultant. We were identifying the amount of carbon in a supply chain for a client. Since the largest amount of carbon was in logistics, we focused on developing a model that would allow the client to not only measure the amount of carbon developed through logistics operations, but also to perform what-if scenarios to decrease carbon and what the impact would be on other business drivers (i.e., inventory, production).

—Chad Boucher '95 Th'96

I have been awarded 10 patents, with the earliest filed as a result of my PhD work at Thayer (1992-97) and assigned to Dartmouth. I spent part of the time as a research assistant in the Interactive Media Lab (IML) at Dartmouth Medical School under Dr. Joe Henderson. We began investigating the (then) novel idea of distributing interactive multimedia content on the Web. IML's partners were keen to leverage the Internet to reach a broader audience with our content, which was directed at healthcare providers and patients. After successfully posting a few videos, we realized that there were no effective means for communicating and transacting copyright in the digital, networked environment, and my research was born. I developed a novel approach to associating rights metadata with digital objects and for transacting permissions, which became the basis of my initial patent application (1995) and the core IP for NetRights, which I cofounded with some local partners, some with Dartmouth ties. A big issue for us was that many decision-makers in the publishing industries weren't quite ready to talk about the digital, networked environment that was about to emerge! My partners and I were evangelizing a rights-management model based partly on the assumption that "mashups" were going to happen, people would want to do rights "right," but stakeholders were instead asking, "Tell me about that Web thing again?" In short we were way, way ahead of the curve. Fortunately, enough people saw value that we found angel investors, kept marching on, and ultimately were acquired by Digimarc Inc., for our IP if not for the specific code or broader vision. Digimarc and its licensees continue to manage the Dartmouth and NetRights-related patents.

I ended up staying in the Upper Valley and in 1997 helped start a spinoff of Yankee Book Peddler Inc. named Yankee Rights Management, which created Copyright Direct, the first fully real-time, web-based rights transaction service. It was a technical success but had difficulty catching on because purveyors of early digital content had not yet gone digital with their record keeping. Around this time I coined the phrase, "Metadata is the lifeblood of e-commerce," which is still referenced in certain circles.

In late 1998 Hewlett-Packard approached me as they began to enter digital publishing, and in late 1999 I went to work full-time for Hewlett-Packard Labs, reporting to a lab based in Bristol, U.K., and working from Norwich, Vt. I then joined the Tetherless World Constellation at Rensselaer Polytechnic Institute in 2010, first as a research project manager, contributor, and guest lecturer, and more recently as an instructor. I am also now affiliated with the Rensselaer Institute for Data Exploration and Application.

—John Erickson Th'97

I hold three U.S. patents and have two U.S. patent applications and two European patent applications pending. The granted patents are for a spinal interbody device (a spine implant), an interbody fusion device and method of operation (a different type of spine implant, plus the associated instrumentation), and a surgical retractor for creating an opening for surgery, holding that open, and moving it around. The pending patent applications are for an additional kit of surgical instruments to be used in conjunction with the retractor and a novel surgical method of using the retractor. Engineering and patents are both things I'm passionate about. I spent 15 years as an engineer, working my way up at various companies from entry level to director of research and development. I went to law school at night and recently made the switch to being a patent attorney.

—Hugh Pfabe '98 Th'99

I am a digital designer at Analog Devices and have one patent so far: "Apparatus and method for image decimation for image sensors," 8749656. This is a method to do image decimation in the analog domain on image sensors that have a color filter. Doing simple averaging of adjacent pixels of the same color creates odd image artifacts. This method weights the averaging to remove these artifacts. It is done in the analog domain to save the time and power of converting all of the raw data to the digital domain first.

—Ned Guthrie '00 Th'01

Having worked at IDEO, a product design consultancy, for the last 10 years, I have touched a range of products. I helped Lilly come up with a novel injection mechanism for folks with chronic conditions to self-inject at home. I helped a transcutaneous vaccination technology make its way into production for the startup Iomai. I helped Steelcase come up with innovative, people-focused furniture designs for hospitals. My favorite products I worked on that have hit the market are several devices for Tria Beauty, as well as a noninvasive temperature measurement system for 3M called SpotOn. Thanks, Thayer, for teaching me how to balance the need for innovation alongside the need to execute and ship product!

—Brian Mason '03 Th'05

My first patent, 6996241, came about from work that I did with Professor Laura Ray. A PhD student of hers had developed a novel feed-forward control algorithm for performing active noise cancellation in headphones. Professor Ray hired me the summer before my BE year to investigate adding feedback noise cancellation to the system. To our surprise, we found that the performance of the combined system was greater than the sum of its parts. Implementing this combined system in portable electronics became the basis of the ENGS 190/290 project the following year. It also became the basis of a spinoff company, Sound Innovations, that attempted to commercialize the technology for the military. My second patent, 8956421, stemmed from work I did at DEKA Research & Development. We had been tasked by the Defense Advanced Research Projects Agency to develop a better prosthetic arm, which came to be known as the Luke Arm. Part of my contribution was developing an advanced socket—the custom-molded interface between the prosthesis and the residual limb—that combined pneumatic elements in order to grip the wearer tighter or looser. The patent, shared with some of my coworkers, covers the design of such a socket and the tiny pneumatic controller I built for it. Although the Luke Arm received FDA-clearance and is approaching a commercial launch, the "dynamic socket" didn't make it that far.

I also have several applications in progress. The recognition of a patent is nice, but is small compared to the satisfaction of delivering something truly useful to the world.

—Alex Streeter '03 Th'05

The strength of a Thayer education is not in book learning, but more so in the approach that is taught to navigate one's way to a successful solution when handed a completely foreign problem. Professor Collier's ENGS 21 course and the old 190/290 series were such great preparation for real-life engineering and for a career in product development.

I worked on a range of products as a consultant at Synapse Product Development in Seattle. I designed the mechanicals for power supply systems for Ingersoll Rand so they could be highly configurable (54 different possible layouts for the panel). As far as I know it's still being produced in the tens of thousands per year. I designed the internals and a lot of the trickier aesthetic details for the TomTom SportWatch GPS powered by Nike. The implementation of the GPS antenna into the watch was one of the harder aspects, since its size and radio-frequency (RF) properties made maintaining a compelling fit, feel, and aesthetic very challenging. I went through many iterations with the Nike industrial design team to come to a product that looked good and was functional, and we won several innovation awards at that year's International Consumer Electronics Show. For the Nike+ basketball and training shoes, I designed the in-shoe puck and aided in the design of the sensor array that allowed for real-time footbed pressure tracking. The biggest challenges were in packaging, sealing, and RF performance. The puck needed to be as small as possible to not be felt in the shoe, but also had some ambitious specifications for battery life, antenna performance, and sealing that were challenging to package. We produced hundreds of thousands of them at very high yields and with good performance, so the design and engineering succeeded.

Currently, I am engineering program manager for the Nima Portable Gluten Sensor (nimasensor.com). There isn't anything like our device out on the market. Currently, if you are trying to avoid certain proteins in prepared foods, your only tools are ingredient lists and trust in waitstaff's knowledge of the food being served at a restaurant. We're trying to build the first consumer-grade tool for people trying to avoid gluten that empowers them to quickly know what is in the food they are eating. A lot of chemistry and design is going into making that a reality, and we are also developing tests for dairy and peanut for future generations of the device. Ultimately our goal is to make food transparent to the consumer.

—Joe Horrell Th'04

I do hold a patent that was a spin-off from my graduate studies at Dartmouth. The patent is for a chemical process related to the conversion of cellulosic biomass to fuels and chemicals. I don't have any products available commercially. My advisor was Charles Wyman and we were looking for ways to make cellulosic ethanol more economical.

—Todd Lloyd Th'05

I am one of a number of names on two of ATDynamics' patents (with Jeff Grossmann '06 and Chuck Horrell '00 Th'01, who should get most of the credit for that work): the WheelShield and SuperSpare. They are products for tractor trailers. The WheelShield improves aerodynamics, while the SuperSpare, the product I worked on more, is a device to carry a spare of the "new" double-wide tires many trucks use.

For my 190/290 project, I worked with Tilting Motor Works to design a speed-controlled pivot lock for a three-wheeled bike. The company has brought to market a TiltLock technology that meets the same need as our work. I don't know how much of this final product is from our research and development—I worked with David Drennan Th'09, Adam Danaher Th'08, and Kyle Lobisser Th'08 on this project [see page 15]—but it's the closest I have to something I worked on that's on the market!

—Laura Weyl Th'08

I hold one patent as coinventor with Professor Elsa Garmire and Dr. Jonathan Bessette: "Systems and methods that detect changes in incident optical radiation," 8174253. With this design, voltage is applied across one or more active areas of a detector while the incident optical radiation illuminates the active areas. Current is sensed across one or more of the active areas, a change in the current being indicative of the changes in incident optical radiation. I also invented a patent-pending product verification service now available in six countries: Sproxil (sproxil.com).

—Ashifi Gogo Th'09

I currently have a patent pending in Germany (PA2013215074) with BMW for a plastic clip design for use in the auto industry. (I am section manager for total vehicle validation and am working at BMW's production facility in South Carolina.) In order to connect with sensors and lights in the headliner of a vehicle, wires must be routed through the tight A-pillar area, next to the windshield. Designers, however, prefer to keep this area as small as possible to increase visibility for the driver. This restriction, coupled with the tight tolerances and manual production process involved with producing a wiring harness, led to high rework costs and damaged parts at our production facility. My design eliminates the tolerances between clips—and therefore the risk of excess material that could be damaged during instal-

just one question

lation—by simply combining several clips into one. This design led to lower production costs due to fewer parts and easier assembly.

—Matt Wallach Th'09

I have a patent pending with Apple Inc.: "Tone detection for interoperability testing," filed in 2015. It covers a method to use signal processing to decode audio signals from wireless payment devices, such as for ApplePay. We needed an automated method of making sure our device works with a large number of third-party electronic payment devices.

—Adam Dohner '10 Th'11

I have the U.S. patent, 8,977,340: "System and method for collection and use of magnetic resonance data and microwave data to identify boundaries of interest," with Thayer Professors Paul Meaney and Keith Paulsen. It is a system and method for detecting permittivity and conductivity boundaries within a high-resolution spatial image of a material. The method may be employed for 2-D or 3-D image reconstruction.

—Amir Golnabi Th'11

I have a pending patent application for "Mixed redox couple electrodes for rate capability and overdischarge protection." It has to do with including materials of different voltages in the same battery electrode to artificially bias current to less-accessible (higher-resistance) regions of the battery electrode. Battery electrodes tend to be assumed to conduct current evenly, but this is not true, and we were seeing premature failures of batteries from a local company due to this problem. I'm currently a PhD student at the University of Florida.

—Michael Kellar Th'11

Spiral-E filed two patents from ENGS 21 for a vacuum suction tissue-stabilizer designed to prevent tissue damage during endoscopic surgery.

—Alison Stace-Naughton '11 Th'13

I am a coinventor of "Systems and methods for converting biomass to biocrude via hydrothermal liquefaction," 20150099275, which details methods for converting sludge into biocrude via a process called hydrothermal liquefaction (HTL). It was a part of the master's research that I just completed at the University of Texas, Austin. HTL is the process of heating and pressurizing an aqueous biomass slurry to 200° to 375° C and 2,200 to 3,200 psi in order to convert the biomass into an energy-dense bio-oil phase. I conducted batch experiments on sludge and biosolids that were taken at various points in the biosolids management process in order to determine how various types of sludge/biosolids, reaction temperatures, heating rates, and solids percentages affected the amount and quality of the resulting biocrude. I also designed and constructed a continuous system that could demonstrate the type of system that would actually be scaled up and used commercially. My experimental results were used to help decide which of the processes in the patent would be the most economically viable.

I just started a job in Minneapolis, Minn., at HVAC company Daikin. I will be on the R&D team focusing on combustion and heat transfer as we develop new products.

—Joey Anthony '12 Th'13

I am an inventor on three issued patents: 8,826,733, "Sensored prosthetic component and method"; 8,720,270, "Prosthetic component for monitoring joint health"; and 8,707,782, "Prosthetic component for monitoring synovial fluid and method." They were all related to a prosthetic component, which includes electronic circuitry and sensors to measure a parameter of the muscular-skeletal system, suitable for long-term implantation. I believe they are currently under commercial development but yet not available. Fellow Thayer alumni John Keggi '12, Natalie Burkhard '12, and Phil Henson '11 are coinventors on these.

—Noah Bonnheim Th'12

This patent is still pending, but I am listed as the primary inventor: "Methods and systems for input to an interactive audiovisual device." It's an optical pointer device that can include an energy source compartment, a light-emitting diode (LED), and a timer circuit capable of modulating a current driving the LED.

—Peter Williams Th'12

I have one patent application that Professor Jifeng Liu and I applied for as coinventors, "Multifunctional Nanostructured Metal-Rich Metal Oxides." We were working on a method to make metal-rich metal oxide thin films to improve light trapping in devices such as solar cells while simultaneously improving electrical conductivity (for efficiency) and lowering the materials processing temperature so it is manufacturable with temperature-sensitive materials. Thin films such as these are typically the top layer on solar panels, and are also on building windows, oven windows, etc., to improve thermal management. The method that we stumbled upon does a number of things quite well. Typically in solar cells you need multiple layers—a conductive layer, a light-trapping layer, and an antireflective layer—above your solar absorber to function well. The method we developed enables a single layer of thin films with all of these functions—we call it a multifunctional thin film. Furthermore, the processing technique is comparable with widespread, industry-standard methods, such as sputtering. The functional properties and low processing requirements of the thin films are comparable with state-of-the-art materials. Photovoltaics are one high-profile application this technique can be applied to. Some of the materials we have made could also have important niche applications, such as thermophotovoltaics, which can convert waste heat into electricity, or semitransparent electronic devices.

I am in my second year as a PhD student at Harvard's Paulson School of Engineering and Applied Science, working on aqueous organic batteries for large-scale energy storage. Just as renewable energy generation is a booming technology space, storing energy from these intermittent sources is also an exciting area of research.

—Drew Wong '12 Th'14

I do have patent, 8948849, which was licensed for a year but is not currently licensed or used in any commercial products. I was working with Professor Solomon Diamond on a device to simultaneously record and monitor adult subjects with electroencephalography (EEG) and near-infrared spectroscopy (NIRS). The patent describes the device we designed to hold 65 EEG electrodes (electrical terminals) and 64 NIRS optodes (optical terminals) in contact with the scalp. The device is an expandable structure of telescopic arms that were assembled in a hemisphere to expand and contract in order to fit a wide range of adult head sizes. The structure holds the terminals in contact with the scalp while accurately and precisely following placement standards.

Currently, I am working at ZOLL Medical in the advanced development team. We are responsible for research and development of medical devices in the resuscitation space, primarily aimed at assisting medical personnel during cardiac arrest emergencies.

—Paolo Giacometti Th'13

I have three filed patents. The oldest patent, "Miniaturized cardiopulmonary bypass circuit for a mouse model," was for our class project in ENGS 57/169 in 2012. I worked on it with classmates Jay Vincelli Th'13 and Stephanie Wolf '12, Professor Ryan Halter Th'06, and DHMC cardiothoracic surgeon James Yun, our project sponsor. The invention was basically a miniature, 3-D-printed blood oxygenation chamber and pulsatile pump that would be used to put a mouse under for cardiopulmonary bypass; this would allow for studies on side effects. The next patent, "Apparatus and methods for structured light scatteroscopy," was filed soon after I started grad school in the fall of 2013. For this I worked with Thayer Professors Venkatramanan Krishnaswamy, Brian Pogue, Keith Paulsen Th'84, and Jonathan Elliott. This is an imaging technique that can directly capture contrast from light scattering rather than absorption. The research was published in the *Journal of Biomedical Optics* (biomedicaloptics.spiedigitallibrary.org/article.aspx?articleid=1891726). The next year we developed a way to quantify the amount of backscatter light, which led to our most recent patent application, "Structured-light imaging systems and methods for determining sub-diffuse scattering parameters," and an article in *Biomedical Optics Express* (osapublishing.org/boe/abstract.cfm?uri=boe-5-10-3376).

—David "Bo" McClatchy '13

thayer notes

1950s

Ron Read '57, Th'58: Twenty-five years ago I started as director of engineering with ITT Industries. I had worked in other companies (Bendix, Midland-Ross, Swedlow, and Vickers) with a multitude of organizational cultures and management styles, but was never trained in how to manage others. With 30 years of work experience as I started with ITT, I decided to try teaching engineers how to manage. Often good engineers are perceived as potential managers but are never trained in how to be effective managers. My first challenge was to find a teaching venue. I had some experience with the Engineering Professional Development (EPD) department at the University of Wisconsin-Madison. I have a good friend, **Ken Ragland '57 Th'58**, who was head of the mechanical engineering department there. I told Ken of my idea for a course for engineers working in industry, and he helped me get on board with EPD. I started teaching a three-day workshop on vacation time from ITT. The class grew in popularity and a few years later, the UCLA Extension asked me to teach in its technical management program. I retired in 2001 after 10 years at ITT, but continued to teach at EPD and UCLA and still do today. I've taught more than 5,000 engineers and conducted on-site sessions at 30 organizations globally. Last September EPD recognized my "25 years of distinguished teaching service" with an award presented by Dr. Phil O'Leary, EPD department chairman, and EPD program director **Tom Smith '67**, and assistant Gail Geib.

1960s

Neil Drobny '62 Th'64: I became an academic after 35 years of environmental engineering consulting, primarily with large companies. I teach sustainable business practices in the business college at Ohio State. My consulting experience led me to conclude that getting a decisive grip on environmental issues was primarily a business issue, so I decided to change my focus to the next generation of CEOs rather than the incumbents (at the time I made my change 12 years ago), whose interests at best seemed to be in slow, incremental change. My courses are oversubscribed and a new campus-wide major in sustainability, which I led at Ohio State in its formative years, has become the fastest growing major on campus. I think my engineering education at Thayer was a great foundation for what I am doing now.

John Clayton Kunz '65 Th'66: I retired a year ago after 25 years of teaching and doing research at Stanford in the area of design and management of projects in civil engineering. I still work with some students and participate in one of the ongoing programs I created—which was based on a class I taught for undergrads and master's students on multidisciplinary modeling analysis of civil engineering projects. Students interviewed project teams around the world; built and analyzed computer models of the physical project, the design-construction teams, and the processes used by those teams to design and build their projects; and then interrelated the product, organization, and process designs, analyses, and measured project performance. Sponsoring companies saw what the students did, working part-time, and wondered how they could do it. With a partner, I started teaching a version of the class for professionals, which now has brought these new methods to hundreds of professionals in many countries around the world. I continue to work with this program and the students as they apply their new skills.

The emeritus position I have now gives me the opportunity to continue some level of engagement, which is rewarding and fun but gives enough time for family, mountain biking, travel and some general free time. Prior to returning to the university, I had worked in the medical community and then in Silicon Valley in the software industry at a couple of startups. I distinctly remember hearing often at Thayer that engineering gives one the opportunity to make things that help people and society. I thought often of that inspiration as, through the years, I traveled across the world to visit project offices in different industries and listen to them and help them use some of the things I had helped to create.

1970s

Steve Askey '76 Th'77: Due to cost cutting in the oil industry, I am now retired as of October 1 (again—the first time was from Schlumberger in 2010 for about three months). I had been working as a quality-assurance engineer for BHP Billiton for the last five years, as a part-time rotating contractor for the last year and a half between my home in Ormond Beach, Fla., and the office in Houston, Texas. The potential is there for ad hoc work as the industry improves, but a full-time job is not really of interest! I'm busy working on this old house, visiting friends not seen in awhile, and playing lead guitar in an old-guy rock band. I'm gigging in Daytona Beach and surrounds at biker bars, so probably not in engineering anymore.

Steve Arcone Th'77: I started and am now steering the science within a robot radar project, jointly funded by the National Science Foundation, Dartmouth, Cold Regions Research and Engineering Laboratory (CRREL), and the University of Maine, to map crevasses and understand ice dynamics in a very dangerous area of Antarctica regularly traversed to haul fuel to the South Pole Research Station. We have just completed a second successful year of surveying using Dartmouth's Yeti robot, my radar equipment, and GPS expertise from the University of Maine. We already have one publication. Key personnel are myself and Dr. Jim Lever of CRREL, Professor Laura Ray at Thayer, and Professors Gordon Hamilton and Peter Koons of Maine. There are two graduate students involved, much undergraduate help from Dartmouth and Worcester Polytech, and non-funded support from Sandia Laboratories. The spectacular results include remote operation of the robot over 28 square kilometers, perfect navigation over a grid that covers the area, and the discovery and imaging of crevasses 160 meters deep in marine ice that has frozen to the bottom of the ice shelf. And we have not had any accidents!

1980s

Kaya Kazmirci '84: I am presently offering cybersecurity and information technology (IT) governance services. I have spent much of the past year consulting with regulators in Turkey and Mongolia, working on developing IT regulatory frameworks and training the regulatory teams. I presented a paper, "Developing Continuous Regulatory IT Audit Approaches," at the Information Systems Audit and Control Association's European conference in Copenhagen, Denmark, on November 9, 2015. The paper is a synopsis of the work that I have done in developing IT control approaches, and includes a principal and framework-based approach to controlling IT so as to ensure that it delivers the services that it is supposed to.

Joe Frankhouse '85: After graduation I tried a job as a thermal systems engineer in Cambridge, Mass., and decided it wasn't for me. So I went with my Plan B, which was medical school. I went to Emory School of Medicine, then the University of Southern California for residency, and now I am a gastrointestinal surgeon in Portland, Ore.

1990s

Doris Martínez '91: With my background in materials and numerical methods, I began developing 3-D animation effects for my husband's commercials productions in 1993. From then on, we built our own production company, Metro Studio (metrostudio.tv), with more than 4,000 TV commercials, branded content, award-winning short films, and documentaries under our belt. I took many of the MEM classes, which, combined with my undergraduate background and further education, allowed us to build a strong, well-managed, profitable company. Of course, my husband's talent has a lot to do with our success. I thank my education at

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Thayer for showing me there is no engineering without a sound financial footing. It is no coincidence that Thayer is next to Tuck—which is a daily reminder throughout the years spent at Thayer of this very important fact of life.

Qi Wang ’97: I am the head of global advisory and the CEO of the Hong Kong subsidiary of MegaTrust Investments. I am responsible for creating customized research and solutions for global institutional investors. MegaTrust is a boutique asset management firm specializing in China A-shares (domestic Chinese stocks). The company was established in 2007 and has approximately $400 million under management. Prior to joining MegaTrust, I was the head of China Equity Research at MSCI Inc., a global index and analytics tool provider.

2000s

Brian Mason ’03 Th’04 ’05: My wife, **Jocelyn Mason ’05**, and I have had an exciting 2015. After 10 years at IDEO, I transitioned to a local consumer medical device startup that is part of ExploraMed. I am helping lead the R&D team to rapidly launch a product in the coming year. It is thrilling. I am flexing my engineering muscles every day as we build prototypes, test electromechanical assemblies, iterate the product in the clinic, and get geared up for high-volume manufacturing. In family news, Jocelyn and I have our hands full with Lynn, 4, and Peter, 1, at home. It is such a joy to tinker together in the garage, bike around Palo Alto, Calif., or clean Cheerios off the floor.

Daniel Hassouni ’05 Th’06: Last year, my wife, **Sarah Isbey ’08**, and I moved to Denver after having spent our entire lives on the East Coast. More recently, I started working at Yes Energy in Boulder, Colo., this past summer as a senior application developer. Yes Energy makes an electronic analytics platform for utilities and traders involved in the North American electricity markets. Prior to this new role, I had spent nine years as a trader and analyst in the power and gas markets. So, while I am taking on new technical challenges, I am thrilled that I am still able to apply my market knowledge in my new role. When we are not working, we love to explore Colorado’s many mountains, whether it be hiking and trail running in the summer or skiing in the winter. We also took an unbelievable trip to Alaska in September. We highly recommend it!

Erik Johnson ’06 Th’11: I have remained in engineering and in 2013 started a company named Synticos LLC with Thayer Professor Emeritus Robert Dean. Our board of directors includes Dick Couch ’64 Th’65 and Professor Sol Diamond ’97 Th’98, as well as business expert and entrepreneurial advisor Robert McCray. We are making the world’s first low-pressure, abrasive water jet-cutting system, called a slurry jet cutter, that utilizes a proprietary high-efficiency, extended-life nozzle design to accelerate a pressurized abrasive slurry (think shampoo with fine sand in suspension) into a high-velocity jet that is capable of cutting all materials (plastic, metal, composites, ceramic). The high efficiency of our nozzle allows us to cut at only 6,000 psi, compared to the abrasive water jet industry standards of 60,000 to 90,000 psi. This 90-percent reduction in system pressure allows us to use lower-cost components, including many off-the-shelf hydraulic parts, and to provide a machine that meets both the cost and performance needs of job shops around the world. Currently, Synticos is fundraising to support the completion of the prototype system and to launch the first production machines in 2016. In other news, I have a 15-month-old named Lachlan, who is a total hoot and loves playing in slurry (at the beach).

Peng Wang Th’09: The biggest news in my life is I am a father now! My baby girl came to the world on September 20, 2015. My wife, **Yihan Hao ’08**, and I are so excited and proud to become parents. The year 2015 was also a key year for my career development. I am now a vice president at CDB Capital, one of the largest private equity funds in China.

2010s

Max Fagin Th’11: I finished my MS in aeronautics and astronautics at Purdue University, with a focus on entry, descent, and landing systems for crewed Mars spacecraft. I worked for SpaceX, certifying the Falcon 9 rocket for launching U.S. Air Force payloads, and for Made In Space, sending the first space-rated 3-D printer to the International Space Station.

Alison Stace-Naughton ’11 Th’13: Washington, D.C., is great! I love working at the State Department and enjoy the bridge between technical and diplomatic-interpersonal work.

Deidra Willis ’13 Th’13: I was recently promoted to systems engineer II with General Mills. I have since moved to one of our largest manufacturing plants, in Cedar Rapids, Iowa, and am currently the engineer for Fruit by the Foot. I live in Iowa City. Previously, I was a manufacturing engineering associate at the General Mills plant in Vineland, N.J., where we made Progresso soup. As a systems engineer, my focus is making sure we have control over anything that interacts with my system—people, ingredients, or products and the equipment itself. There is a lot of future state planning, ideation, and long-term or capital project work that goes into my day to day as well. Each day is never the same—which I love. I could be starting up a new product or flavor for Fruit by the Foot or trying new equipment or modifications to what we have. My role stresses technical knowledge and depth and relies on my influence and leadership skills to be a resource for others on my team. Reaching that level of expertise and building relationships while delivering results is my biggest challenge.

Allison Brinley Beck Th'14: I am living in Salt Lake City, Utah, bought a 100-year-old Tudor house down in Salt Lake, and just finished renovating it. I'm working as an environmental engineer for CH2M, primarily in air-quality compliance for federal clients, and I'm loving my job and my team, even on the crazy days! Spending lots of time playing in the Wasatch-Little Cottonwood Canyon.

Stefan Deutsch '14 Th'15: I'm currently serving as an AmeriCorps National Civilian Community Corps team leader based out of Denver. We (my team of 10 young adults and I) are traveling around the southwestern United States to work on community service projects with a variety of nonprofits. I'm taking a break from engineering for now, but looking to apply to graduate programs for next year.

Sarah Hammer '15 Th'15: I am currently pursuing a PhD in chemical and biological engineering at Princeton University. I just began this past fall and am currently taking classes. I will be choosing a research advisor this winter and beginning my PhD research! I'm hoping to work on the metabolic engineering of yeast for the production of alternative fuels and renewable chemicals.

Evan Landau '15: During the summer I started working at Horizon Media on the mobile strategy team. Horizon is a media and marketing agency in Tribeca, N.Y.C. I've been able to bring a scientific and engineering perspective to a lot of business practices and have spent a lot of time researching the tech that goes into mobile advertising. While I'm not currently in engineering, it's not out of the question for the future.

obituaries

Robert Moore McIlwain '50 Tu'51 Th'51 of Bernardsville, N.J., and Vero Beach, Fla., died October 24, 2015. He grew up in Radnor, Pa., and spent a year in the U.S. Coast Guard before entering Dartmouth. He loved Dartmouth. He was a class president as an undergraduate and never missed a class reunion in 65 years. After college he served as a lieutenant in the Navy for three years, then worked for McKinsey & Co., Singer Corp., Warner-Lambert and Engelhard Corp., retiring in 1992. Meeting and marrying his wife, Joan, was the most important event of his life. For 57 years they had a wonderful time raising four boys. He is survived by Joan; sons Robert, John, David, and Bill; daughters-in-law Michaela, Melissa, AnnMarie and Halley; and seven grandchildren.

William Weetman Bonneville '54 died July 27, 2015, in Boston. He came to Dartmouth from Chevy Chase, Md. He majored in engineering, graduated Phi Beta Kappa, and graduated from Thayer with an MS degree. He was in the Navy from 1955 to 1958, serving as chief engineering officer on the *USS Stribling* in the Atlantic Fleet. Upon discharge he worked for Esso in New Jersey. He left Esso to earn an MBA from Harvard Business School. Moving to New Hampshire, he was VP and CFO of the Nashua Corp. After 12 years he left Nashua and joined Gloucester (Mass.) Engineering Co. for 21 years, becoming VP, CFO, and director. When the company was sold, he opened his own business as a private investment advisor. He is survived by his wife, Nancy, and children William, Martha, and Gordon.

William Conway '52 Th'54, CEO of Modjeski and Masters, a leading civil engineering firm responsible for several accomplishments in long-span bridge design, died December 14, 2015, near his hometown of New Orleans, La. After earning his master of science in civil engineering from Thayer, he joined Modjeski and Masters in 1957, becoming a partner in 1969 and the CEO in 1992. He was the principal-in-charge for eight award-winning Mississippi River crossing projects, including the Greater New Orleans #2 Bridge, which was then the second longest cantilever span in the country. He directed the seismic retrofit of the steel portions of the San Mateo-Hayward Bridge in California and the widening of the Huey P. Long Bridge over the Mississippi, among other projects. He earned the Louisiana Lifetime Achievement Award and the John A. Roebling Medal for lifetime achievement in bridge engineering. He is survived by his wife, Bonnie, and seven children, including sons William Jr. '79 and Edward '86 and daughter Laura '91.

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Galllery

1. Deidra Willis '13 Th'13 was promoted to systems engineer II with General Mills and is the engineer for Fruit by the Foot.

2. Brian Mason '03 Th'04 '05 After 10 years at IDEO, Mason, pictured with wife Jocelyn '05 and kids Lynn and Peter, transitioned to a consumer medical device startup that is part of ExploraMed.

3. Stefan Deutsch '14 Th'15, back row, second from right, is currently serving as an AmeriCorps National Civilian Community Corps team leader.

4. Ron Read '57 Th'58, second from right, was recognized by the Engineering Professional Development (EPD) department of the University of Wisconsin, Madison, for "25 years of distinguished teaching service." EPD program director Tom Smith '67 is on the left.

FROM TOP: COURTESY OF DEIDRA WILLIS, COURTESY OF BRIAN MASON, COURTESY OF STEFAN DEUTSCH, COURTESY OF RON READ

Inventions

OVERHEAD SKI LIFT

>> INVENTOR:

FREDRICK BRYON TOMLINSON ’35 TH’36

When he designed the Dartmouth Ski Tramway, Fredrick Bryon Tomlinson ’35 Th’36 was a student working under the direction of Thayer School Professor William P. Kimball ’28. Tomlinson’s J-bar, installed at Oak Hill Ski Area in 1935 for $3,000—about $50,000 in today’s currency—is considered the nation’s fi st overhead ski lift. With an 80-horsepower engine, it could transport 600 skiers each hour up 1,200 linear feet for an elevation gain of 350 feet. Although the lift was relatively small, its impact was national. It became the conceptual model for Sun Valley’s fi st chairlift, built in 1937 by Kimball’s classmate Charlie Proctor ’28.

What’s up for debate is how much of the Dartmouth Ski Tramway was invention and how much was engineering innovation. Tomlinson’s original pencil sketches are housed in Dartmouth’s Rauner Library, but the actual idea for the Oak Hill project came from Dan Hatch, manager of the Dartmouth Outing Club. Hatch had seen a picture of the Davos, Switzerland, J-bar and asked Tomlinson to design something similar for Oak Hill. What wasn’t known in Hanover was that a Swiss engineer named Ernst Constam had filed a U.S. patent for the Davos ski lift six months before the Oak Hill lift was built. Constam didn’t know about Dartmouth’s J-bar either—until the College contacted him about the improvements it had made to his design. Things then went downhill. In 1939, a Constam representative came to campus and demanded an immediate payment of $500 for patent infringement. Two years later the College settled for $450.

The Oak Hill ski tow remained operational for 42 years until the ski area itself closed in 1977, a victim of lack of snow and a preference by undergrads for the Dartmouth Skiway. Eulogized the *Valley News*, “The lift has reached the end of its rope or cable.”

—Lee Michaelides

DARTMOUTH COLLEGE ARCHIVES. INSET: THAYER SCHOOL OF ENGINEERING

Random Walk

Taking advantage of Dartmouth's revised academic calendar—Fall Term now ends before Thanksgiving—Thayer School offered students the chance to take free short, non-credit courses during the first two weeks of December, a period dubbed Winterim. The mini-courses included small engines workshops, laser engraving and cutting, English technical writing, and the Internet of Things. The 24 students who studied the Internet of Things programmed various objects and systems to interact with the Internet, including a single-room security device, an off-line portable GPS system, a mobile weather station, a system to move a robot along pathways using an iPod, and a system to track real-time info and location data about Thayer School social media mentions. The Internet of Things "can apply to nearly every aspect of our lives," says Director of Thayer Computing Services Mark Franklin '83 Th'85, who taught the course. "There is strong and growing demand for engineers capable of creating and maintaining these systems, utilizing diverse skills, including electronics, electromechanical systems, sensors, networking, servers, and web applications." There's another reason, Franklin adds, why he was eager to teach students about the Internet of Things: "It's fun."

PHOTOGRAPH BY DOUGLAS FRASER

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