DARTMOUTH

Engineer

THE MAGAZINE OF THAYER SCHOOL OF ENGINEERING

SUMMER 2010

COMPLEX SYSTEMS

TACKLING SURPRISES IN MULTI-COMPONENT SYSTEMS, FROM HUMAN BEHAVIOR TO ROBOTIC SMARTS

▶ STATE OF THE SCHOOL

▶ STUDENT CLUBS

▶ “AHA” MOMENTS IN ENGINEERING

DARTMOUTH ENGINEER
VOLUME 6 / NUMBER 2

Eyes on the Gulf *Interview by Elizabeth Kelsey*

We asked **Professor Daniel R. Lynch**, an expert on physical and biological interactions in the coastal ocean and advanced computational methods for tracking water resources, for his perspective on the Deep Water Horizon oil spill in the Gulf of Mexico.

What goes through your mind as an engineer when you think about the oil spill?
I think about transport and fate of the oil and what goes on biochemically while it is being transported. It's released somewhere and it's reacting, but where does it go and what does it become?

Are simulation models of currents being used to predict where the oil is going?
Yes, the Integrated Ocean Observing System (IOOS) covers the ocean shelves with computer models and observations. Right now, those simulating the Gulf are mostly operating in universities and research labs in Texas, Louisiana, Mississippi, Florida, and up the Atlantic coast.

Does your research contribute to the oceanographic work that's being done?
There are people like myself who aren't on the Gulf Stream, but whose research improves the methods oceanographers use for observing, simulating, and making forecasts and predictions. This is a major NSF and NOAA research topic.

Have you noticed any discussion of these models in the news coverage?
It doesn't show up in the newspapers very much, just the simple details. I think it would help people to see images from the Coastal Circulation Nowcast/Forecast System at omglnx6.meas.ncsu.edu/sabgom_nfcast/index.html and the Naval Research Laboratory Nowcast/Forecast System at www7320.nrlssc.navy.mil/IASNFS_WWW.

What technology is available for following the currents and oil dispersion?
For the longest time there was an implied assumption in the press that all the oil would go to the surface. But as tar balls and deep plumes indicate, you can't assume that all the oil floats. A lot of attention was paid to the satellite imagery because satellites are looking down all the time. Satellite imagery will only see the surface, so you have to infer what's below. You can put out moorings and current meters at different depths to record data and observe dispersion. These data are telemetered to a land station, so you can compare that with the satellite imagery and have information for what's underneath as well as what's the surface of the sea. There are also drifting instruments you can just throw into the water. They have GPS units on them and they drift around with the current and radio back their positions with super accuracy. We would like to see some drifters tossed in at different depths. And, of course, simulation models are used to fill in the gaps.

Why aren't agencies using drifting instruments and current meters to track the spill?
It wouldn't be hard to marshal a response. Although the current meters require planning, the drifters are easy to launch and track. But the ocean research community has limited manpower, and it cannot make up for a lack of operational capability. It is clear that we need to attract the best people into our resource agencies, and we need national-level preparedness for rapid, coordinated responses to emergencies. We are living in a dream world if we expect university researchers to mount emergency responses ad-hoc. Relying on that is tantamount to assuming there will be no problems or accidents—clearly wrong.

—Elizabeth Kelsey is a contributing editor at Dartmouth Engineer.

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Illustration by Michael Austin

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Thayer School in summer.
Photograph by Douglas Fraser

THE Great Hall

>>NEWS FROM AROUND THAYER SCHOOL

FINAL PREPS
From left, Yoon-Ki Park '09 Th'10, David Lindberg '09 Th'10, and Steven Walker '09 Th'10 fine-tune Dartmouth Formula Hybrid's race car, Penny. Penny is the first DFR car with a parallel hybrid drivetrain.

COMPETITION

Formula Hybrid Comes of Age

FIVE YEARS AGO, FORMULA HYBRID STARTED AS a small exhibition of one car from Dartmouth and one from McGill University. The event was a proof-of-concept demonstration that a small, open-wheel race car could house a hybrid power train. Dartmouth's car wasn't so small. It weighed 1,200 pounds—three times more than its gas-powered peers. It also wasn't very good at racing. It steered like a cruise liner. But the point wasn't to make it fast or race around a track. The point was to call attention to contemporary challenges in engineering and invite universities around the world to tackle new technologies.

Every year since then a growing number of colleges and universities answered that invitation. In May, 26 of the 30 registered teams made it to the Thayer-hosted Formula Hybrid International Competition at the New Hampshire Motor Speedway in Loudon, bringing with them the most advanced entries the competition has seen.

Were the cars small? Oh, yes. Some weighed less than 500 pounds, thus rivaling gas-powered equivalents. They are also very fast. Most can go from 0 to 60 mph in approximately four seconds—which approaches Porsche territory. Not bad for something that runs on rechargeable batteries.

Formula Hybrid 2010 boosted the competition to a whole new level. Teams have finally figured out the technology and are battling for points in every single event. No car from 2009 other than Texas A&M's could come close to competing with the cars of 2010. This year, the winner, Italy's Politecnico di Torino, was described by one judge as a professional racing outfit. Yet the team outpaced Texas A&M by a mere three points of a possible thousand. Now we're racing!

After A&M and Torino, the other top slots shuffled between Dartmouth, University of Wisconsin-Madison, UC Davis, and Brigham Young University (BYU). Many first-year teams also performed well—which is no easy feat. Yale made it to design finals, and BYU and UC Davis edged out veterans Wisconsin and Dartmouth (3rd, 4th, 5th, and 6th place, respectively). Florida A&M-Florida State University and San Jose State University, while slower, were also first-year teams that scored and completed all of the events. As design judge Andrew Burston of Flux Dynamics put it, "It's been a great year. There's been a fantastic range of teams. The bar has been raised. Definitely."

One mark of progress is that a superior drivetrain configuration has emerged: a simple, mechanically coupled, parallel system. It weighs the least, has built-in redundancy (if the electric motor fails, there's still an internal combustion engine), and opens the door for regenerative braking.

If this year is any indication of how teams will compete in the future, we can look forward to some great engineering—and some real racing.

—*Calvin Krishen Th'08*

THERE'S MORE!
dartmouthengineer.com

“What will I miss? The fabulous staff, impressive colleagues, and all the wonderful students.” —PROF. URSULA GIBSON ’76

CUMMINGS AND GOINGS

New and Departing Profs

▶ **Margaret Ackerman** has been appointed assistant professor. Her research is in protein engineering, biotherapeutics, vaccine technology, and engineering immune responses. Her Ph.D. is from MIT.

▶ **Eric Fossum** has been appointed Research Professor. He previously held positions at Columbia University, NASA Jet Propulsion Laboratory, and in industry. His Ph.D. is from Yale.

▶ **Michael Gerst** has been promoted to research assistant professor. His research is on integrated environmental assessment and modeling of material and energy systems and measuring the sustainability of anthropogenic systems. His Ph.D. is from Yale.

▶ **Venkataramanan Krishnaswamy** has been promoted to assistant professor. He does research on near-infrared imaging. His Ph.D. is from the University of Alabama.

▶ **Jifeng Liu** has been appointed assistant professor. His research is on nanophotonics. His Ph.D. is from MIT.

▶ **Vicki May** has been appointed associate professor. Her research includes inquiry-based learning. Her Ph.D. is from Stanford.

▶ Professor **Ursula Gibson ’76**, a nanomaterials specialist, has left Thayer School after 20 years on the faculty to take up an appointment at the Norwegian University of Science and Technology. She remains an adjunct professor at Thayer.

▶ Assistant Professor **Petia Vlahovska**, on the faculty since 2006, has taken a position as an assistant professor at Brown University. She remains an adjunct professor at Thayer.

FAREWELL

Professor Ursula Gibson ’76, below right, has taken a position at the Norwegian University of Science and Technology, which her husband, Thayer adjunct professor Ulf Österberg, below left, joined last year. “It’s good to shake things up once in a while—it improves perspective,” says Gibson. As for her 20 years at Thayer, she says, “I have enjoyed every course I taught, but ENGS 1: ‘Everyday Technology’ has a special place in my heart. The broad perspective brought by students from all over campus was a special pleasure, and the opportunity to convince them that they could understand and modify modern technological products was a treat.”

OPPOSITE PAGE: KATHRYN LOCONTE. THIS PAGE: PHOTOGRAPH BY DOUGLAS FRASER; ILLUSTRATION BY JAMES O’BRIEN

kudos

>> Dartmouth earned the top spot in *The Daily Beast*’s listing of “Tech’s 29 Most Powerful Colleges.” The website praised the Dartmouth Regional Technology Network, a nonprofit tech incubator supported by Thayer School faculty and alumni through the Dartmouth Entrepreneurial Network.

>> Professor Elsa Garmire was honored as a “Laser Pioneer” at the Smithsonian Museum in February as part of LaserFest, a celebration marking the 50th anniversary of the first working laser. As a graduate student at MIT, Garmire first demonstrated important nonlinear effects produced by laser beams acting on atoms and molecules.

>> Professor Tillman Gerngross, cofounder and CEO of biotech firm Adimab Inc., and his colleagues, co-founder Dane Wittrup and COO Errik Anderson ’00 Tu’07, earned a 2010 Entrepreneur of the Year Award from the New Hampshire High Technology Council. Last October, Google took an ownership stake in Adimab, which identifies therapeutic proteins, for an estimated $10 to $13 million.

>> Douglas Fraser, research engineer and director of Formula Hybrid, was awarded the 2010 Carroll Smith Mentor’s Cup by Formula SAE and the Sports Car Club of America. The award recognizes extraordinary levels of personal time and expertise given to engineering education.

SPOT POLL

What's Your Dream Job?

Working at IDEO as a product designer. I like the way that they approach the task of designing as being free and open. They encourage wild ideas while having as much fun as possible at work.—**Christine Bettencourt '13**

Director of emergency management. Emergency management is all about making sure complex systems and supply chains work smoothly during worst-case scenarios. After interning at my local fire department, I realized that preparing for and responding to disasters are the ultimate engineering problems.—**Dave Seliger '12**

Working with GE using product design and material science to engineer and create new lines of green technology.—**Amanda Duchesne '13**

I'm thinking about: designing and building robots because I envision a world where human productive potential is orders of magnitude higher thanks to robotic help; green technology because we need to change how we produce, store, and use energy; fresh water because designing, producing, and marketing a new means of getting fresh water that is affordable and adaptable will be vital over the next 20 years.—**Matt Strand '10**

Cell phone technology has permeated sub-Saharan Africa at an amazingly rapid speed. It would be cool to design medical technologies and applications that use cell phones to transmit/receive medical data and diagnose diseases. This would literally be mobile, quality healthcare for a large demographic.—**Nana Amoah '11**

Working for Audi developing sports cars that use hybrid technologies to maximize efficiency and acceleration.—**Dylan Payne '13**

I want to become an engineer in the field of sustainability and environmental protection. I am from China, where pollution and environmental damages will eventually cost more than we Chinese can get from the country's breakneck development. Therefore I hope to learn how a city can develop sustainably.—**Yuan (June) Shangguan '13**

Working as a traveling-wave reactor core design engineer. Intellectual Ventures is working on a new kind of nuclear reactor that's fueled with the nuclear waste power plants have produced for the past 50 years. This new reactor, called a traveling-wave reactor, contains a small amount of enriched uranium and the rest is the stockpiled waste. No CO2 emissions, and it cleans the planet of nuclear waste. It's a pretty recent concept, but it sounds like a fission dream solution.—**Manaure Francisquez-Rodriguez '11**

—Compiled by Leanne Mirandilla '10

THERE'S MORE!
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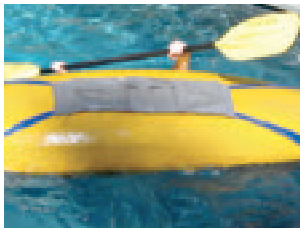


STUDENT PROJECTS

I Want One of Those!

Roll-A-Yak

ROLLING A KAYAK IS CRUCIAL for safety but tricky to learn. The Roll-A-Yak adds weight to the keel to maximize angular momentum and minimize rotational inertia, making the kayak easier to roll. The neoprene-covered weighted device cut average learning times from 11.8 hours to 90 minutes. **Lauren Harad '12, Sarah Jewett '12, Sam Streeter '13,** and **Max Van Pelt '11** won the Phillip R. Jackson Award for outstanding performance in ENGS 21: "Introduction to Engineering." Their teaching assistant was **Sara Rocio '10.**

“Carl had a great sense of when I needed a kick in the butt and when it was appropriate to hand out some praise.”

—STU SCHWEIZER ’66 TH’67

OPOPOSITE PAGE: COURTESY OF ROLL-A-YAK GROUP. THIS PAGE: THAYER SCHOOL ARCHIVES

IN MEMORIAM

Dean Carl Long 1928–2010

CARL LONG, THE DEAN CREDITED WITH USHERING in Thayer School’s modern era, died of complications from Lewy body disease on February 25 at his home in Hanover.

Long came to Thayer in 1954 as a civil engineering professor. As dean from 1972 to 1984, he expanded faculty research and Thayer’s ties with the corporate world. He established the Cook Engineering Design Center, a partnership with industry that gave Thayer students a bridge connecting their engineering studies to industry. He increased faculty research in several areas, including biomedical engineering in collaboration with the Medical School and Dartmouth-Hitchcock Medical Center, ice engineering in collaboration with the U.S. Army Cold Regions Research and Engineering Laboratory, chemical process engineering experimentation in converting biomass into energy, and environmental fluid dynamics. In addition to expanding Thayer’s size and scope, Long engineered the school’s transition to financial independence from Dartmouth, established the Thayer School Annual Fund, and increased Thayer’s endowment.

Following his deanship, Long returned to the classroom. His ENGS 21: “Introduction to Engineering” course, where students created engineering solutions to real-world problems, was among the most popular in the Thayer curriculum. He also served as director of the Cook Engineering Design Center before retiring in 1992. He was a member of several professional and advisory organizations, including the American Society of Civil Engineers, American Association for the Advancement of Science, American Society for Engineering Education, and the U.S. Patent and Trademark Office.

He is survived by his wife of 54 years, Joanna, children Carl Jr. and Barbara Anne, and sister Anne.

TRIBUTES TO CARL LONG:
dartmouthengineer.com

kudos

>> Brent Bilger ’80 Th’81 and Chris McConnell ’75 have been appointed to Thayer School’s Board of Overseers. Bilger is an executive in residence with U.S. Venture Partners in Menlo Park, Calif. McConnell is the founder and president of Adondo Corp., a Radnor, Pa.-based company that develops custom enterprise and web-based solutions for mobile content delivery and advertising.

>> Professor Alex Hartov Th’88 has been appointed director of Thayer School’s M.S. and Ph.D. programs.

>> Professors Charles Sullivan and Christopher Levey and researchers from MIT, Georgia Tech, and the University of Pennsylvania have received a $92-million grant from the Department of Energy for improving integrated power electronics to increase energy efficiency and reduce carbon emissions.

>> Dartmouth has been designated a Center of Cancer Nanotechnology Excellence with a $13-million grant from the National Institutes of Health. Thayer Professors Ian Baker, Keith Paulsen Th’84, Tillman Gerngross, Karl Griswold, John Weaver, Jack Hoopes, and Brian Pogue will work with medical colleagues on using magnetic nanoparticles to destroy tumors.

>> Professor Sue McGrath is a project team member on a patient surveillance system being implemented by anesthesiologists at Dartmouth-Hitchcock Medical Center. The system, which earned the 2009 Health Devices Achievement Award from the healthcare nonprofit ECRI Institute, helps doctors identify and treat post-surgical problems before they develop into medical crises.

>> U.S. Patent 7,701,317, “Low AC resistant foil winding for magnetic coils on gapped cores,” has been issued to Professor Charles Sullivan and Jennifer D. Pollock Th’06.

investiture

THE INVESTITURE CEREMONY honoring Thayer School's Class of 2010 was held June 12 at the Hopkins Center. Dean Joseph J. Helble presided over the presentation of hoods, caps, and awards to 108 recipients of Bachelor of Engineering and graduate degrees.

Dr. Robert S. Langer of MIT received Thayer School's Robert Fletcher Award for distinguished achievement and service. A renowned biotechnology entrepreneur, Langer let students in on the struggles he encountered early in his career.

"I had this dream of using my background to improve people's lives," he said. "I had spent a lot of my time as a graduate student starting a school for poor high school kids and developing new chemistry and math curricula. One day, I saw an advertisement for an assistant professor at City College in New York. So I wrote them a letter, but they didn't write me back. But I liked that idea so I found all the ads I could for an assistant professor position to develop chemistry curricula. I wrote to all of them, but no one wrote me back.

"Another way I thought I could help people was through health-related research. So I applied to a lot of hospitals and medical schools. None of them wrote me back either. Then one day, one of the people in my lab said I should write to Dr. Judah Folkman at Harvard. He said, 'sometimes he hires unusual people.' So I took what, at that time, seemed to all engineers like a huge risk and began doing postdoctoral work in a hospital. It might seem more common today, but at that time no chemical engineer had ever done postgraduate work in a surgery lab before. The projects that I began working on involved two related problems: trying to discover the first substance that could stop cancer blood vessels (and thus stop cancer) and developing plastics that might be able to slowly release these and other substances for a very long time in the body. Before I tackled this problem, no one had been able to develop ways to slowly release these kinds of substances for a long time and, in fact, scientists thought this was impossible to do. In fact, maybe the only thing I had going for me was that I just didn't know that. I actually spent two years working on this and I found 200 different ways to get this to not work. But finally, I made the discovery that I could modify certain types of plastics and use them to slowly release those molecules. And we used this to find the first substances that stopped cancer blood vessels and help stop cancer.

"When I was done with my postdoctoral work, I applied for faculty positions in a number of chemical engineering departments. But I had trouble getting faculty jobs because people felt that, at that time, what I was doing wasn't engineering. They thought it was more biology. So I ended up joining what was then the Nutrition and Food Science department at MIT. The year after I got the position, the chairman of the Department who had hired me left, and a number of the senior faculty in the department decided to give me advice. They told me that I should start looking for another job.

"So there I was, getting my grants turned down, people not believing in my research, and having little hope of even keeping my job—and it was the lowest level academic position one could have. I was fortunate, however, that within a year or two, scientists in the pharmaceutical industry started using some of the principles and even some of the inventions I had made, and things began to turn around, and I eventually did get promoted. More importantly, I like to think that the discoveries we've made both in cancer and drug delivery have helped improve the lives and health of millions of people.

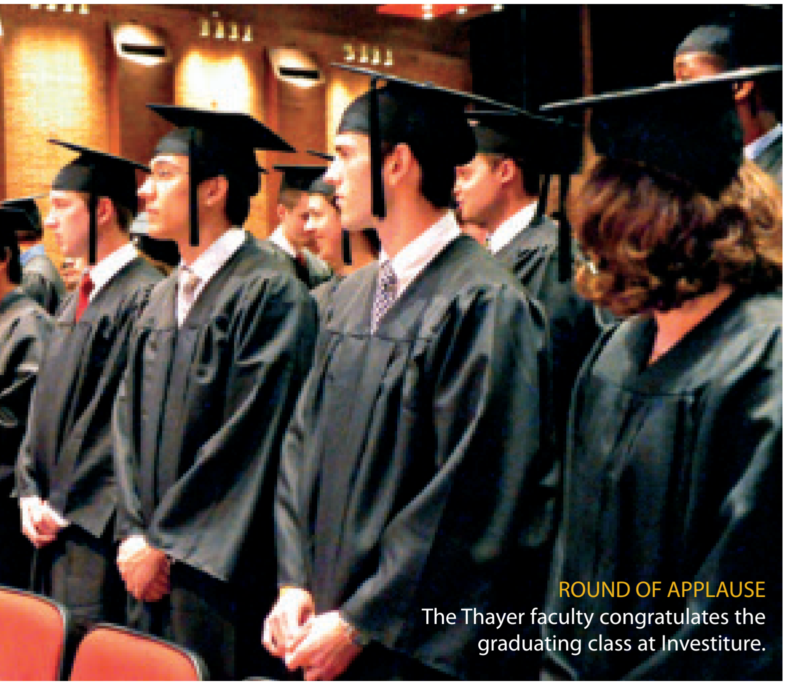
"So when you graduate, the path you may follow may often be confusing, often unclear, and sometimes it's scary. It certainly was for me. But I hope you will all dream big dreams: about how you can do things to help people and to improve the world. And there may be many times when you try to do something, when you try to develop a new product, create a new engineering principle, start a new company or whatever your dream is, that people tell you that it's impossible, that it will never work. But I think that is very rarely true. I think if you really believe in yourself, if you really stick to things and work hard, there is very little that is truly impossible."

For the full text of Langer's speech and more on Investiture, see engineering.dartmouth.edu/alumni/investiture/2010.

CLASS OF 2010
Engineering Graduates

7	Doctor of Philosophy
14	Master of Science
30	Master of Engineering Management
57	Bachelor of Engineering
65	A.B., Engineering Sciences

"You've made us proud to call you our students and today even prouder to call you our graduates."—DEAN JOSEPH J. HELBLE



ROUND OF APPLAUSE
The Thayer faculty congratulates the graduating class at Investiture.

LIKE MOTHER, LIKE DAUGHTER:
Judy Geer '76 Th'83 and Hannah Dreissigacker '09 Th'10 are Thayer's first mother-daughter alumnae duo. Geer is a former Olympic rower—she's rowing behind her sister Carly in the poster below, which hangs in MacLean Engineering Sciences Center. Geer now co-owns Concept2 Rowing, which designs and manufactures oars and indoor rowing machines. Dreissigacker, who skied for Dartmouth, plans to spend the next year working on her sport.

DOUGLAS FRASER

kudos

- >> U.S. Patent 7,713,268 B2, "Thermokeratoplasty Systems," has been issued to Professor Stuart Trembly Th'83, Adjunct Professor Jack Hoopes, and Dr. Paul Manganiello of Dartmouth Medical School.

- >> *The Journal of Professional Issues in Engineering Education and Practice* named a paper co-authored by Professor Daniel Lynch its "Best Paper for 2009." In "Experiential Learning in Engineering Practice" Lynch argues that the current system of pre-licensure experience is inadequate to meet contemporary expectations for professional engineering leadership.

- >> Ph.D. candidates Broc Burke DMS'09 and Claire McKenna '10 have received 2010-11 Albert Schweitzer Fellowships to carry out service projects in Vermont and New Hampshire that address the health needs of underserved individuals and communities. Burke plans to connect mentors from Thayer and Dartmouth athletic teams with children who suffer from chronic illness. McKenna plans to combat obesity and diabetes by creating cooking classes and spreading nutritional information.

- >> Emily Koepsell '09 Th'10 has been awarded a Fulbright Fellowship to study abroad for one year. She plans to take classes in sustainable energy and energy savings at the Technical University of Denmark's National Laboratory for Sustainable Energy in Copenhagen.

- >> Ashley Morishige '11 has earned a 2010-11 Bengt Sonnerup Fellowship to support further research and implementation of her honors thesis project, "A quantification of global pasture yield and the potential to increase biofuel production through pasture intensification." The award encourages applied research that addresses global climate change.

FATHER AND SON
James Meigs '80, left, poses with new grad Benjy after Commencement.

COMMENCEMENT

Welcome to the Family Business

BY JAMES B. MEIGS '80

SOMEWHERE IN EASTERN WYOMING A MILE-LONG COAL TRAIN crawls under the endless sky.

"Coal train," I say.

"Yep," Benjy answers.

The two of us, father and son, are on the third day of a six-day cross-country road trip. A quarter mile slides under our wheels. "That's the third one we've seen," Benjy says. "There must be a pretty big power plant back there."

"Yep. And Wyoming has an awful lot of coal."

Another quarter mile. "Why don't they just build the power plant next to the coal mine," I wonder.

"Hmm...." He thinks about that. "Interesting. But that wouldn't necessarily be more efficient." And then the analysis begins: There are electrical losses over long-distance power lines to consider. And the fact that moving tonnage by rail requires surprisingly little fuel. Then there's the cost of building a new power plant and transmission lines versus using existing infrastructure. The scarcity of water to operate our hypothetical plant's cooling towers.... We could go on like this for hours.

For both of us, the cross-country drive is a break from routine. Benjy has just received his four-year degree from Dartmouth and has a free week before he has to show up for his summer job at an engineering company. (In the fall, he'll be back at Dartmouth for two more terms to complete his B.E. degree.) As editor-in-chief of *Popular Mechanics* I actually have a legitimate excuse to be spending six days driving a hot little sports car across the country (the proper journalistic term for a jaunt like this is "long-term automotive testing"). And it sure beats a week at the office. So when my magazine needed a test car driven from the West Coast to New York, Benjy and I coordinated our schedules and booked a flight to Los Angeles.

As we often do when we're together, we spend the better part of the drive analyzing how the world works—and how it could work better. Benjy's expertise in engineering is the product of rigorous study. For me an interest in science and technology is a longtime avocation that I've been lucky enough to turn into a journalistic career. But for both of us, engineering runs in the family.

We come from a long line of what my father would call "good mechanics." My father, for example, became certified as a journeyman machinist when he was just 21 years old. He worked repairing massive ship engines, and later kept P-38 and B-17 aircraft in flying condition—all before he even went to college. His father, Benjy's great-grandfather, was a brilliant, largely self-taught engineer who loved anything mechanical. In the pre-World War I Navy, Al Meigs served on one of the primitive submarines of the era. Imagine what those must have been like: sweltering steel coffins crammed with clattering diesel engines and banks of crude lead-acid batteries belching toxic fumes. He loved every minute.

After his discharge from the Navy's Pacific Fleet, Al Meigs was making his way across the Isthmus of Panama to connect with another ship that would take him to his home in Florida. The year was 1913, and the Panama Canal—then the grandest engineering project on the planet—was in its final stage of construction. Skilled workers were in demand, and Meigs was soon hard at work installing the machinery that would operate the mighty locks.

With the canal's completion in 1914, Meigs was asked to remain. He spent his whole career maintaining and upgrading those locks and all the equipment needed to operate them. And my father was born and raised among the community of ex-pat Americans who ran the canal. It was a world of skilled craftsmen and engineers who never doubted the importance of their work. They knew the jobs they did were helping to make the world a better place, and they were proud of their skills and training. Being called "a good mechanic" was the highest form of praise.

My father often reminds me that whenever he was machining a part for a ship or fixing an aircraft engine, he knew people's

“Engineering isn’t just knowing how to do things,” Benjy said. “It’s a way of looking at the world.”

lives were in his hands. Long after he left the machine shop, he continued to bring that sense of craftsmanship to everything he did—whether it was building a backyard patio or writing a book. And he passed that ethos along as a kind of family heirloom more precious than any photo or memento.

In fact, the Meigs family penchant for engineering goes back quite a bit further than Benjy’s great-grandfather. In the 1850s, engineer Henry Meiggs (there is no record why his family added that superfluous “g”) departed California after some dodgy business dealings and made his way to Latin America, where he became the most renowned railroad builder of the era. His crowning achievement was Peru’s Ferrocarril Central, which—after a series of hair-raising, zig-zag switchbacks—crossed the Andes at a height of over 15,600 feet. (“I will place rails there, where the llamas walk,” he reportedly promised the Peruvian government.) It remains one of the highest railroads in the world today.

But the brightest star in the family engineering line undoubtedly belongs to Montgomery C. Meigs. After graduating from West Point in 1836, Meigs entered a long service in the Army’s Corps of Engineers. His projects ranged from building various forts and the epic Washington Aqueduct (which included the longest single-span masonry arch in the world) to supervising the construction of the dome of the U.S. Capitol. At the outbreak of the Civil War, he was appointed Quartermaster General of the Union Army. Lincoln may have struggled to find generals who would take the fight to the enemy, but he had clearly found his man when it came to getting supplies to the troops. Meigs was a logistical genius who applied his engineer’s mind to the challenge of moving men and materiel over vast distances. In the end, it was the North’s logistical dominance, even more than the tactical strengths of Grant or Sherman, that won the war. (At least that’s the way we like to see it in the Meigs family.)

When I watched Benjy receive his diploma this past June, I couldn’t help thinking that some of that Meigs family heritage was reflected in his choice of studies. In a sense, he’s entering the family business. He has embraced the hands-on orientation of Dartmouth’s engineering program in a way that would please his mechanically oriented forebears. And, like so many Dartmouth students, he has tried to apply his training to effect some positive change in the world. He’s made two trips to Tanzania as part of the Thayer School’s student-run Humanitarian Engineering Leadership Projects (HELP) Worldwide. Working with several other Dartmouth undergraduates, Benjy helped set up a program that brings improved sanitation and cook-stove technology to remote villages.

Too often these days we take the technology and infrastructure around us for granted. We rely on technologies—from cell phones to the power grid—that we barely understand, and notice their complexity only when they don’t work. We’re irate if our airliner gets delayed on the tarmac for an hour before takeoff. But we fail to marvel that, when that hour is over, we do take off. And we fly.

We need to remember that our highly technological world can’t exist without thoughtful, vigilant engineers. As we rely ever more heavily on the infrastructure of modern life, the costs of poor design, inattention or carelessness can be enormous: levees fail; a bridge collapses; a deepwater oil well blows out. Better engineering could have prevented those disasters. And the slow motion emergencies of environmental damage, resource depletion, and global warming will require new breakthroughs that only engineers can provide. We need good mechanics today more than ever.

“Engineering isn’t just knowing how to do things,” Benjy said at one point during our drive. “It’s a way of looking at the world.” An engineering mindset means always asking questions: How does that thing work? Could it work better? For every problem, an engineer seeks a solution.

After our drive, Benjy will spend the summer troubleshooting medical devices for a bio-tech company. I’ll go back to *Popular Mechanics* and a full lineup of stories in progress—the race to build a 100-mpg car; the real story of how BP lost control of its well. But for now we still have a thousand miles of road ahead of us. And lots to talk about.

“Look, wind turbines.”

“Yep.”

—James B. Meigs is editor-in-chief of Popular Mechanics.

KAREN ENDICOTT

kudos

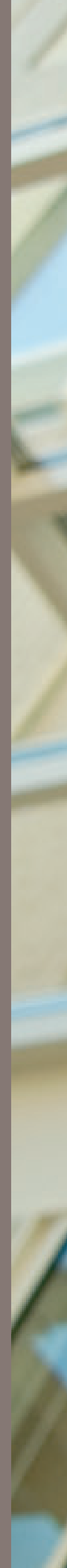
>> Sam Tanyos ’11 was awarded a Mazilu Engineering Research Fellowship for 2010-11 in support of his project, “Improving the activity of alginate lyase, a potential enzyme therapy for cystic fibrosis patients.” The award will enable him to continue enzyme engineering research in the lab of Professor Karl Griswold. The fellowship was created by Jaime Mazilu ’05 Th’06.

>> Hannah Payne ’11, a neuroscience and engineering sciences double major, was awarded a Barry M. Goldwater Scholarship, which supports outstanding students who intend to pursue careers in science, math, and engineering.

>> Sproxil Inc., co-founded by Ph.D. candidate Ashifi Gogo Th’09, was selected as a winner in the 7th Annual MITX Technology Awards in the Mobile Infrastructure category in June. Sproxil’s mobile-phone based anti-counterfeiting service enables consumers to confirm a brand’s genuineness via text messaging.

>> Thayer School won the grand prize in a video contest sponsored by the National Engineers Week Foundation and the American Society of Civil Engineers that addressed the question: How do you make your mark on the world? The video, made by Bonnie Hennessee ’08, Betsy Dain-Owens ’10, Calvin Krishen Th’08, Ph.D. candidate Tao Mao, dual-degree student Evan Lipinski, and Grayson Zulauf ’12, highlights ways Dartmouth students get kids excited about engineering: running a Lego League robotics tournament; mentoring high-school students during Summer Enrichment at Dartmouth; helping middle-schoolers make model solar race-cars; and running an after-school science program for elementary students. To watch the video, search “Engineers Week” at YouTube.com/thayerschool.

A LOT TO SMILE ABOUT
"I can't imagine a better job," says Dean Joseph J. Helble.



PHOTOGRAPH BY JOHN SHERMAN

State of the School

INTERVIEW BY KAREN ENDICOTT

AFTER FIVE YEARS AT THAYER'S HELM, DEAN JOSEPH J. HELBLE TALKS ABOUT THE CHANGES HE HAS OVERSEEN AND WHY HE'S MORE PASSIONATE THAN EVER ABOUT ENGINEERING EDUCATION.

How have your impressions of Thayer School evolved?

I knew this was an institution that had a broad liberal arts-based engineering education, but you can't really appreciate what a wonderful job it does in preparing our students for the careers they've undertaken until you're here. I knew that alumni were devoted to Dartmouth, but you don't appreciate how strong that bond is until you start spending time with alumni and see that it's genuine. Having a faculty who truly believe in interdisciplinary undergraduate engineering education with the same depth and passion that they believe in their research—you can see that from the outside, but you have be here and live it to really understand how unusual it is.

Why is it so unusual?

I think there are competing pressures and mixed messages in many institutions. It's common to say that teaching is important, but what matters most at tenure and promotion time is how much research grant funding you've raised, how many papers you've published, what your peers have to say. The commitment to first-rate scholarship is as strong here as at any peer research institution. But we also raise our expectation for teaching to the same level. We're going to continue doing everything we can to make sure our students get the best possible education.




Why did you want Thayer to choose research focus areas?

The faculty is small, and though individual members of the faculty were making significant research contributions in their own specialized fields, our size was limiting our reputation and ability to attract graduate students. If you're a prospective student interested in a particular research problem and you're choosing between an institution with six professors working collaboratively on the problem and another institution with just one professor, you'd probably assume that there are more opportunities at the more focused institution.

We knew we had to grow the faculty. It was clear that Thayer was too small to be doing everything equally well. In hiring it made sense to develop a cohesive strategy and build a couple of key areas that we would emphasize, nurture, and grow, areas that would be focal points—both for students who came here and for building institutional reputation.

How hard was it to select the research focus areas?

As a faculty we took about 18 months to work through the entire process. The interface between engineering and medicine emerged naturally as a focus area, since so many faculty were already working on medical-related research. Our criteria for a second area of focus were that it had to be: interdisciplinary, significant in the careers of our graduates, an area that reinforced our undergraduate education, a problem area important to the world, an area where graduate-level research was fundable, and an area where Thayer School's interdisciplinary structure was an asset. The faculty decided on engineering in medicine and energy as the areas we would build through investment, including through strategic faculty hires. Complex systems became our third focus area (see page 14), with the understanding that we would not target it for near-term growth. We've been going down this path for three years now, and I think we've developed some exciting new courses and brought in some very exciting new members of the faculty who are contributing in these areas already.

Was funding a factor in choosing focus areas?

We all believe in the words carved in granite on the outside of the building: the most responsible positions and the most difficult service. To many of us that means working to solve the most challenging technology-related problems facing society. That was the principle motivation in our selection of research focus areas. There was a curricular aspect: In hiring faculty who can contribute to these interdisciplinary research problems, we also sought individuals who could contribute to our systems-based engineering curricular approach. The funding aspect was pragmatic in the sense that funding agencies, including the National Science Foundation, are not funding the single investigator, hypothesis-driven, narrowly focused research proposals to the extent that they were 30 years ago. They're trying to fund solutions to interdisciplinary problems.

What has guided student growth?

We were dedicating a new facility shortly after I arrived in 2006, giving us the capacity to educate larger numbers of students. We, the Thayer faculty and staff, believe that an engineering education is one of the best ways to prepare for a productive career in a broad variety of fields in the 21st century. The way we approach engineering education at Dartmouth gives our students a particular competitive advantage and opportunities to assume positions of leadership. It gives them the right mix of quantitative and qualitative skills that are essential for tackling the big problems. We would like to have more students study engineering because we think that's what our nation, what global society needs. And there's a certain energy and enthusiasm that comes with a large cohort who are developing the skills and knowledge to go off and make a difference in the world. Larger in that context is better.

What are the numbers?

We set, and have largely met, goals of growing the A.B. program from 60 to 75–100 majors each year, correspondingly growing the B.E. program, increasing each M.E.M. class to 50–60 students, and doubling the Ph.D. program to 100 students.

Will Thayer School grow so much that it becomes a different kind of place?

No. We are committed to small team-based, systems-based, hands-on learning. We are committed to maintaining a very low student-faculty ratio, so we are growing our faculty at the same time that our student numbers are growing. We won't grow without bounds. We intend to deliver the kind of engineering education that we have been delivering for decades because we think it works exceptionally well for our students.

How are opportunities for students changing?

We've expanded opportunities in all our degree programs. At the undergraduate level, we've added a new biomedical engineering sciences major and modified major options with earth sciences and public policy. And because having an international experience is an important part of an engineering education in the 21st century, we're developing international opportunities in engineering for our undergraduates. Our Thailand exchange program is already in place, we're moving forward with another in Asia, and we're exploring options for a third site.

Our Master of Engineering Management (M.E.M.) program now offers four focus options: healthcare systems, energy and environment, manufacturing and operations, and entrepreneurship. Our new M.S./M.D. program, a joint venture with Dartmouth Medical School, gives future clinicians an understanding of technologies they'll be using as they treat patients. At the doctoral

WE AS A FACULTY AND STAFF BELIEVE IT'S NOT ENOUGH TO JUST DO GOOD DESIGN WORK OR ENGINEERING SCIENCE BUT AS ENGINEERS WE HAVE THE OBLIGATION TO TAKE THE NEXT STEP AND PUT IT TO GOOD USE, TO BE ENTREPRENEURIAL.

level, we've created an entrepreneurial track, the Ph.D. Innovation Program, to give students skills and experience in turning their research discoveries into applied technologies. The Ph.D. Innovation Program—the first of its kind in the United States—is the most recent addition to Dartmouth's Engineering Entrepreneurship Program. Our students now have entrepreneurial opportunities at all our degree levels: ENGS 21 introductory class at the A.B. level, our design sequence at the B.E. level, the M.E.M. program, and the Ph.D. Innovation Program.

How is the Ph.D. Innovation Program progressing ?

We had a wonderful applicant pool this year. Roughly 20 percent of Ph.D. applicants discussed the program in their application, and 15 percent applied to it. I'm particularly excited that 30 percent of the applicants this year were women, given that relatively few women pursue careers in technology-related entrepreneurship. For example, only 5 percent of the founders of energy companies that received venture capital funding in the past two years were women. We have a program that is 33 percent female at the Ph.D. level as well as the undergraduate level; we'd love to see Thayer School and this program contribute to an increase in the number of aspiring female high-tech entrepreneurs.

Is gender still a big issue in engineering?

Yes, but not here. Nationally less than 20 percent of engineering bachelor's degrees are being earned by women, and the same is true at the Ph.D. level. If you go back 50 years and look at medicine, business, law, and engineering, over 90 percent of the degrees were conferred to men. Fast-forward 50 years, and law and medicine are at or close to parity. Medicine is well beyond parity in some specialties. Business is at about 40 percent nationally. Engineering is still at 20 percent.

Why is that?

There is lots of speculation: lack of understanding of engineering and lack of exposure to it at the K-12 level, lack of good role models for young girls, lack of connection between engineering and solving problems that matter to society. A study published recently in the Proceedings of the National Academy of Sciences talked about first- and second-grade teachers unconsciously transmitting their own math phobia to girls. Here at Thayer, we don't have departments, and we're focused on developing team skills so our graduates can go out and solve big problems. Studies have shown that this kind of approach appeals to young people today and particularly to young girls.

Can the Thayer kind of education be reproduced at a larger institution? Should this kind of education be available more broadly?

Yes, emphatically. But I wouldn't say reproduced. I'm disappointed that there's not more project-based education at other engineering institutions. I don't expect every institution to tear apart their departments to implement an interdisciplinary systems-based engineering curriculum, but I am surprised that so few places have integrated senior design projects where electrical, mechanical, chemical, and biomedical engineering students work together. To have a class like ENGS 21 as your first class in engineering and to have an interdisciplinary capstone class like ours where at least a couple of departments come together—I don't think there's any reason why any engineering school in the country couldn't do that.

Why are you so passionate about engineering education?

I grew up in the '70s. I remember the first OPEC oil embargo and the upheaval it caused: gas lines, people wondering how they were going to get to work, prices skyrocketing. I was 12 or 13, and I remember wondering, with this big challenge facing society, how I could make a difference. I wanted to be an engineer to work on energy, to work on protecting the environment and developing technologies to prevent future problems.

I think we've done a really poor job over the past three decades of articulating the connection between engineering and "grand challenges" like energy that are facing society. In the United States the number of engineers we graduate per capita isn't anywhere near what it needs to be to solve some of these challenges. We are far behind every other developed and many developing countries in numbers of engineers. I believe in the skills and knowledge that an engineering education provides. I believe it's the right way to tackle these broad problems we and our children are going to be facing for the next century, and I believe that innovation, entrepreneurship, and job creation in areas of technology are essential parts of the solution.

Do you ever think about what founder Sylvanus Thayer or Robert Fletcher, Thayer's first dean, would think if they walked into Thayer School? You live with them in your office—their portraits hang right above you.

I do look up at those pictures and think about how the school has changed over nearly 150 years. In the early days with Bobby Fletcher there was a focus on contributing to the local area through consulting. Some of that continues, but now there's a much greater emphasis on innovation and entrepreneurship. We've got an entrepreneurial faculty—a quarter of our faculty have started companies in the past decade—and we're teaching students in all our programs some of the skills needed to go down this path. That's absolutely consistent with what Bobby Fletcher practiced under Sylvanus Thayer's vision. I think the students see that we as a faculty and staff believe it's not enough to just do good design work or engineering science but as engineers we have the obligation to take the next step and put it to good use, to be entrepreneurial. And though we're considerably larger than we were in the early days when Bobby Fletcher was the dean and the Overseers still examined every student to determine whether they were qualified to graduate, our focus on the students and close student-faculty interaction has never changed. I think they'd be pleased, even proud, that the words of Sylvanus Thayer are carved in stone on the walls of both of our buildings. I know that the faculty, the staff, and the students read them and believe in them. That is our mission. That hasn't changed.

Karen Endicott is the editor of *Dartmouth Engineer*.

FROM LEFT: DOUGLAS FRASER, JOHN SHERMAN (3)

COMPLEX SYSTEMS

TACKLING SURPRISES IN MULTI-COMPONENT SYSTEMS, FROM HUMAN BEHAVIOR TO ROBOTIC SMARTS

DON'T WORRY IF YOU'RE NOT SURE WHAT A COMPLEX SYSTEM IS. Even the people who study multi-component systems, such as the internet, communication networks, industrial processes, and interacting teams of robots, define complex systems in various ways. Some see complex systems as having so many components that they are difficult or impossible to model. Others emphasize that interacting components produce unexpected emergent properties that make the overall system tough to model. Still others see complex systems as intricate interfaces between humans, nature, and technologies. One of Thayer's three research focus areas (the other two are engineering in medicine and energy), complex systems provides room for creative new ways of thinking about the world around us. Here we look at some of the complex system challenges that Thayer professors are trying to understand and solve.

BY LEE MICHAELIDES AND KAREN ENDICOTT

FLOCKS AND CARS

Professor Reza Olfati-Saber

Six little robots that resemble football-sized beetles scurry around the floor of an empty room in Thayer's basement. They're small, but Reza Olfati-Saber's robots have a big job: simulating a transportation system that could change the way you drive—and maybe save your life.

According to the professor, the robots resemble a flock of birds. "A flock of birds is still capable of flocking, even if hunters shoot down some of the birds—nothing really happens," he says. "We're developing networked sensing and decision-making systems that are capable of working even if you start taking some of their parts away or wrecking some of their components." Moreover, he says, "We are trying to benefit from mechanisms that birds use to avoid collisions to create safer transportation systems."

The road to safer highways began with a new idea about math. In the mid-1990s, physicists started analyzing computer networks, insect swarms, and bird migrations and found a common element—networks. "The existence of this element of networks," says Olfati-Saber, was a "new way of looking at nature."

Olfati-Saber's work with complex systems, which he prefers to call "networked systems," dates back a decade ago when he was a post-doc at CalTech. "At the time, the Air Force was interested in creating unmanned vehicles that could coordinate with each other and collaborate for surveillance, reconnaissance, and combat operations," he says. One of the early problems Olfati-Saber sought to solve was how a network of agents—the technical term for birds, people, robots, ants, or anything that is part of the network—could reach a consensus when there is a difference of opinion. How is it that migrating ducks all go the same way and don't crash in mid-air? The paper he wrote "turned out to be the basis for a new theory called 'consensus theory' that turned out to be an incredibly simplistic framework for understanding networked systems, their behavior and properties," he says. "It was applicable to social networks, biological systems, robotics, and engineered systems."

In other words, whether you are studying a flock of birds, a swarm of ants, or a nation of Deadheads, "the math is the same for all of them—even for bacterial swarming. It is the same for traffic flows, for cars, and for pedestrians. One of the main features of systems science is to take a group of seemingly different applications or phenomena and create a unifying framework that explains all of them. This is one of the main features of systems science we emphasize at Thayer," says Olfati-Saber. "I'm trying to use all these theories, including the flocking theory, to create the next generation of transportation system."

Olfati-Saber says that his idea for safer highways differs from the safety systems now being pioneered by BMW and Mercedes that use sensors to warn drivers about potential collisions. "Our goal," he says, "is to communicate between vehicles."

How would it work? "Cars could use onboard sensors to communicate with other cars to detect when they would collide, and they could take over and react before the driver actually reacts," he says. The system would also help avoid traffic jams. One of the system's capabilities is estimating congestion on a given road. A central server, which is aware of all the cars in an area, could then tell your car about a faster alternative route.

Olfati-Saber and his team are now using those little robots to work out the system details. "The main computing challenge is to keep track of all the other moving objects around a car," he observes. The task will become more complex soon: his six robots will be joined by 15 more. The professor is trying to add more grad students or post-docs to his team as well. "Many of our innovative team coordination methods are inspired by nature," he says. "However, it takes the combination of a sophisticated set of tools from control theory, communications, physics, and computer science to make this inspiration a reality."

SMARTER ROBOTS

Professor Laura Ray

Laura Ray is trying to model a complex system we take for granted: how the human brain works. Then she wants to use that model to create robots that can make decisions on their own, recognize changing environments, and work in teams.

Autonomous robots are still a work in progress. "Robots used in the military and in first response are operated by a joystick or some keypad. They're not smart at all," says Ray. "We want to move away from that one robot, one operator paradigm." But before autonomous robots could substitute for humans in war zones or other dangerous situations, researchers like Ray need to figure out what competencies the robots need—and how to supply them. "Say a team of robots is on patrol. Maybe one robot has to patrol on water and another is patrolling on a road, and maybe they can only communicate two or three times a day," says Ray. "What kind of information should they communicate that makes them more effective? How do they model behavior of another robot when they don't see that robot over time?"

For answers, Ray turned to neuroscience.

Having spent a sabbatical auditing neuroscience courses at Dartmouth, Ray now collaborates with a multidisciplinary team, including Professor Richard Granger of the Department

A COMPLEX GROUP
These Thayer professors don't shy away from complicated problems. Left to right, front row: Professors Minh Phan, Eugene Santos, Laura Ray, Reza Olfati-Saber; back row: Robert Graves, Mark Borsuk, George Cybenko.

of Psychological and Brain Sciences (he's also an adjunct professor at Thayer). Building on his work on how the brain represents information, Ray says, "We're trying to model decision processes the way the brain would model them, which is by creating some kind of hierarchy. The thalamo-cortical circuits in the brain take the inputs and cluster and sequence them. You see a flower and think flower, then red flower, then rose. This kind of representation makes it easy to remember things. We're trying to apply this concept to problem solving with robots, and so far it's been pretty effective."

Ray is also drawing on studies of social cognition in other primates. "Groups of mammals can do some pretty spectacular problem solving in teams," she says. "One example is chimps that hunt monkeys in forest canopies. The chimps are faster on the ground, the monkeys are faster in the canopy. So the chimps have a number of roles. There's a chaser who climbs a tree under the monkeys and starts chasing them. The ambusher on ground runs forward and climbs a tree in the direction of the chase, and blockers try to funnel the action. With just four chimps they're able to hunt.

"What social cognitive skills can we draw from this? The chaser is usually the youngest and least experienced, the blockers are more experienced, and the ambusher is usually older and has the most experience. The teams remain together, even when assembling into larger teams. The dominance hierarchies among teams and between teams are something we're trying to use in our robots. Instead of every robot acting as an individual in a large area, they form sub-teams to divide and conquer."

But robots are still a long way from being able to do many things that are easy for humans. "We can go out to the Green in winter, when it's covered in snow, or summer, when it's green, and know where we are. For a robot that's a really hard task to know this is the same place but a different season," says Ray. "We're currently trying to program competencies, so a robot with a camera can actually see some scene and be able to recognize that it's similar to some other scene that it has experienced."

With modeling of cognition still in its infancy, Ray would like to see more interaction between engineers and neuroscientists, maybe even a joint major at Dartmouth. "If you don't speak the language it's hard to work across the disciplines," she says.

Ultimately, making robots think more like humans—processing numerous inputs simultaneously, making inferences—will necessitate new methods of computing. "The von Neumann computer with its CPU and memory components is too compartmentalized," Ray says. She has her eye on "field programmable analog arrays that are completely different computing tools to replicate dynamic systems. I think they will close the gap between understanding how dynamic systems work and how we model them in electronics. It will be more like having a circuit that behaves identically to the dynamic processes. Then you can start stringing these circuits together and see what comes out of it."

ROBOTS THAT LEARN

Professor Minh Phan

On a computer screen in his office, Minh Phan watches dots representing a group of interacting robots that assemble themselves into an orderly V-formation. As they communicate their positions to one another, the robots are controlled by an algorithm that tells them to split into three small groups and reassemble afterwards. Next Phan watches robots that have a harder job: they have to figure out what they're supposed to do. "In the beginning they are swirling around because they're learning the algorithms themselves," he says. Guided by strategies that only set broad parameters, the robots have to fine-tune their own control algorithms. "When an obstacle shows up, they have to use the algorithms they learned to evade the obstacle and regroup afterward," he says.

Phan works on the theory side of robotic swarm control. "I'm showing that model predictive control, which is well understood for a single system, can be expanded to handle a complex system with many interacting components," he says. Future applications that depend on such control include space exploration and surveillance work. "Rather than using one expensive robot, you could use a large number of less expensive robots," he says. "If some of the robots don't make it you can still accomplish the task."

SOUND AND THE CITY

Professor Minh Phan

Minh Phan is working on a noisy complex systems challenge: modeling how sound waves travel through a complicated environment, such as a city core. "Sound can propagate through or around buildings and bounce off other buildings. It's a complicated path," he says. Modeling this multi-path propagation is computationally expensive. "To simulate how sound propagates through a dense city block with high-rise buildings in 1.6 seconds, it takes more than 11 hours on a high-performance 256-CPU computer. If you have to do this hundreds of times with different source data, it's too much," he says.

He uses system identification to simplify the process. "We run the supercomputer simulation once and collect data from that simulation, then process the data to arrive at a mathematical model that captures the physics of that specific environment. The model can be used to simulate the propagation of another sound source from that location. It is a simple model of a complicated model," he says. "My research group was able to develop techniques that take data from one run of the supercomputer and quickly arrive at a high-fidelity reduced-order model that can run on a laptop in minutes."

The sound propagation model has military, security, and surveillance applications, such as tracing the source of gunshots or bomb blasts. "If we know the dynamics of the forward model, we can produce an inverse model to recover the source signal and its location," says Phan. "My interest," he adds, "is in the creative side of research: inventing unconventional methods to handle unconventional problems."

WHAT TO DO ABOUT CLIMATE CHANGE

Professor Mark Borsuk

Here's what keeps Mark Borsuk awake at night: Scientists cannot rule out the possibility that climate change could become so severe that human life is no longer sustainable. Traditional economic theory for making decisions under uncertainty recommends doing everything possible to avoid the risk of catastrophic outcomes. How much would people have to change their lifestyles to avert the collapse of humanity? If the threat doesn't seem imminent or likely, what would induce them to change to avoid risking calamity for future generations?

Borsuk is developing integrative assessment models to get a handle on these kinds of uncertainties. "The models represent how the Earth is likely to respond to climate change—global warming, rising sea levels, animal and plant extinctions—and what the economic consequences are likely to be," he says. "These models allow us to look at peoples' attitudes toward risk, how uncertainty is represented, how scientists think about climate damage—and what all that can tell us about what we should do."

One theoretical exploration takes a top-down approach. "If there were a global benevolent dictator," he says, "what should that person do to achieve the right balance between cost and benefits with regard to climate change? Obviously, this scenario is unrealistic, but in theory, if society as a whole could do something that was economically optimal, what would that thing be? It gives you perhaps an idealized target for where international negotiations should be headed."

Borsuk also takes a bottom-up approach. "It's an agent-based model: rather than a global dictator, we're looking at the various stakeholders who are emitting global warming gasses, how they currently make decisions that affect the climate, and what kind of incentives could be put in place to drive them toward behavior that is sustainable and socially optimal," he says. "Our basic question is: What kinds of institutional structures at the international and domestic levels can help promote a process of negotiation and feedback that is likely to lead in a direction that's globally optimal?"

His model "will have five or six agents representing the interests of the West, developing nations, former Soviet nations, and other regions of the world to see how different negotiation scenarios might play out," he explains.

Then the real challenge begins. "Once governments decide to do something about climate change, how do they get people to change their attitudes and habits?" he says. "We think that at least in the United States, where people have a large degree of freedom in their behavior and choices, getting to any sort of target with respect to global-warming gas emissions is going to entail incentives that allow people to draw upon things they already find important." His model will try to identify such incentives. "Will it require advertising or some sort of scientific breakthrough?" he asks. For answers, stay tuned.

AGENT-BASED FULFILLMENT SYSTEMS

Professor Robert Graves

Anyone who has ever checked luggage at an airport knows how frustrating it is when your suitcase goes to Miami but you're in New York. Or when you mail-order a medium-size green T-shirt and get a small pink one instead. These are the kinds of widely used complex systems that Robert Graves tries to improve.

In a recent project, Graves, co-director of Thayer's Master of Engineering Management program, worked with Vanderlande Industries, a Dutch company that makes automatic storage and order retrieval systems. Getting the right item from a vast, dense warehouse and ensuring that it reaches the right customer in the right timeframe is no easy task, especially when thousands of such fulfillments are on a daily docket. A disturbance in one part of the system—perhaps a malfunctioning conveyor or a worker on a break—may slow the entire system or shut it down altogether.

"Users of the systems complain about stoppages that necessitated rebooting the whole system. That's lost production time," says Graves. "The challenge for us was: Could we change the control philosophy and system drivers to meet the goal of being more fault-tolerant. Software controls the machines—the cranes in the warehouse, the conveyors, etc. How do you make everything operate as a team?"

The approach Graves took was to replace the control system with intelligent, interacting agent-based controls at all parts of the system, including work stations, totes, and conveyor links. "The agents will accomplish individual, cell-wide, and system-wide goals," says Graves. "You give a set of rules to an agent, and the agent decides which to use, based on conditions at that moment. For example, a tote arrives at the dispatch station section and announces, 'Here I am,' asking work stations to bid on where it should go. If the conveyor queue to a given work station is full, then that work station puts in low bid. If the work station is empty, it puts in a high bid to attract the work. It's a very flexible and responsive system."

A demonstration of the agent-based system showed its efficiencies. Whereas the old system took six hours to fulfill 1,000 orders, the agent-based system completed the same task in four hours. For the same 1,000 order run: when operators were taken out of the system for 30 minutes—long enough to upset it—the agent-based system experienced less disturbance, continued to perform, and recovered faster than the old system. "These improvements were achieved with modifications to the least expensive part of the system: the software," says Graves.

HUMAN INTELLIGENCE
Professor Eugene Santos

Eugene Santos wants to understand the nature of human intelligence. To do so, he is trying to unravel the complex system of human behaviors. "I look at human behavior as: How do people make their decisions and take action. I want to explain the basis for why people do what they do."

Santos examines a wide range of factors that influence behavior, including beliefs and experiences. "I want to tie those influences together," he says. Behavior isn't just a matter of one influence per action. "It's more complex than that." he says. "It's a whole hierarchy or lattice of interactions. I want to figure out how to build such a lattice."

Santos uses the theory of probability to assess, quantify, and rank degrees of influence. "Our influences aren't deterministic," he says. "Just because I have a cultural experience, you can't say this cultural experience will always produce a particular outcome. But influence can make an outcome more or less likely, so I try to capture those elements of what's more likely and what's less likely. That gives me a baseline. Then once I see an action, I can go back through the influence structure, including what they've told me about their beliefs, their demographics, their personal history to see how they got from their background to their final action."

Sounds like reverse engineering—because it is. "At this point the only way to understand complex system is to reverse engineer it. To understand the system is to dissect it," says Santos.

To test his way of quantifying and ranking influences, he assessed voters' shifts from Hillary Clinton to Barack Obama in the 2008 Democratic primary. "We looked at race, economics, whether they're conservative, et cetera," Santos explains. "We had these pieces of influences and key moments from the campaign, as when the black ministers endorsed Hillary Clinton. We also took information from the political pundits at the time. Our model was able to match the polling trends. Then we looked at precise points to see why Hillary was trending up here and down there, Obama was trending up here and down there. With quantitative models you can go in and say which values, perceptions, or events contributed to change. When we compared our results to post-election analyses, we were able to match up with them."

Santos' search for ways to model thought and behavior is leading him to rethink logic and rationality. "As I explore reasoning, I have to go beyond logical reasoning. It doesn't explain everything," he says. "People used to say people are irrational, and that's why you can't model it. No. They're misusing the term irrational. Rational to me means there is some basis, some axioms that all your behaviors follow from. Then irrational can be some sort of randomness or unpredictability. I'm trying to figure out how to capture these factors."

Santos points out that sometimes the seemingly irrational makes sense in its own cultural context. Citing the work of a colleague in Connecticut who studies the Palestinean-Israeli conflict, Santos looks at what drives suicide bombers. "The usual explanation is that they're attacking the West, the great Satan. But in at least one faction, people want to make the point that Hamas and the PLO have too much power. The reason the faction conducted suicide attacks is to show that there's competition for leadership. All of a sudden we have reasons that have nothing to do with the West. It's rational. My goal would be to take something like that, which doesn't seem to fit, and realize my model is missing something, which means I can now try to fill in those pieces."

His quest is hard, but Santos likes it that way. "It's the challenge," he says, "that keeps me going."

DIGITAL MODELS OF HUMAN BEHAVIOR
Professor George Cybenko

To most people, the internet is a mind-boggling resource for finding information, shopping, paying bills, staying in touch with friends, and entertainment. To George Cybenko, the internet is a vast storehouse of data about human behavior that can reveal everything from buying habits to hacker and other malicious activities—if you have the right kind of analytical tools.

Cybenko's development of such tools has evolved along with the continued growth of computational power and scope. Long involved in cyber security, he and colleagues recently developed a new approach—Process Query Systems (PQS)—to assess huge amounts of online information and data collected by acoustical, video, seismic, and other monitoring means. "We now have a tremendous amount of data coming at us; the question remains what to do with it," he and Vincent Berk, who is now an assistant professor at Thayer, wrote in a 2007 IEEE paper. Calling PQS "a new algorithmic and software paradigm," Cybenko and Berk say that it "models the dynamic processes that exist within a social network, not merely the static structural artifacts—such as who knows whom—of such a network. PQS can use the temporal nature of communications and transactions to extract processes." The method provides a way to watch for deviations from normal interaction or activities, which may indicate malevolent and other kinds of anomalous organizational and individual behavior.

Cybenko has also been working with Professor Eugene Santos on a growing area of social modeling called human terrain or human geography. Cybenko compares it to the kind of data available on Google Earth. "Google Earth shows you a lot of things about the imagery of the surface and the roads and the geographic features but it doesn't show you anything about the human layer," he says. "What kind of people live there? What do they do? This is sort of human geography digitalized."

The goal, Cybenko explains, is to build quantitative digital models of human behavior. Applications include computer security, insider threat detection, sensor network analysis, finance, social network analysis, marketing, political campaigning, and the military. "In areas of strife," says Cybenko, "you need to know what the population composition is, what the tribal relationships are if you are in a tribal area, and what the objectives and sentiments of different communities and groups are."

Cybenko is working with a Thayer team on a crucial step in human terrain research: developing a new computer language, Human Behavioral Modeling Language (HBML), to describe behaviors and processes. "Our current research suggests that a common framework for the systematic analysis of behaviors of people, networks, and engineered systems is both possible and much needed," team members wrote in a 2008 paper. HBML is a promising beginning, they add, for supporting "large-scale computational systems' behavioral modeling and analysis across a variety of domains."

Lee Michaelides is a contributing editor and Karen Endicott is the editor of *Dartmouth Engineer*.

CLUB SCENE

SOME STUDENTS JUST CAN'T GET ENOUGH ENGINEERING. HERE ARE SIX CLUBS THAT KEEP THEM BUSY.

ENERGY ENTHUSIASTS
Clockwise from left: Daniel Harburg Th'09, Matthew Christie Th'10, Mike Wood '10, Lois St. Brice Th'09, Kara Podkaminer Th'09.

DARTMOUTH ENERGY JOURNAL

The concept of the Dartmouth Energy Journal Club (DEJC) is simple: Grab your lunch and meet with peers once a week to discuss the latest on such topics as photovoltaics, the automobile industry, and the wind market. Ph.D. candidate Kara Podkaminer Th'09 and M.E.M. student Matthew Christie Th'10 co-founded the club as a low-key way to keep on top of the energy industry. Students take turns selecting journal articles, which are projected on a screen during meetings. "It's not like someone has to do a ton of work every week and give a lecture, but we all have a baseline of here's this basic document that we can ask questions about, here is what we understand, and here is what we don't understand," says Podkaminer.

"DEJC has complemented my education in energy technologies and issues that would otherwise be left without discussion," says Manaure Francisquez-Rodriguez '11. "Every paper we read has accelerated my study of energy technologies."

"Clubs like the DEJC are exactly what make a university experience remarkable," says Ph.D. candidate Kathleen McGill. "It has allowed me the opportunity to learn about energy—something outside of my expertise—and mix with people outside of my academic circles. I also think it's encouraging when we talk about critical problems and why they are hard with some eagerness and optimism."

BY ELIZABETH KELSEY
PHOTOGRAPHS BY JOHN SHERMAN

BIG GREEN BUS

It all started in 2004 when a group of Ultimate Frisbee players and a few Thayer engineers decided to drive across the country to attend an Ultimate Frisbee tournament on the cheap. The students bought a bus on eBay for $1,300 and converted it to run on waste vegetable oil. Since then, 13 to 15 Dartmouth undergrads have taken the bus cross-country each summer to raise interest in environmental issues and solutions. The group maintains the vehicle, develops educational materials, and stops at high schools, libraries, universities, businesses, farmers' markets—anywhere they can engage people in discussing climate change, alternative fuels, and sustainability.

"I first heard about the bus when I was a freshman," says engineering major Mike Wood '10, a Big Green Bus mentor. "I knew some of the upperclassmen on the Big Green Bus and liked the idea of a fun, summer road trip with a lot of like-minded people, seeing really neat things across the country but also getting the word out, getting people talking about these environmental ideas."

Betsy Dain-Owens '10, an engineering major focusing on environmental issues, obtained her commercial driver's license so she could get behind the wheel this year. "Aside from getting to spend the summer with an amazing bus crew, I hope that this summer opens my eyes to the different outlooks that people have toward the environment and our surroundings, and the varied ways in which the natural world connects to social and economic forces within our everyday lives," she says. "I'm excited to learn more about what drives people, and how the natural world fits into that."

BUS POWER
Clockwise from left, Brandon Cohen '11, Ann Elise DeBelina '10, Robert Collier '13, Mike Wood '10, Betsy Dain-Owens '10, Emily Mason-Osann '11.

DARTMOUTH SOCIETY OF ENGINEERS

It's easy to take part in the Dartmouth Society of Engineers (DSE)—in fact, every Thayer student is automatically considered a member. The DSE's student chapter serves as a forum for the welfare of Dartmouth's engineering students as well as a liaison between students and faculty, staff, and alumni.

DSE hosts social events, from the casual Friday Beers for grad students to the more formal "Celebrating Thayer" party that brings faculty, alumni, and staff together each spring. The group also has a weekly philanthropic initiative in which members volunteer at area middle and elementary schools to teach a hands-on After-School Science program.

Ashley Martin Th'10, 2009–10 president of DSE's student chapter, says that although students are already members, she hopes more will become involved. "It's really nice to have this as something I do besides my research," says Martin, who received her M.S. degree in June. "It's also rewarding to have at least one person come up to you after an event and say, 'You know, you did a really great job,' or for the kids in After-School Science to get so excited about the project that we're doing. It's really nice to see."

FUN WITH SCIENCE
Left to right, Yolanda Lin '11, Josiah Gruber Th'10, Elizabeth Kemp '11, Lexie Tilghman '10, and Ashley Martin Th'10 help kids make volcanoes in the DSE After-School Science program.

LEGO LEADERS
Katherine Vonderhaar '10, left, and Caitlin Johnson '10.

LEGO LEAGUE

Legos may be child's play, but in FIRST (For Inspiration and Recognition of Science and Technology) Lego League, kids are in for some serious fun. Every year, teams of 9- to 14-year-olds design, build, and program robots using Lego bricks and Lego Mindstorms technologies. Their goal: to solve missions and compete in tournaments from the local to the international level.

"Lego League provides a great forum for students to explore science outside the classroom—to learn not for a grade but for their own satisfaction," says Dartmouth Lego League (DLL) co-founder Katherine Vonderhaar '10.

FIRST was created by inventor Dean Kamen to inspire young people in science and technology. DLL began as a Schweitzer Fellowship project by Kristen Lurie '08 in 2007. Since then, DLL has matched student mentors with local FIRST teams and has hosted an annual tournament.

Christian Ortiz '11, who has been a technical judge at Dartmouth's tournaments, participated in Lego League when he was in middle school and has been mentoring since high school. "Lego League provides the opportunity for children to explore," he says.

DLL co-founder Caitlin Johnson '10 says, "At that age there is a lot of glory being on the soccer team. Your fans will come cheer you on. But if you're a mathlete or something—nobody comes and cheers you on for that. Lego League is like a sporting event for science and engineering, so the kids get really into it."

Adam Strom '10 has served as head referee. "I watched over the playing fields, scored them, and helped resolve any disagreements—which were usually from the parents." His fondest memory of the event? "Definitely listening to the teams discuss strategy before they pushed 'start' on their robot. It's serious business!"

HELP

By definition, engineers solve human problems. That's the philosophy behind Humanitarian Engineering Leadership Projects (HELP) Worldwide, a Thayer organization founded in 2006 to address global poverty reduction through local and sustainable solutions. Forty students comprise HELP, which sends groups of approximately seven volunteers to rural areas of Africa for eight weeks every summer. This year, the organization is working on two pico-hydro electricity-generating systems in Rwanda that HELP students installed a few summers ago. It is also working in association with Dartmouth's John Sloan Dickey Center to develop fuel-efficient stoves and implement water and sanitation projects in Tanzania.

While communities in developing nations acquire improved sanitation and infrastructure, "there's a lot of benefit for HELP's members, too," says Annie Saunders '12, the group's VP of communications. "It's a learning process. You're taking these classes and you have these theories of how they'll work in the real world. But having the chance to get some practice and applying it to real-world situations is a great opportunity."

"A lot of student groups will do educational or awareness initiatives, but I think HELP is unique in that students are involved in actually doing these projects," says the club's president, Nick Edwards '10.

"In Tanzania, a lot of people were surprised to see us in the village and actually working every day, working hard," says M.E.M. candidate Parker Reed '09. "We were there for eight weeks and working with the people and were told afterwards that most people in the village are used to seeing Europeans come in and sit in a meeting and leave. We were the first people they had actually seen working really hard to help their community."

HELPERS
Left to right, Manaure Francisquez-Rodriguez '11, Zachary Losordo '10, Parker Reed '09, Jeff Spielberg '10, Nick Edwards '10.

THAYER GEAR

At the student-run store Thayer Gear, M.E.M. candidates such as Weirong "Jake" Chang put their theoretical knowledge to practical use. "Most of our courses revolve around business," says Chang. "Working at Thayer Gear is a great way to see how these courses can be applied."

Ten Thayer students manage the shop, which was founded in 2007 by Meredith Lunn '06 Th'07 and Sally Smith '05 Th'06 '07. Located in the main entrance to Cummings Hall, Thayer Gear sells T-shirts, sweatshirts, coffee mugs, water bottles, and other items that bear the Thayer logo. The club meets once a week for an hour to discuss business, and its members take turns running the shop, which is usually open twice a week during academic terms.

"We are always trying to put into effect new ideas, new products, and new strategies," says M.E.M. candidate Ramkumar Jayasankar. "Working to create these new ideas, trying to promote ourselves, coordinating with vendors—all these make Thayer Gear a great thing to be involved in."

The students recently launched an e-commerce site to serve some of the most interested customers: alumni. "Quite often when they come to visit, the store is not open," says M.E.M. candidate Rohan Cherthedath. "Because of our classes, we cannot keep the store open for as long as we would like, and this would ensure that we are open 24/7 for everyone." Shop online at thayergear.myshopify.com.

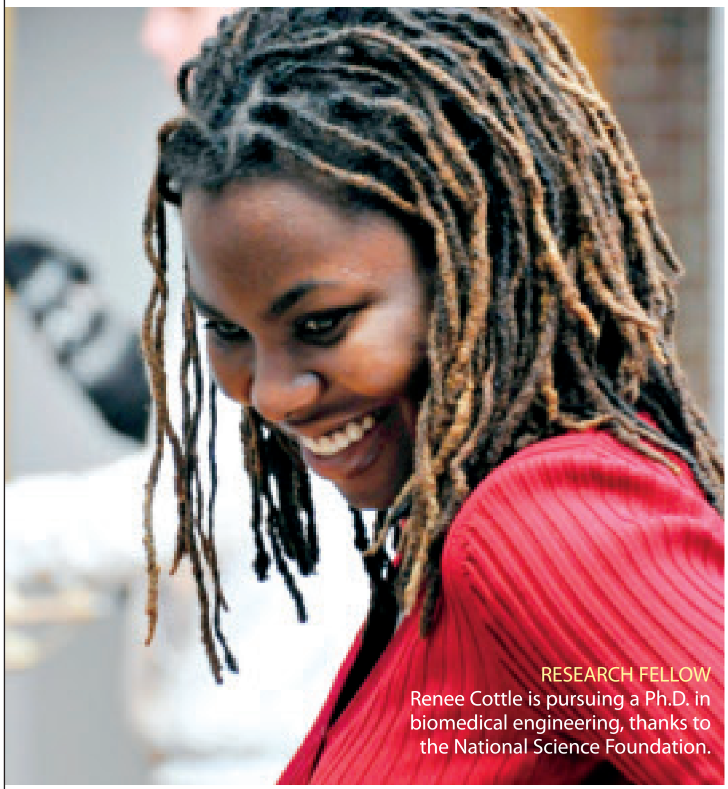
MINDING THEIR BUSINESS
Left to right, seated: Wei Peng, Andrea Chan; standing: Weirong "Jake" Chang, Rohan Cherthedath, Aditya Chaoji, Vishoka Balasubramanian, Sarah Smiley. All are M.E.M. students.

MORE THAYER CLUBS: dartmouthengineer.com

Elizabeth Kelsey is a contributing editor at *Dartmouth Engineer*.

Alumni News

spotlights



RESEARCH FELLOW
Renee Cottle is pursuing a Ph.D. in biomedical engineering, thanks to the National Science Foundation.

Renee Cottle '07 Th'09 and **Kristen Lurie '08 Th'08** have received 2010 Graduate Research Fellowships from the National Science Foundation to support their graduate studies. Lurie is studying electrical and electronic engineering at Stanford University. Cottle is pursuing a Ph.D. in biomedical engineering at Georgia Tech and Emory University.

"I plan to develop microRNA biosensors and a mathematical model that will distinguish between normal and breast cancer cells and predict the stage of breast cancer. The biosensors will be designed to target six specific microRNAs that are significantly over-expressed in blood samples of breast cancer patients," says Cottle. "Once optimized, the biosensors will be incubated with microRNA extracted from blood samples of breast cancer patients and the fluorescence of each biosensor will be measured. The fluorescence signal from the biosensor will be correlated with the known stage of breast cancer so that a mathematical model will be optimized for a strong correlation with the disease stage. I am hoping that this project will be a novel diagnostic approach for non-invasive detection of diseases."

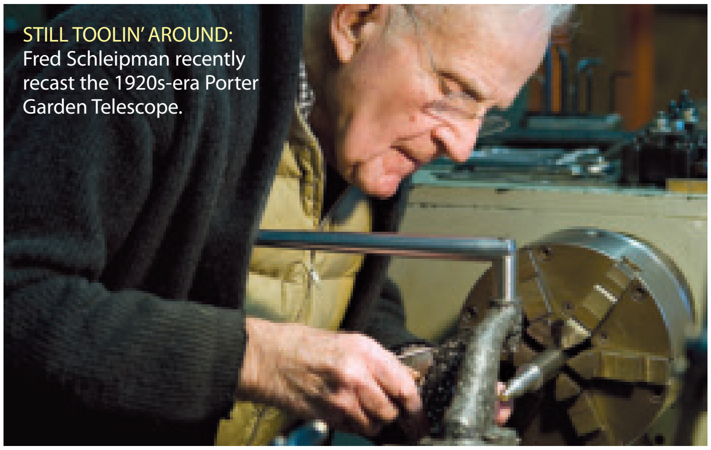
Cottle got her start in biomedical engineering as an undergraduate at Dartmouth. "My most critical research experiences were my honors thesis on peptide mimics of Vibrio cholerae LPS and my capstone design project, in which I worked with two other students to develop a medical device that sterilizes intravenous fluids," she says.

Ron Muller '55 Th'56 appeared in the PBS series "History Detectives" in their Season 8, Episode 1 presentation on NASA's first communications satellite, a 100-foot Mylar balloon called Echo. Muller, who worked on Project Echo early in his long career with NASA at the Goddard Space Flight Center, explains on camera how the satellite was made, launched, deployed, and used. "Anybody could use it. It's just flying up there. It's just a passive thing. It's like a mirror," he says on camera. Echo I, launched in 1960, and Echo II, launched in 1964, boosted the United States into the space race against Russia, enabled the first coast-to-coast satellite telephone call, and set the stage for global communications. Watch for Muller at video.pbs.org/video/1513607701.

Fred Schleipman, director of Thayer's machine shop from 1969 to 1980, is fondly remembered by many alumni for teaching them to build Stirling engines. Today, at age 90, Schleipman works in his Norwich, Vt., machine shop on his start-up venture Telescopes of Vermont (gar dentelescopes.com), which offers a $43,000 hand-finished cast bronze reproduction of the Porter Garden Telescope. The elegant telescope, first created in the 1920s, caught Schleipman's eye in 1973. "It was love at first site. I was determined to have one," he recalls. One problem: fewer than 20 were known to exist. Schleipman concluded that the only way he could own such a telescope—a work of art with high-end optics—was to build several of them and keep one from the production run. In 2007 Schleipman finally assembled a team, including a pattern maker, optics experts, and foundryman, that met his exacting requirements. Most crucially, Schleipman was loaned an original Porter Garden Telescope to digitize. He then had to design and build all the tools to machine the castings. It was a long and expensive process. The patterning alone cost $150,000. Despite his success selling the telescopes (he even appeared on the CBS show *Sunday Morning*), there is one glitch he has yet to overcome. Not unlike the shoemaker's son, he still hasn't assembled a telescope for himself. At least now he has all the parts.

Dinsie Williams '97 Th'97 volunteered with Doctors Without Borders in earthquake-torn Haiti this spring. "Many of the Haitians I met were amazed to learn that I was a Sierra Leonean (an African) and expressed being proud that I was part of the team, especially as an engineer," she says. Her account of her work there is at dartmouthengineer.com.

THERE'S MORE!
dartmouthengineer.com



STILL TOOLIN' AROUND:
Fred Schleipman recently recast the 1920s-era Porter Garden Telescope.

CANTILEVERED
Creating the Emerald Art Glass Home was an "aha" moment for architect Eric Fisher '82.

▸just one question

Q. We asked alumni: Have you had an "aha" moment in engineering?

I came to Dartmouth with the dream of entering the Tuck-Thayer major, the best of engineering with a solid underpinning of business savvy. The only problem was when I entered Dartmouth with the class of '46 in the summer of 1942, the nation was at war. After several months of relatively carefree freshman life, I had to decide about serving in the armed forces. The Navy had a strong presence in Hanover, and the V-12 program offered Thayer students a continued study in civil engineering leading to a degree, then officer training school, a commission in the Civil Engineer Corps, and service in the Seabees. When I told the recruiting people about my Tuck-Thayer dreams, they said, in effect: "If you want to study business you may end up with a commission in the supply corps, but more likely as an able-bodied seaman in the fleet. Is that what you want? We're looking for civil engineers who will earn a degree and be both a top-level technologist and a leader of men. Make your choice." That's when I had an "aha" moment and opted for civil engineering. As the timing worked out, I received my degree and commission and military training, and arrived in the Philippines on the very day that the peace treaty with Japan was signed. I am a member of the luckiest generation. Once I got hooked on civil engineering, and on construction in particular, that is the path I followed.

—Sam Florman '46 Th'46

My professional engineering experience has been involved with building construction, usually as a construction manager and in recent years as a forensic engineer. Some projects were major constructions, such as the New York State Exhibit at the World's Fair and Harkness Medical Research Building at New York Hospital/Cornell Medical Center, but many were of moderate size. Even after 56 years in engineering, I experienced my "aha" moment this past March in Puerto de Valle, Mexico.

Engineers Without Borders (EWB) had received a request from the village of Puerto de Valle for an assessment and design to improve the water supply for the 2,000 inhabitants. I was on vacation in nearby San Miguel de Allende, Mexico, and volunteered to do the preliminary reconnaissance. The drilled well has been unreliable and contaminated by poor sanitation practices. Inhabitants draw water only three hours each day. The adjacent river, used as backup, is polluted. I spent maybe four hours in Puerto de Valle, but I consider it a most rewarding engineering experience because I was able to contribute to the solution of the problem in support of this Mexican rural population. As a civil engineer I felt at home in evaluating the well and distribution system to the 300 separate houses. I never would have obtained permit approval in New York for a well only 50 feet from an open sewer ditch. I took three water samples, one from the Lerma Santiago River and two from the well distribution.

My ability to speak Spanish at an intermediate level was important to my communications in Puerto de Valle. I gathered together drawings and documents from the village elders and made my report to the EWB chapter in Tucson, Ariz., which has the design responsibility for improving the water supply system. A new well located above the community and away from the sources of contamination may be the solution.

—Harlan Fair '53 Th'54

Memorial Day 2010: My "aha" Thayer day, perhaps my penultimate such day. My wife of 53 years and I are in what is euphemistically called "downsizing." We dispose of physical objects, all of which evoke memories of which we cannot dispose. Today I discarded several dozen books from Thayer days: Strength of Materials, Concrete Design, Timber Structures, Soil Mechanics, Mathematical Analysis, and more. These are obsolete, irrelevant except to one matter: what they and Thayer enabled me to accomplish through a career and a life, full of satisfaction and dedication to the essence of the Dartmouth liberal education and the Thayer School discipline. So now, as I approach my 80th birthday, after a life with countless "ahas" attributed to Thayer and Dartmouth, downsizing comes easily. All readers will eventually be where I am, and will revere their Thayer faculty as I revere Carl Long and others.

—Albert G. Melcher '53 Th'54

I don't recall any "aha" moment, but I did have a "?" moment. At Thayer I began to wonder what computers could not do. After about 55 years in the computer field, I still don't know the answer to that question. However, I'm beginning to get a feel for what computers can—but maybe should not—do.

—Pete Knoke Th'56

So much of school is not about learning exactly how to do a particular task, but rather how to go about solving the diverse problems one may face later in life. Two years after I graduated from the Thayer School of Engineering I started working at the University of California's Lawrence Radiation Laboratory in northern California. One of my very first assignments was to design a special screw made from a rare-earth metal. Of course, I knew about metal screws from the hardware store, but I didn't know how to design one from scratch, least of all in an unfamiliar metal. How would I decide how many threads per inch and how deep should the threads be? Should they be square or round or some other shape? How much clearance would each thread need? How would I show the machinist exactly what I wanted? To make matters worse, the ramp angle of a screw thread—how fast it climbs—depends on the frictional properties of the metal, and rare earth metals have very different properties than brass or steel. So I couldn't just copy the dimensions of a brass or steel screw and expect it to work. I'd never even thought about how to design hardware involving exotic metals, and Thayer School had not taught me about nuts and bolts in such detail. Fortunately, I remembered that Thayer School had taught me how to solve problems, and soon I finished designing that screw and gave all the

OPPOSITE PAGE: LEFT, DOUGLAS FRASER; RIGHT, RUSS SCHLEIPMAN '71. THIS PAGE: COURTESY OF ERIC FISHER '82

LIFESAVING APP
Creating the PocketCPR was an "aha" moment for Mark Totman '71 Th'72.

dimensions to the machinist to cut on a lathe. He thought it was pretty unusual too; he'd never seen a bolt or screw like that before. It was probably the most trivial engineering task I ever did, but I got a lot of satisfaction from the experience, and over the years have met many other engineers who didn't know how to design a screw from scratch either. Thanks to Thayer School, my "aha" moment was realizing that Dartmouth had prepared me to solve all kinds of problems—trivial and difficult—with the scientific and engineering insights and skills necessary to tackle them.

—Philip E. Coyle III '57

After receiving my A.B. as an engineering sciences major at Dartmouth and Thayer, I followed Thayer Professor **Sidney Lees** to Boston, where we founded the bioengineering department at the Forsyth Dental Institute. Our principal project, "Looking into Teeth with Ultrasound," became a five-year graduate program that, with Sid, remained an extension of my Dartmouth-Thayer experience, leading to a master of science in electrical engineering from Northeastern University. In 1973 I became responsible for continuing development of a real-time ultrasound imaging system at the University of Washington. The objective was to detect atherosclerotic plaque in the carotid artery, one of the primary causes of stroke. The first patient I looked at was scheduled for surgery the next day to remove a major arterial blockage that had been diagnosed, correctly, by standard X-ray angiography. To our collective dismay, the artery looked just fine (blood-filled) with our new ultrasound machine! An ultrasound system produces images by transmitting pulses into the body and detecting echoes from minute structural variations in soft tissues. Therefore, if the patient's plaque was not differentiable from blood it must not contain these structural characteristics. Then came the "aha" moment: Though plaque and blood might look the same, as seen by pulse-echo ultrasound, they would not sound the same if they were examined with Doppler ultrasound, which would recognize flowing blood by the Doppler shift in the frequency of minute echoes scattered by the blood cells. I realized that by integrating imaging and Doppler into the same machine one could see both stationary tissues, such as artery walls that are normally reflective, and simultaneously differentiate very weakly reflective tissues, such as the patient's plaque, from blood, by the Doppler shift. This discovery led to the development of duplex Ultrasound, the early and current standard for every medical ultrasound imager. In 1974 I performed the first examination of a carotid artery by duplex echo-Doppler ultrasound on my technician, and the first duplex echocardiogram on my 4-year-old daughter, Jennifer.

—Frank E. Barber '62

After consulting with companies on environmental issues for about 30 years it occurred to me that my clients' problems were not environmental problems but rather business problems. Viewed through this lens, a portfolio of solutions emerged that led not only to solving problems but also to delivering bottom-line results. Such solution sets have come to be known by phrases such as pollution prevention, life-cycle product development, sustainable supply chain management, product stewardship, and triple bottom line management. The "aha" moment set the stage for my professional morphing into academia (about half time), where I teach sustainable business practices in the Fisher College of Business at Ohio State University. My courses are delivered at both the M.B.A. and undergraduate level and teach future business leaders how to grow a business and prosper by managing the triple bottom line: people, planet, and profit. My courses are a mix of lectures and projects carried out for local companies, including large corporations such as American Electric Power and Limited Brands. The other half of my time I spend as executive director of two nonprofits focused on recycling: the Waste Not Center (wastenotcenter.org), which takes items that would otherwise be discarded by businesses and individuals (about 60 tons per year) and turns them into educational and creative supplies for teachers and artists; and the Association of Ohio Recyclers, which works to instill recycling best practices in businesses and promote a regulatory environment conducive to recycling in Ohio.

—Neil Drobny '62 Th'64

I'm the president of Bio-Detek Inc., and I've developed a handheld device that reminds a rescuer how to perform CPR. Using accelerometer technology, the device actually measures the depth of each chest compression and gives feedback to the rescuer to "push harder" if compressions are too shallow. We wanted to enable 911 calling in the device when the "aha" arrived—put our software in a cell phone. We launched PocketCPR (pocketcpr.com) for iPhone last fall and have had more than 65,000 downloads. My hope is that within five years, all smart phones will arrive with my software preloaded.

—Mark Totman '71 Th'72

I'm an architect (fisherarch.com) with an undergraduate engineering degree. I was working to win the trust of husband-and-wife clients who wanted to build a home above their glass factory that would be like an old-time foreman's shack perched on a warehouse roof. However, my early analysis had demonstrated that code and structural restrictions prevented their dream from becoming a reality. The "aha" moment occurred when I proposed cantilevering the home out 50 feet over the warehouse from a concrete block base garage that would be located behind. This was an outlandish idea for a number of obvious reasons, and I risked losing the client if they thought my idea was unsound. Yet, despite my misgivings, they were intrigued. The result—the Emerald Art Glass Home, or "the mother ship" as it has come to be known—became what we believe to be the world's longest cantilevered home. Why was this an "aha" moment? When they gave me the go ahead, I realized that although jumping off the Ledyard Bridge at midnight with my engineering major pal **Ken Marra '82** as a college junior may not have been a strong idea, sometimes risking everything is necessary in order to move forward.

—Eric Fisher '82

MORE MOMENTS:
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IN THE LEED
Andrea Korber '98 helped design and build this residential project to LEED platinum standards.

thayer notes

1940s

Warren Daniell '48 Th'50: One of my professors at Thayer was **John Minnich '29**. In the fall of 1951, while working diligently but not too happily for a public utility, I got a call from John. In his folksy drawl, he said he was consulting at a "great engineering company" with an office in Concord, N.H., that needed structural engineers, and I would be a perfect fit. So I talked with **Tad Comstock Th'48**, who was with the firm (Anderson-Nichols), met with the office manager, negotiated a salary ($100/week), and started work in November. By 1955 I had been transferred to the Boston headquarters with management rather than engineering responsibilities, but I continued to work with John until the mid-1960s. In 1999, now co-owner, and having been responsible for engineering projects worldwide, I sold Anderson-Nichols, staying on with the new firm, Dewberry, as consultant until 2008. I owe it all to John!

1950s

Weston G. Bruner '55 Tu'56 Th'56: I was a Tuck-Thayer major and in the Air Force ROTC. After graduation, I went to work for Westinghouse Electric Corp. A month later I was called to active duty in the Air Force. I spent one and a half years at Griffiss Air Force Base as a second lieutenant and studied radar. When I returned to Westinghouse, after I received an early out from the Air Force, I worked on advanced airborne radar. I was very involved in the development of the radar for the F-16 aircraft. In 1993, after 38 years, I retired from Westinghouse. My wife and I are very active in our church and I play bridge weekly with some friends I have known for a long time. We have done some traveling overseas and throughout Canada and the U.S.A. My son, a plastic surgeon, has three girls. My daughter, a teacher, has two boys.

Philip Coyle '56 Th'57: For 33 years, from 1959 to 1979 and then later from 1981 to 1993, I worked at the Lawrence Livermore National Laboratory, which was originally called the Lawrence Radiation Laboratory, retiring in 1993. In 1979, during the Carter administration, I left the lab to serve as principal deputy assistant secretary for defense programs in the Department of Energy (DOE). In this capacity I had oversight responsibility for the nuclear weapons research, development, production and testing programs of the department, as well as the DOE programs in arms control, non-proliferation and nuclear safeguards and security. I've remained in engineering, although I haven't been in a job that involved detailed engineering calculations and design work since I left the lab. From there, from 1994 to 2001, I served as assistant secretary of defense and director of operational test and evaluation in the Department of Defense (DOD), where I was the longest-serving director in the 25-year history of the office. As director of operational test and evaluation, I had responsibility for overseeing the test and evaluation of more than 200 major defense acquisition systems. This included reporting to the Secretary of Defense and Congress on the adequacy of the DOD testing programs, and on the results from those testing programs. At the DOD my responsibilities also included stewardship of the major range and test facility bases of the DOD, including the large test ranges and test centers the DOD operates from Maryland and Florida to California and Hawaii. After leaving the Pentagon I became a senior advisor to the president of the World Security Institute, and to its Center for Defense Information, a Washington, D.C.-based national security study center where I still serve. In 2005 and 2006, I served on the nine-member Defense Base Realignment and Closure Commission appointed by President George W. Bush and nominated by House Democratic Leader Nancy Pelosi. The commission was responsible for determining those U.S. military bases and facilities to be closed or realigned beginning in late 2005. On October 28, 2009, the White House announced my nomination to become the associate director for national security and international affairs in the White House Office of Science and Technology Policy. I was appointed to the position in July of 2010.

1960s

Frank Barber '62: Until two years ago I was at the National Center for Physical Acoustics at the University of Mississippi, directing an Army program trying to stop soldiers from bleeding to death on the battlefield using ultrasonic Doppler and imaging to locate internal bleeding, followed by high-intensity, focused ultrasound to cauterize the wound—all non-invasively. My retirement was concurrent with the loss of hope for early success, and the funding. Timing is everything! My wife, Debbie, and I now live in Golden, Colo., for our "golden" years. Life is hiking, biking, climbing, skiing, etc. With three kids (two Debbie's and one mine) and two grandkids nearby we are blessed. Retirement feels more like being on sabbatical. I maintain usefulness by teaching cross-country skiing for the Colorado Mountain Club, volunteering at the Denver Museum of Nature & Science, and, to pay my REI bill, instructing and mentoring students at Red Rocks Community College in its medical imaging program. The Dartmouth Winter CarniVail is the greatest thing since the freshman trip and I recommend it highly to any of you out there who want to get together with old friends and a few faculty and staff from the College. It's a three-day weekend every February, organized by graduates of Dartmouth and its affiliated schools who live in Vail, Colo. Skiing is optional, so they say.

John Pearse '62: I married my childhood sweetheart two weeks after graduation—my best life decision. I founded a software company in 1979; grew it for 25 years to a very respectable size, and sold it for a bundle in 2004. Now I'm enjoying my wife and the good life in Florida during the winter, and the grandchildren in Connecticut during the summer. Who could ask for anything more?

Thomas E. Brady '66 Th'68: I am the interim dean for the Judith Herb College of Education at the University of Toledo (UT). Prior to this I was the founder and chairman of Plastic Technologies Inc. and six related companies in plastic packaging, plastics technology development, and plastics recycling. Before that I was vice president of plastics technology for Owens-Illinois Inc., where I directed the technical activities for all plastic product lines. I sit on the Ohio governor's Third Frontier Advisory Board and served as a trustee for the Medical University of Ohio and the New University of Toledo from 2005 to 2009. I'm active in the Society of Plastics Engineers and the American Chemical Society, and serve on the boards of the Ohio Polymer Strategies Council, the Regional Growth Partnership, the Toledo Symphony, the UT Innovation Enterprise Corp., and the engineering advisory boards for the materials science department at the

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University of Michigan and the College of Engineering at UT. My wife, Betsy, and I have three married children, and I spend my spare time playing the piano, restoring classic cars, and working in my woodshop with my grandchildren.

1970s

Chris Yule '70: I am the president of Yule Development Co. (yuledevelopment.com), a real estate development firm based in Newton Center, Mass., that focuses on energy-efficient commercial rehab projects. Our Abbot Mill project in Westford, Mass., looks like it's finally about to go into its main construction phase. Securing financing has been difficult because of the financial and political climate, but now appears to be coming together via local banks. This will allow the final renovations to take place to convert the historic mill complex to residential housing. During the past three years we have been constructing two levels of parking underneath the existing structure, and also built a tunnel under a part of the building to gain access. This proved to be an extraordinary engineering challenge because of the complex structural issues and also because of the two canals running under the complex, but that work is now complete. (It had to be done before the rest of the work could proceed.) The project also includes one building that will be dismantled and moved across the site. Also, I wrote an article on energy conservation that was published in the *Pittsburgh Post-Gazette* (post-gazette.com/pg/10157/1063246-109.stm.) December 6, 2009, that proposes we consider recycling energy as a means of getting off our addiction to oil. This is done via hybrid vehicles, which are commonly misunderstood as an energy recycling technology. The article mentions Thayer School's Formula Hybrid program as a powerful example of the progress already being made in hybrids.

J.R. Bartlett '72 Th'73: I'm retired now. I currently spend my time totally involved in charitable activities—Habitat for Humanity, teaching life skills to those in need, community leadership, etc. A 180-degree about-face from a career in engineering. I managed to accumulate a sizeable retirement portfolio and now I am driven by two things: the desire to give back, and the God-inspired imperative of the parable of the talents.

Bob Tsigonis '72 Th'73: I am the president and owner of Lifewater Engineering Co. in Fairbanks, Alaska. I started Lifewater as an environmental engineering consulting company in January of 1998. In 1999, some friends asked me to design an above-ground sewage treatment plant for their house on permafrost. They wanted a system that would not put heat into the ground, causing the permafrost to thaw. I designed a system and eventually received U.S. and Canadian patents on it. Lifewater morphed into a manufacturing company that designs and manufactures sewage treatment plants for extremely cold climates and harsh environments. We also offer cold regions engineering consulting and I teach portions of a cold region engineering short course at the University of Washington four times per year. I recently did the conceptual design and guided my small team of engineers and fabricators through detailed design and fabrication of a fun sewage treatment project on Mount Washington, N.H., "home of the world's worst weather." Waste-water treatment has been one of the greatest challenges on the mountain due to a steadily increasing number of summer visitors, large seasonal variations in flow, and the complexities of discharging into a sensitive alpine environment during harsh winter conditions. Now the effluent product is close to drinking water quality and much better for the environment.

Steve Askey '76 Th '77: I'm still with Schlumberger Oilfield Services, after 32 years, as an international accounts manager. I repatriated to Houston in February 2008 after about 10 years in Indonesia. I also came back with an Indonesian wife, the second one for me, after divorcing in 1998. I've been in the technical sales and marketing side of Schlumberger for most of my career, after spending five years as a field engineer working on rigs offshore Gulf of Mexico and a couple of years as an applications development engineer in New Orleans. I'm currently working on a retirement plan, I hope by 2011, with the idea of either working for an operator (the other side of the desk!) or hitting the beach and being a Walmart greeter to keep busy and out of the house (and keep my wife happy). I still play the guitar whenever possible, for sanity now rather than money. The louder the better. Also try to work out, golf, run, etc., although recent rotator cuff surgery has put a damper on that—can't have anything to do with age.

Doug Cogswell '77: I am using my Thayer School skills to lead Advizor Solutions, a well-regarded data discovery and analysis software company that leverages in-memory-data-management and data visualization technology, which I spun out of Bell Labs. Advizor (advizorsolutions.com) is enabling business people to understand their business data without relying on others to prepare data or interpret the results. I live in the Chicago area with my wife, Kim. Our son, Dan, just received his Ph.D. from MIT and is working on advanced battery technology there. Our older daughter, Heather, is in Zambia working on HIV/Aids prevention programs and will attend grad school in public health at Johns Hopkins next year. Our younger daughter, Brenna, is a student at Mount Holyoke.

1980s

Kim Quirk '82 Th'83: I recently moved from the Boston area back to the Upper Valley after 27 years in various high-tech jobs. I started a renewable energy company called the Energy Emporium. The goal of the company is to provide information, demonstrations, products, and support for people who want to decrease their dependence on fossil fuels and their energy use and help take better care of the environment. I have two retail stores and provide full-service sales, installation, and support for solar hot water systems, solar electric, and wind and water turbines as well as energy monitoring devices, LED bulbs, and energy-efficient and sustainable products. My husband and I are renovating an 1860s house into my business and our home (on the upper floors). This will be a zero-net-energy house, which means all of our energy usage for heating or running appliances will be generated onsite from renewable sources. We have built an annual water/sand storage tank that is being heated by thermal solar collectors all summer. It will provide the heat we need next winter. The house will be super-insulated, cutting down the requirement for heat to a lot less than the Energy Star rating for this house. The solar collector will continue to provide some heat in the winter, but most of the heat will come from the stored energy we are putting in there this summer. We will have solar photovoltaic modules on the roof to provide the needed electrical energy. I am blogging about conservation, renewable energy products and ideas, as well as details on the house renovation project at my website, energyemp.com.

Michael Collette '84: I am CEO of Healthy Advice Networks (healthyadvice.com), a provider of patient education programs for physician office and hospital environments.

Sumit Guha Th'88: I will complete 10 years with Intel this year and have a sabbatical planned for next year. I'm

BACK FOR REUNIONS
Left to right, front row: Jim Lyons '50 Th'51, Robert Kirby '50 Th'51 Tu'51, Ward Hindman '65 Th'68, Jerry Boyle '60 Th'61, Duncan Wood '70 Th'71; back row: Chris McConnell '75 Th'76, Ed Keible '65 Th'66, Dave Beattie '65 Th'66, Bob Lichtenwalter '65 Th'66, Peter Gulick '55 Th'59, John Ballard '55 Th'56 Tu'56, Dwight Macomber '70 Th'71.

KATHRYN LOCONTE

an engineering manager in the latest technology node (45nm), and lead two metals process technology groups. I'm about to complete my advanced program management degree from Stanford and am changing my career focus and coming back to Tuck School for executive education this summer. My wife, Aruna, is also an Intel employee, and we have two daughters, 11-year-old Indira and 2-year-old Ishya. Life is hectic. We've lived in New Mexico since 2009. I'm traveling a lot nowadays—Australia, Asia, and Europe in the past few years and Africa planned for 2011. My advice to other Thayer alums: It was awesome going back to Thayer after 19 years and meeting my professors. For those who haven't done it, you should try it.

1990s

Brian Crounse '94 Th'95: I've been appointed to the Concord, Mass., municipal light board. This board oversees the activities of the Concord Municipal Light Plant (concordma.gov/pages/ConcordMA_LightPlant/index), our town electric utility. We're implementing a smart-grid project and looking closely at a megawatt-scale solar installation in town. I was primarily an environmental engineer at Thayer and later at MIT. My day job is still principal at Carlisle & Co., a small supply chain consulting company in Concord, where I've been for a decade.

Vishal Gupta Th'94: I am a vice president at Cisco Systems and have completed two years of a three-year international assignment to Bangalore, India, where Cisco has established a globalization center and its second world headquarters. I lead global delivery of advanced services for Cisco and have established a network of global delivery centers in India, China, Jordan, and Mexico, with almost 700 engineers. I am also incubating innovative healthcare solutions for the East out of Bangalore to enable affordable access to healthcare for all. My family (wife Anjali and daughters Meera and Richa) and I are all having a great time in Bangalore.

Heather Harries Adv'97: I started a medical device consulting company in 2009 and am keeping quite busy! I am now the proud mother of a daughter who is 3 and a son who just turned 1. I live with them and my husband, David, in south Florida.

Andrea "Andi" Korber '98: I'm an architect working in Colorado for Land+Shelter, a cross-disciplinary firm that does planning, development, and architecture. I've been here three years now, working on a mix of commercial, institutional, and residential projects, both new buildings and remodels, and have even been able to develop some renewable energy projects. After Dartmouth I went to design school for an architecture master's at Harvard, which I graduated from in 2002. I have been working since then in architecture. My current job expands the architect title into planner/developer as well, and Land+Shelter is totally connected to the rural community where we're located. We just finished remodeling the old elementary school into a nonprofit center, and I'm renting an art studio space in the building. I love knowing all the players in our projects—the neighbors, the town. We recently completed a super-efficient residential project that we designed and built to LEED-platinum standards. The home includes some pretty incredible geometry and structural moments that sprang from a site concept. We modeled the roof in-house and I worked with the structural engineer to design and size the visible members. It was a moment where my engineering background came in handy in my architectural career.

2000s

Kate Baus Bogumil Th'05: My husband Thomas and I would like to announce the birth of our daughter, Sophie, on May 4, 2010. We are still enjoying life in Germany!

Eric Gruber '07: I start medical school in August at the University of Massachusetts. For the past two years, I've been working in a medical physics lab at Tufts Medical Center in Boston. At the lab, I did R&D work on several portable devices to detect muscle atrophy and elemental deficiencies in aging populations.

Mukta Acharya Th'08: I graduated from the M.E.M. program in December '07. After graduating, I started working with Kaiser Associates, a boutique management consulting firm in Washington, D.C. At Kaiser, I worked on several strategy projects in the technology, telecommunications and manufacturing fields. After almost two years with Kaiser, I am now working with CVS Caremark in their retail strategic product development group. In both my previous and current job, I have been able to put engineering and business concepts that I learned at Dartmouth into practice. For example: I was working on an operational strategy project for a global flour manufacturing company. I was the only engineer in my team and was able to understand and perform in depth analysis around their manufacturing process. At the same time, I was able to apply my business skills to give some recommendations on process improvements to increase efficiency and lower costs. Overall, this project was a success and my Thayer experience and learning played a key role in the final outcome of the project.

Elizabeth Jensen Th'08: I just finished my second year as a Ph.D. candidate in the mechanical and aerospace engineering department at Princeton University. I am working on designing instrumentation for telescopes to take pictures of exoplanets (planets orbiting stars besides our sun). Also, I recently got engaged and will be married next year in Princeton, N.J.

Laura Weyl Th'08: I've repositioned my trajectory since Thayer a number of times from product development to management consulting to AT-Dynamics (a Tuck/Thayer startup) and back to school for structural engineering. I graduated with my M.S. this spring from Stanford and am figuring out my next move. I hope to find something in northern California, allowing me to continue my love affair with the lifestyle here. Between Tahoe, Yosemite, Emigrant Wilderness, Big Basin, Marin, the bay in general, I've found the ultimate playground for non-work time and am not ready to give that up. I'm spending time and in touch with a number of Thayer grads out here (there is a surprising number!). I hope to find a position with an environmentally conscious structural design firm in the bay area before I go broke paying off my student loans!

MORE PHOTOS!
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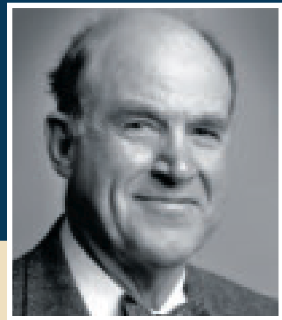
AN EYE FOR THE EYE
Ralph Crump's cold and hot ways for surgeons to treat vision problems include his patented cryosurgical instrument.



inventions

CRYOSURGICAL INSTRUMENTS

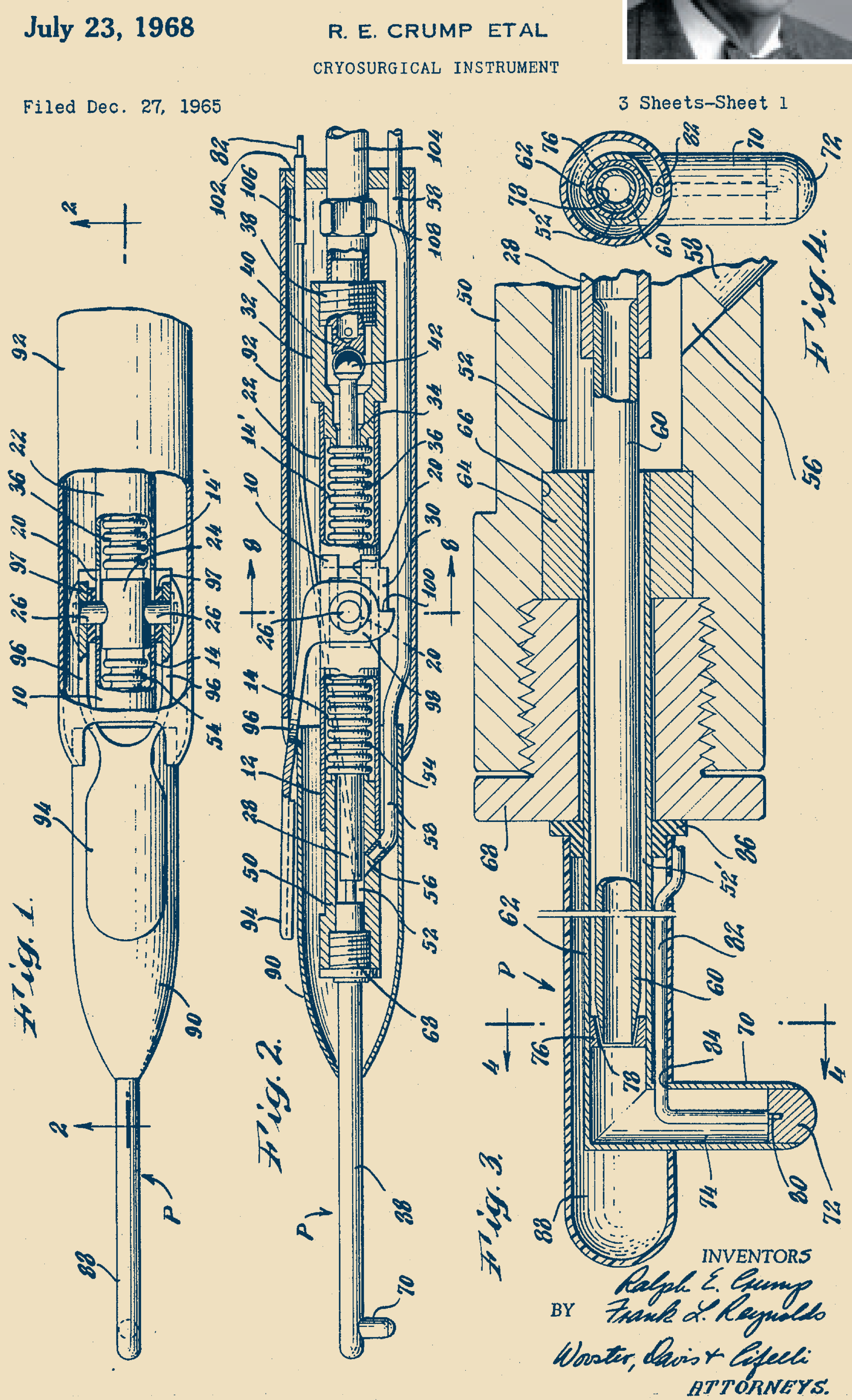
>> INVENTOR:
RALPH E. CRUMP

Ralph Crump, a member of the Thayer Board of Overseers from 1986 to 2009, has long had an eye for the eye. In the 1960s he invented a tiny refrigerator that was, for 16 years, the state-of-the-art technology for cataract removal. The "cryosurgical instrument" that froze and safely removed cataracts was produced by his company, Frigitronics, and was later adapted for other surgical procedures. Frigitronics also invented a soft contact lens originally intended as a drug delivery device. It proved so comfortable that it became a consumer product known as the SoftCon lens.

Crump has been involved with Thayer ever since the 1960s, when Dean Myron Tribus, formerly Crump's teacher and colleague at UCLA, tapped him to help guide entrepreneurial activities. Crump became an avid supporter of the work Professor John Collier '72 Th'77 was doing on orthopedic implants.

Crump also turned an interested eye on grad student Stuart Trembly Th'83. "We discussed treating near-sightedness by application of microwave energy to the cornea," says Trembly, now a Thayer professor. That meeting of the minds led Trembly to start Avedro, a company that offers a less invasive alternative to Lasik. "Avedro," says Trembly, "treated its first patients last spring using the microwave technology that came directly out of the original discussions with Ralph."

—Lee Michaelides



RANDOM WALK

The halls of Thayer turned into a twist car race-course for a final class exercise in ENGS 146: "Computer-Aided Mechanical Engineering Design." Propelled by rotating a steering mechanism from side to side, the cars tested students' design and fabrication skills. With one month from concept to race day, students mocked up wood prototypes, designed digital prototypes using SolidWorks software, fabricated their cars in the machine shop, and then wiggled their way around Thayer to see whose car worked best. The project is about "teamwork, project management, mechanical design, technical communication, and the challenges of reducing theory to practice," says Professor Solomon Diamond '97 Th'98. "Culminating in a fun, competitive, and silly race makes it an engaging and memorable experience." Watch the race by searching "twist cars" at youtube.com/thayerschool.

Photo by Douglas Fraser.

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