DARTMOUTH
Engineer
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WINTER 2013

Kristen Colwell '13 combines music and engineering.

CREATIVE CONNECTIONS

STUDENTS FIND INTERSECTIONS BETWEEN THE ARTS AND ENGINEERING

DARTMOUTH ENGINEER
VOLUME 9 / NUMBER 1

THE RIGHT TIME TO INVEST IN SCIENCE

BY DEAN JOSEPH J. HELBLE

I SUSPECT I AM NOT ALONE IN STRUGGLING TO RECONCILE STATEMENTS of support for STEM (Science, Technology, Engineering, Math) education from politicians across the ideological spectrum with diminishing federal support for scientific research, particularly in areas of the physical and biomedical sciences that are so important to engineering programs like Dartmouth's.

The automatic discretionary spending cuts embedded within the federal budget sequester are the latest example of eroding support for investments needed for our long-term economic health. Federal spending on non-defense discretionary R&D as a percentage of the federal budget has been falling for four decades, and the cuts associated with the sequester bring us back to the R&D spending levels of the late 1990s in constant dollar terms. At the same time, many nations have been posting double-digit annual increases in R&D investment, and the global R&D organization Battelle has forecast that Asia will soon surpass the Americas in R&D spending for the first time.

Locally, as many of our alumni know, federal investment in R&D has had an enormously positive impact on the Upper Valley. Over the past decade, one in four members of the Thayer School faculty has started a company based on his or her scientific work, which on a per capita basis is one of the highest levels (if not the highest level) for an engineering school anywhere in the nation. Most of these startups are in the Upper Valley and employ local residents in growing high-technology enterprises. Other companies—SustainX, now located in Seabrook, N.H., or Sproxil, located in Cambridge, Mass.—were cofounded or founded by students in our Ph.D. Innovation Program, a unique effort to help Ph.D. students learn the skills necessary to become technology entrepreneurs.

Over the past six years, we have hired 14 new tenure-track faculty members at the Thayer School, and three additional searches are currently underway. Of the 14 new professors, 11 either came to Thayer with a history of developing patented technologies or have already done so in their brief time in Hanover. Three members of this group have already commercialized their technologies. We are in the early stages of contemplating further growth of Dartmouth's engineering program that would bring even more entrepreneurial faculty members to Hanover. Without strong federal support, their ability to conduct the research, develop the technologies, and transfer those innovations into high-tech enterprises will be severely impeded.

Last year, the President and the recently disbanded Council on Jobs and Competitiveness set a national goal of producing 10,000 more engineers annually. They were right that we need more engineers. In fact, I believe we need at least 30,000 more engineers a year, given the challenges we face in energy, health care, the environment, communications, and infrastructure. Now, a time of slow economic growth, is exactly the time to *invest*. Cutting non-defense R&D disproportionately sends a very discouraging signal to students and young faculty at a time when the nation has just started to reverse a 30-year decline in the production of engineering talent. If we want a strong future, we need to keep funding the work—and education—of our scientists and engineers.

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>>NEWS FROM AROUND THAYER SCHOOL

FLOW-MO
A Dartmouth Humanitarian Engineering team harnesses water for hydropower in Rwanda.

HUMANITARIAN ENGINEERING

Zero-Emissions Hydroelectric Power

DARTMOUTH HUMANITARIAN ENGINEERING (DHE) students traveled to southern Rwanda during the summer of 2012 to install a zero-emissions hydroelectric generating station on the Rugaragara River. Collaborating with e.Quinox, a student group from Imperial College London, the team designed, refined, and built a pico-hydro system to provide enough electricity to charge cell phones and light homes in the villages of Rugote and Nyamirambo.

"The plans originally called for civil works consisting of a weir, settling tank, penstock, kiosk, tailrace, and a gabion wall that could handle water volumes necessary to generate 1 kilowatt of power," says participant Kevin Francfort '15. "Later, we scaled these designs up in order to provide our team and our partners the ability to increase our power output to 5 kilowatts in the future."

The team also designed a way to make the power realistically affordable to local people. They surveyed villagers to find out how much people actually could pay to use the system. Since most people didn't have enough cash to buy a battery, the team came up with a less-expensive business model: a monthly rental system. Shopkeepers or others who do have money can buy the batteries, charge them from the generator, and rent them out to customers. When the battery needs to be recharged, the customer returns it to the shopkeeper.

"The battery can charge 11 cell phones on one battery charge or power LED lights, which we hand out to all consumers, for two or three hours a day for three or four weeks," says Asher Mayorson '15.

By opening day for the system, 60 families had signed up. Shortly after, the customer base rose to 80 families. "We believe that our system is providing electricity to far more than the 80 community members who signed up for our business. It is typical for the batteries that we provide to be used in businesses, which have a multiplier effect on the local economy and benefit many community members not actively renting a battery," says Francfort. "There are over 300 families living in close proximity to the site—about 2 kilometers or less—many of which are experiencing the benefits of having electricity in their village for the first time. We're pleased to have been able to improve the lives and opportunities of these people."

There are over 300 families living close to the site, many of which are experiencing the benefits of having electricity for the first time.

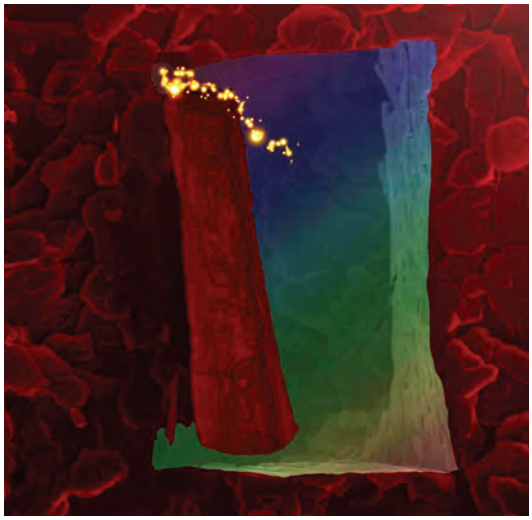
In December, DHE was awarded nearly $15,000 from the U.S. Environmental Protection Agency's National Student Design Competition for Sustainability Focusing on People, Prosperity and the Planet to support ongoing work on the hydropower and battery rental system in Rugote.

In addition to the work in Rwanda, DHE continues to address health and energy needs in Tanzania. Dartmouth students designed a stove that burns the region's abundant coffee husks instead of scarce wood. "The stove could effectively cook even the most difficult of Tanzanian staple dishes using both coffee husks and sawdust, a versatility we believe will make our stove attractive to a much larger market," says Nik Ortman '13. An NGO, Educational Model Organization, and local crafts people will oversee the 10 stoves that DHE gave to villagers, and DHE members will make any needed modifications on their next trip.

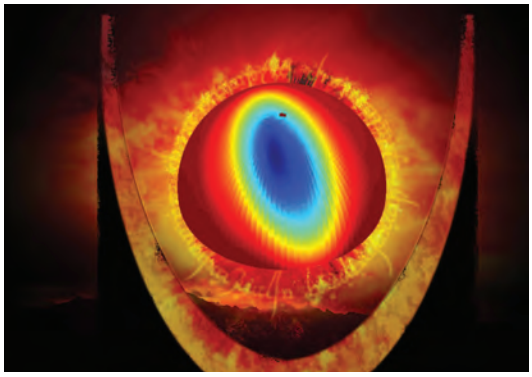
DHE also helped two Tanzanian communities produce briquettes of compressed composted cornhusks and charcoal dust for cooking. "Briquetting reduces the amount of smoke and need for firewood," says Amelia Ritger '15. Sale of the briquettes can also become a small business. "One group was so excited about the technology that they invested in their own briquette press almost immediately," says Ritger. In the future, DHE will partner with the NGO Sustainable Harvest to optimize charcoal for use in briquettes and in high-quality fertilizer.

—Kathryn LoConte Lapierre

OPPOSITE PAGE: KURT KOSTYU. THIS PAGE: UPPER, AMALIE DONIUS; LOWER, JAY VINCELLI; ILLUSTRATION BY JAMES O'BRIEN



THE DOOR OF OPPORTUNITY
Micrograph obtained in a dual beam focused ion beam system at a voltage of 10 kV. The alumina-chitosan composite wall was sectioned at an ion beam current of 50 pA and acceleration voltage of 30 kV, creating a doorway through which to view the inner structure. Image by Ph.D. candidate Amalie Donius.



HIP OF SAURON
The central portion of this image illustrates the linear wear depth of a metal femoral head from a failed hip replacement. It was generated through MATLAB analysis of 3D coordinate data obtained from a Zeiss Contura G2 CMM. Image by Ph.D. candidate Jay Vincelli.

VISUALS

The Art of Science

SHOWING AN INVESTIGATOR'S EYE VIEW OF their research, graduate students recently revealed the beauty of materials they manipulate in the lab. Several of their images were displayed during the inauguration of Thayer's Visionaries in Technology Distinguished Lecture Series in October, when Harvard chemistry professor George Whitesides, a pioneer in microfabrication and nanoscale self-assembly, spoke about simplicity as a component of invention.

Two of the images are shown above. To view more, see dartmouthengineer.com. To listen to Professor Whitesides' lecture, go to engineering.dartmouth.edu/events/visionaries.

kudos

>> Professor Eric Fossum has been elected to the National Academy of Engineering, the highest honor the engineering community bestows. He also has been named a Charter Fellow of the National Academy of Innovators in recognition of his invention of the CMOS active pixel image sensor, now found in nearly every cell phone and digital camera.

>> Professor Jifeng Liu was named a 2012 recipient of the National Science Foundation's CAREER Award for outstanding young faculty who through their work "exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research." The award will enable Liu to pursue research on low-temperature growth of high crystallinity germanium tin (GeSn) on amorphous materials for advanced optoelectronics.

>> Professor Keith Paulsen was named a Fellow of SPIE, the international society for optics and photonics, for his achievements in multi-modality medical imaging technologies for the detection and treatment of cancer, especially in the breast and brain.

>> Professor Brian Pogue was named a Fellow of the Optical Society of America for his contributions to optical tomography and spectroscopy of breast cancer and advancement of optical diffusion modeling software for tissue spectroscopy and imaging.

>> Professor Ulrike Wegst was one of 78 young engineers selected to take part in the National Academy of Engineering's 18th annual U.S. Frontiers of Engineering symposium in September. The materials scientist also serves on the editorial board of the *Journal of Bionic Engineering*.

"I watch all sports differently from your average fan. Now, though, I find myself watching sports as an engineer and materials scientist as well."

STUDENT PROJECTS

I Want One of Those!

DiagnoseMe

THIS USER-FRIENDLY DEVICE consists of a sweat collection clip, an enzyme-linked immunosorbent assay (ELISA) biosensor, and a color densitometry-based iPhone app to monitor wellness. The noninvasive system measures cytokine concentrations in sweat to indicate health or illness. Inventors Riley Ennis '15, Katherine Franklin '15, Robert Lauzen '15, and Kiah Williams '15 won the Phillip R. Jackson Award for best overall performance in ENGS 21: "Introduction to Engineering." Their TA was Anne Lape '13.

CLASSROOM

Materials in Sports Equipment

BASEBALL HELPS STUDENTS relate to engineering in ENGS 8: "Materials in Sports Equipment," in which students learn about the manufacturing of items such as mitts, helmets, baseballs, bats, and cleats.

"We start the course by learning about historical and current uses of wood in equipment, so of course the bat figures heavily in that," Professor Rachel Obbard Th'06 says. "We move on to metals and alloys, and discuss aluminum bats as part of that. Then we cover polymers and polymer foams, which are used in footwear and protective equipment, such as batter's helmets, gloves, and catcher's equipment, and finally we cover composite materials, which brings us back to bats. I compare and contrast the materials, and baseball bats provide a good example of the use of two different classes of material: wood and aluminum. I cover failure mechanisms, for which we have some good examples in bats. And finally, I try to have students consider some of the ethical considerations around sports equipment, and corked bats are a great example."

Offered to students who are not yet science or engineering majors, the course attracts future engineering students and athletes alike. Having the athletes in class, Obbard notes, is a big plus in terms of giving a real-world perspective to the syllabus.

"Students always relate better to technical material if they have a frame of reference for it," she says. "So yes, the baseball players—and even the avid fans—understand the baseball-related material better at first than the other students and in return are able to contribute their own experiences to the class' overall understanding."

Obbard describes herself as a fan of baseball, one of the many sports she brings into class. And just as sports influences the academics, the academics can influence how a professor sees the sport. Obbard can't help but watch the game on different levels.

"I like the way baseball brings people together," she says. "Since teaching this course, I watch all sports differently from your average fan. I have always watched sports because the human achievement inspires me. Now, though, I find myself watching sports as an engineer and materials scientist as well—watching how people use equipment, the subtle variations in how they interact with it, and the occasions where it fails."

—Nick A. Zaino III

(Editor's Note: This article is adapted, with permission, from the New England Baseball Journal.*)*

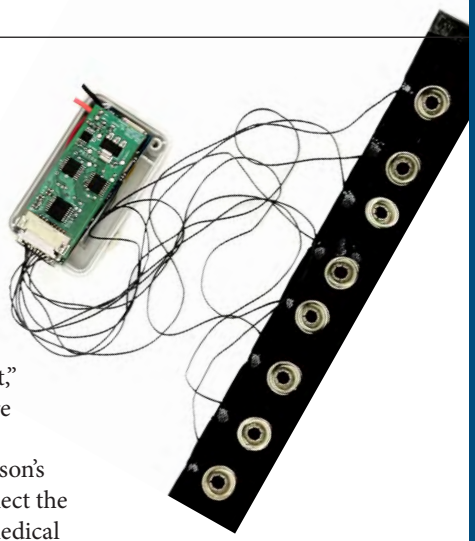
lab reports

BETTER BRAIN PROBE

A new probe developed at Thayer School and the Norris Cotton Cancer Center in collaboration with the University of Toronto helps surgeons better distinguish cancer from normal brain tissue during surgery. Currently, patients take an oral dose of chemical 5-aminolevulinic acid, which produces the fluorescent protein protoporphyrin IX (PpIX). Tumor cells accumulate more PpIX than normal brain and "glow" when exposed to blue light. The new tool combines violet-blue and white light to allow surgeons to analyze the concentration of PpIX and four other tumor biomarkers. "Our big discovery is that we can use the probe's reading of PpIX to measure the presence of low-grade brain tumor which otherwise does not fluoresce visually," says Professor Keith Paulsen, who worked with neurosurgeon David Roberts, M.D., and Pablo Valdes Th'11, who is pursuing his M.D.-Ph.D. In a pilot study reported in the *Journal of Biomedical Optics*, in 10 patients with low-grade brain cancers, identification of low-grade tumor tissue during surgery based on visual fluorescence only had an accuracy of 64 percent; diagnostic accuracy increased to 94 percent when data from the new probe was used.

PERSONALIZING MOBILE HEALTH DEVICES

Professor Ryan Halter Th'06 is part of a Dartmouth team developing personal mobile health (mHealth) devices that will allow physicians to monitor patients' health on a more frequent basis. One wrist-strap device under development, the "Amulet," would function as a secure communications hub for mHealth devices on a person's body and ultimately connect the patient to an electronic medical records system. Halter is helping two Dartmouth computer scientists, Professor David Kotz '86 and graduate student Cory Cornelius '07, ensure that the health records of patients monitored with mHealth devices remain private and secure.



MEDICAL BRACELET ▶
Ryan Halter helped develop a wearable mHealth device with bioimpedance-based identification capabilities. Eight electrodes gauge a person's electrical properties.

"Most people are already carrying portable phones with sophisticated computation and some type of sensor. An insulin monitor or heart rate monitor, for example, can easily wirelessly communicate with these devices, and that information can be transferred to a database and monitored by medical personnel," says Halter. "The difficult part is if someone puts the wrong device on and their heart rate speeds up. There could be a conflict with who is actually treated."

Halter is helping the team use bioimpedance, how tissue responds to electrical currents, as an identification tag. "A person's bioimpedance is not unique across an entire population, but usually is within a small group, such as a family," Halter says.

The bioimpedance method accurately identified 90 percent of 50 test subjects last spring. The research team plans to test the robustness and wearability of the identification sensors on a larger sample over a longer period of time.

NEXT BIG THING IN ORTHOPEDICS

Professor Douglas Van Citters '99 Th'03 '06 and Professor John Collier '72 Th'77 told *ODT (Orthopedic Design & Technology)* magazine what they believe is gaining traction—beyond hips and knees—in orthopedics. "The resurgence of the total shoulder and reverse shoulder arthroplasties" will be the next big thing in the field, according to Van Citters, in part because of advances in polymer science and a better understanding of bone biology. Collier is interested in developing cures for arthritis—starting with measuring outcomes. "It's like heart disease," he told *ODT*. "If you can change diet, you can change heart disease. I don't know that anyone has tried to do that for arthritis yet, but it may be the case once they get in it that there are nutritional aspects, exercise aspects, physiological aspects of arthritis that you can identify so you help people out."

OPPOSITE PAGE: COURTESY OF DIAGNOSEME TEAM.; ISTOCK. THIS PAGE: CORY CORNELIUS

kudos

>> The world's most exciting, groundbreaking technology is pointless if it is unable to address an urgent and relevant need, Professor Tillman Gerngross argued in a recent issue of *Nature Biotechnology* magazine. "As basic scientists, our impact is measured by generating new knowledge and advancing our understanding of how the world works," stated Gerngross, cofounder of therapeutic protein companies GlycoFi and Adimab. "Not all problems are worth solving, and your job as a bio-entrepreneur is to figure out which ones are."

>> Ph.D. candidate Kaitlin Keegan provided a critical data point to a NASA announcement last summer regarding extreme melting of the Greenland Ice Sheet. "An estimated 97 percent of the ice sheet surface thawed at some point in mid-July," reported NASA, pointing to Keegan's analyses of ice cores. Keegan and Professor Mary Albert are among the coauthors of a new paper published in *Nature* reconstructing the climate of the Eemian interglacial period, based on the analysis of a 2,540-meter-long ice core from northern Greenland.

>> Elizabeth Chang Th'12, Amanda Christian Th'12, and Christopher Ng Th'12 were finalists in the annual Collegiate Inventors Competition sponsored by Invent Now Inc. The Thayer team—advised by Professor Doug Van Citters '99 Th'03 '06—invented an "Expandable Hydrogel Sphere for Orbital Implantation" for patients either lacking an eyeball or having a small eyeball. This was the third time in four years that Thayer students have won or been finalists in the competition.

>> Robbie Cholnoky '13, Kevin Dahms '12, Annie Saunders '12, and Robbie Moss '12 traveled to Fond des Blancs, Haiti, in November to examine the town's water pump system and research ways to increase its durability. The students undertook the project in post-earthquake Haiti as part of ENGS 89/90, Thayer's capstone B.E. engineering design course.

CREATIVE CONN

STUDENTS FIND INTERSECTIONS BETWEEN THE ARTS AND ENGINEERING

BY KATHRYN LOCONTE LAPIERRE
PHOTOGRAPHY BY JOHN SHERMAN

VIEWPOINT
"I bring my art into other aspects of my life," says Nora Hodgson '13.

NORA HODGSON '13

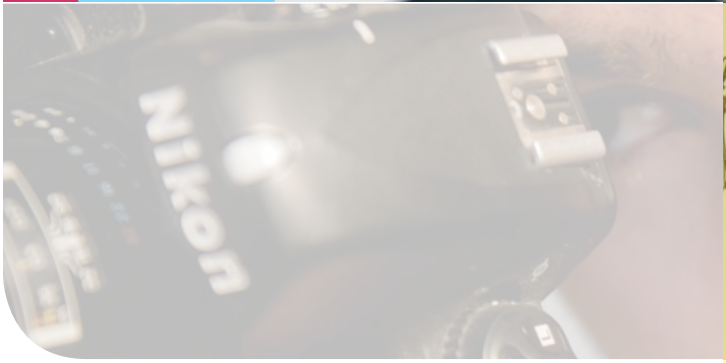
Major: Engineering Modified with Studio Art

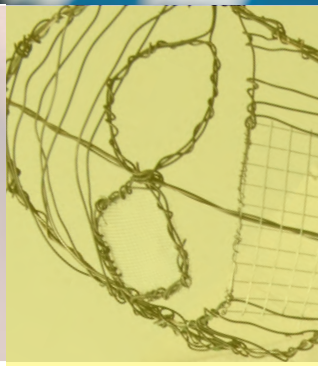
Arts Focus: Creative Process

My engineering focus is in product design. My focus for studio art is on the creative process. I really enjoy drawing and drafting because of the steps in the process. I look at a still life initially and do a rough sketch, then look again and go back and refine the lines. I bring my art into other aspects of my life. As a study break I'll sit and draw a coffee cup that's sitting on the table.

Engineering focuses on ideas and processes that can sometimes seem very technical, and you think of studio art as being much more artistic and free flowing. But there's a lot of process and diligence that comes with making a piece of art that I think is very particular to engineering as well. The two come together very nicely.

Engineers benefit a lot by having an art background because it's another way to tackle a situation or assignment. In a product design class you have to think of a lot of different points of view. You have to think about it as a work of art, because you're not just making some clunky piece of machinery, you're making something that somebody is going to want to interact with. Art is an enforcement of everything you should be learning in engineering.





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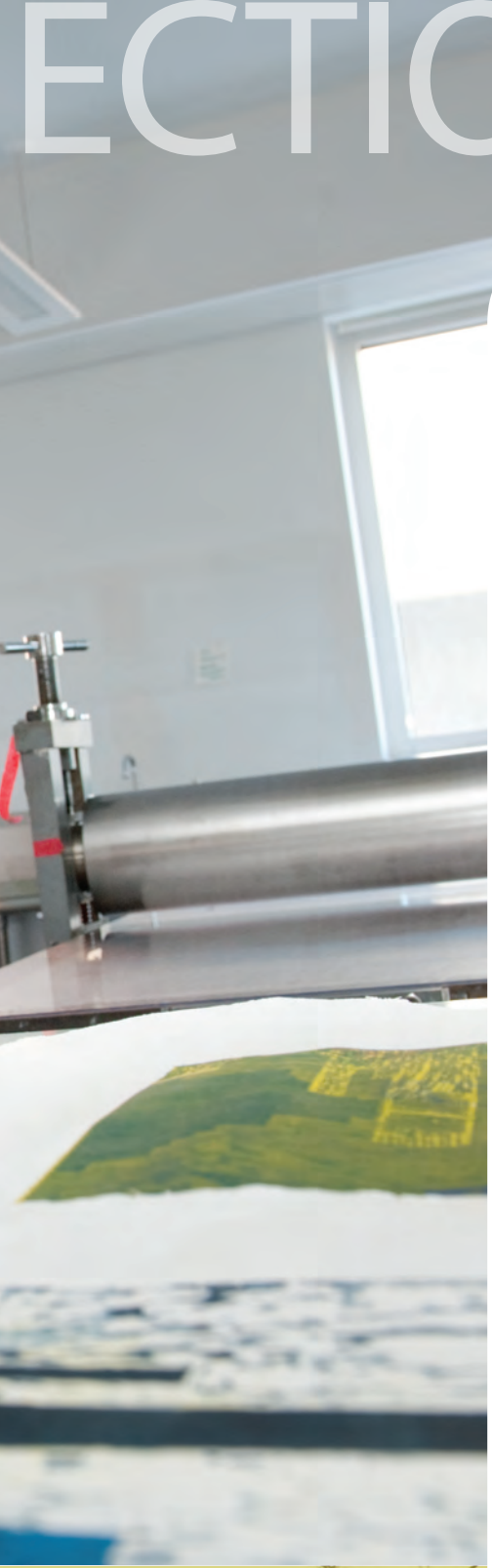


PERSPECTIVE
"Most engineers could use more art in their lives," says Chris Magoon '13.

AS DARTMOUTH CELEBRATES THE YEAR OF THE ARTS, MARKING THE 50TH ANNIVERSARY OF THE HOPKINS CENTER FOR THE ARTS, NINE ENGINEERING MAJORS DESCRIBE HOW THEY BRING ART AND ENGINEERING TOGETHER.

CHRIS MAGOON '13

Major: Engineering with a Minor in Studio Art

Arts Focus: Design

I'm interested in mechanical engineering, the prototyping, the design of simple components and mechanical devices. I've always liked to make stuff and experiment with different designs. My dad's a mechanical engineer and my mom's an artist. The kitchen table would be covered with projects, whether engineering or art. We had airplanes being made, and paintings, drawings, and boats. It was an environment where anything was possible.

I've enjoyed every single class I've taken in studio art. Most engineers could use more art in their lives. Simply being able to sketch things out and understand how to draw simple perspective drawings and convey your ideas helps a lot. You have to not just plan how a product is going to work, but also how is it going to look so you wind up with an aesthetically pleasing device.

The connections stand out in sculpture, where you have to design things that have to stand up on their own without a base or wires holding them up. In both of my sculpture classes the first assignment has been like, here's a pile of cardboard, make something extremely tall out of it. It had to be twice our height using very little material. The engineering aspects that go into that are pretty crazy.

The technical aspect of printmaking—understanding the pressures that go into plates, printing them, the technical process with acids, all this crazy stuff happening at the molecular level—is almost chemical engineering. The attention to detail, the precise etching, relate back to engineering. Printmaking is such a process-driven class. So much repetition goes into making plates and printing them. There's a huge amount of technical stuff you have to learn for printmaking.

I've been working on long-board design and construction. Understanding all of the engineering and art that goes into that has been a huge adventure.

WOUTER ZWART '14

Major: Engineering Modified with Studio Art

Arts Focus: Architecture, Sculpture

I was determined not to become an engineer. I thought it was too constraining, and I wanted to travel and have flexibility in my schedule. Then I got involved in Dartmouth Humanitarian Engineering and traveled to Rwanda. I saw a practical application for my interests.

Taking engineering and studio art at the same time is a good balance of classes. My focus in studio art so far has been in architecture and sculpture; I really like working with 3D space. In architecture you balance what you can do in reality and what you want to do with space creatively. You bring the two together. Engineering is analytical and problem-based, but sculpture is similar in approach. You have an idea in your mind and you have to think how to bring this idea into physical reality. You have to create something that functions for a person or for a purpose. In both disciplines there's a similar mindset in how you think spatially.

DIMENSIONS
Wouter Zwart '14 likes working in 3D.

FOCUS
"The camera is able to transform what we often dismiss as the everyday mundane into something beautiful," says Sam Worth '13.

SAM WORTH '13

Major: Engineering Modified with Studio Art

Arts focus: Photography, Sculpture

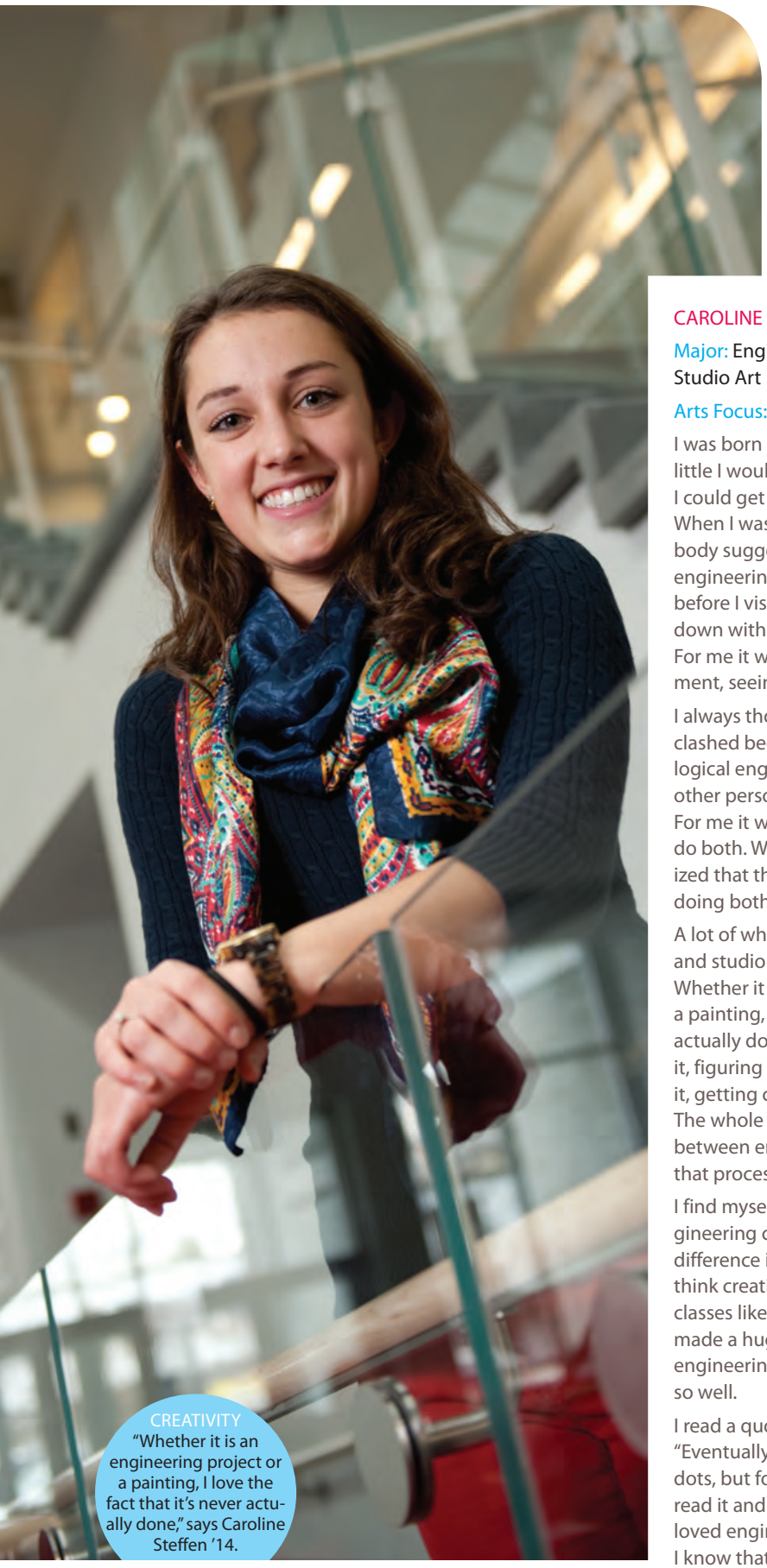
My focus is on the creative and innovative aspects of engineering. I also wanted to have a hands-on, purely creative process to complement my engineering study. Studio art fulfilled that.

Engineering has a large aspect of trial and error and refinement. The first iteration is rarely going to be the best one. In modern photography, manipulating a picture—the setting, lighting, aperture, frame—over and over again to make it say something has a lot of overlap with the constant restructuring and rethinking of problems involved in engineering.

My sculpture class connected the most to engineering. Sculpture is in some ways a reduced, more intuitive form of engineering design. It's taking a space or object and making it functional in a way that people wouldn't expect.

My final sculpture project was a three-point structure. We had to pick a body position that wouldn't normally support itself. I chose diving to catch a baseball. We were given two 2x4s and had to build a structure to support the position. Only a square 1/4-inch could touch the ground at each of the three support points. There were extreme design challenges to tackle. It was similar to engineering in that way, discovering how to best use limited materials to create a functional and aesthetically pleasing product.

Studio art has enhanced my sense of design intuition and has taught me to appreciate the importance of both function and form in engineering.



CREATIVITY
"Whether it is an engineering project or a painting, I love the fact that it's never actually done," says Caroline Steffen '14.

CAROLINE STEFFEN '14

Major: Engineering Modified with Studio Art

Arts Focus: Creative process

I was born interested in art. When I was little I would play with anything that I could get my hands on to create art. When I was applying to college, somebody suggested to me that I look into engineering. I e-mailed Professor Collier before I visited Dartmouth. I got to sit down with one of his ENGS 21 groups. For me it was a very big light bulb moment, seeing the creative passion.

I always thought that engineering and art clashed because one person is the very logical engineer doing equations and the other person is the very out-there artist. For me it was kind of a bizarre thought to do both. When I got to Dartmouth I realized that there's actually a ton of people doing both.

A lot of what I love about engineering and studio art is the creative process. Whether it is an engineering project or a painting, I love the fact that it's never actually done. Going back and looking at it, figuring out what you don't like about it, getting critiques, and then reworking. The whole cycle is a huge commonality between engineering and studio art. It's that process that really gets me thinking.

I find myself learning things in my engineering classes that will really make a difference in my art. Similarly, learning to think creatively and outside the box in classes like sculpture or architecture has made a huge difference in what I do in engineering. They play off of each other so well.

I read a quote the other day. It said, "Eventually you're going to connect the dots, but for now do what excites you." I read it and thought, that's me. I've always loved engineering and art and eventually I know that it'll end up connecting.

HARMONY
Liliana Ma '14, at the Hopkins Center for the Arts, finds release in playing music.

LILIANA MA '14

Majors: Engineering, Music

Arts Focus: Music

My research is in biomedical engineering and is a collaboration with Thayer and the Geisel School of Medicine. Using computer simulations of a nuclear event, we compare biodosimetry methods for measuring radiation levels in people. I was drawn to biomedical engineering partially because it is the most related to medicine. I've always wanted to do medicine.

I play piano and violin and am in the Dartmouth Symphony Orchestra. I'm also involved in dance on campus. I'm the vice president of the Dartmouth West Coast Swing Club.

There is scientific research being done on how human bodies respond to music. While I don't think that consciously music was a way to balance engineering, dancing and music make me happy. The engineering major is a lot of work and the music major is a good amount of work, but it is on a totally different side of the spectrum. I really enjoy playing music, and it's a release in that way.

INSTRUMENTAL
Kristen Colwell '13, who sings and plays piano and French horn, calls composition the design side of music.

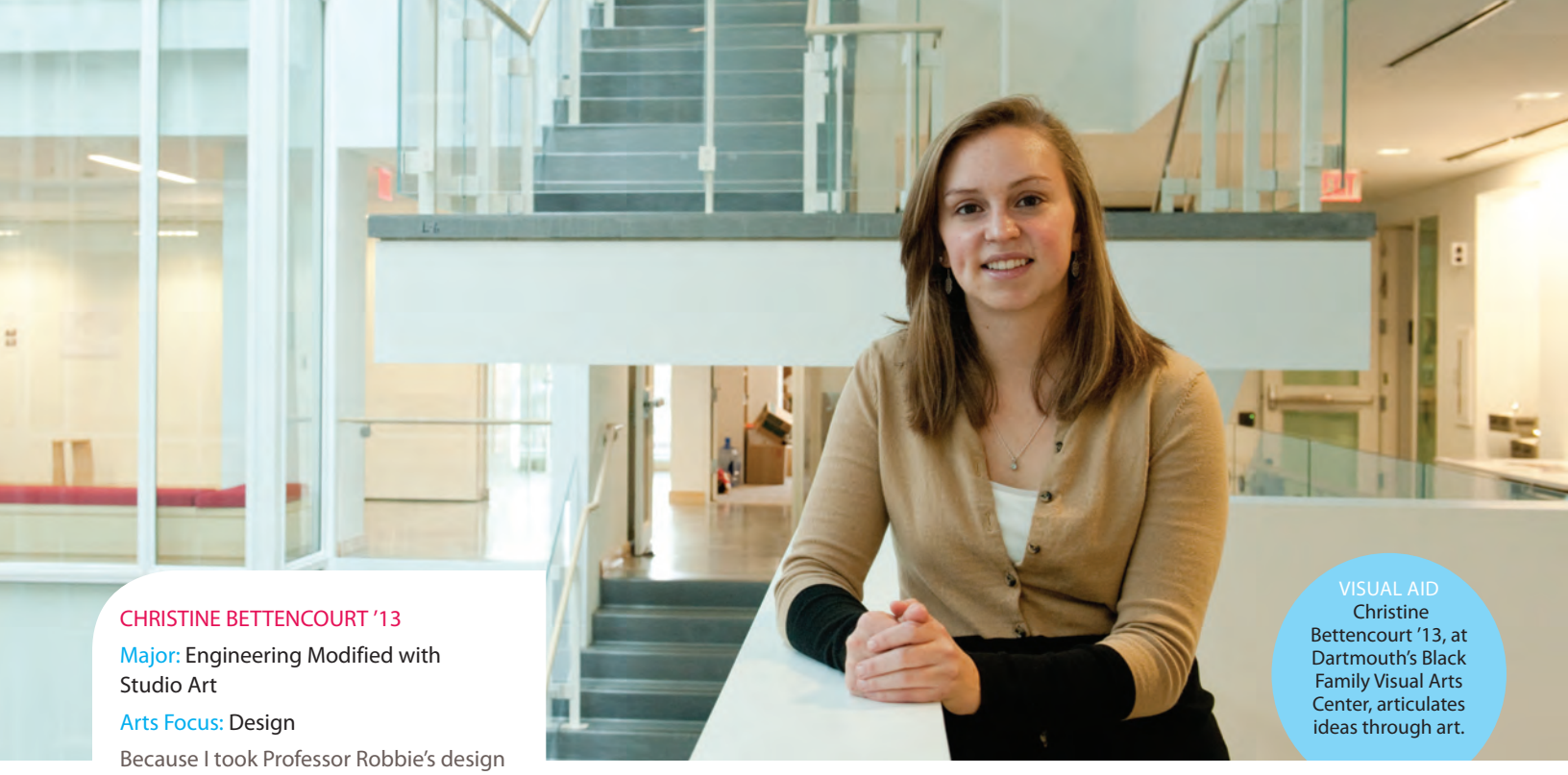
KRISTEN COLWELL '13

Majors: Engineering Modified with Chemistry; Music

Arts Focus: Music Composition

Chemical engineering and musical composition are a lot more similar than people realize. You have an initial idea, and that bit of it is inspiration. Once you have that idea, you have to see if it's good. You have to ask yourself how to develop it, how to make a finished product.

People think of composers as this sort of lofty echelon of people who are walking through fields humming things, and inspiration hits them, and they run back home and write everything down really fast. A few people have done that. But in general what most people do is take an idea and turn it upside down, and turn it the other way, and find ways for instruments to work well together. How do you connect a melody and a counter melody? What sort of chords can go behind this or that? How do you get from point A to point B? Transitions can be really difficult. A lot of it is actually sitting down with pen and paper and staring at something and saying, "What if I try this?" It's a lot more like a process of creative design than the ethereal process that people seem to think it is. The process is remarkably similar for music composition and any sort of engineering you want to do.



VISUAL AID
Christine Bettencourt '13, at Dartmouth's Black Family Visual Arts Center, articulates ideas through art.

CHRISTINE BETTENCOURT '13

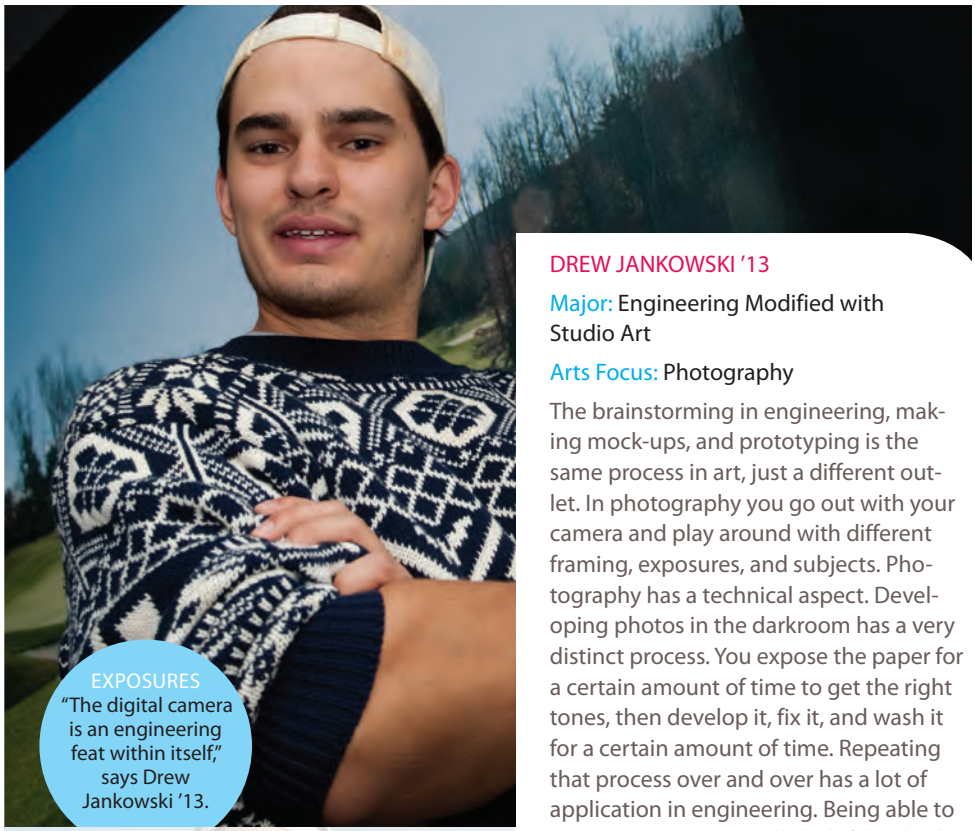
Major: Engineering Modified with Studio Art

Arts Focus: Design

Because I took Professor Robbie's design thinking class, I'm interested in human-centered product design and human factors research, in going out and finding how people use things and why they do certain things. For example, when companies started doing self-serve gas pumps, everyone would get out of their car to pump, but then they'd have to go back to their car. And the question was, why? Did they forget their debit card? No, it's because they forgot their glasses. The pumps didn't have fonts big enough for people to read. It's little things like that that interest me, trying to find the real root of a problem and the things that don't work.

I think that engineers are well served by having an art background. It goes both ways as well. I'm taking a sculpture class and I'm working on a project that has a water component. I'm trying to figure out how to plug a tub, and all of the materials that I've tried so far are not working. I'm spilling water everywhere. And really trying to figure out how materials work is important and that's a connection to engineering. There's the whole debate over form before function, but the connection for me is trying to find the right balance in it.

I'm all for the liberal arts education. I don't think that engineers should just be engineers. They should know how to write and convey ideas and tell stories and do all the different things that you wouldn't normally think engineers would need to know how to do. If you have this great idea and you can't articulate it to somebody, then it's lost. What better way is there to show that than visually?



EXPOSURES
"The digital camera is an engineering feat within itself," says Drew Jankowski '13.

DREW JANKOWSKI '13

Major: Engineering Modified with Studio Art

Arts Focus: Photography

The brainstorming in engineering, making mock-ups, and prototyping is the same process in art, just a different outlet. In photography you go out with your camera and play around with different framing, exposures, and subjects. Photography has a technical aspect. Developing photos in the darkroom has a very distinct process. You expose the paper for a certain amount of time to get the right tones, then develop it, fix it, and wash it for a certain amount of time. Repeating that process over and over has a lot of application in engineering. Being able to ingrain a process is really helpful in both fields.

I'd like a job in user interface design for a software company, web-based service, or design firm. Art and engineering have tangible applications for that field. It's the process of identifying a problem that you want to frame, coming up with a list of possible solutions, narrowing it down, taking the best ones, and combining them.

SPACE WEATHER RESEARCHERS WILLIAM LOTKO AND SIMON SHEPHERD WANT TO HELP PROTECT THE TECHNOLOGICAL WORLD FROM SOLAR STORMS.

BY ANNA FIORENTINO

THE SPACE WE

PHOTOGRAPH BY LIZA CHRUST

EYES ON THE SKY
Professors William Lotko and Simon Shepherd, left to right, are developing better ways to forecast solar storms.

ATHERMEN

IF METEOROLOGISTS could have predicted the exact path and strength of Hurricane Sandy, more people might have moved their families and possessions to safer ground. Similarly, if scientists like Professors William Lotko and Simon Shepherd could forecast the path of radiation hurled into space by solar storms, operators of satellites, spacecraft, planes, and various other vulnerable technological systems could adapt as needed.

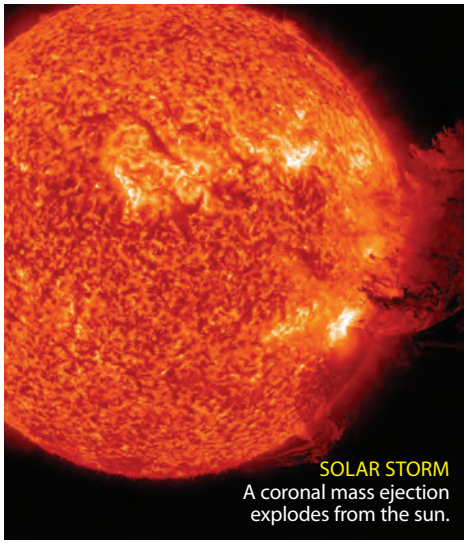
Solar storms may look beautiful—they produce the Northern and Southern Lights—but they have the power to wreak havoc on and above Earth. Unleashing enormous amounts of plasma and electromagnetic energy, solar flares and coronal mass ejections (CME) can jeopardize the health of astronauts in space and crews aboard aircraft, damage satellites, and disrupt GPS signals. The largest CMEs—huge squall fronts in the solar wind that warp and puncture the magnetosphere, the protective magnetic cocoon surrounding Earth—can knock out the electric grid, corrode oil and gas pipelines, and cause other technological troubles on earth.

"When a CME with the right characteristics impacts geospace, electrons and protons permeating the magnetosphere are accelerated to relativistic energies and transported into the hazardous Van Allen radiation belts," says Lotko. "These charged particles behave like pebbles in a slingshot with the energy in the extended rubber band going into the rock when the slingshot—the stretched magnetic field—is released."

Although scientists are far ahead of where they once were in predicting when these events will take place—on spaceweather.com anyone can find out if a solar storm is on its way—there is much more to understand.

"People already know when the storm is coming, based on observing explosions on the sun," says Shepherd. "But because a CME usually takes several days to get here, distortions happen along the way that complicate factors, like the amount of mass, the speed, and orientation of the sun's magnetic field."

Both Shepherd and Lotko are probing such complexities at a particularly relevant time: a solar maximum. "Right now we're entering a period where more sunspots are occurring, so you're more likely to see a massive solar storm," says Shepherd. "An apocalyptic solar storm might happen every few hundred years, with a few 'superstorms' occurring every solar cycle, approximately every 11 years."



SOLAR STORM
A coronal mass ejection explodes from the sun.

During the largest recorded solar storm, the Carrington Event of 1859, a CME reached Earth in 17 hours instead of a few days. Aurorae were seen across the world, and telegraph systems caught fire because of the huge currents flowing in the wires. In 1989 a huge CME knocked out power for 6 million people in Quebec.

With enough advance notice of bursts of solar radiation, people could shut down sensitive equipment in satellites, change load distributions in power lines, reroute power on the electric grid to lower latitudes, and siphon off electrical currents from pipelines. Astronauts could avoid space walks and retreat into the most shielded interior spaces of spacecraft. Airlines could steer clear of polar regions to minimize crew and passenger exposure to radiation.

Lotko and Shepherd are working on ways to extend the window of advance warning.

PROFESSOR WILLIAM LOTKO: Modeling Space Weather

Lotko is working on a forecasting model to predict the impacts of solar flares and CMEs. "The National Weather Service tracks the disturbances leaving the sun and tries to forecast their path and impacts on the near-Earth space environment. At Dartmouth, we are developing numerical prediction models to improve their forecasting ability," he says.

There's not much time to stay ahead of solar flares, which reach Earth's upper atmosphere and ionosphere in just eight minutes. And although it usually takes two to four days for an enormous CME to reach Earth, current tracking techniques only give forecasters 30 to 60 minutes advance notice to infer the impact.

The limitations are due in part to the fact that data come from a single source, a NASA satellite at a location known as L1, where the gravitational pull of the sun and Earth are equal and opposite. "We use measured characteristics of the solar wind at L1 to initialize global simulation models to predict likely effects on geospace or to verify that our models give results similar to what actually happened," Lotko says. Eventually he and his colleagues hope to use information derived from optical measurements of the sun to initialize simulation models—and produce a longer forecasting window of two to four days.

Lotko's model focuses on how energy dynamics in the magnetosphere and ionosphere affect each other. The work is helping to advance and expand a model launched in 1987 by Dartmouth physics professor John Lyon that provides a self-consistent physical description of the global magnetosphere. Still being refined by Lyon, Lotko, and others, the Lyon-Fedder-Mobarry (LFM) model currently includes more physics and thus produces more precise diagnostics than the seven other models under development worldwide. It is being evaluated for use by the National Oceanic and Atmospheric Administration and National Weather Service.

Two of Lotko's recent Ph.D. students, Oliver Brambles Th'12 and Bin Zhang Th'12, used the LFM model to resolve a 20-year-old mystery: why the entire geospace environment sometimes goes into a three-hour "sawtooth" oscillation. "Bin augmented the LFM simulation model to include intense flows of electromagnetic power into the Earth's upper atmosphere during geomagnetic activity, and Oliver used Bin's electromagnetic power to drive the massive outflows of atmospheric oxygen ions into geospace that excite the sawtooth mode," says Lotko. "Before their work, no one imagined that oxygen ion outflows could produce such an effect. It's a brilliant example of research in 'Pasteur's Quadrant'—discovery science motivated by practical application."

Lotko regularly collaborates on NSF-funded space weather modeling with colleagues from

Johns Hopkins University and Colorado's National Center for Atmospheric Research. Since 1992 he has led Dartmouth's NASA-funded Heliophysics Theory Project, aimed at understanding how ions that flow from the ionosphere to the magnetosphere are energized. Lotko also collaborates with his wife, Dartmouth physics professor Mary Hudson, and John Lyon on the NSF-funded Center for Integrated Space Weather Modeling based at Boston University.

"I've always had an interest in electromagnetic fields and in fluid mechanics, even as an undergraduate. Space weather merges my background in plasma physics and hydrodynamics, which are also useful in describing thermonuclear fusion reactions and processes that occur in the stars and sun," says Lotko. "But in contrast to solar physics and astrophysics, I gravitated toward geospace weather for its social relevance. We need these models to predict the effect solar flares and CMEs have on satellite operations as we become a more technology-reliant society."

STUNNING EVIDENCE
Auroral displays are visible manifestations of space weather.

PROFESSOR SIMON SHEPHERD: Measuring Auroral Activity

Shepherd is part of an international team of about 100 scientists and engineers using ground-based radars to measure the drifts of plasma in the mid- and high-latitude regions of Earth's ionosphere. This group, using the Super Dual Auroral Radar Network, or SuperDARN, is looking to better predict the effects of solar disturbances and CMEs on the ionosphere —the electrically conducting layer above the Earth that facilitates the propagation of radio waves for very long distances. SuperDARN is a term coined by Raymond Greenwald, who earned his Ph.D. in physics from Dartmouth in 1970 and a decade later pioneered the technique and design of these radars.

Today the SuperDARN project consists of more than 30 ground-based radars operated by more than a dozen countries in the Northern and Southern hemispheres. The radars are directed toward polar latitudes to measure the motion of the plasma, the ionized matter that fills more than 99 percent of space, at ionospheric altitudes greater than 100 kilometers above earth. Each radar in the network is capable of transmitting roughly 10 kilowatts of radio wave power that can travel several thousand kilometers before reflecting off irregularities in the density of the plasma. "The frequency of the return signal is Doppler-shifted according to the speed of the plasma, so we can measure the motion of the plasma over a very large area," says Shepherd. "The system works similarly to a weather Doppler radar, except that we use a lower frequency, radio waves travel farther, and they reflect off the plasma rather than rain, snow, or sleet." The radars are situated to make observations in the polar regions, where converging magnetic fields focus the effects of coupling to the solar wind most strongly.

In 2008 Shepherd and his former fellow postdocs under Greenwald at the Johns Hopkins University Applied Physics Laboratory (JHU/APL) received an NSF grant to build eight radars at four mid-latitude locations: Kansas, Oregon, the Aleutian Islands, and the Azores, worth a combined $6 million. Shepherd and the researchers from Virginia Tech, the University of Alaska, Fairbanks and JHU/APL have built six of these radars so far—extending the mid-latitude network of SuperDARN radars already in Virginia and Japan. Coupled with existing high-latitude arrays, the radars will measure drifting plasma in the ionosphere over a region stretching from Eastern Asia to Europe and from Kansas to the magnetic North Pole. Of particular importance, the mid-latitude radars will be able to track the movement of plasma into lower latitudes during geomagnetic storms.

Shepherd, who earned his Ph.D. in physics at Dartmouth in 1998, helped build two radar arrays in Kansas before leading construction of two arrays in central Oregon. He recently helped build another pair of radars in remote Adak, Alaska. Components for the final pair of radars, slated for installation this year on the island of Graciosa, Azores, are being fabricated in Shepherd's Thayer laboratory with the help of Dartmouth undergraduates.

"We work unbelievable hours just to build these things," he says, although he admits, "I enjoy the physical labor."

Of course, building the radar arrays is just the beginning. Thayer hosts tens of terabytes of radar data that are regularly analyzed by Shepherd and his students in order to develop more accurate models of the large-scale motion of the plasma in the polar ionosphere.

Ellen Cousins '08 Th'12 helped Shepherd on several radar builds during her doctoral studies. "It's cool to think that I helped build something that now provides data to scientists across the world," she says. Cousins, now a postdoc at the National Center for Atmospheric Research, uses SuperDARN data to examine high-latitude plasma drifts. "I like that space weather is a relatively small and new field, which means there are still a lot of unanswered questions," she says.

Questions about space weather have a growing sense of urgency.

"You know what it's like when a meteorologist misses a regular weather forecast," says Shepherd. "Well up there, multimillion-dollar satellites orbiting the Earth have been rendered inoperable—and we are becoming more reliant on these types of satellites everyday."

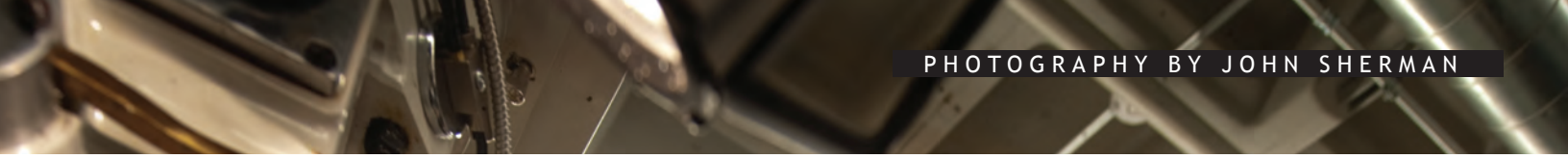
Anna Fiorentino is senior writer at *Dartmouth Engineer.*

OPPOSITE PAGE: COURTESY OF NASA/SOLAR DYNAMICS OBSERVATORY; THIS PAGE: DAVID CARTIER SR.

re-engineering the mach

NEW SPACES AND EQUIPMENT REMOVE BARRIERS TO INVENTIVENESS.

KNOWING THE DRILL
Machine Shop Design Fellow Max Fagin Th'11, in black shirt, checks that B.E. student Natalie Miliano '12 works safely.



PHOTOGRAPHY BY JOHN SHERMAN

ine shop

BY ANNA FIORENTINO

STANDARD PRACTICE
(Below) With identical models of each kind of machine in the tool room, when students learn to run one, they can operate them all. (Lower right) Students use a laser cutter.

THAYER SCHOOL DEBUTED ITS RETOOLED MACHINE SHOP FALL TERM, COMPLETE WITH A LARGER SPACE, REORGANIZED LAYOUT, NEW EQUIPMENT, AND AN EXPANDED STUDENT TASK FORCE TO HELP RUN THE SHOP. THE IMPROVEMENTS ARE MAKING MACHINING EASIER AND SAFER THAN EVER FOR STUDENTS.

"OUR MISSION IS TO BE INSTRUCTIONAL," says machine shop manager Kevin Baron. "We made it easier to learn how to get about in the machine shop by the location and selection of the tools."

Walls were torn down to create an open-concept shop consisting of seven functional areas placed in logical adjacencies:

- fabrication lab (a.k.a. "Fab Lab")
- polymer processing room
- router lab
- welding and fabrication lab
- stock room
- tool room (a.k.a. machine shop)
- tool crib

"The layout was important so students could see the coherence of how things got made," says Baron. The openness also ensures that staff can keep an eye on students from any vantage point.

The Fab Lab, which is open around the clock, is a launch pad for fabrication. "The idea here was to equip a room with easy-to-use, easy-to-learn tools that students could access after hours," says Baron. "We can teach a student to use the tools in a couple of hours, and it's safe."

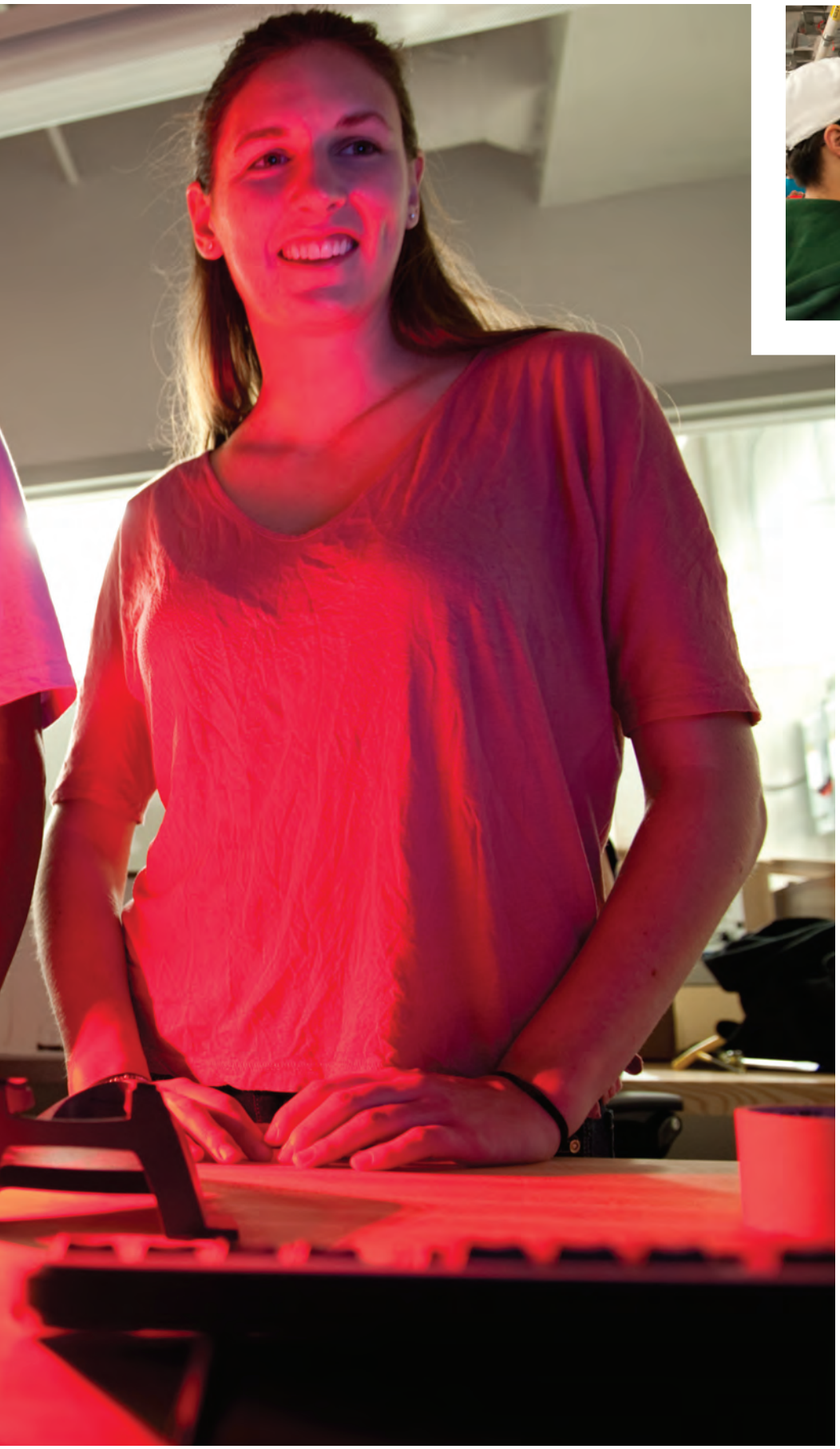
But even in the Fab Lab students can create sophisticated projects. A 2Bot Model Maker allows them to carve a foam model they've made in SolidWorks in as few as 20 minutes. A rapid prototyper lets them easily output parts. A laser cutter produces precision-cut shapes from 2D CAD images. "All you need to do at the Fab Lab is bring in your file, plug it in, press a couple of buttons, and the machine will make the piece for you," says machine shop design fellow Max Fagin Th'11, who helps students and faculty with design and fabrication work.

New equipment is boosting capabilities in other areas of the shop as well. About $700,000 in new mills, lathes, and other equipment replaced

DESIGNED FOR LEARNING

Max Fagin Th'11, left, watches dual-degree students Nicole Sonnert, Phiwokuhle Shongwe, and Jamie Potter (left to right), use a 3-D scanner, one of the Fab Lab's easy-to-learn tools.

(Upper right) Improved signage aids shop workflow and organization. (Lower left) Digitally controlled machines allow students to work on sophisticated design solutions.



machinery that in some cases dated back to the World War II era. Reflecting changes in industry, all the new machines are digitally controlled.

"Software engineers are capturing in code all the expert knowledge that once made machining processes the domain of specialists. Now by answering questions, students are able to work way over their heads long before they've understood the details," says Baron. It helps that all the new machines are alike, he adds. "The controls run every one of them. You learn how to use one, you can use all of them."

In addition to the machine shop's four professional instructors, a large cadre of student helpers supports other students working in the new space. "We are engaging students at every level of operation—as users, as shop assistants, and in strategic planning," says Baron. Experienced students are trained to assist newer students with projects. Undergraduates carry out essential day-to-day tasks, such as keeping the shop clean, putting tools away, and being alert for unsafe conditions. Master of Engineering Management (M.E.M.) students help with operational strategies, including implementing a 5-S plan of workspace organization: sort, set in order, sweep, standardize, sustain. M.E.M. students are using social media to make the machine shop more user-friendly, and they're creating an electronic catalog to capture institutional knowledge. Christian Ortiz Th'11, the machine shop's first design fellow, helped develop the Fab Lab, and current design fellow Fagin has created several video tutorials to help students learn how to use equipment.

"I think the argument can be made that this is the finest machine shop accessible to undergraduates anywhere," says Fagin. "Here we get the best of both worlds: a completely open machine shop and a professional level of equipment and instruction."

Anna Fiorentino is senior writer at *Dartmouth Engineer*.

Alumni News

spotlights


E. Stina Brock '01 Th'02

Dave Girouard '88 Th'89 is betting on the payback of a new crowdfunding platform he describes as a "true investment in a person." The former VP of apps and president of enterprise at Google, Girouard launched Upstart (Upstart.com) last summer to connect enterprising students with people who want to invest in them. "We aim to make Upstart a network that people are engaged with, not just a place where they receive funding," Girouard told *Forbes*. He says he wants to help young people "forgo the traditional job search and pursue what they want to do." He speaks from experience. "My career was really shaped in the early years by my need to pay back student loans," he says. "It wasn't until six years after I left Thayer that I made a career decision based on what I wanted to do, rather than what I felt I needed to do. Younger people have all the energy needed, and are actually in a better position to take on a risky venture. Why not help more grads make the right decision by giving them a bit of economic freedom, coupled with advice and mentorship from those who have done it before."

Upstart initially launched at five colleges, including Dartmouth, and plans to expand the program across the country this year. Says Girouard, "We're also going to let backers invest on various affinity lines—things like women in technology, particular genres of arts, pursuing careers in teaching."

Ariel Diaz '02 Th'04 organized a hackathon in early November to jumpstart the creation of a free, open physics book. It's the latest effort of his startup, Boundless.com, which offers students online course materials—a mix of government and nonprofit open-licensed content—intended to replace traditional, and costly, printed textbooks. His team enticed physics professors, researchers, and graduate students to its Boston office with the promise of free food, ping-pong matches, and the chance to work on a textbook for release in spring. "It typically takes two years to write a traditional textbook," Diaz told *BostInno.com*. "We're attempting to write ours in three days." A former team captain of the Dartmouth Formula Racing Team, Diaz credits Thayer's M.E.M. program with helping him polish his leadership skills. Fellow B.E. and M.E.M. grad **Matt Hodgson Th'06** is VP of engineering at Boundless.

E. Stina Brock '01 Th'02 earned a Young Alumni Distinguished Service Award for her contributions to Dartmouth. Brock, who holds the A.B. and B.E., has been a vice president of the Dartmouth Club of Western Washington, a member of the Alumni Council, and a member of her class' fifth and 10th reunion committees. She is the director of product management at Sunverge, where she oversees product development and design for the solar system integrator.

Chris Vander Mey Th'04 has distilled the lessons he learned as an engineering manager at Amazon and senior product manager at Google into a step-by-step approach to the entire software life cycle in his book *Shipping Greatness* (O'Reilly Media). Vander Mey, who completed Thayer's M.E.M. program, emphasizes the need for technical expertise in the industry. "It doesn't really matter how good your grasp of strategy or finance is if you can't write solid code," he says. Vander Mey, who led teams developing Google Maps, iOS, and Android software, says, "You impact so many users with software launches when your products are as large as Amazon.com and Google Apps. This is thrilling, and it's also scary because customers find your flaws immediately." Last year Vander Mey started a new software business, Scaled Recognition (scaled recognition.com), providing text, face, and object recognition services. He says he hopes "to make a real impact on how you interact with the images you acquire with mobile devices."

Superstorm Sandy revealed a new use—disaster relief—for the BioLite CampStove created by **Jonathan Cedar '03** and **Jonathan den Hartog '03 Th'05**. The stove burns twigs and other simple fuels for cooking, heating, and generating electricity to charge mobile devices. After Sandy left hundreds of thousands without power in the Northeast, BioLite teams set up charging stations in Manhattan and dropped off cases of the stoves in Queens. *The Daily Beast* and *The New York Times* touted the stove's versatility. BioLite is gearing up to distribute its larger HomeStove in India, Uganda, and Guatemala.

When he's not working on his M.Phil. in energy technology at Cambridge University, **Nate Brakeley '12**


Dave Girouard '88 Th'89

is entering the scrum for the Light Blues rugby team. Calling him "one of the stars," *Cambridge News* reports, "Brakeley's agility round the park has been one of the key features, but that is not isolated in his work at the breakdown—it is also the ball-carrying skills that constantly put the Light Blues on the front foot." Brakeley, who took up rugby at 15, says, "I had very little idea of the character of the rugby club, but the reason I picked Cambridge was because they had a better option of engineering courses."

Sproxil, founded by Ph.D. Innovation Program alum **Ashifi Gogo Th'10**, was honored in December by the Institute for Safe Medication Practices for important and lasting contributions to patient safety. Sproxil collaborated with GlaxoSmithKline in 2011 on a pilot anti-counterfeiting program with the antibiotic Amplicox distributed in Nigeria. To verify drug authenticity, consumers could text a code from the medication package to a central toll-free phone number. By the end of 2012, more than 480,000 patients had texted 600,000 verification requests; 2.5 percent of the messages led to a counterfeit alert.

Chris Polashenski '07 Th'07 spends his days studying arctic ice at the U.S. Army Cold Regions Research and Engineering Laboratory in Hanover before heading home to spend a few hours on a tractor. Polashenski and his business and domestic partner, **Norah Lake '06**, bought an 87-acre farm, which stretches across Norwich and Thetford, Vt., from the Vermont Land Trust, with a perpetual conservation easement attached. Polashenski and Lake, who worked together at the College's organic farm, have big plans for their farm, including a community-supported agricultural program in which customers buy a share and receive a certain amount of produce. They also want to set up community workshops, classes, and a youth agricultural camp. "They're coming at absolutely the ideal moment to capitalize on rising food awareness," Scott Stokoe, director of Dartmouth's organic farm, told the *Valley News*.


Nate Brakeley '12

"Many people are looking for a path to reduce or eliminate fossil fuels over the next decade," says **Kimberley Smith Quirk '82 Th'83**, owner of green-energy business Energy Emporium (energyemp.com). "I want to help find solutions that can work for them." Case in point: She converted a 154-year-old house in Enfield, N.H.—her business showroom and home—into a zero-net-energy building that requires no fossil fuels or combustion for heating or hot water. Quirk earned the 2012 Green Building Award from *Business NH Magazine* for the two-year conversion project. She created a solar heating system that includes a hydro-air system, water storage tanks, pumps, and a solar array, and followed LEED-H guidelines for air quality, water and land use, materials, and energy efficiency.

The Packaging Hall of Fame has inducted **Tom Brady '66 Th'68** in recognition of the contributions he has made to the packaging industry. His R&D work for Owens-Illinois Inc. helped commercialize the earliest PET carbonated soft drink containers. He founded Plastic Technologies Inc. in Holland, Ohio, in 1985 and continues to serve as chairman and CEO. His other recent honors include the Society of the Plastics Industry Hall of Fame Award (2012) and the Society of Plastics Engineers Lifetime Achievement Award (2010).

EXPERTISE

A Bridge Too Narrow

William P. Conway widens the Long Bridge over the Mississippi

The Huey P. Long Bridge, which crosses the Mississippi River outside of New Orleans, was an engineering marvel when it opened in 1935. The cantilevered bridge, whose largest clear span measures 790 feet, hovers 200 feet above the river. Modjeski and Masters engineered the project.

Eight decades later Modjeski and Masters, led by CEO **William B. Conway '52 Th'54**, has been re-engineering the bridge for 21st-century traffic. Modjeski and Masters is a storied firm in the world of bridge builders and Conway himself is a giant in that arena. A winner of the John A. Roebling Medal for lifetime achievement in bridge engineering, Conway directed the design of numerous bridges, including eight over the Mississippi. Deep-water foundations, long-span trusses, cable-supported bridges, and retrofit strengthening of steel structures are his technical specialties.

The Huey P. Long Bridge had become a bottleneck. Its four traffic lanes straddled a railroad track. Each lane was 9 feet wide and there were no breakdown lanes. Locals referred to it as the Huey P. Narrow Bridge.

The state of Louisiana asked Modjeski and Masters to widen the bridge—without closing it. That meant that the usual method of removing the old road and building a new road with new floor beams, couldn't be done. Luckily for New Orleans motorists, someone at Modjeski and Masters—Conway says modestly that it might have been him—came up with an out-of-the box idea. "What if we were able to reuse the existing floor beam bracket that stuck out on each side of the bridge?" says Conway, explaining how the plan evolved. "And rather than remove it, we incorporate it into the new extended floor beam?"

Work began in 2006 on the seven-phase, $1.2-billion project. When completed later this year, the overhaul will have taken longer and cost more than building it. The original took three years and cost $13 million—about $204 million in current dollars.

Some might question the wisdom of rebuilding an old bridge rather than starting anew. "If they are reasonably cared for, bridges will last," Conway says reassuringly. "This bridge has already had 76 years of life, and we have thoroughly analyzed it for fatigue, strength and fatigue life, and it has a long life ahead of it—as in several hundred years from a purely fatigue-cracking point of view."

Reflecting on his life in bridge-building, Conway says, "I use these words when asked about my career: 'It fulfills me.' I think my grandchildren can look at this thing and say, 'I don't know quite what, but I think my grandfather had something to do with that.' That bridge will be there not just one or two but probably three generations from now because these big bridges will last 150 years. It is a matter of some pride."

—Lee Michaelides

OPPOSITE PAGE: LEFT, KATHRYN LOCONTE LAPIERRE; RIGHT: GIGAOM.COM. THIS PAGE: LEFT: CAMBRIDGE NEWS; RIGHT: BUCK SCOTT '51

STAGE PRESENCE
Susan Ettinger Burkhart '96 Th'97 performs in a duo called Stumble Fox.

just one question

Q. Have you been involved in the arts?

I started Dartmouth in September 1940 in the class of 1944, and made it to December 1942. I had enlisted in June 1942 in a program that protected me from the draft as long as I stayed in college, but in December 1942 I left for Washington, D.C., and the Office of Strategic Services. Between those dates I devoted my efforts to the Dartmouth Players as part of the stage crew, particularly electrical. I recall a production of *Heaven Can Wait* where I was stage manager. I had always been annoyed by errors in the program, and made a $5 bet that there would be no mistakes. The student who bet with me tried to win on the theory that I had not listed the dog in the cast. But the dog was given credit elsewhere, so I won. This apparently made an impression on the membership, and they elected me president. Unhappily, I left before I could serve. It's fair to say that life in Hanover was a bit confused at that point.

Another seminal event, at least for me, occurred when Paul Robeson gave a concert in Webster Hall and I was the stage manager. Mr. Robeson knew exactly what he wanted, and I was apparently able to rise to the occasion. I remember him as courteous and charming to the weedy sophomore he was dealing with.

After the war, living in a New York suburb with a wife and three kids, I took up the French horn. For the next several decades I enjoyed playing in community orchestras, summer concert bands, Christmas programs, and chamber groups. You can play almost anywhere with a French horn, which was one of the reasons I chose it. Eventually, business pressures closed in on me and I had to give it up, with great regret.

—Tom Streeter '44 Tu'48 Th'48

Binary Arithmetic

The decimal system is based on "10"
Its origin's not in doubt.
Just count the number of your toes
That's how the "10" came about.

We share our limb number with monkeys and chimps
Close DNA explains all we need.
Other species count four, six, or eight
And of course, there's the millipede.

Learning decimal math involves
Distinguishing 10 different shapes.
A difficult task, to say the least
No thanks to the primates and apes.

Ten-toed creatures have lived here on earth
For eons and eons of years.
So our decimal system's been around for a while
But not by itself, it appears!

We claim we originated our system of "two"
To simplify computer design,
For it's simpler to recognize "on" versus "off"
Than the symbols "zero" through "nine."

Had we but paid attention to the two-toed sloth
Rote learning our "10s" wouldn't last.
We'd be used to a totally binary world
Making decimals a thing of the past.

—Ace Taylor '54 Th'55

Between my senior year at Dartmouth and my last year at Thayer I attended the Art Center College of Design. Today, the main campus is in the Pasadena, Calif., hills, and "the main building is a dramatic postmodern steel-and-glass bridge structure spanning an arroyo in the San Rafael Hills, just above the Rose Bowl," to quote from the school's website. It's a spectacular site, but in my day the campus was in downtown Los Angeles. At the time, I was considering a career in industrial design, and the Art Center had a fabulous reputation. It is best known for its automobile design program, but it also has outstanding photography, product design, packaging, graphic design, fine art, illustration, advertising design, film, and environmental design programs. I loved it there. After four years at Dartmouth focusing on math, science, and engineering, working at the Art Center was liberating and a nice break from engineering school. The experience certainly changed how I thought about engineering design—and inspired me to work for engineering designs that were beautiful as well as functional. Architect Louis Sullivan said, "Form follows function." (Actually, he really said, "Form ever follows function," but that's been shortened to the more recognized phrase.) In industrial design, a particularly effective design will not only be beautiful to have and to hold, but also will call attention to how it is to be used. There are lots of good examples in kitchen gadgets, everything from corkscrews to garlic presses. Sadly, I can't claim to have designed anything particularly beautiful myself. For most of my career I worked at the Lawrence Livermore Laboratory, a University of California research center in northern California. We built prototypes of a wide variety of hardware. For example, at the lab I was involved in helping to manage our work on high-power lasers, which I think are quite beautiful. I did not design those lasers myself; nevertheless, throughout my career, I was inspired by my experience at the Art Center to work for engineering designs that were beautiful.

—Philip Coyle III '56 Th'57

From 1980 to 1995 our daughter Susan and our son Bob were involved in three local community theaters. Susan was an actress and Bob was a technician with a specialty in lighting and pyrotechnics. As parents, we supported their activities, driving to auditions, rehearsals, and performances, and attending them. From mid 1985 to about 1995, I was on the board of directors

LANDSCAPES
Far left: *Connecticut River* by Amir Golnabi Th'11.
Left, *Windmills* by Hannah Dreissigacker '09 Th'10.

of the Indianapolis Civic Theatre, our largest community theater and one in which both our children were involved. Susan was also a charter member of the Indianapolis Children's Choir, founded in 1986 and now one of the largest such choirs in the country. We were parent volunteers: I went on the choir board of directors in 1988, served as president of the board from 1989 to 1996, and have continued as a board member and served as assistant treasurer since 1996. From 1963 to the mid 1970s, I helped as a fundraiser for the Indianapolis Symphony Orchestra. For the last several years, we have been active financial contributors to these organizations as well as the Interlochen (Mich.) Arts Academy.

—Bill Batt '60 Tu'61 Th'61

My most recent artistic activity was to perform the Brahms *Requiem* baritone solos last May with the Sangre de Cristo Chorale in Santa Fe, N.M., where I live. I have through the years had numerous opportunities to perform this work, in both English and German (this performance happened to be in English), but my most challenging performances of this work took place in February of 1987. Due to a scheduling problem brought about by a large snowfall in Los Alamos, I performed the solos in German with the Pacific Mozart Ensemble in San Francisco on a Saturday evening, flew the next day to Albuquerque, drove to Los Alamos, and did the solos in English with the Los Alamos Choral Society.

—Loren "Jake" Jacobson '60 Th'61

I've been involved in the arts since I moved to Washington State. I was a member of the board and president of the Mid-Columbia Symphony in the 1980s. My wife and I have collected visual art, and we have been loaning some of it to local organizations to show. My engineering contributed to that effort when it was time to hang it on walls.

—Jerry Greenfield '61 Tu'65 Th'62

From 2006 to 2012, I managed the Waste Not Center (WNC), which accepted donated materials and supplies from businesses and residents in Columbus, Ohio, that were redeployed as arts and crafts supplies used by teachers and artists. The nonprofit was started by the Solid Waste Authority of Central Ohio in 1989 and I took over in 2006. On an average day, the center will host 40 to 50 clients who collectively select about 2,500 pounds of materials and supplies for which they pay nothing other than the small annual membership fee. Member clients estimate the collective value of what they obtain at the center each week is about $4,500 based on what the items and supplies would cost if they were purchased commercially. The WNC accomplishes the dual objectives of enabling teachers to obtain materials for their work that would otherwise be unaffordable and reducing the burden on local solid waste disposal systems. It is in recognition of this dual objective that we adopted the tagline "Unleashing Creativity Through Recycling."

There are many success stories, including the solution we found to a monthly donation of about 200 ladies shoes—right shoes only!—from a local photographer after he photographs them for manufacturers. Many members have found creative uses for the shoes. The most creative: A local elementary schoolteacher was taking a creative writing class last summer along with other local teachers. One of her assignments was to develop a writing lesson and deliver it to her classmates as if they were her elementary students. When she saw the shoes she had an inspiration: She took a variety of shoes, gave one to each classmate, and asked each to write about the person who would wear the shoe.

Business skills, entrepreneurial interests, and an appreciation for sustainability developed at Thayer and Dartmouth were instrumental in preparing me for this endeavor.

—Neil Drobny '62 Th'64

If engineering sciences was my major, then the theater was my minor at Dartmouth. I was actively involved as a technician in the Players all of my years at Dartmouth. I spent two summers as master electrician at the Dartmouth Repertory Theater. I took courses in theater lighting design and theater technology (they appear on transcripts as English 84).

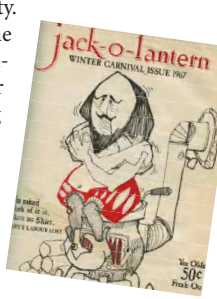
While figuring out what to do for my B.E. project, Professor Laaspere suggested that I talk to the new professor in the music department who wanted to upgrade and improve the primitive electronic music studio. That professor was Jon Appleton, who ended up being at Dartmouth for 40 years. The design of the electronic music studio became my project. My research included a trip to Trumansburg, N.Y., to visit Moog Music and another trip with Jon Appleton to N.Y.C., where we visited Milton Babbitt at Columbia's electronic music studio (and saw this incredible movie, *2001*).

—Bill Judd '67 Th'68

I was coeditor of the *Jack-O-Lantern* humor newspaper from 1967 to 1968. The accomplishment of which I am proudest was a Shakespearean tragedy about Winter Carnival that was based on a mixer fiasco that Robert Reich '68 organized freshman year. I also wrote a *Field & Stream*-style article about Dean Thaddeus Seymour hunting down the last Dartmouth animal. After graduation I did not write any more fiction, unless you count numerous government documents.

I was a dual major. My other major was medieval history, which led to an interest in Gothic cathedral architecture. I am now an adjunct professor of materials science at the University of Maryland. Through the years I have worked on the conservation of a number of architectural monuments, including Cologne Cathedral, Westminster Abbey, and the National Cathedral in Washington, D.C. Buildings from other periods that I have worked on include the Parthenon in Athens, the Hagia Sophia in Istanbul, Colonial Williamsburg, and the Alexander Hamilton Custom House in New York City.

My work involved mostly determining the cause of damage to the monuments, particularly from air pollution and soluble salts. I also have developed some nondestructive test methods. This helps the conservators determine the best treatment method. I have also worked on the materials science of historic brick and mortar to understand how they were made in order to predict durability. I have worked on some structural problems (including writing a paper that concerned cracking of some stone pinnacles at the National Cathedral). I also wrote for the Federal Highway Administration's *Public Roads* magazine to try to explain how research in the materials science of conservation can be applied to highways.



The interdisciplinary approach of my Thayer School education was critical to all of this. The field of materials science combines aspects of civil engineering, mechanical engineering, chemistry, materials science, and nuclear engineering. In most conventional engineering schools, one becomes stovepiped in a single discipline. Also, Thayer School's emphasis on a liberal arts education made it easier for me to take a lot of history courses.

—Richard Livingston '68 Th'69

I became a black-and-white darkroom landscape photographer for several years after I quit being a lawyer. I did that for about three years until my husband was diagnosed with cancer, at which point I devoted myself to his care. Because he assisted during my photo travels, helping to carry tripods and extra lenses and such, I chose not to return to landscape photography when he died in 2006.

—Drea (Papp) Thorn '82

Is writing considered an art? That's what I do for a living. It really could not have worked out better. My beat at the *Philadelphia Inquirer* is science, and also to some extent medicine,

OPPOSITE PAGE: COURTESY OF SUSAN ETTINGER BURKHART. THIS PAGE: AMIR GOLNABI, HANNAH DREISSIGACKER

ACTOR
Lincoln Potwin Th'06 appeared in the title role in the independent film *Killswitch Billy*.

so it is helpful that I am familiar with basic concepts of physics, chemistry, and mathematics—realms that are somewhat foreign to more than a few journalists!

I like to think of myself as a bridge between scientists and our audience. My Thayer education (along with my experience working at *The Daily D*) helped prepare me for writing about technical subjects in a way that is accessible without sacrificing any accuracy. While I was struggling through thermodynamics with Professor Horst Richter, I went to him for some career advice. I did not see myself as someone who would practice engineering for a living, so he clairvoyantly suggested that I might enjoy technical writing. I never did go into technical writing per se, but certainly I write about technical things for a lay audience, so he was right on target. A piece I wrote in November about new research on Parkinson's disease (philly.com/philly/health/20121116_Penn_unlocks_a_Parkinson_s_puzzle_piece.html) is an example of the kind of writing I hope accomplishes that goal.

Because of my engineering background, I also try to write about engineers whenever possible. They are a valuable pillar of society that does not always get its due.

—Tom Avril '89

My involvement in music started as a youngster, when I used to sit under the grand piano while my father played Scott Joplin rags. I went on to learn piano and trumpet, and I was thrilled to continue trumpeting at Dartmouth in the Barbary Coast Jazz Ensemble, the orchestra, and various other groups. Now, almost 20 years after Dartmouth, I still play trumpet at least a few times a week with various ensembles, including a Swiss/German "village music" band. Although my music and engineering experience have not directly influenced each other, they have been integral and intertwined parts of my life. While racing with Dartmouth's solar car in the Swiss Tour de Sol, I took my trumpet along and sat in with a jazz combo in a Zürich restaurant and played reveille to rouse the solar race participants camping by the Bodensee. In Hanover I was late to an orchestra rehearsal because my B.E. group had just gotten our electric pickup truck (dubbed "Electruck") running for the first time and I felt compelled to take a victory lap around the Green. While on a business trip to Germany to commission hydrogen-powered fuel cell transit buses, I trumpeted the Canadian national anthem atop a bus roof to commemorate Canada Day (my company's fuel cells were installed on the bus roof, so we regularly worked up there).

—Laura Iwan '93 Th'94

When I was a student at Dartmouth, I took advantage of individual guitar instruction through the music department, but it wasn't until I took a break in my technology career to have children that I started to devote more time to music. Since graduation, I have been involved in several musical projects as a guitarist. My current project is called Stumble Fox. We are a female duo and have been performing around the Tampa Bay, Fla., area for the past year. We are currently working on writing and recording original music. Our sites are facebook.com/stumblefox and reverbnation.com/stumblefox. Prior to that I was in an all-female alternative rock/pop band called Kore.

I feel that music taps into the same part of my brain that math and logic do—in a way that's hard to articulate. There is something scientific about rhythm and harmony and the way that different instruments work together. On a practical level, my engineering background comes in handy when diving into the details of figuring out how to use technology (sound equipment, effects pedals, editing software, etc.) and discovering how to put things together to get a sound that you want.

—Susan Ettinger Burkhart '96 Th'97

Most of my artistic endeavors were prior to college, when I attended School of the Arts in Rochester, N.Y., as a musical theater major for grades seven to 12. While I loved it, I knew I wanted a more stable career and went into engineering. I did perform in *A Chorus Line* my freshman year in college, but then it was many years before I had the opportunity to express my artistic side again. After Thayer for grad school, I was married and had my son Elliott, who showed his ear for rhythm and music at only 1 year old. At 4, he started drum lessons and now, at 8 1/2, he is a fantastic player. He and I formed a band called Lightning, and have given two fundraising concerts, one in 2011 and one in 2012. He played the drums and I played the piano, and we raised money for the American Heart Association and Children's Hospital Boston. (Elliott had a heart defect when he was born and had open-heart surgery at 6 weeks old.) It has been great to see my musical interest come through in my son. He has even tried his hand at musical theater camp these past two summers. Now, as a human relations director at Allegro MicroSystems in Manchester, N.H., hiring many engineers, I love to see an interest in the arts come through in engineers' resumes.

—Mandy Kraus Frank Th'99

After graduating from Thayer I started doing some acting. I have done a few commercials—for Sundrop soda, Miami Children's Hospital, and INDY RaceCar—and I was also on the USA TV series *Burn Notice* for one episode as well as in many independent films and theater productions.

It was engineering that inspired me to try acting. During my undergraduate studies at Wentworth Institute of Technology, our professors required that we present our projects to our class every month. This "rehearsal" helped me hone my skills as a presenter, which in turn helped me to win the American Society of Mechanical Engineers Old Guard Presentation Competition (Northeast Region) and go on to win fourth place at the National Competition held in California. I feel that acting was a natural progression that stemmed from these experiences. I believe that my engineering background greatly influences my acting because I was trained as an engineer to focus on the details. This becomes very important when creating a character. As in research and engineering, every detail about my character is first proposed, then researched and tested during the rehearsal process, and finally accepted or rejected, sometimes by myself and sometimes by the director.

—Lincoln Potwin Th'06

I'm on the U.S. biathlon team and training full time for biathlon in Craftsbury, Vt. But I need something to do in my off time when I am traveling and stuck in hotel rooms, so I've been doing a lot of painting. I am trying to sell my paintings to help support my racing. I have an art blog, hannahsartventure.blogspot.com, which includes a recent painting I did called *Windmills*. I've been watching all summer as more and more windmills slowly appear on the horizon. Everything else aside, I think that they're beautiful—like big, functional kinetic sculptures. Our landscape in Vermont has been shaped so much by humans already—the fields, barns, stone walls, rows of corn. Many parts of this human-created landscape are what make Vermont beautiful. And they also serve(d) a function. Plus, the world needs more windmills and fewer oil wells.

I did a modified major with studio art, mainly because I love art and I found that it was a great way to balance my brain between engineering problem sets. I also think that there is a lot of room for engineering and art to combine and basically be the same thing—instead of just complementing one another. So I think I'll try to do something like that when I am done with my biathlon career.

—Hannah Dreissigacker '09 Th'10

AFTERMATH
Dave Seliger '12 recorded damage while working on Hurricane Sandy recovery operations for the New York City Office of Emergency Management.

I started pursuing digital photography while at Dartmouth/Thayer School and greatly benefited from photographer Doug Fraser's experience. I started by documenting skiing and biking adventures with friends. Since graduating I have moved to Utah and enjoy photographing the hugely varied landscape here (as well as continuing to document my skiing and biking adventures). Just recently I've started to have some success selling prints! See some of my images at thomasjcollier.com.

—Tom Collier '11

I used to paint a lot before starting my Ph.D., and I did paint once while I was at Thayer. I painted the Connecticut River and the train bridge viewed from the bridge between Hanover and Norwich. This particular painting [see page 27] was a result of a two-day break from a period of intensive and exhausting work on my research project in summer 2010. Sitting on the Ledyard Bridge and watching the Connecticut River with the train bridge on the back, I was inspired to start it! I believe engineering has influenced my artistic approach. In fact, I find my creative endeavor more consistent since starting to study engineering at Thayer.

—Amir Golnabi Th'11

OPPOSITE PAGE: COURTESY OF LINCOLN POTWIN. THIS PAGE: DAVE SELIGER

thayer notes

1960s

Joe Cramer '60 Th'63: I've been happily retired since 2001. I'm busier than before retirement, spending time keeping up with five kids and their families (11 grands now!), and dividing time between Illinois, Wisconsin, and New Hampshire. I have a great wife and am very lucky. Every day is a gift. I spent just shy of 38 years with Motorola Communications, and later, Motorola Cellular. I designed radio pagers and then, for a brief time, led some designs for walkie-talkies, mostly in Florida. In the Chicago area, I managed design teams for mobile radios for U.S. markets (police- and fire-type land-mobile radios), then mobile cell phones for the Japanese market, working with Nippon Telephone and Telegraph. I later led engineering and business teams working with many automakers worldwide—Ford, GM, Lexus, Infiniti, Mercedes, BMW—on mobile and portable cell phones integrated into new automobiles for sale as accessories. There were varying degrees of sales successes, with lots of learning as you go. This work paved the way for the safer automotive cell phone use via Bluetooth links and the integrated navigation systems of today. We visited with both Apple and IBM in the early days, circa 1990 and later, on ideas for marrying cell phone and computer technology, but nothing came to fruition at the time. It was great fun. But we needed to have a better vision of a superb user experience, à la Steve Jobs.

Loren "Jake" Jacobson '60 Th'61: As I write this, I am sitting in my temporary office at New Mexico Tech, about to complete a semester of teaching "Introduction to Physics," a course aimed at those students who arrive without the math skills to go into the regular physics course that requires calculus. This is the fifth time that I have taught this course, beginning in the spring of 2007. I recently recalled my time in ROTC at Dartmouth, where I was commissioned as a second lieutenant in the U.S. Air Force (I retired in 1982 as a lieutenant colonel). My last active duty years were spent as a program manager in the materials division at Defense Advanced Research Projects Agency. In my last year at DARPA, the metallurgy manager at the National Bureau of Standards came to visit and asked whether I would be willing to sponsor a sabbatical for Danny Shechtman, a professor at the Technion in Israel. I had worked with Danny some years earlier, so it was not a problem to consider sponsoring him, until I learned that his research would involve rapid solidification technology, which at the time was on a critical technologies list, not for export. I called around to various officials in the Department of Defense hierarchy, and each told me that I would have to make up my own mind as to whether or not to sponsor him. I knew that Danny was going to do something quite fundamental, and decided that basic research of this nature should probably be exempt from export control, so I agreed to sponsor him. In April of 1982, Danny came to my office and showed me an electron diffraction pattern from a rapidly solidified aluminum-manganese alloy that exhibited five-fold rotational symmetry. Under normal circumstances, this is forbidden, since objects with such symmetry cannot fill space—a 2D example would be to try to tile a floor with pentagons—it cannot be done and completely cover the floor. He had discovered a substance that subsequently was called a "quasicrystal" and it was so controversial that it took two more years, until 1984, for a journal to accept his paper for publication. You can imagine my surprise on learning last fall that Danny had been awarded the Nobel Prize in Chemistry for the discovery of quasicrystals. It is very satisfying to recall that I sponsored his work, and that I went out on a limb to do so.

Richard Zartler '62: I have applied my engineering education almost exclusively to a career oriented toward the management and development of technical services, principally in the oil and gas exploration industry. My extracurricular activities mostly involve the out-of-doors, including participation in sports, hiking, and environmental education. I am a certified master naturalist, a Texas A&M/Texas Parks designation.

Mark S. Tuttle '65 Th'66: On November 12 I started working as chief scientist of Loc8te, a few-months-old startup in San Francisco. It's the best title I've ever had. This neighborhood in San Francisco is said to contain 4,000-plus startups, and the building I work in, RocketSpace, contains 140-plus startups. Being outside healthcare is novel for me. I will be helping to coach high school lacrosse again beginning in January.

Dennis Drapkin '68 Th'69: I will emerge from a brief retirement to teach "Tax and Fiscal Policy" as an adjunct member of the Southern Methodist University law school faculty starting in January of 2013.

1970s

Peter Areson '72 Th'73: I've come a long way since Thayer. I went back to school for an M.S., then drifted into medicine. Perhaps foolishly, I elected for a long, strenuous training in surgery, then wandered to the mid-coast of Maine for a career in gener-

ACADEMIC
Min Song Th'05 is an associate dean at the Research Institute of Powder Metallurgy at Central South University in Changsha, China.

"TORQUEDOS"
Left to right, Tom Carney '07 Th'10, Justin Rouse, Yoonki Park '09 Th'10, Zach Currier Th'12, Peter Williams Th'12, Yoonki Park '09 Th'10, Mario Noya, Josiah Gruber Th'10, and Erik Bell '08 Th'10 pose with the $500 cars they plan to drive in the 24 Hours of Lemons this summer.

al surgery. I have since retired, but spent the last 16 months doing a temporary assignment in New Zealand, again as a general, rural surgeon, in the East Cape area of the North Island. It is absolutely lovely here, and I hate to leave. Leave we must. One son is in Alaska, fishing, and the other at UVM, finishing his medical training. We plan to move near one of them, but we are not sure yet just which one! I miss all my friends at Thayer. I regret having missed our 40th last June, but hope to see you for our 45th! My best wishes, and those of Cyndy, to you all!

Christopher Davis '76: I'm director of investor programs at the Boston-based nonprofit Ceres, where I work with institutional investors on investment risks and opportunities associated with climate change and other sustainable investment issues. I'm chief of staff to the 100-member Investor Network on Climate Risk (INCR), whose members include the nation's largest pension funds and asset management firms (including the California Public Employees' Retirement System, New York State comptroller, BlackRock, State Street, and Prudential) and manage more than $11 trillion. We make the business and investment case for environmentally sustainable investment and business strategies, putting my engineering, legal, and financial background to good use in helping to save the planet. I spoke at Thayer School on January 18 on sustainable business strategies [engineering.dartmouth.edu/events/the-triple-bottom-line-the-business-case-for-sustainability/].

Will Fraizer '78: I have been working in a senior engineering role with Chevron on the Wheatstone liquefied natural gas (LNG) project since June 2009. The detailed engineering and procurement for the LNG plant is being managed from Houston, but the actual plant site is near the small community of Onslow, which is located on the northwestern coast of Western Australia. In 2013, I will be moving to a new position on the Wheatstone project; I will be leaving the engineering team and moving to what we call the project execution team, which is responsible for managing the fabrication and construction work, including all the major subcontracts. That means I will be traveling regularly to the construction site, where I will be technical team leader. Wheatstone is a $29-billion project, which involves development of offshore natural gas fields, an offshore production platform, pipeline to shore, and a LNG production and export facility. My focus is on the design and construction of the LNG plant (chevronaustralia.com/ourbusinesses/wheatstone.aspx). I was recently able to visit Thayer School during Dartmouth Homecoming 2012, and with the help of the Thayer career services office, organized an information presentation and discussion on careers in the energy industry for interested students and staff. Thayer Board of Overseers member **Christopher Gaut '78** was generous enough to join part of the discussion and provide his insights on career opportunities for Thayer grads. My next planned visit to Hanover is in June for my class of 1978 reunion.

Michael Geilich '79 Th'82: I recently moved to Cornish, N.H., after 20 years in Hanover, our first act as empty-nesters. I'm continuing to play clarinet with the Dartmouth Wind Ensemble and sax with a number of local groups. I'm working as director of software development for Resource Systems Group, a company started by Dennis Meadows, Tom Adler, and others as an offshoot of the Thayer/Tuck policy studies program in the 1980s. We do consulting work, mostly related to transportation and environment, but a little bit of everything. My kids are in college and graduate school. Life is good.

1990s

Michelle Fortier '94 Th'95: Jason '94 Th'95 and I each turned 40 in 2012 and have lots of grey hairs to prove it! Jason heads Covidien's R&D department in Bedford, Mass. That division works on sealants and other types of medical devices. He and his team were awarded two patents this past year related to a hemostatic patch that will launch in 2013. Early clinical results and doctor feedback are very exciting! I work on a handful of startup investments. The first is a video game review company called Game Empire Enterprises. Based in Santa Monica, Calif., the company has one of the Top 500 YouTube video channels to review new game content. I also help advise an online education company called Studyblue.com, which helps students make online flashcards. It is exciting to see how education is changing rapidly with the adoption of new technologies. On the home front, we are busy as our three kids—Julia (8), Douglas (6), and Sarah (4)—grow. We try to get back to Hanover once a year.

Jan Lammerding Th'97: I married Yu Miyaji in Tokyo on May 13, 2012. Yu and I met at Dartmouth in 1996, when I was pursuing my B.E. at Thayer School and Yu was an exchange student from Keio University. Wedding guests included **Mark Banner '00** and Ming Yan Reinemer, who was a visiting student from Germany at Dartmouth in 1996–97.

2000s

Charles Augello '03: For the past seven years, I worked as a software developer and analyst for AllianceBernstein in New York. I spent the first few years helping to build financial models for its value equities business and the past several years building the models and systems to manage the portfolios in its new Dynamic Asset Allocation product. While there, I became a certified financial advisor charterholder and volunteered with one of the FIRST robotics teams that the company sponsored. I recently decided to change careers, so this summer I left my job at AllianceBernstein and am currently searching for my next career. In November, I spent two weeks in White River Junction, Vt., apprenticing with a local building company, Geobarns.

Kirk Ferland Th'05: On December 2, my wife, **Jennifer (Freeman) '93 Th'95**, and I welcomed our third child, Elise Dorothy Ferland, into the world. She joins her brothers Reed (5) and Charlie (3).

Joe Gwin '05 Th'06 '09: I recently got a Ph.D. from the University of Michigan and I am now VP of research and development at an exciting Boston-based startup called BioSensics (biosensics.com). BioSensics develops wearable sensor technologies for point-of-care assessment and telemedicine. One of the ongoing projects is a $1.2-million Phase II Small Business Technology Transfer grant from the National Institute on Aging to extend and clinically validate the capabilities of our physical activity monitoring system (PAMSys) for use in telemedicine applications or with older adults. This device will enable early intervention prior to a fall and facilitate rapid intervention in the event of a fall. One of the things I am trying to do is create a relationship between Dartmouth and BioSensics via internships and possibly 190/290 [now ENGS 89/90] projects. I had such a great experience with my 190/290 project, also at a startup, and I'd love to recreate that experience for this generation of Dartmouth students.

Lauren Padilla '05 Th'05: My very recent news is that I just completed my Ph.D. in mechanical engineering at Princeton; my thesis defense was on December 10. My husband, **Todd Whitehead '06**, and I are now both living/working in Montpelier, Vt. We are very excited to be back in New England and so close to Dartmouth.

Min Song Th'05: In November I took a position as an associate dean at the Research Institute of Powder Metallurgy at Central South University in Changsha, China. My responsibilities are academic affairs. My projects/research efforts include metal nanowires, amorphous/nanocrystalline composites, and metal matrix composites.

Andrew Argeski '06: I work as a supervising engineer for a utility company in New Jersey. After Hurricane Sandy, I spent my time working to provide support and strategy in the repair of gas and electric service. After working for gas for a week helping in the restoration of service, I ended up on a team in electric managing about 300 mutual aid employees from Arkansas, Texas, Mississippi, North Carolina, and West Virginia. We would compile information from our field-scouting reports and send the crews to locations where they would provide the most im-

OPPOSITE PAGE: COURTESY OF MIN SONG; THIS PAGE: MATT BROWN

pact with their repairs. Our team also provided technical support and circuit information to the field employees. Not having power at home for 10 days really kept me motivated to do my part in getting the work done!

Won-Mo Koo '07: I am currently serving in the Korean Air Force to fulfill my military duty. And I have been working as a designated interpreter for the minister of national defense.

Laura Weyl Th'08: I'm a designer at Degenkolb Engineers; we specialize in seismic structural engineering. I recently designed my first building—start to finish! It is an executive headquarters in the San Francisco Bay Area.

2010s

Josiah Gruber Th'10: Several Washington, D.C.-based Thayer alums—**Yoonki Park '09 Th'10, Zach Currier Th'12, Peter Williams Th'12, Tom Carney '07 Th'10, Erik Bell '08 Th'10, Calvin Krishen Th'08** and I—started a racing team last June. We've bought two cars so far and are going to be competing in the 24 Hours of Lemons event this coming summer (24hours oflemons.com/). It's a weekend-long race for cars valued under $500 before the added safety equipment. Our website is fullytorqued.tk (we call ourselves the Torquedos) if you're interested in checking it out.

Caitlin Johnson '10 Th'11: I have been living in Boston for the past year and a half, since graduating from Thayer, and absolutely love it. I work as an energy efficiency consultant for Navigant, where I partner with our main client, the U.S. Department of Energy, in their work to set energy efficiency standards for appliances. I occasionally get to don a green jumpsuit, head to our lab, and rip apart appliances piece-by-piece, right down to the very last screw. It's a lot of fun! In other life news, I ran my first-ever road race—the Maine Half Marathon—this past September and I had a blast! I can't wait to run my next race!

Matt Strand '10: I am a new design engineer at an industrial controls company called PQ Controls in Bristol, Conn., and I have been working on a miniature thumb. It is roughly the size of an X-box controller joystick, but it will be rated for approximately 8.5 million cycles—and be much more expensive!

Jeff Forsyth Th'11: I work at Mako Surgical Corp. in Fort Lauderdale, Fla., as an embedded engineer. Along with a few of my coworkers, I recently participated in a 50-mile bike ride in support of those living with multiple sclerosis. I am also training for a triathlon.

Amir Golnabi Th'11: After completing my Ph.D. at Thayer School in June 2012, I joined the pulmonary imaging and bioengineering lab at Massachusetts General Hospital and Harvard Medical School in Boston. I am currently working on a "Complex Systems Approach to Bronchoconstriction in Asthma" project. On a personal level, my wife and I welcomed our second baby in January. We are all very excited to have a new little member in our family.

Caroline Hamman Th'11 and **Rohan Lathia Th'11:** After joining life sciences consulting firm Trinity Partners (located in Boston) following graduation from the M.E.M. program, we both celebrated two years with the company in January. We were promoted from associate to consultant in July, and have returned to Thayer to recruit at the career fair for the past two years. As biomedical engineers, we put our science and business training to work at Trinity, providing strategic and tactical insights to clients worldwide. While at Trinity, we have had the opportunity to work on projects spanning a number of disease areas, including diabetes, pulmonary diseases, blood disorders, and oncology, among others. Trinity has proven to be a dynamic and rewarding work environment.

Max McClorey '11 Th'12: I had been working for a company in New Hampshire doing software for its unexploded ordnance detection operations but in January returned to my job as an engineer for the Sea Education Association, sailing one of their ships from French Polynesia to Hawaii. I've been working with them for the past two summers. It's my responsibility to keep all the ship systems—electricity generation, wastewater, fresh water, etc.—running and happy. The first summer I worked with them, a plug shattered in one of the generators, forcing us into an emergency blackout. That was exciting. There is a blog: sea.edu/voyages/blog_seamans_244.

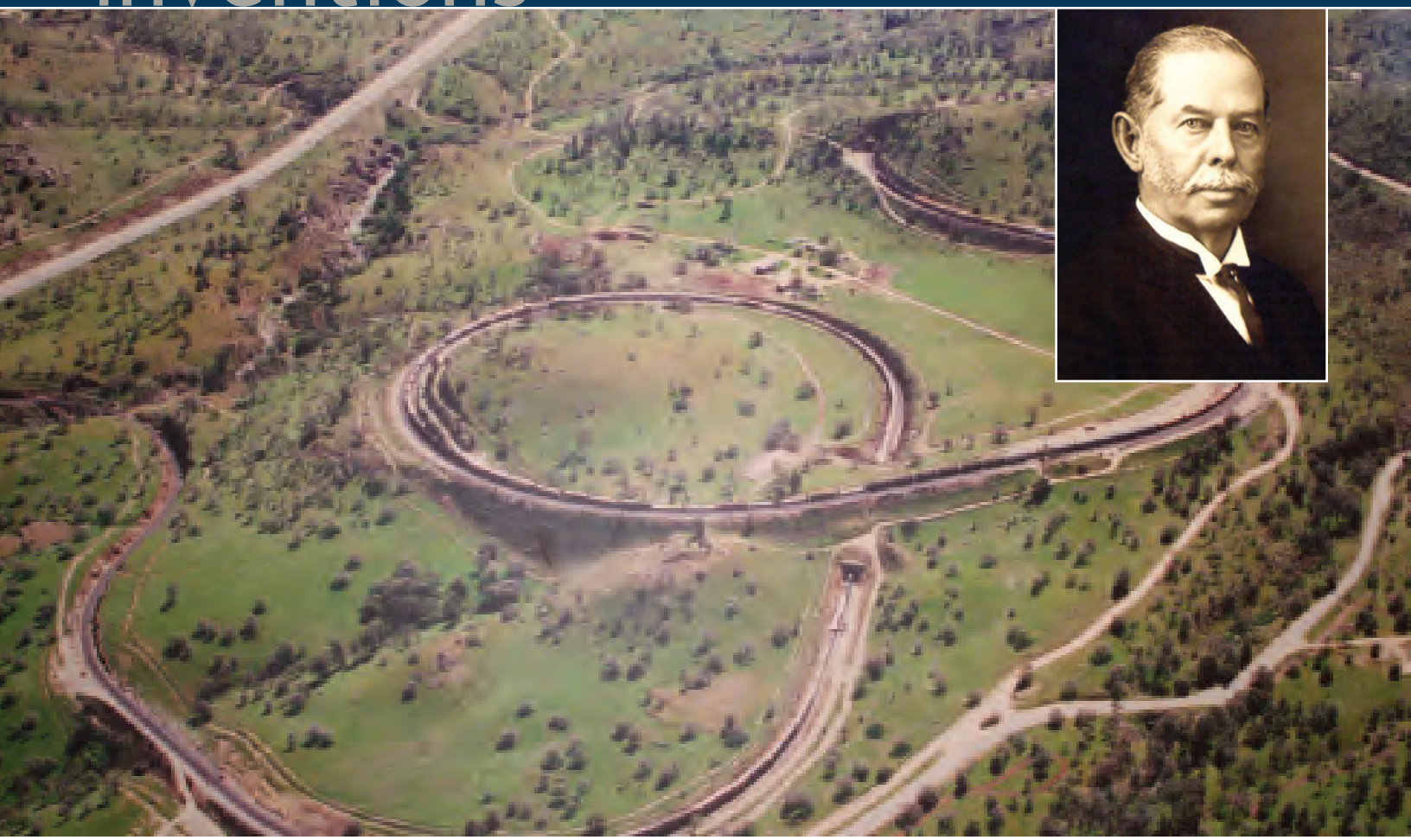
Natalie Burkhard '12: I'm in the M.S. mechanical engineering program at Stanford University with the intention of pursuing a Ph.D. with a concentration in biomechanical engineering. Current research involves studying the effects of gait modifications on the progression rate of knee osteoarthritis. I do a lot of woodturning and woodworking in my spare time.

Dave Seliger '12: I serve as a disaster logistics coordinator for Hurricane Sandy recovery operations for the N.Y.C. Office of Emergency Management, an opportunity funded by the Dartmouth Dickey Center's Lombard Fellowship. I started off coordinating the deployment of the city's emergency supply stockpile to support 76 hurricane shelters. I then had to demobilize 65 of the shelters in less than 72 hours so that school could open! Right now I'm a data technician at the city's logistics staging area at Citi Field/Mets Stadium, where I work closely with the National Guard, the N.Y. State Guard, and the N.Y. State Emergency Management Office.

OBITUARY

Malcolm Lewis Th'71, an internationally recognized expert in the design of energy-efficient buildings and the past chair of the board of trustees of Harvey Mudd College, died of bladder cancer October 13, 2012, at the age of 66. Lewis founded Constructive Technologies Group Inc., a consulting firm that provides support to building owners and designers to optimize the performance of new and existing buildings. Through his consulting work, Lewis educated architects, engineers, building owners, city planners, and utility workers about sustainability and building comfort and efficiency. Well known for his expertise in the design of sustainable buildings, Lewis was active in the development of the Leadership in Energy and Environmental Design (LEED) green building rating system. He served as a board member of the U.S. Green Building Council from 1997 to 2002 and as chairman of the LEED Technical and Scientific Advisory Committee from 2001 to 2009. He oversaw more than 150 LEED-certified projects, and developed and delivered online training on energy efficiency and sustainability for multiple clients. A registered professional in mechanical, electrical, and civil engineering, Lewis served as the engineer of record for more than 25-million square feet of new construction and renovation projects for the public and private sectors. He managed sustainable design projects at a number of colleges and universities, and was the driving force behind the LEED certification of a resident hall and a dining complex at Harvey Mudd. "I love working with buildings," Lewis said in 2002. "They are very tangible, almost everyone lives and works in them, they consume a huge fraction of our energy and natural resources, and they last for a very long time. So it is important to make good decisions before they are built." He is survived by his wife of 28 years, Cindy, children Holly and Geoff, and grandchildren Max, Chris, and Nick. More information about his life is available at hmc.edu/remembering-malcolm-lewis/malcolm-lewis and at dartmouthengineer.com/2004/09/building-green.

inventions



CIRCULAR LOGIC
William Hood's Tehachapi Loop in the mountains between San Francisco and Los Angeles was completed in 1876 and still carries up to 40 trains a day.

TEHACHAPI LOOP

>> INVENTOR:
WILLIAM HOOD,
DARTMOUTH CLASS OF 1867

Dartmouth produced engineers of national importance even before the founding of the Thayer School. William Hood, for example, was the engineering genius behind California's Tehachapi Loop, one of the seven wonders of the railroad world and a National Historic Civil Engineering Landmark.

When Hood joined the Central Pacific Railroad after graduation in 1867—just as Thayer School was being established—the company was a startup with only 90 miles of track. By the time he retired 51 years later as chief engineer of the Southern Pacific Company, which had absorbed Central Pacific, more than 11,000 miles of track had been laid, much of it running through rugged Western mountain ranges.

Robert Fletcher, dean of Thayer from 1871 to 1918, described the Tehachapi Pass between San Francisco and Los Angeles as "a bewildering labyrinth of lofty peaks and ridges where the roadbed twists and squirms by every sort of horseshoe curve, S curve and spiral." Hood's loop is the crowning glory of the 28 miles of rail line that snakes through the mountain pass. The elegant .73-mile spiral alone ascends at a 2-percent grade for an elevation gain of 77 feet. A train longer than 4,000 feet—some 85 cars—passes over itself as it travels along the extraordinary layout.

Hood's spiral became an industry standard. It was incorporated into Thayer's railroad curriculum, and Hood personally prepared teaching materials for the school. He also offered up this piece of advice: "The essence of engineering consists not so much in the mere construction of the spectacular layouts or developments, but in the invention required—the analysis of the problem, the design, the solution by the mind which directs it all."

Dean Fletcher surmised that Hood's training in descriptive geometry at Dartmouth was key to his success because descriptive geometry was to the engineer what the study of literature was to the poet: It "compels the man to be exact and true." The same can be said of the Tehachapi Pass, with its 18 tunnels, 10 bridges, and Hood's remarkable loop.

—Lee Michaelides

71.165.227.225/TRAINS.HTML. INSET: DARTMOUTH COLLEGE ARCHIVES

RANDOM WALK

When Emily Mason-Osann '11 Th'12 signed up as director of Dartmouth's First-Year Trips, she brought more than enthusiasm to the job. She also brought her engineering skills. She oversaw 350 student volunteers and the logistics for transport, food, tee shirts, and other organizational details for 1,300 people participating in the pre-fall term orientation outings for Dartmouth's incoming freshmen. "We put in over 77,000 volunteer hours this year, not including my paid hours," she notes. A checklist in the director's manual helped her manage the workload, but the real advantage, she says, was "being able to look at it as a complex system and see how all the parts of it work together and support each other and how changing one aspect can change the efficiency or tone and have a major impact." One such change was packing group gear the night before a trip rather than the morning of the trip. "Because of that we had fewer calls to our safety phone about missing gear. Something we did for getting an earlier start made a big impact on how prepared people were," she says. "The experience helped me think critically about the root of a problem, what needs to be fixed, what doesn't matter. It was cool to practice this in a nontechnical setting, and it will be transferable back to engineering." Mason-Osann says her favorite parts of the job were getting to tell the traditional Doc Benton ghost story to the freshmen at Moosilauke Ravine Lodge and "watching the students come back from the trips and seeing how much they had changed. They came in nervous and came back excited to be at Dartmouth and starting to feel like this is their community and their home. That was an awesome feeling."

Photograph by Eli Burakian '00

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