DARTMOUTH
Engineer
THE MAGAZINE OF THAYER SCHOOL OF ENGINEERING
SUMMER 2012

THE ENGINEERING PIPELINE

TIMOTHY WEIHS AND OTHER ALUMNI BRING THAYER'S INFLUENCE TO UNIVERSITIES ACROSS THE NATION.

- EDUCATION FOR THE TECHNOLOGY ECOSYSTEM
- HIDDEN SIDES OF SOLAR POWER

SNEAK PEEK

Thayer's machine shop is now a "FAB Lab" with a new space, new tools, and bigger and better fabrication capabilities. The full FAB Lab revamp debuts Fall Term.

LIZA FRIEDMAN

DARTMOUTH ENGINEER

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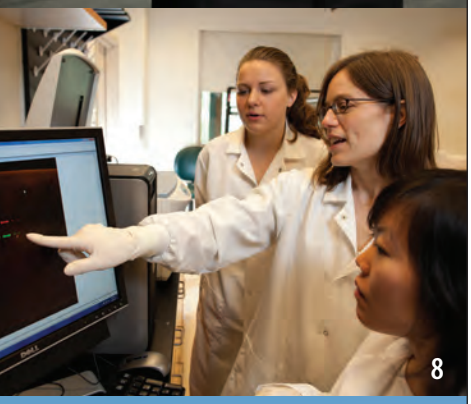


DEPARTMENTS

COVER
Timothy Weihs '83 Th'85 teaches at Johns Hopkins University.
Photograph courtesy of Johns Hopkins University

BACK COVER
Thayer graduates strike a final pose.
Photograph by Douglas Fraser

THE Great Hall

>>NEWS FROM AROUND THAYER SCHOOL

STARTING OUT
Alison Stace-Naughton '11 won the Greener Ventures Entrepreneurship Contest held by Tuck School of Business for a medical device she co-invented for ENGS 21: "Introduction to Engineering."

ENTREPRENEURSHIP

Undergrad Major Wins Greener Ventures Contest

BETWEEN CLASSES AND RESEARCH on her honors thesis, Alison Stace-Naughton '11 took a crash course in regulatory clearance and intellectual property rights. The hard work was worth it. She placed first in the Greener Ventures Entrepreneurship Contest held in April by Tuck School of Business for a vacuum suction tissue stabilizing device designed to prevent tissue damage during endoscopic surgery. A hefty $25,000 in prize money catapulted her ahead in her plan to patent the device and ready it for clinical use.

"I thought the contest would be a good experience to practice giving my pitch. Winning came as a complete surprise," says Stace-Naughton, cofounder and manager of Spiral-E Solutions, LLC. "Thayer encouraged me to take charge of this opportunity and to file for the patent."

Just 18 months ago she co-invented the Spiral-E Solutions Tissue Stabilizer in ENGS 21: "Introduction to Engineering" with classmates Ihab Basri '13, Brenna Gibbons '12, and Ph.D. candidate Scott Snyder '00 Th'01. All cofounded Spiral-E Solutions, LLC, and serve on its board.

Stace-Naughton took the most active role in establishing the company and achieving proof of concept. "I couldn't have done any of it without the critical business development advice of Gregg Fairbrothers and Scott Schorer," she says. Schorer '90 Th'91, a medical-device industry professional, and Fairbrothers '76, founding director of the Dartmouth Entrepreneurial Network, connected Stace-Naughton with patent lawyers and clinicians at Dartmouth-Hitchcock Medical Center to perform an in-vitro study on a pig stomach.

"Surgical procedures lack appropriate tissue stabilizing platforms, limiting surgeons' ability to effectively hold tissue and close the incision site without complications," she says. "Our device uses vacuum pressure to stabilize tissue around an incision and minimize tissue damage from any angle during surgery."

The young entrepreneur is now on her way to raising $400,000 to build a medical-grade prototype of the device. She plans to reach out to industry players, land an in-vivo study, and keep on with her studies. "I am hopeful that Spiral-E Solutions will continue," she says. "But I plan to keep the company as a side project as I write my honors thesis on neuroscience engineering and pursue a career in research."

—Anna Fiorentino

"We also were able to experience first-hand a new culture and their philosophy on healthcare."

ENGINEERING DESIGN

Students Create Eye-Socket Implant

AFTER SIX MONTHS in the lab synthesizing polymers for an expandable eye-socket implant, Amanda Christian Th'12, Elizabeth Chang Th'12, and Chris Ng Th'12 traveled to Madurai, India, to present their prototype to project sponsor Aurolab and tour the eye hospital where their research will be implemented.

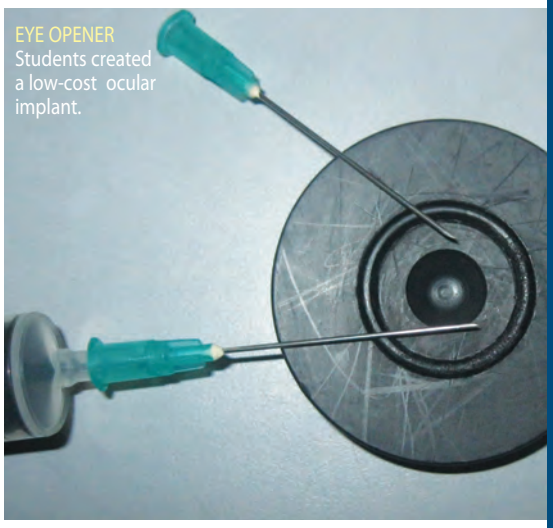
Carrying out their project for ENGS 89/90, Thayer's B.E. capstone engineering design course, the students made the spring-break trip with Professor Douglas Van Citters '99 Th'03 '06.

Aurolab, a nonprofit that makes high-quality, low-cost eye products, wanted the students to improve implants for treating anophthalmia/microphthalmia, a rare condition in which infants are born with no or atrophied eyeballs. Without the eyeball to support it, the facial structure of the skull develops incorrectly and can cause cosmetic and sinus problems later in life. A spherical implant inserted into the eye socket in infancy supports proper skull development. But current spheres do not expand with growth and have to be replaced every month. Christian, Chang, and Ng created a hydrogel sphere that grows with the skull by absorbing fluid from the surrounding tissue, reducing the number of implant surgeries during growth.

The prototype is made from a network of cross-linked synthetic polymers. "Our original idea was to go with natural polymers," explains Chang, "but it was hard to make them work. One day Professor Van Citters came by and showed us a toy he'd bought for his son. It was an acrylamide whale that expands in water. We all knew acrylamide from electrophoresis gel, but we hadn't thought about its expansive properties. It was a no-brainer once it was pointed out."

Experimenting with composites of varying amounts of acrylamide and HEMA, a synthetic polymer used in soft contact lenses, the students synthesized a compound that both expands in water and remains stable under pressure comparable to that inside the eye socket. Their prototype costs $8 per sphere to produce, compared to $500 per current state-of-the-art implant.

FIELD TRIP Left to right, Elizabeth Chang, Douglas Van Citters, Amanda Christian, and Chris Ng in India.



EYE OPENER Students created a low-cost ocular implant.

The trip to Aurolab was eye-opening. "They had lots of ideas for us on how to implement and test our research in real bodies," says Christian.

"Not only did we learn a great deal about materials and chemical engineering," says Ng, "but we also were able to experience first-hand a new culture and their philosophy on healthcare."

—Annelise Hansen

OPPOSITE PAGE: KAREN ENDICOTT. THIS PAGE: COURTESY OF OCULAR IMPLANT PROJECT GROUP

kudos

>> Professor Brian Pogue has been named chair of the National Institutes of Health's new grant review panel for biomedical imaging technology. The panel will review applications in optical imaging, ultrasound imaging, X-ray imaging, nuclear medicine, and magnetic resonance imaging. Pogue also won the Light Path Award from the American Society for Photobiology for "substantial and innovative contributions to the fusion of photobiology with other disciplines, thus broadening the frontiers of photobiology."

>> Professor Jifeng Liu has led a research team developing a process for creating less expensive solar cells that are up to twice as efficient as the current technology. Because current methods can harness only a "very small portion" of solar energy (less than 10 percent), the team's findings could be "groundbreaking" in the field of renewable energy studies, Liu says. His team, which included Haofeng Li Th'15 and research scientist Xiaoxin Wang, developed a method of manufacturing single crystal thin-films directly on ordinary glass over a large area, allowing for the commercialization of single crystal silicon thin-film solar cells for the first time.

>> Professor Eric Fossum delivered the keynote address, "Quanta Image Sensor: A Possible Paradigm Shift for the Future," at the Image Sensors Conference in London in March. Fossum, who coordinates Thayer's Ph.D. Innovation Program, invented the CMOS active pixel image sensor, which is used in cellphone cameras, webcams, digital still cameras, and medical imaging.

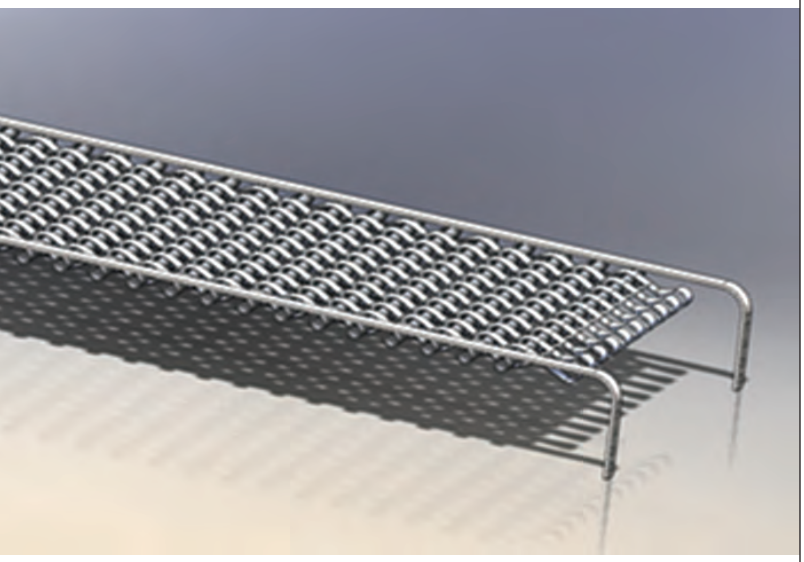
Dartmouth concentrated on reliability and simplicity—and for the first time ever completed the 22-km endurance race

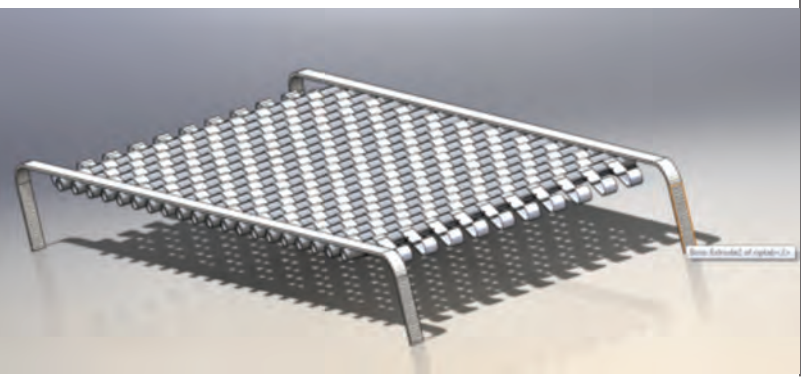
STUDENT PROJECTS

I Want One of Those!

Grand Slam Stringing Technologies

IF YOU'RE A TYPICAL AMATEUR tennis player, restringing your racket takes you 30 to 60 minutes. Grand Slam Stringing Technologies halves the time with an easy one-use weaving template made of biodegradable cellulose acetate. Inventors Siddharth Agrawal '14, Ramesh Govindan '13, Elliot Kastner '13, Albert Kim '14, and Jonathan Pedde '14 won the Phillip R. Jackson Prize for outstanding performance in ENGS 21: "Introduction to Engineering." Their teaching assistant was Noam Rosenthal '13.





COMPETITION

Formula Hybrid Speeds Ahead

AN ELECTRIC-ONLY category debuted at the sixth annual Formula Hybrid International Competition, the Thayer-founded challenge to design, engineer, build, and race the best, fastest, most reliable, and most efficient hybrid racecar. Students from the United States, Canada, and Spain descended on the New Hampshire Motor Speedway in Loudon, N.H., in early May to put their engineering skills to the test in events for autocross, endurance, acceleration, design, and marketing.

The 24 teams that made it to competition (36 had registered) presented a flood of novel ways of tackling automotive and electrical issues. Universite de Sherbrooke (tied for 1st place, hybrid class; 1st place, design) mastered a paramount challenge the automotive industry faces today: the battery management system. Brigham Young University (tied for 1st place, hybrid class; 1st place, unlimited acceleration) worked closely with its battery supplier and motor manufacturer to optimize power. Universitat Politecnica de Catalunya (3rd place, hybrid class) analyzed multiple hybrid solutions to justify its final choice. University of Texas Arlington (4th place, hybrid class; 1st place, endurance) designed and constructed a battery that was serviceable, easily manufactured, and highly functional. Dartmouth (5th place, hybrid class; 1st place, marketing presentation) concentrated on reliability and simplicity—and for the first time ever completed the 22-km endurance race. University of Kansas (1st place, electric class; fastest electric-only acceleration; fastest autocross lap) complemented an efficient mechanical design with an ex-

THE RIGHT FORMULA
Dartmouth's hybrid succeeded in finishing the endurance run.

tremely fast electrical drivetrain. Illinois Institute of Technology (2nd place, electric class) experimented with four independently driven 40-hp motors to capture the power density and finite control inherent in electric motors.

Once again the competition showed that success in Formula Hybrid is all about teamwork. Mechanical engineers can't ignore electrical systems, electrical engineers have to learn to integrate their work into a mechanical system, and software engineers find themselves interfacing with more than just a computer. Formula Hybrid is about bringing engineers from different disciplines into the same room together to design complex systems. It's about a team of students pulling all-nighters and bonding over shared successes and failures. It's about preparing a new generation of engineers to meet unsolved challenges and define new ones. And it's about designing and building a badass racecar.

—Josiah Gruber Th'10

LEFT: COURTESY OF GRAND SLAM STRINGING TECHNOLOGIES GROUP. ABOVE: KATHRYN LAPIERRE. RIGHT: MARK WASHBURN

TRIBUTE

Professor Paul E. Queneau

PROFESSOR PAUL E. QUENEAU, a pioneer in smelting with oxygen pyrometallurgy who co-invented the Queneau-Schuhmann-Lurgi (QSL) process for efficiently extracting lead, died March 31, 2012, at the age of 101.

Entering Columbia University at 16, he earned his B.A. in 1931, B.Sc. in 1932, and Engineer of Mines degree in 1933. He worked at International Nickel (INCO) for 35 years, beginning as a "hot metal man" in a nickel alloy plant. In 1937 he was transferred to the Copper Cliff research laboratory to work on improving efficiency and reducing environmental degradation, and in 1941 he became superintendent of research.

After Pearl Harbor, Queneau volunteered for military service and was deployed to Europe with the U.S. Army Corps of Engineers. Battling from Normandy to the Rhine, he was awarded the Bronze Star, Army Commendation Medal, ETO Ribbon with five battle stars, and the rank of lieutenant colonel. Having seen the mass destruction of war, Queneau returned to INCO determined to improve the environmental record of smelters. By the time he retired from INCO in 1969 as vice president, chief technical officer, and assistant to the chairman, he had advanced cleaner methods of extracting copper, nickel, and iron.

Queneau earned his doctorate at age 60 from the Delft University of Technology in the Netherlands and joined the Thayer School faculty in 1971. In 1974 he and Reinhardt Schuhmann Jr. developed the Q-S Oxygen Process for smelting in a single process within a continuous oxygen converter. Working with the German company Lurgi, they demonstrated that the QSL process would be feasible on an industrial scale. Berzelius Metall in Stolberg, Germany, converted to using the QSL process in 1990; the plant is still operating. The QSL process is also employed in two smelters in Korea. (See "Inventions" in the Winter 2010 issue archived at dartmouthengineer.com.)

Awarded 36 U.S. patents, Queneau was a fellow and past president of the Minerals, Metals & Materials Society and past chairman of the Engineering Foundation. His many honors included the American Institute of Mining, Metallurgical, and Petroleum Engineers' James Douglas Gold Medal, the Gold Medal of the British Institution of Mining and Metallurgy, *Chemical Engineering*'s Kirkpatrick Award, and Thayer School's Robert Fletcher Award for distinguished achievement and service. In collaboration with INCO, he endowed Thayer School's Paul E. and Joan H. Queneau Distinguished Professorship in Environmental Engineering Design.

kudos

>> Dartmouth's Class of 2012 chose Professor Vicki May as the recipient of the College's Jerome Goldstein Award for Distinguished Teaching. May, whose research focuses on engineering education, inquiry-based learning, and seismic engineering, says, "Teaching, to me, is about the students, connecting with them in ways that encourage them to learn and grow. I enjoy experimenting with different teaching approaches."

>> Vermont Public Radio featured recordings from the Dartmouth Jewish Sound Archive. The treasure trove of 36,000 recordings, ranging from the UN announcement of the creation of Israel to comedy from Groucho Marx, was established in 2002 by Professor Alex Hartov Th'88 and Dartmouth Hebrew Professor Lewis Glinert as a resource for researchers and students. Hear it at vpr.net or djsa.dartmouth.edu.

>> Adjunct Professor Michael Mayor, a Dartmouth orthopedic surgeon and past chairman of the FDA's Advisory Panel on Orthopedic and Rehabilitation Devices, discussed the issues surrounding hip-replacement surgeries on Alaska Public Radio's "Line One" show. Hear him at alaskapublic.org/2012/02/24/hip-implant-failure.

>> The Big Green Bus kicked off its summer cross-country tour in June, stopping in Washington, D.C., to meet with U.S. Secretary of Energy Steven Chu. The waste vegetable oil-fueled vehicle will travel through 30 states while its crew of 12 students and recent grads promotes sustainable living. "I am greatly looking forward to adventuring through the country in a way I never have before, all the while addressing the most important issues that face humanity and the Earth," says engineering major Ari Koeppel '15. The bus is scheduled to pull back into Hanover on September 5. Follow its progress at thebiggreenbus.org.

MELT LIFE
Phytoplankton thrive below sea ice.

LAB REPORT

Phytoplankton Under Ice

ADJUNCT PROFESSOR Donald Perovich was part of a team that discovered extensive blooms of phytoplankton under sea ice off the coast of Alaska. These tiny free-floating photosynthetic organisms comprise the base of the marine food web. The results were published in the journal *Science* in June.

Scientists previously thought there were few or no phytoplankton beneath sea ice because so little light could reach the water. Discovered during NASA's ICESCAPE expedition to the Beaufort and Chukchi seas in 2010 and 2011, the under-ice blooms were concentrated enough to turn the water bright green. "It's a pure discovery," says Perovich, who studied the optical properties of the ice, "and now we have an entirely new ocean."

The ice over the Chukchi Sea has shrunk from a 2- to 4-meter multi-year cover to a thin sheet that forms and melts each year. The thin ice and melt ponds transmit more light to the underlying ocean than do thick ice packs.

Perovich, a glaciologist at the U.S. Army Cold Regions Research and Engineering Laboratory in Hanover, and his *Science* article coauthors conclude: "Work is still required to determine the timing and spatial distribution of under-ice phytoplankton blooms across the Arctic Ocean, the extent to which they are controlled by thinning sea ice and proliferating melt pond fractions, and how they affect marine ecosystems. This is particularly important if we are to understand and predict the biological and biogeochemical impacts of ongoing and future changes in the Arctic Ocean physical environment."

WELCOME

New Prof and Overseer

>> BRENDEN EPPS has been appointed assistant professor. He received his bachelor's degree in mechanical engineering from Carnegie Mellon University in 2001, worked as a product development engineer at Ford Motor Co., and then earned his doctorate in mechanical engineering from MIT in 2010 with research in experimental hydrodynamics and marine propeller design. He is the author of OpenProp, an open-source propeller and turbine design tool that has thousands of users worldwide. He recently completed a postdoctoral position at the MIT Sea Grant Design Lab.

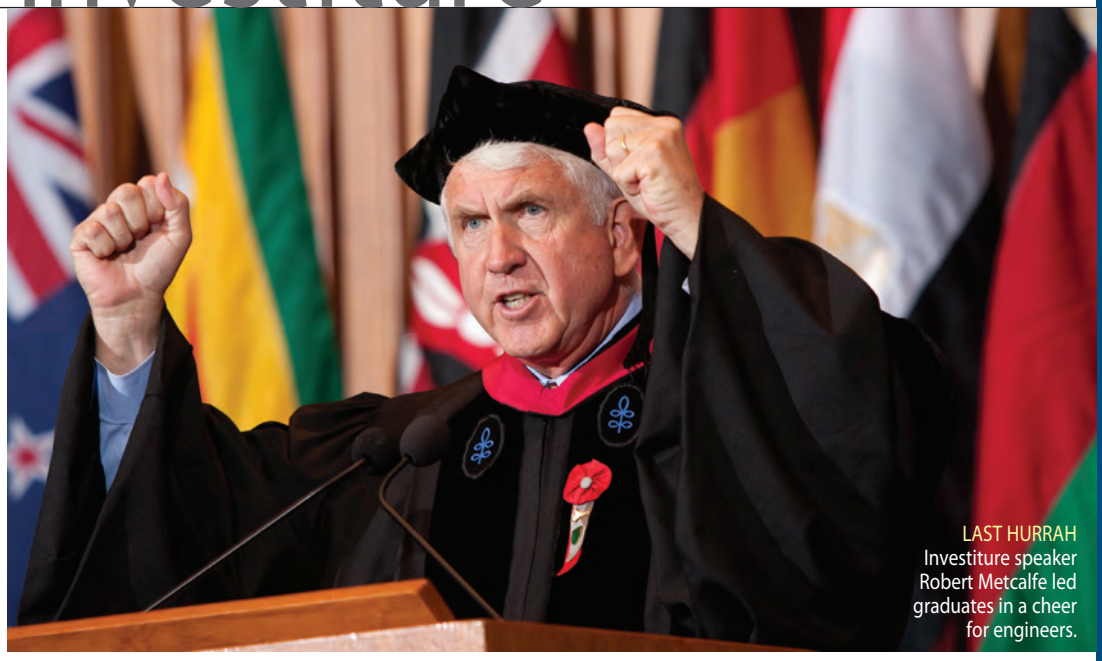
>> ELIZABETH C. LEMPRES '83 TH'84 has been elected to Thayer's Board of Overseers. She is a director in McKinsey & Co.'s Boston office and the global leader of McKinsey's consumer sector. She is a trustee of Catholic Charities of New England, the Cristo Rey Boston High School, and the Winsor School, and she is a member of the Visiting Committee of the Board of Overseers at Harvard Business School. She received her A.B. and B.E. from Thayer School and her M.B.A. from Harvard Business School.

SERVICE TO HUMANITY

Replacing Kerosene in Africa

FIVE STUDENTS—Ph.D. candidate Daniel Harburg Th'06, M.S. candidate Louis Buck '10 Th'11, Lee Taylor Tu'12, Adam Price Tu'12, and William Kamkwamba '14—won the regional level of the Hult Global Case Challenge for their ideas about how to help the NGO SolarAid encourage Africans to replace kerosene lamps with solar-powered lights. According to Harburg, solar-powered lights cost $10 to $30 in SolarAid's current approach. "The problem is that people don't have the up-front money to pay for the lamps. They're used to using kerosene, which they buy for $.30 a can," he says. The team's solution: replace the light's solar panel with a battery and create a battery-swapping system through a local entrepreneur. "When your battery dies, you go to your entrepreneur and pay $.30, just as you would for kerosene. He gives you a new battery that's been recharged from his solar panel. Now you have light, and the payment structure looks a lot like kerosene," says Harburg. Though the students didn't win the competition finals, they are trying to take the idea forward. "We talked to the manufacturers of the lights, and they were excited about doing pilot projects," says Harburg. Teammate Kamkwamba, whose self-taught engineering efforts are the subject of the book *The Boy Who Harnessed the Wind*, may handle part of the initial implementation. "William is really excited about it and wants to try it out back in his hometown in Malawi," says Harburg.

investiture



LAST HURRAH
Investiture speaker Robert Metcalfe led graduates in a cheer for engineers.

THAYER'S GRADUATING class was honored at Investiture, held June 9 at the Hopkins Center. Dean Joseph J. Helble presided over the presentation of hoods, caps, and awards to 143 recipients of B.E. 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 Dr. Robert Metcalfe, inventor of Ethernet and Professor of Innovation and Murchison Fellow of Free Enterprise in the Cockrell School of Engineering at the University of Texas at Austin.

"I'm an engineer, and proud of it," Metcalfe told graduates. "We engineers make the world go round. By solving the world's problems through technological innovation, we engineers energize the virtuous circle of freedom and prosperity. And so I say to you today, with great enthusiasm: Hurray for us!"

Metcalfe, author for many years of a weekly *InfoWorld* column, "From the Ether," reviewed the National Academy of Engineering's 14 Grand Challenges. "It's going to be fun meeting these challenges over your next 50 years. It will also be fun adding to this list," he said. Then he added one of his own: "NASA knows about thousands of asteroids large and close enough to threaten life on Earth. I'm more worried about the million asteroids NASA does not know about," he said. "I think we should learn how better to detect and deflect asteroids, probably using space robots. Who wouldn't want to work on that?"

In his address to graduates, Dean Helble reflected on comments students made about Thayer School at a recent end-of-year gathering. "In these comments, over and over again, from A.B., B.E., M.S., M.E.M., and Ph.D. students alike, the common denominator was the value they derived from being part of the Thayer community, part of a community of innovators," he said. "I am encouraged and optimistic about our future in your hands," Helble concluded. "I know that you will carry that spirit of innovation, that spirit of inquisitive problem solving, that sense of community, and that determination to use your education to push the boundaries of knowledge to make a difference in the world."

For videos and photos, visit engineering.dartmouth.edu/events/investiture/2012.

CLASS OF 2012
Engineering Graduates

14	Doctor of Philosophy
7	Master of Science
47	Master of Engineering Management
75	Bachelor of Engineering
78	Bachelor of Arts, Engineering Sciences

OPPOSITE PAGE: COURTESY OF DONALD PEROVICH. THIS PAGE: MARK WASHBURN

kudos

>> Dartmouth Humanitarian Engineering has earned a grant from the Environmental Protection Agency for its work in Rwanda. The project, which was also one of three finalists out of 1,800 applicants in the Dell Social Innovation Challenge, involves using small-scale hydropower to generate electricity in Rwandan communities that are decades away from accessing the national grid.

>> M.S. candidate Rezwan Khan has been named a 2012-13 New Hampshire-Vermont Schweitzer Fellow. As one of about 240 Schweitzer Fellows nationwide, he will organize a group of students from different disciplines at Dartmouth who will provide consulting services to nonprofits and social service organizations working to improve the health and well-being of people in the Upper Valley.

>> Thayer graduate students Yang Shen Th'12, Yicai Bao Th'12, Vedant Rathi Th'12, and Boyu Zhang Th'12 won first place in the Oliver Wyman Case Competition in March. The competition, organized by the Thayer Consulting Club, the Dartmouth Society of Investment and Economics, and the Graduate Consulting Club, rated student teams on how closely their strategic planning resembled that of an actual consulting firm. Second place went to Haider Syed Th'13, Saaid Arshad '14, and Jonathan Pedde '14. Judges included Tuck and Thayer faculty, Oliver Wyman consultant John Engstrom Th'10, and Axia consultant Mat Ackerman '05 Th'06.

>> Engineering major Eric Packer '12 was selected for a new elite professional ski team at Stratton Mountain School. Last winter he earned All-America honors at the NCAA Championships, competed in the U23 World Championships in Turkey, and won the classic sprint at SuperTour Finals to cap off a strong final collegiate season.

INSPIRED
Timothy Weihs says that Thayer faculty made him want to become a professor.

COURTESY OF JOHNS HOPKINS UNIVERSITY

The Engineering

IT'S NOT ONLY DARTMOUTH STUDENTS WHO RECEIVE A THAYER-INSPIRED EDUCATION. ALUMNI WHO TEACH AT UNIVERSITIES THROUGHOUT THE COUNTRY BRING THEIR THAYER EXPERIENCES INTO THEIR OWN CLASSROOMS AND LABS. WE ASKED EIGHT ALUMNI IN ACADEME ABOUT THEIR RESEARCH, THAYER INFLUENCES, AND HOW TO ENCOURAGE MORE PEOPLE TO BECOME ENGINEERS.

INTERVIEWS BY ANNA FIORENTINO

Pipeline

TIMOTHY WEIHS '83 Th'85 (A.B., B.E., M.E.)

Professor of Materials Science and Engineering Whiting School of Engineering, Johns Hopkins University

Research: My research group investigates exothermic reactions that self-propagate and produce rapid bursts of heat and light in a variety of composite systems. These reactive materials are fabricated using vapor deposition or cold forging. We have developed these materials to act as local heat sources for joining temperature-sensitive materials and for igniting other reactions. I cofounded Reactive NanoTechnologies in 2002 to pursue commercial applications and then sold the company to Indium Corp. in 2009. The technology is now being used to join LEDs and sputtering targets, and many other applications are being pursued.

Thayer Influences: I went to Dartmouth to major in history. I took a thermo course from Horst Richter, really liked it, and decided to major in engineering sciences. Then I took a course from Harold Frost that convinced me I wanted to study materials. I stayed an extra two years to complete a master's degree while working with Erland Schulson. Seeing Erland's passion for his teaching and research, I said, this is what I want to do. I want to earn a Ph.D. and become a professor.

Incorporating Thayer's Educational Approach: Thayer gave me a broad education that has served me well, especially as I've entered areas beyond my current research. The breadth of education that I received at Thayer has been especially useful as engineering research becomes more interdisciplinary. Through a role I play here at Johns Hopkins, as director of the Center for Leadership Education, I've been in contact with Professor Robert Graves about our new program similar to Thayer's M.E.M. program. I also serve on the Bachelor of Engineering External Advisory Committee at Thayer, and it's been inspirational.

How to Produce More Engineers: We need to make sure we have great teachers in the high school system to encourage students to think about engineering at an early stage. I had a wonderful history teacher in high school, so went to college to major in history. Getting better stimulation early on is critical.

ANALOGIES
Kathryn Miller-Jensen, left, views cells as complex machines.

KATHRYN MILLER-JENSEN '97 Th'98 (A.B., B.E.)

Assistant Professor of Biomedical Engineering, Yale University

Research: My lab studies biological engineering and systems biology of virus-host molecular interactions. We make quantitative experimental measurements and computational models of how viruses perturb host cell networks, especially networks of chemical reactions involved in cellular communication, referred to in biology as signal transduction networks. As an engineer, I think of a human cell as a very complex machine that takes in environmental cues, processes the information via networks of chemical reactions, and outputs a behavior, such as growth, death, or differentiation. Pathogenic viral infection fundamentally changes how a cell processes information by hijacking the cell's communication networks for its own purposes. What is especially impressive is that a virus is able to do this with a much less complex genome than our own. If we can measure and model how the cell's information processing networks change before and after infection, we might better understand how to treat the infection and how the cell machine itself works. We are currently applying our methods to understanding HIV pathogenesis. We study how HIV manipulates its host cell using HIV model viruses, which we can genetically alter to study particular aspects of the viral life cycle. We do a lot of wet lab and cell culture experiments to gather quantitative measurements of changes in gene expression, transcript, and protein levels inside the cell caused by HIV infection. Then we use various computational methods to simulate our data and develop hypotheses about how the the virus is affecting the cell, which we can test experimentally.

Thayer Influences: Working in Professor Lee Lynd's lab was my first introduction to biotechnology and the remarkable power of a microorganism. I was testing genetically engineered bacterial strains for their capacity to convert cellulose into ethanol.

Incorporating Thayer's Educational Approach: Engineering is more than a field; it is a way of approaching problems that transcends disciplines. I think Thayer captured this especially well because the curriculum did not break engineering down into sub-disciplines. Rather, we were taught to see analogies across many applications. In both my teaching and my work, I hope to demonstrate how an engineering approach can help us truly understand and manipulate biological processes at the cellular and subcellular level.

How to Produce More Engineers: In general,

the way we teach science and engineering does not reflect what it's like to work in these fields. We tend to teach facts and methods and evaluate students based on an exact answer worked out in isolation. But innovative research and design requires creativity, collaboration, and communication skills. If we incorporated these aspects of science and engineering into early educational experiences, I think we would retain a more diverse set of young people and tap into new talent.

ABOVE: COURTESY OF KATHRYN MILLER-JENSEN
RIGHT: COURTESY OF DAVID FREYBERG

UNBOUNDED
David Freyberg calls himself a zealot for the liberal arts.

DAVID FREYBERG '72 Th'72 (A.B., B.E.)

Associate Professor of Civil & Environmental Engineering, Stanford University

Research: I research old dams and reservoirs, particularly sediment-impacted reservoirs. My students and I investigate summer low flows and streambed drying in coastal California streams and surface-subsurface water interactions in reservoir wetlands. We also work on estimating rainfall and stream flow prediction uncertainty in data-poor regions of southern Africa, optimal scaling of urban water reuse systems, and hydrologic ecosystem services. On one level these issues matter to me because they matter to students, as individuals and as a generation facing a future requiring increasingly challenging decision-making about water resources. On another level they matter to me because all the systems I work on are at the intersection of science, technology, and policy. On a third level, I am intrigued by puzzles that require integrating field investigation and mathematical modeling and that involve water flows that follow complex paths through very different environments, from atmosphere to land surface to subsurface to plants.

Thayer Influences: It's not easy to single any individual out, since I view the impact of my time at Thayer and Dartmouth as deriving from the incremental impacts of many. Professor Alvin Converse somehow found the right buttons to push to lead me to recognize that I could learn on my own, think on my own. That was a turning point in my education.

Incorporating Thayer's Educational Approach: I am zealously committed to liberal arts education, and that certainly got its start at Dartmouth and Thayer. I also don't have much use for disciplinary and departmental boundaries in either teaching or research, and that probably has some roots in my Thayer education.

How to Produce More Engineers: The issues are complex. They involve our social values as expressed in our political economy, the nature and quality of K-12 education and undergraduate engineering education, as well as the behavior of professional engineering societies.

MENTOR
John McNeill, second from right, has won teaching awards at WPI.

JOHN MCNEILL '83 (A.B.)

Associate Professor of Electrical & Computer Engineering, Worcester Polytechnic Institute

Research: I work on "mixed signal" analog and digital integrated circuit design, unlike most integrated circuits, which are digital, like microprocessors. My research is sponsored mainly by Analog Devices and Allegro MicroSystems, semiconductor companies with a strong presence in Massachusetts.

Thayer Influences: Friends at WDCR, the radio station at Dartmouth, told me I had to take a course with former Professor David Stratton in electronics. Both Stratton's material and his style of teaching caught my interest, and I decided to get a job in that area after I graduated. He guided students through the learning process by recalling how he understood and learned things. He could do theory as well as practical real-world thinking. He didn't just push equations around. About a year and a half ago a group of alumni from the class of 1982, who I kept in touch with, had a dinner for him, and I was honored to go.

Incorporating Thayer's Educational Approach: I won WPI's Board of Trustees' Award for Outstanding Teaching in 1999, and the 2007 Chairman's Exemplary Faculty Prize for combining teaching, research, and scholarship. I learned most of the techniques that make me an effective educator from this brilliant professor at Thayer.

How to Produce More Engineers: We're losing talent to big-money finance companies because society is skewed that way right now. Students have to pay back thousands in loans, so how can I encourage them to take low-paying jobs? I love engineering—the problem solving and the aspect of it that you're helping people, improving drug development to save lives, for example. But we have a real problem of retention. To encourage more people to become engineers—and we do need more engineers in all areas of society—we need to make engineering a more rewarding profession.

ABOVE: COURTESY OF WORCESTER POLYTECHNIC INSTITUTE. RIGHT: COURTESY OF SARA ATWOOD

DETERMINED
Sara Atwood is passionate about pulling more women into engineering.

SARA ATWOOD '03 Th'04 '05 (A.B., B.E., M.S.)

Assistant Professor of Physics and Engineering, Elizabethtown College

Research: My research consists mostly of engineering education scholarship, as Elizabethtown is primarily a teaching-focused college, and working with undergraduates to continue some of my master's and doctoral research on the material properties of the polyethylene used in hip and knee replacements. My most recent undergraduate researcher created computational models from scanning electron microscope images of the microstructure of various formulations of polyethylene and performed a parameter study to assess the effects of microstructural changes on the bulk material properties. I enjoy working on an aspect of engineering that directly helps people and one that creates more young engineers to work on solving the world's problems.

Thayer Influences: Professor Francis Kennedy was the first to suggest early on that I consider becoming a professor. His statics course first got me really interested in mechanics, and as my senior thesis and master's thesis advisor, he inspired my interest in biomaterials. Professors Erland Schulson and Horst Richter mentored me when I was a teaching assistant and showed me how wonderful a course can be when taught well. I think of them often when teaching my courses. Doug Van Citters was an important mentor to me as well when he was a Ph.D. candidate.

Incorporating Thayer's Educational Approach: Elizabethtown College reminds me a lot of Thayer in that we emphasize a broad-based general engineering curriculum, where mechanical engineers must take electrical courses and so on. We also are housed in a liberal arts setting, and I try to tie the students' core liberal arts distributives to the engineering curriculum, as well as emphasize skills, such as communication and teamwork.

How to Produce More Engineers: I am starting a Society of Women Engineers chapter at the college and am passionate about getting more women into engineering. I think that part of it is a marketing issue. Instead of the message "Engineering is for you if you like math and science," I want to see the message "Engineering is for you if you want to make the world a better place." I do K-12 engineering outreach. One of my undergraduate classes just visited a local middle school where they showed cool engineering demonstrations to students. The men in the class enjoyed it as much as the women. I think it is key to engage men as well in our effort to diversify engineering.

COLLABORATIVE
Steve Beyerlein, left, calls teaching and learning a two-way process.

STEVEN BEYERLEIN Th'81 (M.S.)

Professor of Mechanical Engineering, University of Idaho

My Research: I research catalytic engine testing, engine tuning with alternative fuels, engineering graphics, design pedagogy, and scholarship of teaching and learning. I approach research collaboratively, with reflective practice and engagement of all stakeholders. It gives me the opportunity to join ranks with undergraduates, graduate students, professional staff, and faculty and colleagues in contemporary engineering problems recognized by the National Academy of Engineering, in Society of Automotive Engineers competitions, and in Thayer's Formula Hybrid International Competition.

Thayer Influences: I was especially impacted by Thayer's community-focused approach to teaching, learning, and research—an enterprise that respected and fully embraced undergraduate students, graduate students, professional staff, and faculty as significant contributors.

Incorporating Thayer's Educational Approach: Authentic problems, collaborative approaches, process documentation, and entrepreneurial spirit are in all aspects of engineering life. I believe that teaching and learning is a two-way process that should change what one knows, how one learns, and how this is internalized in daily life.

How to Produce More Engineers: Addressing general literacy about engineering and its role in society involves impacting general student populations at the K-12 level and as part of collegiate core curricula through design activities and group processing of compelling case studies. We need to remediate risk factors and learning liabilities that cause students to drop out, without compromising academic rigor or professional preparation. It's important to fix the leaks in the STEM (science, technology, engineering, and mathematics) pipeline before we try to push more people in the front end of the existing pipeline. Faculty development is also an important, non-trivial piece in the puzzle. The goal isn't to have everyone doing exactly the same things in the same way, but to have a broader population of faculty who are reflective practitioners about teaching and learning and dedicated to continuous improvement.

DAN O. POPA '93 Adv '94 Th'94 (A.B., M.S.)

Associate Professor of Electrical Engineering, Automation & Robotics Research Institute, The University of Texas at Arlington

Research: I work primarily in micro- and nanorobotics and human robotic interaction. I've worked with robots that are a millimeter in size, with nanometer resolution. The robots I make are so small that we can place them inside a microscope. The field of nanorobotics is just getting started. Though it has yet to really create a significant industry, we are undergoing a major evolution away from expensive, bulky, and difficult-to-use machines, toward inexpensive, small, user-friendly, safe systems. We take system-level approaches from the macroscale and combine them with the microelectromechanical systems (MEMS) technology to provide a new way to set up machines. If large robots were scaled down, a person couldn't make grippers or gears with their hands for them. MEMS technology and micro-assembly give you the ability to put these systems together.

Thayer Influences: Former Assistant Professor Sunil Singh got me started with robotics. I worked on two research projects with him. One, with the MIT Media Lab, involved a virtual reality simulation training project for the Navy called Virtual Sailor. The other was with Dartmouth-Hitchcock Medical Center anesthesiologist Chris Wiley creating a training device for simulating spinal tap surgery—a common process now.

Incorporating Thayer's Education Approach: The Navy project was one of my first exposures to engineering research. It convinced me to do a Ph.D. in robotics. I credit Sunil for that and for the experience I had at Thayer. Sunil went on to try his fortunes in

GRATIFIED
Thierry Blanchet says he likes being a link in the dissemination of knowledge.

starting companies and became a successful entrepreneur. He was kind enough to give a talk about starting companies to my students a few years ago.

How to Produce More Engineers: First, we need to relate their professions to solving grand challenges of humanity, such as extending human lifespan, improving the social and family lives of people, or exploring unknown environments, including space, oceans, and the nanoscale. Science can help, but without engineers major steps forward in these professions won't be possible. The other way to get students involved in engineering is to improve the image problems engineers seem to have. Engineers are not geeks but multifaceted individuals with a larger horizon and entrepreneurial potential. The efforts at Thayer to connect engineering to the arts, social sciences, and medicine are very valuable.

THIERRY BLANCHET Th'88 '92 (M.S., Ph.D.)

Professor of Mechanical Engineering, Department of Mechanical, Aerospace & Nuclear Engineering, Rensselaer Polytechnic Institute

Research: I'm interested in solid lubrication, particularly self-lubricating materials—an approach whereby low levels of friction can still be achieved even in the absence of fluid lubricants by having contacting materials whose surfaces are covered with low shear strength surface films. Maybe I'm still trying to master my own Thayer doctoral thesis on self-lubricating polymers and the wear resistance that hard filler particles provided them. The wear-resistance mechanism put forth for such composites described the wear resistance mechanism of filler particles, which at that time were generally micro-scale. A journal paper we published on it in 1992 while I was still a student at Thayer remains my most frequently cited work. However, extrapolation of that model predicts this wear-reduction mechanism should become ineffective as filler particle size is decreased. To the contrary, as we subsequently began to study nanoscale fillers here at Rensselaer, we found them to not only remain effective, but even more so than traditional micro-scale fillers previously studied. Fortunately, it appears that the wear-reduction mechanism of my thesis still stands, but is limited to micro-scale fillers. The challenge for us now is to understand additional wear reduction mechanisms that emerge and become predominant as particle size is drastically reduced.

Thayer Influences: Thayer provided me with the good fortune of small classes and close interaction with a collection of faculty members in the area of solid mechanics. My research advisor, Professor Francis Kennedy, and Professors Erland Schulson, Harold Frost, and Ian Baker were not only unusually strong technically, but also shared a materials science-based approach to this topic. If I had the foresight to know that my own research later at Rensselaer would get into hip joint materials for a period of a few years, I would have absolutely taken Professor John Collier's biomaterials course, but nonetheless it was great to have him on my doctoral committee with his own work on polymer wear, even if on a different polymer system than the one I was studying at the time. Finally, it would be too inexcusable an oversight if I didn't credit heavily Victor Suprenant for his experience and the personable manner in which he shared it with his students as we conducted experiments and for his subsequent role as a resource to tap in our research efforts.

Incorporating Thayer's Educational Approach: Professor Francis Kennedy is recognized for approaching tribology from a standpoint of frictional heating and thermal aspects of contacts—an approach I learned from his tribology and surface mechanics courses and now base my own tribology course upon at Rensselaer. It has been a pleasure to see this basis for viewing tribology propagate on from this course to subsequent generations of courses elsewhere, with students in my course continuing on as faculty members, and their students doing the same. To be a link in that dissemination is remarkably gratifying.

How to Produce More Engineers: As a cycling enthusiast, I would encourage aspiring engineers, particularly those mechanically focused, to understand how a bicycle—or some similarly basic mechanical system—works and how to maintain and perform simple repairs upon it. I think simple experiences such as this help provide a solid foundation upon which an engineering education can be built, while also providing one form of occasional yet necessary distraction that is not only healthy but also clears the mind for some wandering thoughts that sometimes prove creative or even revelatory.

Anna Fiorentino is a contributing editor at *Dartmouth Engineer*.

LEFT: COURTESY OF UNIVERSITY OF IDAHO
ABOVE: COURTESY OF RENSSELAER POLYTECHNIC INSTITUTE

THE BROAD VIEW
Dean Helble says that problem solvers need more than a technical toolbox.

PHOTOGRAPHS BY JOHN SHERMAN

EDUCATION FOR THE TECHNOLOGY ECOSYSTEM

THE NATION WANTS MORE ENGINEERS. DEAN JOSEPH J. HELBLE SAYS WE NEED A DIFFERENT KIND OF ENGINEER.

[INTERVIEW BY KAREN ENDICOTT]

THAYER SCHOOL DEAN JOSEPH J. HELBLE was among the engineering leaders invited to the White House in February to discuss the call from the President's Council on Jobs and Competitiveness for the nation to produce 10,000 more engineers a year over the next decade. We asked him about the challenge and Thayer School's role in meeting it.

> AS LONG AS THERE ARE CHALLENGES IN AREAS SUCH AS CLEAN RENEWABLE ENERGY, CARBON CAPTURE AND SEQUESTRATION, TRANSPORTATION, LOW-COST NETWORK COMMUNICATION, AND EVERY PROBLEM YOU CAN IMAGINE IN HEALTHCARE, WE SHOULD BE GRADUATING PEOPLE WHO HAVE AN ENGINEERING BACKGROUND WHO CAN TACKLE THESE PROBLEMS.

What is your perspective on the national call for 10,000 more engineering graduates a year?

Deans of engineering schools were invited to a discussion at the White House about finding ways to boost science, technology, engineering, and mathematics literacy and increase the number of engineers we graduate in the United States annually over the next 10 years. My expectation is that we'll reach that goal of 10,000 additional engineering graduates this year, based on projections from recent freshman and sophomore enrollment data.

I think the real goal should be higher. As long as there are challenges in areas such as clean renewable energy, carbon capture and sequestration, transportation, low-cost network communication, and every problem you can imagine in healthcare, we should be graduating people who have an engineering background who can tackle these problems. It doesn't mean that all of them have to be practicing engineers. We need attorneys who can understand engineering quantitative and analytical thinking. We need more physicians who are trained as engineers and can take an appropriate quantitative approach to healthcare. We need venture capitalists and bankers with backgrounds in engineering. We need people working in all aspects of the technology ecosystem to address the pervasive problems that are going to be with us for a century.

Will there be jobs for these engineers?

That's part of the challenge. There are going to be periods when there's a supply-and-demand mismatch. But if we change our focus in engineering schools to help our students understand what it takes to convert an idea into a real product or process, we can change the conversation so students are not just thinking about jobs at large multinational corporations like IBM or Dupont or General Electric as the only outlet for their degrees. We need students who see themselves as technology entrepreneurs, who think about creating jobs, starting their own companies. That's the mindset that students here and students at places such as Olin College of Engineering have—places with an emphasis on open-ended, project-based learning. But I don't think it's the pervasive mindset among engineering students at most institutions.

Are attrition rates a concern nationally?

The American Society for Engineering Education is trying to develop a better measure of student attrition. We all talk about a 60-percent retention figure, but that's really an indication of students who apply to schools of engineering but after matriculating choose to pursue something else. A reasonable question is whether we should take a line on someone's college application—written when they were a high school senior—as the benchmark for an intention to major in engineering. Our engineering retention rate at Dartmouth ranges from 98 to 102 percent when we use as our starting point the number of A.B. candidates who've filed a major card by the start of their junior year. At the other Ivies, where most students declare a major in freshman or sophomore year, retention rates are also in the high 90s. Once students take the engineering prerequisites at an Ivy League institution, they

generally graduate with a degree in engineering.

The President has asked engineering deans to think about whether we have appropriate mentoring programs in place. His question is whether we're losing students who are genuinely interested in engineering but get derailed because of challenges with the prerequisites or because they don't see the excitement of engineering at an early enough stage.

I think the incorporation of engineering into the liberal arts, and of the liberal arts into engineering, is a fantastic way to address this challenge, but it's not something that the majority of engineering programs are in a position to adopt. But I do think there will be increasing emphasis on team-based, project-based, design-based learning at many campuses. There is broad recognition that this kind of experience helps keep students motivated to study engineering because they're not just doing the interesting design work at the end, they're solving open-ended problems that aren't from a textbook from the very beginning. This approach, which is so much a part of the culture at Dartmouth, will become more common. But I don't foresee widespread incorporation of the liberal arts because there are engineering faculties that feel the objective of an engineering education is to compress as much technical information as possible into the four-year undergraduate degree. There is resistance to any effort to understand the human element, the broader context, to do more than simply solve the problem technically. If you're trying to educate students to be entrepreneurs, context and the liberal arts component of the education are as important—and in some ways more important—than understanding the mechanics of starting a business. Understanding context helps students recognize and articulate a problem, define a possible solution—and see where the opportunities may lie.

Many people grow up not really knowing what engineering is or thinking simply that engineers are people who are good at math and science. How do we address that?

Engineering means applying all the tools of understanding at our disposal to help people live better, happier, healthier lives. That's how most of us see engineering, and that's the message that we would like to convey. But whenever we define engineering as first "applying the tools of math and science" or being a path for only those who "are good at math and science," we immediately set engineering as something apart from the way most high school students envision themselves. Of course we use the tools of science and math, but we, especially as engineers in a liberal arts institution, expect that you will also use the tools of persuasion, logic, rhetoric, writing, finance, economics, history, political science, anthropology. You need to understand the challenge that you're trying to address and how it affects people, why it's important, why it needs to be solved. You need to understand that the best solution isn't always a technical solution. I think engineers who are educated in a liberal arts context don't approach any problem with a toolbox that contains only engineering tools.

Should engineering be part of everyone's education?

There's a strong argument that can be made for this. In a liberal arts college, I think we all intuitively understand "the liberal arts" as a concept but would acknowledge that there is no uniformly agreed-upon core curriculum, and the curriculum isn't static—the core components have changed over time. At one point there were questions about whether modern languages should be part of a liberal arts curriculum; that changed, as it should have. The educational core continues to evolve. In the 21st century, shouldn't some fundamental understanding of technology, its role in society, its creation and use, its adaptation to meet basic human need be part of the liberal arts education? Ioannis Miaoulis, president and director of the Museum of Science, Boston, makes this point very effectively. When he was dean of engineering at Tufts he recognized that science curricula in middle and high schools focused exclusively on the natural environment and ignored the built environment. His argument is that most humans spend the vast majority of their lives interacting with the built environment. He's been on a crusade to not just improve science literacy but to inject engineering concepts and understanding of the built environment into K-12 education in Massachusetts.

Humans have had a profound impact on the environment, and engineered invention affects everyone's life on a daily basis. It's as important that we understand this as it is that we understand basic mathematics or know how to speak in complete sentences.

Who is responsible for educating the next generation of engineers?

I think it's a shared responsibility. Is it the responsibility of political leaders to say that this is important? Yes. Is it the responsibility of educational leaders to say that this needs to be part of the educated citizen's education in the 21st century? Yes. University faculty can partner with K-12 educators to help them develop methods and approaches they can use to help their students understand the process of engineering, even with simple materials, without advanced mathematics, starting at the earliest level. While I wouldn't say that it's the responsibility of every individual professor, I think we do have a responsibility to spread the excitement and awareness of what engineering is and why it's central to our lives.

What is Thayer's role in the 10,000 engineers challenge?

I think we at the Thayer School would be teaching students to recognize human need and use their skills to develop solutions, to improve the human condition, regardless of any national call for more engineers. There are pervasive problems that are crying out for new, less expensive, simpler technology solutions. On a numbers basis, even if the Thayer School were to grow dramatically, we would not be in a position to produce more than a handful of the 10,000 additional engineers a year, but I see our role as continuing to provide opportunities to motivated and creative students who take the broad view. Our role is to help them learn to use their learning and skill to tackle some of these very challenging problems in innovative, creative, and entrepreneurial ways. That's our impact.

Karen Endicott is the editor of *Dartmouth Engineer*.

POWER

PROFESSORS CHARLES SULLIVAN AND JASON

FROM THE MIDST OF GRASSY FIELDS TO THE PEAKED ROOFS OF FARMHOUSES AND FLAT ROOFS OF COMMERCIAL BUILDINGS, PHOTOVOLTAIC (PV) INSTALLATIONS ARE ADVANCING OVER THE LANDSCAPE. ALTHOUGH SOLAR POWER ACCOUNTS FOR LESS THAN 1 PERCENT OF THE COUNTRY'S ENERGY PRODUCTION, PHOTOVOLTAICS ARE EXPANDING GLOBALLY, DRIVING THE PRICE OF SOLAR POWER DOWN TO A LEVEL THAT MANY PEOPLE NEVER THOUGHT POSSIBLE. OPTIMISTIC PREDICTIONS PLACE SOLAR ON THE THRESHOLD OF BEING

ISTOCKPHOTO

PLAYERS

STAUTH ARE BRIGHTENING THE FUTURE OF SOLAR ENERGY.

BY KATHRYN LAPIERRE

competitive with other sources of energy.

Working toward that end, Thayer Professors Charles Sullivan and Jason Stauth Th'00 are developing aspects of solar power that are hidden to most people: power electronics.

Photovoltaic installations consist of multiple solar panels, each of which contains strings of solar cells—photo diodes that convert photons into electrons. But you have to do something to the energy that is gathered on your rooftop to make it useful. After all, you can't plug your toaster into a solar cell and get breakfast. That's where power electronics comes into play.

"Power electronics is the glue that holds together all the different parts of an energy system," says Sullivan. "It's what interfaces between the solar panel and the grid, between the grid and the device that uses energy."

PROFESSOR CHARLES SULLIVAN

>> THE GOAL

Sullivan works on the inverters that convert DC to AC and drive power to and from the grid. "We want to make inverters as efficient as possible so that we don't lose energy during that conversion process," he says. "We want to make them inexpensive, small, light, and convenient to install."

Progress in inverters is already making solar panels easier to use. Microinverters that handle about 200 watts have become an attractive alternative to standard inverters, which range from handling about 1.5 to about 300 kilowatts. "A typical residential installation would use one standard inverter, located in the garage or basement, connected to multiple solar panels on the roof by special DC wiring," he says. "With microinverters, you put one on each of the solar panels on the roof. There is nothing else to install, and all of the wiring is standard AC wiring that any electrician can do. Additional advantages: each one can optimize the operation of that particular panel; the system is modular so you can add more panels easily; if something goes wrong, only one panel stops working instead of the whole system; and each panel gets monitored individually, so you know if there is a problem with one of them and you know exactly what the problem is."

But microinverters still lose too much energy.

>> THE PROBLEM

According to Sullivan, the magnetic components of inverters—both standard and micro—are the bottleneck. "They are expensive, large, and have a high power loss. They're the most problematic components," he says. "Integrated circuit companies are making electronics smaller and cheaper all the time, but this doesn't include the components that are unique to power electronics."

>> THE RESEARCH

One focus of Sullivan's research group centers on developing more accurate and sophisticated models around where power loss occurs in conventional magnetic components. "These are mostly wire-wound inductors and transformers with ferrite cores," Sullivan explains. "Ferrite is a magnetic material that works reasonably well at frequencies up to about 1 MHz. Our optimizations include changing the geometrical parameters to get the best performance/cost ratio or performance/weight ratio for a given application, choosing the particular ferrite, and looking at the way the winding is constructed. At high frequencies, the 'skin effect' forces current to flow only in a thick layer on the surface of a conductor, and the related 'proximity effect' can multiply the losses by a factor of as much as 100. It is generally good to have the conductors in the winding have a dimension that is thin compared to the skin depth—the thickness of the layer that current flows in—but the dimension depends on the field configuration. Thin conductors inherently have high resistance, which means that it becomes necessary to connect many in parallel, but then electromagnetic coupling between them usually makes the current flow unequally or even in counter-productive 'eddy-current' loops. So we work on ways to configure conductors to get the benefits of thin layers without these problems, and at low cost. We also develop tools that designers can use to develop better components more easily or come up with a new configuration."

Another focus of Sullivan's group is developing alternative magnetic components. "We're working in Thayer's micro-fabrication lab to deposit new magnetic materials that have lower loss at high frequencies," Sullivan says. "The main material we're working with is cobalt zirconium oxide. We are also exploring related materials with different magnetic metals to build a portfolio of materials with specific characteristics for different applications."

>> THE FUTURE

"Our holy grail would be to approach having 100-percent efficiency, zero size, and zero cost, but obviously we're never going to get to any of those. We'll never be finished in that sense," Sullivan says. However, new semiconductors, such as gallium nitride and silicon carbide, are on the horizon. "Those materials have attractive properties that could make them very good for making very

JOHN SHERMAN

CHARGED UP
Charles Sullivan tests high-efficiency materials for magnetic components used in PV systems.

"MAGNETICS IS THE PART OF POWER ELECTRONICS THAT IS THE MOST CHALLENGING. WHEN I STARTED HERE AT THAYER I ACTUALLY THOUGHT, WELL, I'LL SPEND A FEW YEARS, SOLVE ALL THE PROBLEMS IN THAT AREA, AND THEN GO BACK TO CIRCUIT DESIGN. BUT IT HASN'T BEEN THAT EASY TO SIMPLY WRAP THAT UP. THERE CONTINUE TO BE NEW CHALLENGES, BUT ALSO NEW OPPORTUNITIES."

efficient, very high-frequency power electronics," he says. "If people make them with good performance, that could allow dramatic improvement in the size and efficiency and eventually the cost."

In the nearer term, Sullivan would like to see power electronics play a greater role in the power grid by replacing conventional transformers. "These transformers are giant, heavy, very simple devices—just steel and copper. There's no electronics in there at all right now. A lot of people would like to replace those transformers that are running at 60 hertz with a power electronics circuit running at a much higher frequency," he says. The conversion would be costly, he admits, but would boost efficiency and control for a smarter grid. "Being able to control the grid to make sure that you have the right power flowing to the right place at the right time is going to become more important as we have more renewable energy," he says.

"WHEN I FIRST STUDIED POWER ELECTRONICS IT WAS A TOTALLY DIFFERENT ENVIRONMENT. IN 2003 THERE WAS NOT NEARLY THE SAME FOCUS ON ENERGY AS THERE IS NOW. CUT TO YEARS LATER, THERE'S A BOOM IN ENERGY AND EVERYONE IS WORKING IN IT. POWER ELECTRONICS IS VERY IMPORTANT IN REDUCING THE AMOUNT OF ENERGY WE USE."

PROFESSOR JASON STAUTH

>> THE GOAL

"The goal is to make solar more efficient, to improve the energy capture of solar installations, and at the same time reduce the cost," says Stauth, who earned his B.E. at Thayer in 2000, then worked in the private sector and completed a Ph.D. before joining the Thayer faculty last year.

>> THE PROBLEM

"Each solar cell in a panel gives you 0.5 volts, which isn't useful since your wall circuit is running at 120/240 volts. A central inverter may require 500 volts to operate efficiently. Solar cells are wired in series to achieve higher voltage. In a typical system there may be up to 1,000 cells stacked in series to reach the 500 volts for the central inverter. Each panel may have 60 cells stacked in series and there may be 10 to 20 panels connected in series," says Stauth.

"We try to operate the solar panel at a very specific operating point where it is achieving the maximum power. But you can't simultaneously run cells that are connected in series at their optimum operating point," he says. Like batteries in a flashlight, if one is bad, it limits the energy production of all the rest. If one solar cell is in shade or is coated with dust and debris, it will block the flow of current. "You're limited to the worst case because all the cells have to operate at the same current. Current mismatch reduces energy production of the entire string of modules."

One inexpensive solution to mismatch, says Stauth, is to put bypass diodes in the junction box behind each PV panel to let current flow around underperforming strings. "The problem is that if bypass diodes turn on, they throw away all the power that could have been available in the underperforming string of cells," he says.

>> THE RESEARCH

Stauth, a cofounder of the company QVSense, which was acquired by Solar Semiconductor, has developed a different approach: a converter that lets all the strings of cells operate independently. "Our converters connect to strings of cells through connections that are made in the junction box," he says. "They move charge in parallel with the strings of cells so that if one string of cells has less current available, our converters can 'shuffle' it around the underperforming string. If we didn't do this, the current of the entire panel, and the entire string of panels, would have to be reduced to the worst performing string of cells."

The parallel architecture brings advantages: converters handle only the mismatch power, can turn off with no mismatch in the system, and the devices are exposed to only a fraction of the total voltage stress. This allows for "higher efficiency, near zero insertion loss, and higher reliability," says Stauth. "It's a way to optimize power at the sub-module level, around the terminals that are normally connected to bypass diodes. People have built converters that let each panel operate independently. But this is a solution that lets *regions* of each panel operate independently so they can operate at their maximum power point, regardless of how much variation is in the system. We are developing a solution that in the future will let *each* cell operate independently. We hope to do this by integrating all of the electronics on a single silicon chip that can be embedded in the PV laminate. The solution will leverage Moore's Law, scaling to achieve exponential reductions in size and cost."

>> THE FUTURE

"Power electronics is one piece of the effort to get solar to grid parity, to get the cost of PV below the cost of coal-based electricity. Reducing the cost of solar panels, improving their energy efficiency, improving the installation process, reducing overhead for systems integrators, streamlining the regulatory framework, and even little factors, like where the wiring goes—all these things are important as well. Overall it's getting there. Power electronics is more exciting now than it has been in many decades."

Kathryn Lapierre is the senior editor of *Dartmouth Engineer*.

JOHN SHERMAN

LIGHT TOUCH
Jason Stauth develops solutions to the problem of current mismatch in strings of solar cells.

Alumni News

CLASS TIME
Ayorkor Korsah, center, teaches in Ghana.

spotlights

Ayorkor Korsah '01 Th'03 has a challenge for fellow roboticists: build a $10 robot. As cofounder of the African Robotics Network (AFRON), an initiative to enhance robotics education, research, and industry in Africa, she is hoping to find the tools to help expose schoolchildren to robots. "There are many robotics activities emerging in Africa," Korsah, a computer science professor at Ashesi University in Ghana, told *IEEE Spectrum* magazine. "Our goal is to highlight, enhance, and provide support for efforts in different parts of the continent." One project involves an international competition to design a simple programmable robot for education with parts costing under $10 that students would use to explore science and engineering topics. The robot would be connected via USB to a computer, and students would use open-source software to program the robot's behavior and share the results. Details about AFRON and the "10 Dollar Robot" are at robotics-africa.org/design_challenge.html.

Javelin thrower **Sean Furey '04 Th'05 '06** made it onto the U.S. Olympic track and field team competing in London. While at Thayer, where he earned his A.B., B.E., and M.E.M. degrees, he was named the 2005 U.S. Track & Field and Cross Country Coaches Association Men's Scholar Athlete of the Year. His sport infused his studies; he co-created a "TurboJavelin" with **Daniel Hassouni '05 Th'05** and **Colin Murray '04 Th'05** as an ENGS 190/290 engineering design project.

"Nobody *needs* electric motorcycles," says BRD Motorcycles CEO **Marc Fenigstein '01 Th'04**, "but we found a way to make everyone *want* electric: by making them go faster." In the Bay Area, among some of the most innovative companies in America, Fenigstein and the rest of the BRD team (including cofounder **David Drennan Th'09**) are busy changing the face of the motocross industry through their pioneering electric bikes, reports core77.com blogger **Dave Seliger '12**. BRD's flagship 250-pound RedShift charges in a wall socket and, unlike the gas-powered competition, is legal on the street. BRD (faster-faster.com) is now taking orders for its first two models, each about $15,000, and a police variant designed for city patrolling. For more about BRD, see the Winter 2012 issue of *Dartmouth Engineer* at dartmouthengineer.com.

When Mongolian agricultural workers expressed a desire to extend the growing season for crops, **Bill Hess '90 Th'93** melted down beer bottles to create a model greenhouse. In summer 2010 the Charlottesville, Va.-based glass engineer and artist was first approached by colleagues from M·CAM, a business development firm that had been advising communities, businesses, and the government in Mongolia on economic policies and eco-friendly technologies. Hess and the M·CAM team designed a yurt-shaped greenhouse model with a steel infrastructure and windows of Corona bottle glass. The project gained enough interest and funding that by last summer Hess was leading four student volunteers from the University of Virginia through markets in Ulaanbaatar, the country's capital, to find supplies and tools. He helped build the final 19-sided structure with salvaged wood, a base of rock and concrete mixed in an old bathtub, and a design that used stacked bottles along with panels made with glass melted on-site. He shares details at his blog, ideasonlegs.com.

WOW FACTOR
BRD's electric motorcycle is generating buzz.

UPWARD TRAJECTORY
Sean Furey '04 Th'05 '06 threw his way to the London Olympics.

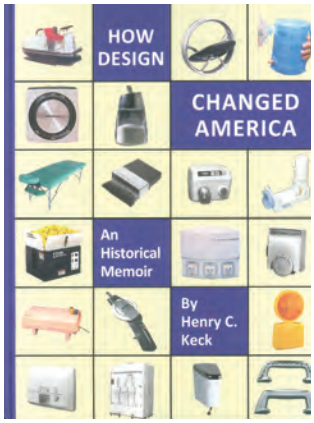
Books By Alums

Thomas Brady '66 Th'68, founder and CEO of Plastic Technologies Inc. (PTI), recently discussed the role of the entrepreneur with **Gregg Fairbrothers '76**, founding director of the Dartmouth Entrepreneurial Network, and **Catalina Gorla '09** for an article in *Forbes*. "I was first exposed to entrepreneurship in an undergraduate engineering course at Dartmouth where we were presented with a 'gap' in the commercial world and asked to fill that gap by proposing a solution, developing a prototype process or product, and then selling that solution as a commercially viable business," says Brady. He applied the lessons learned in that class when he joined Owens-Illinois Inc., "where I was almost immediately asked to lead the technical development of a family-sized plastic carbonated soft drink container which wasn't technically or economically possible in metal or glass, but which was theoretically possible in plastic—another gap in the commercial world." As vice president of plastics technology, Brady led the development of the first PET plastic soft container for Owens-Illinois before founding PTI in 1985. Holland, Ohio-based PTI now employs 200 worldwide. Read the full interview at forbes.com/sites/greggfairbrothers/2012/02/06/who-is-the-entrepreneur-tom-brady-part-1.

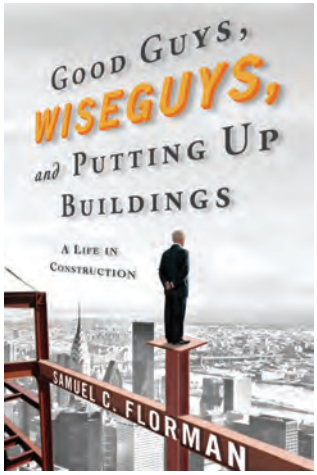
Dartmouth men's rugby coach **Alex "Mags" Magleby '00**, who was named interim head coach of the USA men's sevens team through its season ending in mid-May, returned to Hanover in time to prepare the Dartmouth team to win its second consecutive national Sevens Collegiate Rugby Championship in June. As Dartmouth's head coach since 2001, Magleby, who majored in engineering, led the Big Green to nine Ivy championships. He and **Rich Akerboom '80 Th'82** cofounded Sylvan Advantage, a distributor of sports performance analysis tools. Magleby discusses coaching at youtube.com/watch?v=wZe6eweZi6o.

The TrailerTail, a four-foot aerodynamic fairing developed by **Jeff Grossmann Th'06** that streamlines airflow at the back of a tractor-trailer, has earned California's highest environmental honor. Transportation technology company ATDynamics Inc., where Grossmann is vice president of engineering and **Andrew Smith Tu'07** is CEO, received the 2011 Governor's Environmental and Economic Leadership Award for its efforts to "reduce greenhouse gas emissions while providing significant economic benefits." The fairing reduces fuel consumption by 6 percent, and is expected to save the long-haul trucking industry $20 billion through the next decade.

The New York Times "Great Homes" section raved about the Emerald Art Glass House—a 53-foot-long wedge of glass and steel cantilevered over a Pittsburgh factory—designed by architect **Eric Fisher '82**. "Come at the house straight on, driving across the river up to the door of the factory on Josephine Street, and you might not notice it, for the factory is two stories high and the house is set so far back. But walk a half-block down the street, past the neighboring wood-frame houses, and look up, and it will stop you in your tracks," the article notes. Fisher, who majored in engineering, told *Dartmouth Engineer* about the Emerald Art Glass House in the Summer 2010 issue, which is at dartmouthengineer.com. A spectacular slideshow is at nytimes.com/2012/02/09/garden/bob-and-kim-zielinski-build-an-untraditional-house-in-pittsburgh-on-location.html.

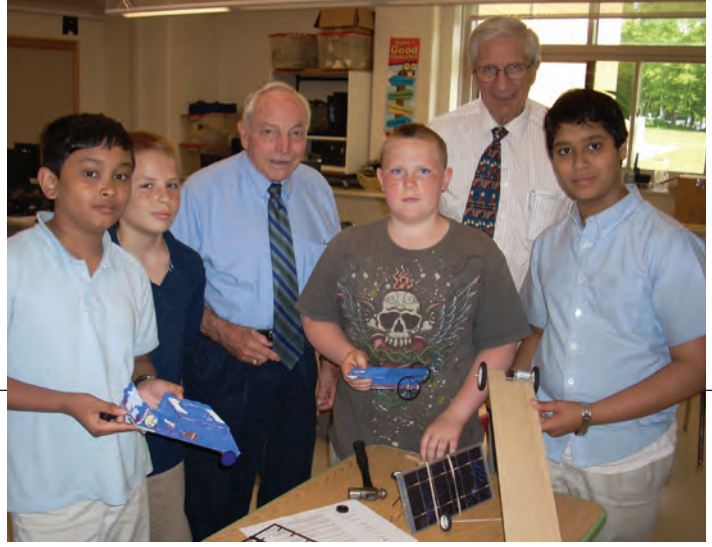


After more than 50 years at the forefront of industrial design, **Henry Keck '43 Tu'44 Th'44** has published *How Design Changed America: An Historical Memoir*. Keck founded Keck-Craig in Pasadena, California, in 1951, and since then has improved the design and reduced manufacturing costs of more than 1,700 products. His designs are ubiquitous in American life: the bright-yellow hazard lights flashing along construction sites, the soap dispensers and hand dryers found in many restrooms, the most popular tennis ball-throwing machine on the court, the glass sugar and syrup dispensers on virtually every diner tabletop. "This decanter is iconic," design historian Bill Stern, the guiding force behind the Museum of California Design, told the *Los Angeles Times* when it profiled Keck in 2008. "The very essence of modernism, a perfect meld of function and form." Keck created the dispensers in 1955 for Dripcut Starline. "We hesitated on taking on the project thinking that it was too simple for our 'exalted' company," he writes. "But wisdom and the need to pay the rent prevailed." The book contains many examples of the ways his designs have affected our lives; contact Keck at keckhenry@gmail.com for a copy.



Samuel Florman '46 Th'46 offers the low-down on high-rises in his memoir, *Good Guys, Wiseguys, and Putting Up Buildings: A Life in Construction* (St. Martin's Press). As the chairman of Kreisler Borg Florman General Construction Co. (KBF) for more than 50 years, he provides "a unique insider glimpse into the politics of building the most important city of the 20th century," according to *Publisher's Weekly*. Florman made his way as a general contractor in New York City, interacting with politicians and civil servants, developers and technocrats, saintly do-gooders and corrupt rapscallions. KBF has built more than 350 projects throughout the metropolitan area since it formed in 1955, including the 76-story Beekman mixed-use tower designed by architect Frank Gehry, the eighth tallest building in the city when it was completed in 2011; a tapered 17-story condo designed by I.M. Pei; the Battery Park City marina; and the 55-story Corinthian, which was Manhattan's largest apartment building when it opened in 1988. "I look back on this career with relish…because of the challenges met, the rousing adventures encountered," Florman writes. "Also there have been satisfactions of a different sort: the enchantment of seeing architecture made real…the pride of creating housing, hospitals, schools, places of worship—shelter for the body and nourishment for the spirit."

OPPOSITE PAGE: TOP, COURTESY OF AYORKOR KORSAH; BOTTOM, COURTESY OF MARC FENIGSTEIN. THIS PAGE: TOP, COURTESY OF TRACKTOWNUSA



SOLAR SPRINTS
John Kennedy '53 Th'54, third from left, and fellow engineer Mike Tucchio help competitors with their Solar Sprint models.

just one question

Q. Have you been involved in any activity that encourages children or teens to pursue engineering or science?

If you're a civil engineer in the construction industry, it's easy to capture the interest of kids. Several years ago I met with the class of one of my granddaughters. I believe they were fourth-graders, but the approach can be tailored to any level. I first introduced a carpenter's tool belt supplied with all the usual tools. This was greeted with great enthusiasm. I then passed around tapes and other instruments for measuring distances and angles. Next we discussed job safety and handled hardhats, goggles, safety harnesses, and an unexpected favorite: masks to protect the mouth and face from dust. Once I had a captive audience I introduced plans of a fairly simple six-story apartment house: first the architectural drawings, which make it clear what the building looks like in plan and elevation; next the structural plans with beams and reinforcing rods; and finally the mechanical plans, plumbing, heating, air conditioning, and elevators. This led into a discussion of design—the strength of beams, the efficiency of air conditioning, etc.—the role of engineers, and the need for math, chemistry, physics, and computer science. At this point you take the group as far into the technical as you can without losing them. My "teaching career" ended before the introduction of BIM, the 3D computer modeling of a proposed building, but that remarkable development would surely have an important role in any discussion today.

Naturally, when you leave you have to be prepared to leave that tool belt and other props behind!

—Sam Florman '46 Th'46

Since I started Dartmouth some 69 years ago and graduated from Thayer School 64 years ago, I am no longer involved with youngsters now other than family. I do have one grandson (now 30) who went to Swarthmore and became a civil engineer and another grandson (15) who I will encourage to study science and engineering when he considers colleges in a couple of years. However, having retired some 20-plus years ago, I am out of touch with current engineering and its modern practice in this electronic world. Therefore I would not be able to do much encouragement with young people—that should be done by younger persons who can better relate to present-day young people and can stress the enjoyable and challenging aspects of science and engineering.

—Bob Keane '47 Tu'48

The only thing I do in this regard is to make regular contributions to the SME (Society of Mechanical Engineers) Education Foundation, which does a lot!

—Foxhall Parker '48 Th'49

I am on the board of directors of a middle school in New Haven, Conn., called St. Martin de Porres Academy. The school is private, tuition-free, and supported by donations from private citizens. I have mentored some kids and teachers. I think some possibilities exist for the kids through their science studies in areas that I believe are far beyond what they are currently taught. For example, the activity at the Large Hadron Collider in Geneva (quantum physics) could be fascinating to students if presented in a kid-friendly way. I could just see a cartoon figure named Mr. Higgs Boson as the star of the show; I believe kids would be as fascinated as I am in these topics if presented in a cartoonish manner.

—Bart Lombardi '52 Th'54

I have been involved with a program that could lead middle school kids to a science career. A number of years ago the Northeast Sustainable Energy Association (NESEA) established a program for students in the middle schools of New England called Junior Solar Sprint wherein teams of sixth-, seventh-, and eighth-graders would build and race solar car models on a 50-foot line-guided run. Each student would be given a 6-inch-by-12-inch solar panel and an electric motor, and with help from science teachers and engineers like me they would proceed to build their models and then race them in a statewide competition. My engineering background is ideal for this kind of mentoring. I used to work at Yardney Technical Products, where I was program manager for electric vehicle battery development and owned and operated my own electric-powered van for a number of years. Since 1990 I have been a consultant in the field of alternative fuel vehicles (AFV), and have been responsible for a number of major Clean Cities projects, including AFV educational programs in the Norwich, Conn., public schools and at the UN International Children's Conference on the Environment. My associate, also a mechanical engineer, and I have assisted the kids for the past 15 years on this program. We typically go to their classrooms at the beginning and talk about the engineering principles involved with model design (weight, friction, gear and shaft alignment, energy conversion). When their models are nearly complete, we help them put on the finishing touches and fine-tune them for the race. The kids from our local schools have done remarkably well through the years, almost always placing in the top three in the speed event, plus winning other awards for design innovation, among others. My associate and I have received some nice accolades for our work assisting the kids. Unfortunately, NESEA has discontinued its K-12 education program. The program is still supported to a limited extent by the U.S. Army, and in Connecticut continues under regional support.

—John Kennedy '53 Th'54

Somewhere around 1973 Dean Carl Long asked the Dartmouth Society of Engineers (DSE) for help in encouraging high school students to apply to Dartmouth with the intention of going to Thayer School. Dean Long felt that he was losing too many students to math and physics. As president of DSE, I helped organize an orientation meeting at a home in Hartsdale, N.Y. We queried the various high schools in Westchester County, N.Y., to send juniors with engineering aptitude. Dean Long made the trip to Hartsdale to make his pitch.

—Harlan Fair Th'54

For the most part I teach computer science and software engineering courses within the computer science department (part of the College of Engineering and Mining) at the University of Alaska Fairbanks. Usually the software engineering courses are graduate level, but I sometimes teach CS101 (computer literacy) to fairly large classes of students. The age range of CS101 students is from 17

DENTAL CHEMISTRY
Dr. Richard Dickinson '00 Th'01, right, and a colleague test the pH of popular drinks at a Catamount Kids presentation in St. Albans, Vt.

to 65, and their majors include the full spectrum—including English, history, psychology, music, political science, computer science, and criminal justice, etc. It is a challenge to keep these students interested and to ensure that they also learn something worthwhile. I cover computer basics, computer productivity tools, the Internet and the web, and elementary web programming (mainly HTML and JavaScript). In addition, I cover current relevant emerging technology issues, such as the cloud, intellectual property, artificial intelligence, and software law. I doubt whether many of the above-mentioned students will end up in engineering fields because many of them have deep concerns about even basic mathematics. I try to cover some mathematics whenever I can without causing serious danger of student cardiac arrest. I'm thinking of upgrading CS101 to a so-called "digital literacy" course, which could be more helpful for fledgling engineers.

—Pete Knoke '55 Th'56

I have funded three scholarships awarded annually in perpetuity to a family member of a service person by the Military Officers Association of America (MOAA), under the umbrella of the MOAA scholarship fund. I request that the awardee intends to pursue a four-year academic program at an accredited college or university leading to the award of an engineering or engineering sciences degree primarily or a degree in the physical sciences secondarily. Each awardee receives $500 in cash and a $3,000 loan annually. There is no interest charged on the loan until the student graduates. I have also left a legacy (two variable annuities), one half of which is to fund as many $25,000 scholarships as possible from the proceeds at the time of my death. The primary reason I selected this organization and this scholarship is that every dollar is given to the awardee(s); MOAA doesn't take any money for overhead or other purpose.

Two of my grandsons are engineers. One attended Vanderbilt and works as a civilian employee of the U.S. Army Corps of Engineers; the other graduated from the U.S. Naval Academy and is a co-pilot with Delta and an active aviator in the U.S. Navy Reserve. A grandson-in-law is an aeronautical engineer and a civilian employee of the Army at Redstone Arsenal.

—Arv Hickerson '56 Th'57

My grandchildren are doing very well in math and science. I encourage them and provide all necessary tools—computers and websites. I also assist them in science projects, which have earned them blue ribbons. However, the cost of school is skyrocketing. If we want more scientist and engineers, perhaps tuition and cost breaks would help.

—Don Jansky '62 Th'63

The best program for students is the one founded by Dean Kamen, the FIRST Robotics Competition (FRC; www.usfirst.org/roboticsprograms), which last year attracted close to 300,000 students. My older son was born an engineer. He spent more time at 3 years old looking behind the merry-go-round than riding it. He went to Bellarmine Prep and joined its FRC team. He won the world championship in 2011 as operator and then went to Missouri University of Science and Technology. My younger son joined a robotics team as well. He just finished freshman year at Bellarmine and became operator as a freshman. That team made it to the finals of their division at the world championship in St. Louis, Mo. They have a great website at team254.com. Bellarmine is very fortunate in that it is sponsored by NASA Ames and has the resources of a private Catholic school and some big donors. It also attracts some of the best students from Silicon Valley, but still critical is parental involvement. Invaluable are the mentors in industry and college, most of whom were not paid in the past.

—Andrew "Kip" Sides '77 Th'78

My team at Azarias International—I'm the president—is developing a STEM (science, technology, engineering, and mathematics) program for schools and colleges. We're researching an advanced STEM development concept that will pair high school students with graduate students for collaboration on real-world projects. This approach leverages the best of individual and institutional strengths to help students discover their natural gifts and passions within a STEM education setting. Our STEM concept aligns sponsors, colleges, and schools on an institutional level and connects students, teachers, and professors on an individual level. Each student accomplishment will be stored electronically in a secure STEM portfolio. Sample projects are environmental and global resource analysis, mathematics modeling and analysis of Internet traffic, biochemistry/healthcare clinical research assistance, and information security analysis and design.

Schools benefit by gaining access to low-cost STEM mentors, faster adoption of online resources by teachers, enrichment of course materials through filtered online resources, course-consistent material for extracurricular activities, and new funding sources through corporate sponsorship. Colleges benefit by developing graduate student interest in STEM teaching, creating additional funding sources for professors, building stronger school relationships, an increased application submissions through long-term student relationships. Sponsors benefit by directing funds toward targeted regions and specialized fields of study, tracking specific student achievements, obtaining granular STEM life cycle metrics, hiring greater numbers of better trained U.S. STEM graduates in targeted fields; and accessing low-cost research resources.

We are in the process of developing a Phase 1 National Science Foundation grant proposal to research the viability of the portal and portfolio. We will be inviting up to five schools and five colleges to participate in this research and development over the next two to three years. If anyone is interested in participating or if you have any comments or suggestions for improvement, please contact me at mtuttle@azariasintl.com.

—Mark Tuttle '80 Th'82

I am a structural engineering professor at Vermont Technical College and a licensed consulting structural engineer. My work involves teaching, performing, or researching the design and analysis of bridges, buildings, and other structures. Last year I became the Southeast Vermont Chapter coordinator for MATHCOUNTS, a national mathematics competition for middle school (sixth-, seventh-, and eighth-grade) students. Students, who are called "Mathletes," compete both individually and on teams to perform mathematics problems ranging from easy to extremely challenging. The experience, which is fun for all involved, rewards them for their mastery of mathematics. It also allows me and my fellow volunteers—including engineering students from Vermont Tech and Norwich University—to show them how mathematics relates to engineering so that they can consider engineering as an educational and career path. There is also a chance for me to let the students know what the letters "P.E." after a person's name mean, because many have no idea what a professional engineer is. There are regional, statewide, and national levels of

OPPOSITE PAGE: COURTESY OF JOHN KENNEDY. THIS PAGE: COURTESY OF RICHARD DICKINSON

HARD HATS
Laura Weyl Th'08 took Boy Scouts to a construction site.

competition, and MATHCOUNTS is sponsored, in part, by the National Society of Professional Engineers, of which I am a member.

The greatest challenge with kids this age is working within a schedule broken into short bursts of activity with snack breaks inbetween. They are not yet at the age where sitting down for multiple hours of activity is their nature. The most unexpected element of the competition is how incredibly quick and bright many of the students are, solving complicated problems without calculators faster than many of the practicing engineers in the room can!

—Scott Sabol '88 Th'88

My 10-year-old son and 13-year-old daughter like LEGO robotics using the LEGO NXT kit; 3D animation and CAD using Maya; and programming with Scratch, Python, and pygame. Scratch has a YouTube-like site that allows you to share your creations, and my son has posted several games he has written. They also like to program using Alice and HTML and model fluids with OE-cake. When they were younger they enjoyed building simple electronic circuits using snap circuits, and they went to Camp Invention and various science camps at their school.

—Suchitra Ram '91 Th'92

I help students at Duke University in the electrical and computer engineering laboratories. A video is at ondemand.duke.edu/video/32970/engineering-students-turn-desi.

—Kip Coonley Th'99

Our community is fortunate to have a company named Med Associates and its affiliate, Catamount Research and Development, based in St. Albans, Vt., that performs contract research and development for the biomedical research community. The president of Catamount, Dr. Gerald Herrera, runs a program called Catamount Kids to "give children an opportunity to explore science and the natural world." I was invited this spring to present the chemistry of dental caries and the role that fluoride plays in helping to prevent dental decay. We conducted an experiment evaluating the efffects of fluoride treatment in preventing the dissolution of eggshells exposed to acid solution (soda). Another fun demonstration we did is testing the pH of various beverages to show the kids how their diet choices also affect their risk for dental decay. We do a similar presentation at some of the public elementary schools in our corner of northwestern Vermont. See facebook.com/CatamountKids.

—Richard Dickinson '00 Th'01

Since 2006 I have given presentations on space exploration to elementary school children in northern New Jersey almost annually. I started doing these talks when I was a grad student at Purdue, pursuing my M.S. and Ph.D. in aerospace engineering. (I am currently a propulsion development engineer at SpaceX.) I always wrap up the presentation explaining to the students that they are the future leaders of space exploration. During the most recent talk, at least half of the female students stated that they want to be the first woman to walk on the moon. Every time I give this talk I see a lot of excitement in the students' faces.

—Erik Dambach '04 Th'05

I've been involved with a high school outreach program that presents to math and science classes about structural engineering. It's a one-time presentation followed by a hands-on building activity to show students what we do and let them know the best path to pursue if they are interested by what we do. (I am a designer at Degenkolb Engineers, where I design new buildings and retrofit existing buildings to meet and exceed current seismic building design standards.) We do a contest with a certain number of toothpicks and mini marshmallows and see which group can build the tallest structure in 15 minutes. It's great for team building, communication, brainstorming, and thinking about basic geometric shapes. We also ask them before they start to think about the project limits, so they do some quick math with 250 toothpicks and 100 marshmallows end-to-end to determine the limiting factor. If you could make the structure end to end, how long could it be, approximating the length of a toothpick as 2 inches? They usually have a lot of fun with it! I also recently talked to a Boy Scout troop about one of my buildings and gave them a tour of the construction site for an engineering badge. They were some of the most curious kids I've worked with! They had some good questions: What is the best type of building to be in during an earthquake? Why is glass a bad material to use in earthquakes? How do you get that tractor out from inside the building? We were on the job site when they asked that last question, and it was a great way to get them thinking about the building process as well as design.

—Laura Weyl Th'08

1940s

Bob Sundblad '44 Th'48: I've been retired since 1989, and moved to Florida in 1994. I maintain my professional engineer license, although I have not been active professionally for some time. I was president for several years of our local engineering society and, hence, was involved with some of our Cape Coral utility problems.

1950s

Robert Helsell '59 Tu'60 Th'60: I've been in engineering my entire career. I first joined Alcoa as a plant engineer in 1960, then left to join the U.S. Coast Guard at officer candidate school in Yorktown, Va. I returned after active duty to Seattle, where I became a consulting engineer with Haskins and Sells. Later I joined up with another consultant in a business called Data Planning. One of my early client calls was to a firm called Howard S. Wright Construction Co. I joined Wright in 1968, and eventually became president and CEO in the early 1980s. In 1987 we sold the business to Fletcher Challenge of New Zealand. After a year of working with them, I left to purchase the Wilder Construction Co. from the Wilder family. Wilder was a heavy civil contractor specializing in roads, bridges, airport runways, heavy sewer, and environmental remediation. I served as president and CEO from 1989 to 2002. We sold the business to Granite Construction Co. of Watsonville, Calif., and I remained on the Wilder board as chairman until 2007. In 2003 I joined the board of Fisher Cos, a design-build firm specializing in food processing and cold storage projects. In 2011 the CEO of Fisher resigned and I was asked to chair the board of directors. I'm a minor owner of Fisher, so after all these years, I'm still in the construction industry. I was honored in 2004 to be included in the Construction Hall of Fame for the State of Washington. I have

HIGH TIMES
Center: Ike Anyanwu-Ebo '94 Th'95 atop a wind turbine in Denmark like the one to his left. Right: Bruce Clark '60 Tu'61 Th'61 cycled up L'Alpe d'Huez in France in 2007.

loved my career in construction.

1960s

Bruce Clark '60 Tu'61 Th'61: I retired in 2001 after founding, building, and selling the interim management recruiter IMCOR, where I was president and chairman of the board. Since then I have been on the board of the Lake Waubeeka Association, which is a 264-home community in Danbury, Conn. I have been the president of that board for several years. I am an active cyclist who has competed in the National Senior Games four times and have done 12 bicycle tours of Colorado, starting in 1999. My engineering training serves me well in my role as the chairman and operating manager of our community's water system, which is presently implementing a major treatment upgrade.

Jerry Greenfield '61 Tu'65 Th'62: I retired 16 years ago from Westinghouse Hanford, where for 16 years I was a computer systems analyst/programmer and for two years was a contract administrator. I was the only contract administrator who had passed the bar exam, and I advised the other group members on the applicable law as well as administering the Boeing/Westinghouse contract. Since retirement, I have been a city councilman for Richland, Wash., president of my Kiwanis Club, lieutenant governor for my Kiwanis division, chairman of laws and regulations for my Kiwanis district, president of my Toastmasters Club, and involved with a few other community activities.

1970s

Steve Askey '76 Th'77: I retired from Schlumberger in July 2010, after almost 33 years with them. In November 2010 I started work again as a contractor for PPI Technology Services. I'm now a global quality-assurance engineer in-house at BHP Billiton in Houston. Less stress and more money than the previous job, so life is good. Maybe try to retire again 2014 or so…we'll see.

1980s

Sue Spencer Th'82: Living in the middle of the Boundary Waters Canoe Area Wilderness, I built a solar-powered, handicapped-accessible, low-maintenance, hypoallergenic, energy-efficient, luxurious home. I hope to develop my 102 acres, preserving the virgin forest and a lake with a pristine watershed without development, where I am the sole non-government owner. I am planning to build five more cabins to sell with a 99-year lease for the home site and access to the 102 acres. The designs combine four building philosophies: Living Building Challenge, LEED platinum certification, building biology, and Maharishi Vedic architecture. Last winter I championed better decisions in mining and water-quality issues through system dynamics, with the help of the Humphrey Institute and the Natural Resources Research Institute; acid rock drainage can pollute waterways if the feedback loops are not well understood. As always, I teach Transcendental Meditation.

Andrew Mannes Th'83: I was recently promoted to chief of the department of perioperative medicine at the National Institutes of Health. Following completion of a B.S. in bioengineering at the University of Pennsylvania and an M.E. at Thayer, I received my M.D. at George Washington University. I have a long-standing interest in the treatment of severe pain often seen at the end of life. My current interests include developing pain therapies using gene therapy; targeting pain pathways with selective agonists, toxins, or fusion proteins; and improving the diagnosis of disease states using proteomic and genomic techniques. I am a member of the American Medical Association and on the editorial advisory board of *Open Pain Journal*. One last note: My son starts his freshman year at Dartmouth this fall.

Ralph "Buz" Wright Th'84: I went to medical school after Thayer, and subsequently specialized in radiation oncology. I do get to use some of my engineering background. I was in practice in Cincinnati for 20 years and just relocated to Denver to work for Rocky Mountain Cancer Centers.

1990s

Ike Anyanwu-Ebo '94 Th'95: I live and work in Århus, Denmark, for the world's largest wind turbine manufacturer, Vestas Wind Systems A/S (vestas.com). I lead a team of 15 engineers in the Turbines R&D Organization, which performs product development for Vestas globally. My time has involved site visits, including a few climbs up our 2MW, Mk7 turbines. I never realize how afraid of heights I was until these climbs! On a personal note, my wife Carmen Harden '96 and I were doubly blessed late last year with the birth of twins Nnenna and Emeka. They join their older siblings, Nnamdi, 8, and Amara, 3.

Darren Perry Th'99 Tu'05: I've been promoted to vice president at L.E.K. Consulting in Boston. I focus on aerospace, aviation, travel, building materials, and industrial products practices. I have more than 10 years of consulting experience working on a wide variety of projects, including corporate strategy development, mergers and acquisitions support, new product development and commercialization, pricing strategy, and customer loyalty. Prior to joining L.E.K. in 2005, I worked as a senior consultant for MicroStrategy, a global leader in business intelligence technology.

2000s

Phil Frost '04 Th'06: I live in the Upper West Side of Manhattan with my wife, Erin. I started my own business, Main Street ROI, in January 2011. We teach business owners how to profitably use online marketing. I ran the N.Y.C. Marathon in November 2011 and I plan to run the five-borough series plus the N.Y.C. Marathon this year. For many of these races I raise money for the American Cancer Society as part of the Determination team.

Brooks Smith '08 Th'09: In May I graduated from the M.S.C.E. program at the University of Massachusetts, Amherst. My thesis focused on experimental studies and finite element analysis microstructural simulations of porous steel as a new material for structural engineering applications. The research was fascinating and gave me an opportunity to present at conferences as far away as South Korea, as well as publish a few journal articles. We may have the next generation of structural blast protection systems on our hands! This summer I started my career as a forensic structural engineer based in New York City, working for Whitlock Dalrymple Poston and Associates. I'll be traveling around the country investigating buildings and bridges that have collapsed or have other structural problems, figuring out why they failed and, I hope, finding ways to fix them. If you're in the New York area, give me a shout and let's grab a drink!

Peng Wang Th'09: I recently joined the Danish sovereign investment fund for developing countries as an investment manager, mainly in charge of the fund's direct investment and portfolio management in China. After graduating from the M.E.M. program I started my career at the World Bank in Washington, D.C., focusing on infrastructure investment and policy advisory in the East Asia and Pacific region. I left the World Bank in 2011 and returned to my hometown of Beijing for a new phase of career development. Now I travel frequently across Europe and Asia and work with various co-investors and partners. I have also served as an alumni interviewer for the class of 2016.

OPPOSITE PAGE: COURTESY OF LAURA WEYL. THIS PAGE, LEFT AND CENTER: COURTESY OF IKE ANYANWU-EBO; RIGHT: COURTESY OF BRUCE CLARK

Jonathan Cedar with the Biolite Stove

THE BIOLITE STOVE

>> CO-INVENTOR:
JONATHAN CEDAR '03

At first Jonathan Cedar '03 and Alec Drummond just wanted to make a camping stove that didn't burn gas or use batteries. The two colleagues at Smart Design in New York City, both engineers and outdoors enthusiasts, figured there had to be a way to better harness one of the world's most ubiquitous resources.

"We basically said, 'How do you use wood as a modern fuel?' The whole idea is to jettison the fuel supply chain," Cedar says. Several prototypes later, they realized that their solution—a biomass-powered cook stove that uses its own waste heat to improve combustion efficiency—had resonance beyond camping. Almost 3 billion people around the world still cook with wood and dung on open fires or in inefficient stoves. The resulting pollution leads to more than 2 million premature deaths every year, according to the World Health Organization.

So Cedar and Drummond quit their jobs and teamed with Thayer alum Jonathan den Hartog '03 Th'05 to found BioLite, a Brooklyn-based company that aims to transform the way millions cook.

BioLite's core innovation is an ingenious deployment of a Peltier junction—a device that uses the temperature difference between two metals to create electric current. BioLite installs the junction in a wood-burning chamber. As the wood burns, the junction sends current to a blower, which pulls in air for improved combustion.

There's an innovative bonus, too. The excess power generated can charge small electronic devices of up to four watts through a USB port. The prospect of a wood-powered iPhone has gear and gadget blogs abuzz here in the United States and could appeal equally in the developing world. India, for example, has more than 900 million cell phone subscribers and chronic electricity shortages.

BioLite claims that its stoves produce 90 percent fewer particulate and carbon monoxide emissions and use 50 percent less wood than cooking over an open fire. If its HomeStove sells well in India and sub-Saharan Africa, it could make a serious dent in the health crisis caused by chronic exposure to these pollutants.

Cedar, who majored in engineering modified with environmental science, sees another potential benefit of the technology: cutting soot's black carbon emissions, a major contributor to global warming.

"But the biggest story here is that two million people die," he says. "That's ultimately, in my view, the reason to be doing this."

—Jonathan Mingle

COURTESY OF BIOLITE, TOP: PHILIP MONTGOMERY

RANDOM WALK

School Day at Thayer School's Formula Hybrid International Competition in May attracted middle school students from around New Hampshire for an up-close look at how college teams design and build hybrid racecars. School Day is one of several ways Thayer School opens the engineering door to the public. Thayer students regularly share their engineering enthusiasm by mentoring local youngsters through LEGO League, an After-School Science Program, Junior Solar Sprints, robotics competitions, and similar projects. And every April Thayer School invites the public to an Open House featuring tours of research labs, demonstrations of student projects, and opportunities for kids to sit in racecars, operate remote-control robots, and experience the ingenuity and fun of engineering.

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