

DARTMOUTH

Engineer

THE MAGAZINE OF THAYER SCHOOL OF ENGINEERING

WINTER 2011

VENTURE CAPITALIST
TERRY MCGUIRE TH'82
HAS THE CONNECTIONS AND
VISION THAT HAVE HELPED
BUILD MORE THAN
25 NEW COMPANIES.

NO WONDER
HE'S IN DEMAND.

THE START-UP STAR

- THE NEW GUARD
- PROFS' ENGS 21 FAVES

BROADER HORIZONS

BY DEAN JOSEPH J. HELBLE

FOR MORE THAN 50 YEARS, STUDY ABROAD HAS BEEN AN IMPORTANT component of a Dartmouth education. Dartmouth routinely ranks first among Ivy League institutions in the percentage of students undertaking an international academic experience and has one of the highest levels of participation nationally. More than 60 percent of Dartmouth's class of 2010 earned academic credit for a language or foreign study program, an impressive increase from the slightly more than 50 percent participation levels seen as recently as five years ago.

Perhaps even more impressive is the growing level of participation of engineering students in Dartmouth's international study programs. In the class of 2008 35 percent of engineering A.B. recipients earned academic credit for study abroad. In the class of 2009 the level grew to 41 percent participation; in the class of 2010 it reached 52 percent, approaching the levels seen for Dartmouth as a whole.

In a world increasingly defined by global markets, capital flows, and collaborative scientific and design teams, providing engineering students with opportunities for a substantive international experience is a priority for the Thayer School. Our students have always taken advantage of Dartmouth's language and foreign study programs in arts and sciences, but in recent years we have looked for ways to provide our students with an international *engineering* educational experience. By studying engineering in an international setting, taught by faculty from that country, while sitting in the classroom and working in the laboratory with engineering students from that country, Thayer students are able to experience not just a different culture and language, but a different approach to technology development. This experience will serve them well when they find themselves part of an international project development team at an early stage of their careers.

Since 2001 Thayer students, primarily at the B.E. and master's levels, have been able to study mechanical engineering at Helmut Schmidt University in Hamburg, Germany [see page 4]. In 2008 we added our first formal A.B. engineering exchange program, with Chulalongkorn University in Bangkok, Thailand. Through this exchange, a small group of "Chula" students comes to Hanover each fall to participate in our project-based, hands-on approach to engineering education. A group of Thayer A.B. students then travels to Bangkok each January to spend a semester studying engineering in the structured, lecture-centered format characteristic of engineering education in much of Asia [see "Travelers' Tales," Winter 2010].

We are in the process of adding two new exchange programs for A.B. students. We have sought partner institutions that provide a high-quality engineering education in a region where technology-driven economic growth is of primary importance. In fall 2011 we will initiate our next exchange program in partnership with the Chinese University of Hong Kong. We are working on another such university partnership for 2012 as we look to further develop our strategic focus on Asia and provide a range of international academic opportunities for our students.

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Venture capitalist Terry McGuire Th'82 in Thayer's Jackson Conference Room. Photograph by John Sherman

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Scanning electron microscope image of a snowflake.

Photograph by Ph.D. candidate Si Chen

THE Great Hall

>>NEWS FROM AROUND THAYER SCHOOL

FACULTY

John Collier: N.H. Professor of the Year

THE CARNEGIE FOUNDATION for the Advancement of Teaching and the Council for Advancement and Support of Education (CASE) recently named John Collier '72 Th'77 the 2010 New Hampshire Professor of the Year. Collier was one of 38 state winners selected from more than 300 top professors in the nation.

Collier, Dartmouth's Myron Tribus Professor of Engineering Innovation, received his A.B., B.E., M.E., and D.E. from Dartmouth and has been a member of the engineering faculty since 1979. For three decades he has mentored students in ENGS 21: "Introduction to Engineering," Thayer School's signature undergraduate project-based course (see page 20). He also teaches courses in design methodology, product design, and biomaterials, and advises the Dartmouth Formula Racing team on designing and building hybrid racecars.

At the end of a busy fall term — his ENGS 21 class had more than 70 students — Collier sat down with *Dartmouth Engineer* in his Cummings Hall office to

talk about his approach to teaching. Behind him you can see photos of his students, which he uses to memorize their names.

"I love working with students and student groups to teach them problem-solving. In my view, those skills are one of the key distinguishing characteristics of Thayer graduates," says Collier. "We work really hard at getting students to take a global perspective in solving problems. Teaching those techniques and making sure everyone has picked them up and demonstrated that they have also learned the skills to design and fabricate what they dream about — I've always thought of as my responsibility."

Collier believes that to get a lot out of students, you have to give a lot of yourself. "If you're going to do this effectively, you've got to get to know them. It's important to learn the names of the students and be able to

discuss their efforts in an informal atmosphere. I look for opportunities to show them that I am as invested in the process as they are. I've found that coming into the Couch Lab on Monday and Wednesday nights and working with the students has been very effective. I also encourage those who are interested to come over to the house and play pond hockey, or I mountain bike with them. I try to eliminate the barriers to dialogue and learning and share the hands-on fabrication process. For me that's how I know that what I am doing has some impact," he says. "My hope is that we are providing our students with the tools and strategies they need so that they can achieve their goals, whatever it is they want to make, whatever difference they want to make."

Despite being N.H. Professor of the Year, Collier currently is taking extra advice on teaching from two engineering students who know him well: his sons Tom '11, a senior, and Rob '13, who just finished ENGS 21. "I don't think there's anything more intriguing than having your son or daughter in class. You get direct feedback on what works and what doesn't work: 'Dad, why do you do this, can't you make your notes clearer, why don't you tape the lectures?' So now I tape the lectures and work on the notes," says Collier. "I don't think either of my children hesitates to criticize me. You know you're going to get really honest criticism. They're just going to be blunt. What could be more helpful than that? It's too bad everyone can't get that."



FIRST CLASS
Professor John Collier leads a session of ENGS 21: "Introduction to Engineering."





“We slowly became accepted members of the community as opposed to the pale-skinned ‘freaks’ that made small children cry.”



STOKED Kevin McGregor '11, left, and Ryan Birjoo '11, second from right, introduced Tanzanians to cooking stoves that use coffee husks as fuel.

SERVICE TO HUMANITY

Improving Health in Africa

STUDENTS FROM DARTMOUTH Humanitarian Engineering (DHE) — formerly called Humanitarian Engineering Leadership Projects (HELP) — have implemented a novel cook-stove program to address health and energy needs in Tanzania.

“Most of their cooking is done indoors with a simple three-stone stove,” says DHE president Annie Saunders ’12. But these woodburning stoves have become problematic for health and environmental reasons.

“The Kigoma region was suffering from severe deforestation, which made gathering firewood a time-consuming task,” says Zachary Losordo ’10. “Also, statistics from local health clinics indicated that the incidence of acute respiratory infection, a disease that can be caused by exposure to indoor air pollution, was extremely high in the area.”

The students introduced two alternatives. One is a clay rocket-style stove for the lakeside village of Mwamgongo. The clay stove is easily constructed from local materials and is designed to efficiently burn small amounts of wood. The cooking is done on top of the short insulated “rocket” chimney. The second design is a metal stove that burns wood and coffee husks for the village of Kalinzi in the coffee region.

Students worked closely with community members. “Our process involves training a group to build the stove,” says Losordo. “These individuals will conduct seminars in the subvillages, where they will teach other community members. This chain of knowledge will continue until everyone has access to the technology.”

The approach is producing results. “The stove was widely adopted in Mwamgongo, already reaching approximately 25 percent of families in the community,” says Losordo. “We are confident that the rocket stove will supplant the three-stone stove in the future.”

Overall, the work in Tanzania is promising. “We slowly became accepted members of the community as opposed to the pale-skinned ‘freaks’ that made small children cry,” says Losordo.

Partnering with the Jane Goodall Institute, the students have seen their work spread to 10 other villages. The project has attracted attention beyond Tanzania as well. *Scientific American* has featured DHE blogs at scientificamerican.com/blog/expeditions. (You can also read DHE blogs at tanzaniahelp2010.blogspot.com.)

As for changing the group’s name from HELP to DHE, Saunders says that the organization wanted to reflect the collaborative efforts of engineers and communities. “The acronym HELP implied a certain type of service, a charity,” she explains. “Really there’s an equal partnership and an equal benefit in these projects. We thought that DHE would be a nice change.”

—Kathryn LoConte Lapierre

kudos

» Professor Reza Olfati-Saber, an expert on self-organizing complex systems, has been awarded a Presidential Early Career Award for Scientists and Engineers, the government’s highest such honor. The award will support his research on the next generation of smart cars.

» Professor Solomon Diamond ’97 Th’98 was one of 53 early-career engineering educators chosen to participate in the National Academy of Engineering’s Frontiers of Engineering Education symposium in December in Irvine, Calif. The program focused on ways to ensure that students learn skills necessary to be effective engineers or researchers.

» ICECODE LLC, founded by Professor Victor Petrenko, is one of five innovation award-winners in the 2010 GE Ecomagination Challenge. ICECODE was cited for a technology — using high-power pulses to apply heat from the inside — “that instantly deices wind turbine blades so they never slow or shut down.”

» The GE Ecomagination Challenge named SustainX Inc., founded in 2007 by Dax Kepshire Th’09, Ben Bollinger ’04 Th’04 ’08, and Troy McBride Th’01 with the help of former Thayer Dean Charles Hutchinson, as one of 12 new partners selected for investment by GE “to develop and commercialize technologies vital to helping build the next-generation power grid.”

STUDENT PROJECTS

I Want One of Those!

▼ Hill Breaker

WITH THE HILL BREAKER THERE'S NO NEED to fear longboarding down steep slopes. The Hill Breaker uses centrifugal force to automatically regulate speed. On each front wheel a pair of pivoting brake shoes rotates within a brake drum fixed to the axle. At low speeds the brake shoes are held retracted by springs. As speed increases and the centrifugal force of the brake shoes exceeds the spring force, the brake shoes pivot outwards against the brake drum, generating smooth resistance that increases with speed. Hill Breaker team members Katherine Conway '13, Ethan Dreissigacker '13, Scott Lacy '13, and Christopher Magoon '13 won the Phillip R. Jackson Award for best performance in ENGS 21: "Introduction to Engineering." Their teaching assistant was B.E. candidate Anastasia Milano '10.



FOREIGN STUDY

Germany Exchange is Wunderbar

WITH MORE THAN 60 PERCENT of undergraduates studying overseas, Dartmouth is well known for its foreign study programs. And since 2000, Thayer School Professor Horst Richter has been encouraging advanced undergraduates and graduate students to participate in the Germany Exchange Program he and German colleague Heinrich Kreye established between Thayer School and the Helmut Schmidt University in Hamburg. So far, 13 Dartmouth students, 33 Helmut Schmidt students, and another six from Munich have done the exchange, which includes opportunities for internships.

Christabell Makokha '11, one of the most recent participants, completed an internship at a materials science lab in Hamburg, where she worked with students from Japan and Brazil, as well as Germany. "The lab was so international, and because of that, I learned there was no one way of doing something. Just because I do it one way in the United States doesn't mean they do it that way in Japan," she says.

Focusing on biomedical engineering, Makokha worked on cold-spray technology for using titanium dioxide powder to kill bacteria. "If you spray it onto a surface at the right temperature, the surface will also have

bactericidal activity," she explains. "The problem is that once you spray the powder on a surface, it's gray and dull. You don't want that if you're going to be using it in a hospital, for example. Most people associate being gray and dull with being dirty, and it's just depressing, too. My task was to figure out a way to smooth the surfaces and make them shiny and incorporate color into the powders but still maintain bactericidal activity. We developed our own protocol, and they basically told us, 'Okay, go and work miracles.'"

Doing so in Germany added to the challenge. "You have to navigate life in a completely different culture," says Makokha. "The first few weeks it was scary, thinking I was going to mess everything up. But it challenged me a lot because I was with the Ph.D. students and graduate students who know so much, and because of that I was more motivated. It fortified my desire to become a biomedical engineer."

That's just the kind of insight Richter hoped students would gain from the program. Students need the opportunity to practice their field of engineering to discover if it is a good fit, he says. "Many years back," he recalls, "I had a student who wanted to become a chemical engineer. So we got her an internship at one of the big chemical engineering companies, and after that summer she came back and said that she would do anything, but not chemical engineering. And so I always encourage our students to get a little bit of industrial experience. They need to really find out just what is in a company or how

“You have to navigate life in a completely different culture...it was scary. But it fortified my desire to become a biomedical engineer.”



GOING WITH THE FLOW Christabell Makokha '11, in yellow vest, canoes with other international students in Germany. Professor Heinrich Kreye, in blue, co-founded Thayer's Germany Exchange Program with Thayer Professor Horst Richter.

you work intensely with other engineers inside a research lab.”

German student Christian Busch, a master’s student at Helmut Schmidt University, knows exactly what he wants: to combine automotive engineering with materials science. Most of his work during his exchange experience at Thayer School has been with Professor Douglas Van Citters ’99 Th’03 ’06 and with the Dartmouth Formula Racing (DFR) team. “We have a Formula student team in Germany, but the focus is different from the project I do with the Formula Hybrid racing team here,” says Busch.

His thesis is about the development, testing, and simulation of lightweight carbon fiber parts for the racecar. “At the moment, a lot of parts of the chassis and frame are made out of heavy steel. And the main point is to

improve the weight and the performance ratio of the car,” he says.

Busch’s work with the DFR team appears to be mutually beneficial. He gained experience in a new area of automotive engineering, and he hopes it will give Dartmouth’s racecar an edge at the Formula Hybrid International Competition May 1–4. “The Dartmouth team does not have a lot of experience with these kinds of adhesive connections,” he says. “The Formula Hybrid guys invited me to the competition, which I’m pretty proud of, and I’m excited to see how the part I designed performs.”

Busch found this kind of project work instructive. “In Germany it’s pretty theoretical,” he says. “There are lab classes but no projects until the fifth term. When you’re only working from a theoretical aspect, it’s pretty hard to imagine how something

is going on, how something fits. Here, though, you have to think like an engineer to solve a problem from the beginning. With a project, everything is connected, and you know how to design it, how to calculate all the processes, and how to manufacture it. It’s pretty important for engineers to see the result at the end, to have it in their hands.”

Busch would like to see more Germans study overseas. “A lot of people don’t see the point of going to other colleges if you can work on the same project in Germany. But it’s not only to work on a project. It’s to see the country, to meet new friends, to improve your language or learn new languages. You get in contact with other cultures,” he says. “So I want to promote this exchange program, and not only with Dartmouth, but in general.”

—Kathryn LoConte Lapierre

» Biomedical product development firm Simbex, led by founder and adjunct professor Rick Greenwald Th’88, will partner with Thayer School and the Dartmouth Institute for Health Policy & Clinical Practice to create the Center for Translation of Rehabilitation Engineering Advances and Technology (TREAT). With a \$3.4-million, five-year award from the National Institutes of Health, TREAT will offer technology assessment, intellectual property evaluation, concept prototyping and testing, market evaluation, and clinical trials development for rehabilitation technologies.

» Recent B.E. students Devon Anderson Th’10, Jonathan Guerrette Th’10, and Nathan Niparko ’09 Th’10 earned the second-place, \$5,000 prize in the undergraduate category of the 2010 Collegiate Inventors Competition for the biodegradable surgical sponge they created as a project for Thayer’s design methodology course ENGS 190/290 (now known as ENGS 89/90). The team used a novel combination of materials, including cellulose and alginate, and a novel fabrication method involving electrospinning to create a sponge that, if accidentally left in a patient’s body during surgery, breaks down into harmless substances that can be absorbed by the body. Anderson, now a visiting research assistant at Thayer, and Guerrette, a master’s candidate, are continuing research on the sponge.

» Master’s candidate Lucas Ellis co-chairs the Next Generation Scientists for Biodiesel initiative, formed to increase support for biodiesel among tomorrow’s scientific leaders. Chosen for the position by the National Biodiesel Board, Ellis will help create a forum where students can collaborate and share ideas, including through virtual conferences and Facebook exchanges.

Q&A

Dartmouth President Jim Yong Kim on Engineering

Questions from *Dartmouth Engineer*, students, faculty, and alumni:

What attracted you to engineering as an undergraduate?

I was fascinated by the idea of biomedical engineering, and the biomedical engineering department had given me a scholarship. I did a year and a half of research with professors at the University of Iowa.

Why did you switch fields?

I switched to a double-major in anthropology and biology because I became interested in social issues. I loved my first anthropology class and felt that I would be a mediocre engineering student and a much better anthropology student. More than anything else, I was really passionate about race, culture, and ethnicity and how they related to social justice, so the anthropology major was right in line with those concerns. And I wanted to be a doctor, so I got a degree in biology.

Did you take any engineering perspectives with you?

To this day, I am extremely impressed with the precision and structure that engineering can bring to very complicated problems, not only technical problems, but also human problems. I have always felt that engineers, especially ones who have studied complex systems, have huge contributions to make to the kinds of problems I was concerned about.

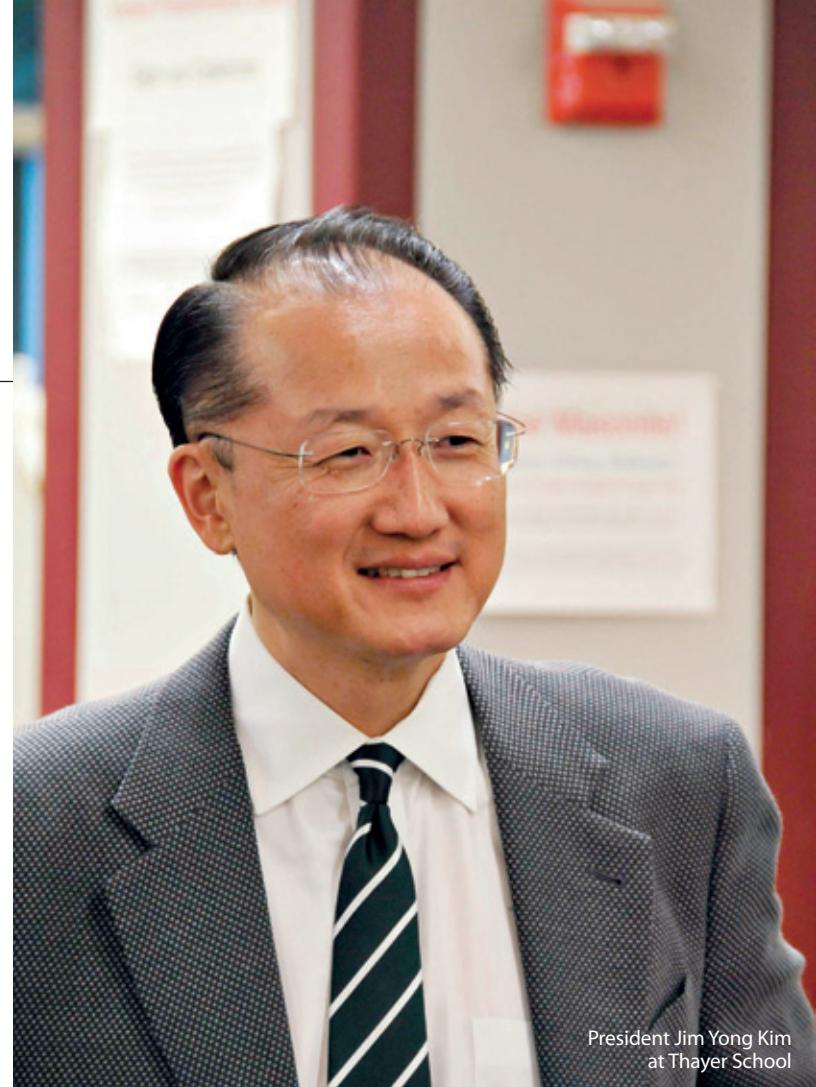
What can physicians and engineers learn from each other?

Both groups can learn a lot from each other, but I'm very interested in what physicians can learn from engineers. And the most important thing that physicians can learn from engineers is to think in terms of systems. By working with engineers, we can bring a rigorous, analytic approach to understanding how something as complicated as healthcare delivery systems work. Physicians and engineers can then use this approach to make systems work better.

How would you like to see physicians and engineers work together to promote global health initiatives?

The potential is enormous. In my view, most of the problems in global health are not about the treatment of individual patients but about the systems that can support wide-ranging and effective healthcare delivery. I think engineers are critical in building those kinds of systems.

Nana Amoah '11 asks: Where do you see Dartmouth and its engin-



President Jim Yong Kim
at Thayer School

eering program on a global scale in the next decade, and what is your plan for taking Dartmouth there?

Thayer is such an important part of Dartmouth. I think that Thayer is in a great position to dramatically increase its impact in areas like healthcare, but in other areas as well. Already Thayer is having an impact on sustainability on campus and around the world. There's a lot of value in having Thayer the size that it is currently, but I would like to explore the possibility of expanding into areas where we know it can have a huge impact and where we can build on synergies that exist throughout Dartmouth College. I would love to see that happen, and I would be willing to help make that happen.

Michael Wood '10 asks: What advice would you give to humanitarian engineering groups to improve interactions

between engineers and non-engineers?

Be patient. Most people that I have worked with in global health and global development don't yet understand the potential impact of engineers and their work. But they will. My prediction is that soon everyone will understand the enormous impact engineers can have on all types of global problems.

Betsy Dain-Owens '10 asks: How important will carbon neutrality and developing sustainable energy sources at Dartmouth be to you during your presidency?

Carbon neutrality and sustainability are very important to me and to Dartmouth. Again, this is another area where engineers and Thayer have enormous potential. I think we're starting to see the impact engineering can have on sustainability and also

TRACKING SPACE WEATHER

Professor Simon Shepherd led the construction of a massive new SuperDARN radar array in Oregon.



on specific initiatives here at Dartmouth.

Professor Elsa Garmire asks: With mobile phones making possible many applications that are revolutionizing medical care in developing countries, do you have any pet applications that you've seen or that you would like to see developed at Thayer School? One of the things I've worked on for more than a decade is the use of electronic medical records to keep track of information on particular people who are suffering from diseases. What we found is that electronic medical records can be implemented with great impact. By bringing electronic medical records to the bedside in villages all over the world, we can keep information on individuals to make them healthier in a way that will leap-frog decades of a lack of technology.

Professor Kofi Odame asks: How do you think Thayer can prepare students to respond to global challenges in general? The most important thing for Thayer students is that they're also Dartmouth College students. I would strongly urge Thayer students, especially undergraduate students, to take full advantage of the breadth of the Dartmouth College liberal arts education. As they're growing and gaining a more sophisticated understanding of quantitative methods and complex systems, they have to realize that no matter where they go or what kind of job they do, they're always going to be dealing with human relationships. I think there's

nothing that prepares people to deal with the complexity of human relationships better than a liberal arts education. While our engineers obtain practical skills, they have to make sure to take demanding courses in the humanities and the social sciences in order to prepare them to take on the challenges that they will eventually face. No matter what you do, you still have to succeed in your relationships with other human beings, and I think there's no question that Dartmouth College's liberal arts education prepares you for that.

Kristina Brock '01 Th'02 asks: Given the hundreds of thousands of engineering students graduating from India and China each year, and the fact that leading technology firms are increasingly looking off-shore for top technology talent, how can we ensure that today's Dartmouth science and engineering graduates are prepared to compete and win? We have to educate these companies on the value of an engineering and liberal arts education. I don't care how technical problems are, it's teams that solve those technical problems. So I want everyone to understand that when you hire a Dartmouth engineering graduate, you're not only getting the quality engineering education, but you're also getting someone who has had the Dartmouth College experience. These are people who are going to be much more successful at managing complex human relationships, and that's a key to success in any line of work.

—Compiled by Elizabeth Kelsey

lab report

NEW RADAR EXPANDS VIEW OF SPACE WEATHER

Predicting the weather isn't easy, but it's a relative snap compared to predicting space weather. But measuring geomagnetic storms and other phenomena involving plasma in the near-Earth environment got a boost from a new pair of radars that a team led by Thayer associate professor Simon Shepherd Adv'98 built last summer on 25 acres near Christmas Valley, Ore.

With 16 transmitters per radar sending up to a kilowatt of radio waves several thousand kilometers away, the radars are the latest addition to the international Super Dual Auroral Radar Network (SuperDARN), a series of radars covering polar latitudes and now expanding into middle latitudes to increase views of electromagnetic activity.

Learning more about plasma, the ionized matter that comprises more than 99 percent of space, goes beyond pure science. "We are interested in space weather because it can have negative effects on society," says Shepherd. "Satellites spend their time in an environment that is extremely variable and not as well understood as we would like. Solar events can disrupt communication with satellites, shorten their lifetimes, or in extreme cases, cause them to fail. If radio or satellite communication with ships or planes is lost, the results could be disastrous."

Geomagnetic storms can wreak other havoc as well, including knocking out electric power and causing corrosion in oil and gas pipelines. "If we could predict when and where these events occur, we would be able to take various protective measures such as rerouting planes and electric power, and putting satellites in 'safe' modes," says Shepherd. "We want to be able to predict space weather, just like terrestrial weather forecasts."

Shepherd's Oregon radars are part of a National Science Foundation-funded collaboration with colleagues at Virginia Tech, the University of Alaska, Fairbanks, and Johns Hopkins University for constructing radars in four mid-latitude locations, with each colleague overseeing at least one of the projects.

Shepherd prefabricated thousands of parts for the radars at Thayer, with help from Vipul Kakkad '13, Matthew Knight '11, and Ph.D. student Ellen Pettigrew Cousins '08. The Thayer team spent several weeks in Oregon working with construction crews to turn those parts into working radars. The first transmission occurred November 25, 2010, Thanksgiving Day.

Shepherd, who continues the work in Oregon, will host a SuperDARN conference at Thayer School May 30–June 3. To view plasma convection images and more radar construction photos, visit engineering.dartmouth.edu/superdarn/gallery.html.



A JUDICIOUS INFLUENCE

At Thayer School Terry McGuire Th'82 chairs the Board of Overseers and helps spur entrepreneurship.

THE START-UP STAR

BY SCOTT KIRSNER

VENTURE CAPITALIST TERRY MCGUIRE TH '82 HAS THE CONNECTIONS AND VISION THAT HAVE HELPED BUILD MORE THAN 25 SUCCESSFUL NEW COMPANIES.

NO WONDER SO MANY ENTREPRENEURS WOULDN'T DREAM OF LAUNCHING A BUSINESS WITHOUT HIM.

IN A CONFERENCE ROOM AT HIS SUBURBAN BOSTON OFFICE, VENTURE CAPITALIST **TERRY MCGUIRE TH'82 SITS DOWN**

across from an entrepreneur whom he is meeting for the first time. Within a few minutes, they are discussing Wolf Blitzer and beef-on-weck sandwiches.

The sandwich — roast beef piled atop a seedy, salty roll — is a delicacy in Buffalo, where both McGuire and the entrepreneur, Ronald Dozoretz, were born. (Blitzer, the CNN anchor, hails from Buffalo, too.) Every initial meeting between a venture capitalist and an entrepreneur pitching a new business idea is a kind of courtship ritual: Is there mutual interest, and if so, who has the upper hand? McGuire has sat through hundreds of these encounters. Dressed casually in khakis, a blue button-down shirt, fleece vest, and black clogs, McGuire doesn't strain to impress Dozoretz or a colleague accompanying him. He's mainly in listening mode.

McGuire, who co-founded Polaris Venture Partners in 1996, doesn't need to be overly eager. His firm has raised more than \$3.5 billion to invest in promising companies. He has backed start-ups including Akamai Technologies (one of the most successful public stock offerings of the dot-com era, and today worth nearly \$10 billion) and the Dartmouth spin-out GlycoFi, acquired by pharmaceutical giant Merck for \$400 million. He has been working in the venture capital field since 1984 and recently wrapped up a stint as chairman of the National Venture Capital Association. He's a regular recipient of calls from top academic researchers interested in forming new companies around their latest breakthroughs. And far more often than he decides to pull out his firm's checkbook, he calls an entrepreneur after the initial meeting to say that the opportunity just isn't right for Polaris. "Hopefully, I'll read about you in *The Wall Street Journal* someday," he often says, "and I'll be the first to raise a toast to you."

Dozoretz has started and sold several successful healthcare businesses, and he's here to talk with McGuire about his latest project, Genomind, which aims to use genetic information about a patient, obtained from a saliva sample, to help psychiatrists better prescribe antidepressant drugs. He's looking for about \$5 million of funding.

The job of a venture capitalist is a mix of tal-

ent scout, thoroughbred handicapper, wise uncle, pinch hitter, and, occasionally, axe-wielder. Venture capitalists collect money from wealthy individuals, university endowments, and pension funds that they invest in a collection of fledgling companies. By picking the right ideas, markets, and teams — and trying to guide them as a member of the board of directors — their aim is to build a company that can go public or be acquired by a more established player, usually within a decade of their initial investment. Venture capital firms survive by taking an annual fee on the money they manage (usually about 2 percent), and also pocketing 20 percent of any profits that their investments yield. (The other 80 percent goes to the investors who have bankrolled them.) Venture capitalists such as McGuire are sometimes called upon to help their start-ups recruit key employees, forge relationships with important partners, and, on occasion, fire a CEO who isn't working out or pull the plug on a company that isn't making progress fast enough.

McGuire himself had only had one brief job at a start-up company after earning his master's degree from Thayer. He spent about two years at a Boston-area company that was developing computer simulations to test out different corporate strategy scenarios. A few years later, while earning his M.B.A. at Harvard Business School, he landed a summer job at American Research & Development, generally regarded as the very first venture capital firm. "The appeal of venture capital, for me, was being able to work with lots of different companies," he says. He currently serves on the boards of directors of 10 companies in the life sciences and energy industries, all but one of them still privately held.

For McGuire, there have been two key components to his success. One is a network of contacts who can introduce him to promising entrepreneurs and academic researchers. The other is a collection of scientific, technical, and business themes he feels will be important in the next decade or two, which serve as a lens through which he views potential investments (see sidebar).

McGuire says that he has funded and helped build more than 25 start-up companies in collaboration with researchers at MIT, Dart-

mouth, and the Scripps Research Institute. GlycoFi, which sought to control the sugars on the surface of a protein in order to produce better biotech drugs, was among that group, as was Momenta Pharmaceuticals (now publicly traded) and Sirtris Pharmaceuticals, a company that sought to commercialize research on anti-aging mechanisms done at Harvard and MIT. Sirtris was acquired by GlaxoSmithKline for \$720 million, even though its drugs are still wending their way through clinical trials.

"Based on seeing many, many things being done in research labs, Terry has a sense of what's good and what has potential," says Robert Langer, head of a lab at MIT that is best known for developing polymer-based systems for drug delivery. "It ultimately comes down to a judgment call of what's just a laboratory project and what's big science and good intellectual property that isn't too far off."

One of McGuire's latest investments, SustainX, certainly qualifies as "big science." Based in West Lebanon, N.H., the Dartmouth spin-out is designing a system that can store energy as compressed air. "Renewable generation technologies like wind or solar are intermittent, so you need to store the energy somewhere if there's not immediate demand," McGuire says. "And we think using compressed air has a lot of advantages over batteries," such as lower cost. The company was co-founded by Charles Hutchinson, Thayer dean emeritus, and three Thayer alumni, Dax Kepshire '07 Th'09, Ben Bollinger '04 Th'04, and Troy McBride Th'01.

"Terry has built relationships with researchers to the point where neither Bob Langer nor I would ever think about taking an idea forward without taking it to him first," says Hutchinson. "He has committed himself to establishing those networks of people, who in turn help connect him to other professors and students." As for McGuire's passion for commercializing academic research — which is not universally shared among other venture capitalists — Hutchinson says, "For him, I think it's a very straightforward analysis of why he does it this way, namely that it makes money, which is his world."

But McGuire says there are challenges in trying to pluck the best ideas from university campuses. "At some universities, there is a feel-



ing that commercializing an idea might taint great research,” he says. “But others see start-ups as a mechanism to get great research out into the world. Still, I think too few universities actively celebrate entrepreneurship.” (He says his continuing involvement with Thayer, where he currently chairs the Board of Overseers, was triggered by the school’s interest in spurring more entrepreneurial activity.) And some professors, he says, simply view venture capital money as another source of research funding. That’s a danger when an idea may not necessarily be maturing fast enough to become a marketable product or service, but its originator is reluctant to acknowledge that. “The attitude can be, just keep sending those checks,” McGuire says.

McGuire’s past investments have already begun to shift the way that medicine is practiced and drugs are delivered. One company, Advanced Inhalation Research, developed new ways of making drugs inhalable that could previously only be injected. Another, Remon Medical, designed a tiny implantable sensor to monitor diseases such as congestive heart failure from inside the body and wirelessly transmit the information to doctors. The company deCODE Genetics created a vast library of genetic data and is using that to develop new tests that could diagnose diseases earlier.

“He sees where things can go,” says John Santini, co-founder of a Polaris-backed company called MicroCHIPS. The Boston-area start-up is developing a small implantable chip that can either perform sensing of a disease state inside the body or dispense regulated doses of a drug. Within a few days of the first meeting Santini had with McGuire, McGuire sent over the paperwork for Polaris’ initial \$250,000 investment in the company. “As an investor, Terry doesn’t feel like he needs to be in the weeds of technical details. I think he puts a high degree of trust in the people running the company,” says Santini. McGuire says his strategy is to start with small investments to help a company get to its first “proof point,” followed by more money if things are working out well.

McGuire isn’t a self-promoter by nature. He doesn’t maintain a blog or use Twitter. “He avoids publicity,” says Bob Metcalfe, an entrepreneur and Polaris partner who recently

MONEY SMARTS

VENTURE CAPITALIST TERRY MCGUIRE’S GUIDE TO INITIATIVES WORTH FUNDING

Reducing healthcare costs. The amount we spend on healthcare is climbing faster than other parts of the economy, so I look for opportunities to take costs out of the system.

Home healthcare services. If people are going to live to be 100, how do you keep them from spending those last 15 years in and out of hospitals?

Regenerative medicine, such as the potential for stem cells to grow new tissue or organs that can be transplanted into patients.

Personalized medicine: delivering the drugs and treatments that will work best for a given patient based on the individual’s genetic make-up.

New approaches to producing and distributing energy represent an enormous opportunity. It’s huge, which is the good news and the bad news. Shifting the United States from its reliance on fossil fuels will be a project comparable to the Marshall Plan after World War II. It needs to be a substantial commitment, driven by industry and government.

joined the faculty of the University of Texas. “He doesn’t think that’s important.” More important to McGuire, perhaps, is a good cup of coffee in the morning. At home and in his office, he has a Bezzera espresso maker, and Metcalfe says that McGuire has imparted some of his cappuccino-making techniques, “like holding your hand on the metal milk pot so you can tell how hot it is.”

Metcalfe describes McGuire as “magnanimous and articulate and open with praise,” but

says he’s not afraid of making the tough decision. “It’s interesting to watch the switch flick, from nodding and smiling and listening carefully, to saying, ‘No, we’re not going to do that, we’re going to do this.’”

“He’s very straight with people,” says Langer, the MIT professor. “I’ve certainly seen him let people go or be dissatisfied or feel that things could’ve gone better — and he’s not hesitant to tell people.” But Langer also says McGuire is quick to roll up his sleeves. With Advanced Inhalation Research, McGuire helped the company forge partnerships with Eli Lilly, Pfizer, and GlaxoSmithKline. “He’d fly in with us and go to meetings and get the deals,” Langer says, adding that McGuire eventually helped sell the company to Alkermes, a publicly traded drug developer.

In Polaris’ conference room on a cloudy Monday morning, Dozoretz, the Genomind founder, is trying to persuade McGuire that his start-up could be Polaris’ next big hit. “We will change psychiatry around the world,” he says. “No one will order an antidepressant without getting a couple hundred dollar sputum test done on their patient.” McGuire asks a string of questions about the company’s potential competition, its business model, and the way psychiatrists and pharmaceutical makers might regard genetic tests.

After a little more than an hour, McGuire thanks him for coming, and says, “Let me talk to my guys.” It isn’t yet clear whether McGuire considers Dozoretz’s concept worthy of Polaris’ backing.

“You try to make the most educated decision you can possibly make about whether to invest or not,” McGuire says, sitting in his office after the initial meeting with Genomind. “No one bats a thousand. Not every company we touch will work out. But the fun part is that oftentimes we’re dealing with industry segments that are just being born, and technology that is rapidly changing. And with life sciences companies, when we do our jobs right, we can actually change people’s lives.”

Scott Kirsner writes the “Innovation Economy” column for *The Boston Globe*. He can be reached at sk@scottkirsner.com

The New



MARGARET ACKERMAN

I was inspired to become an engineer because engineers do things that matter. The driving force behind engineering is applying knowledge. If you know the rules by which a system operates, you open the possibility of productively manipulating the system. You can take information and use it to have an impact on human life and health.

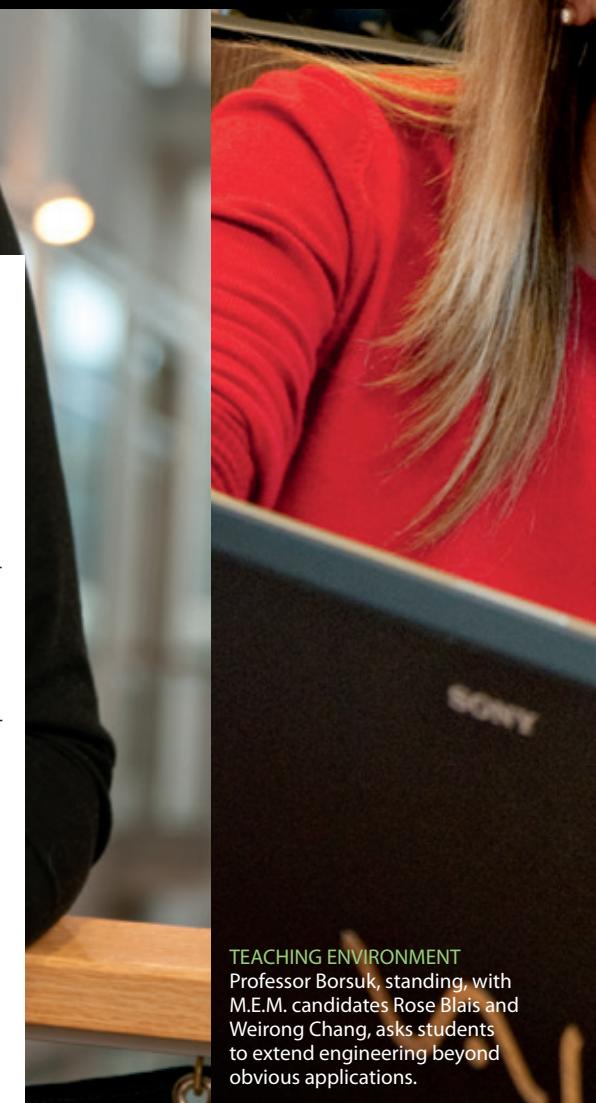
I'm working on applying protein engineering methods and tools to studying the immune system in order to make novel protein drugs and vaccines. Historically, we haven't gone about treating disease in the same way the body does naturally. We've been using small-molecule drugs, but the body primarily uses peptides, proteins, and cells to combat disease. Even after extensive research, some of the worst diseases — HIV, malaria, tuberculosis — have either no vaccines available or vaccines that are not effective enough. Now that we have the tools to manipulate proteins and cells in the same way we have manipulated small molecules in the past, there's a great opportunity to use this progress to fuel molecular engineering-based advances in therapeutics.

We need better models of the immune system. Immunology has been largely phenomenological rather than intuitive and predictable be-

cause we don't understand enough about the components and workings of the biological networks of the immune system. The simple assays that work for testing the responses of single cells can't be easily applied to the immune system, which is a complex network of hundreds of different cell types — often interacting with each other as well as pathogens. Unfortunately, even animal models don't provide the kind of information we really need because they have divergent immune systems. Biologists are making much more rapid advances in this area, including working toward "humanizing" the immune system of mice and more efficiently collecting information from individuals with natural exposure to disease. These advances will enable biologists to figure out what knobs we can turn in order to influence the immune response. Once we know what responses are protective, engineers can design therapies to trigger those responses.

I enjoy teaching engineering because it's an applied science. You teach rules that make the behavior of the world around you predictable, and allow students to use those rules to solve real problems.

THAYER'S EIGHT NEW TENURE-TRACK ASSISTANT PROFESSORS WILL INFLUENCE THE NEXT FEW GENERATIONS OF STUDENTS. HERE'S A LOOK AT WHY THESE PROFS BECAME ENGINEERS, THE GRAND CHALLENGES THEY'RE TRYING TO SOLVE, AND HOW THEY SEE THEIR ROLE AS TEACHERS.



TEACHING ENVIRONMENT
Professor Borsuk, standing, with M.E.M. candidates Rose Blais and Weirong Chang, asks students to extend engineering beyond obvious applications.

W Guard



MARK BORSUK ➤

I have always been a rather logical and quantitative person, and yet never really a "techie." Rather than inventing or building things, I was more interested in exploring the natural world and our relationship with it. For example, I wondered why some kids would prefer going to the mall rather than going on a hike, why some families traveled to Disney World for vacation and others to national parks, why the plot of land at the end of the street was now more valuable as a parking lot than as the forest and farmland it used to be. In college I learned that I could combine my analytic problem-solving skills with my interest in the natural environment by studying environmental engineering.

Reconciling society's development goals with the limitations of the Earth is a challenge that will never be fully resolved. I'm working to understand this challenge by studying the interacting roles of human values, knowledge, governance, and technology in our management of the environment, particularly with regard to climate change. I think that solutions to the complex environmental problems we face as a society will not come in the form of a centrally planned silver bullet, but rather will emerge from a messy collection of policies, incentives, and technologies implemented at multiple scales. We need models and decision-support tools that can help us understand, anticipate, and exploit such emergent behavior.

I enjoy teaching how to apply an engineering way of thinking to problems that may not obviously be engineering problems. This may mean applying systems analysis to healthcare delivery, risk assessment to product design and marketing, or agent-based modeling to climate policy. Students seem to appreciate this approach, especially at Thayer, where they have a multidisciplinary and "big picture" perspective.





SOLomon Diamond '97 TH'98

In my heart of hearts, I've been an engineer since I was born. There was no point when I decided that I wanted to be an engineer; it just was a process of discovering that engineering is who I am. When I was a really young boy, I considered myself an inventor and used to spend a lot of time tinkering, building, and inventing different toys and gadgets. There were strings running all over my room, where you could pull the string, turn the light on or off, or pull another string to open the door. I had my dresser hooked up with cables as well, and I made my own little dumbwaiter to go up and down the stairs.

I realized that engineering was a tool that could really do a lot of good in the world, and I decided to pursue biomedical engineering. It started with an interest in rehabilitation engineering and assistive devices and evolved into an interest in the brain and neuroscience.

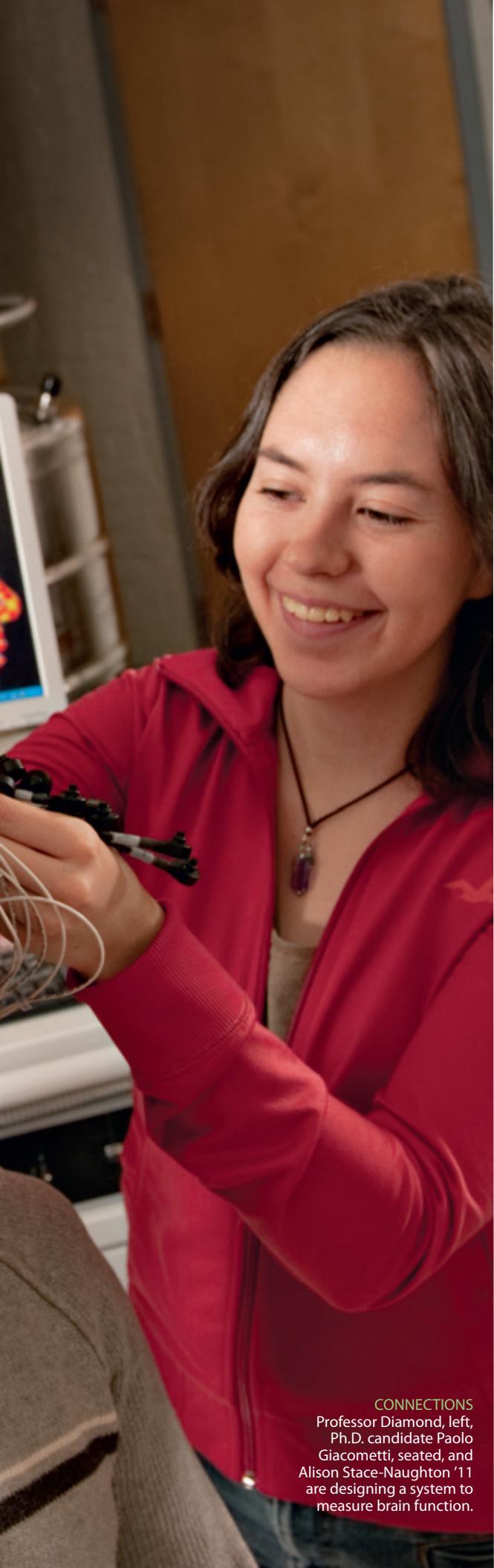
The grand challenge that I'm working on is to develop better non-invasive technologies for imaging human brain function. I see neuroimaging advancing to the point where a number of key research areas start to deliver on their long-term promises, including neuro-diagnostics for Alzheimer's disease and using neuroimaging to effectively monitor recovery after stroke. Physical therapy is still more of an art than a science, and I think until we're able to see what's happening in the brain during the therapeutics, it's hard to know if what we're doing is truly optimal. I'd



like to see neuroimaging cross that threshold where it becomes a driver of better diagnostics, better treatment, and better medicine.

There is this tangible excitement in the air that I feel when teaching. It invigorates me. I think it's a reciprocal experience between the students and me — a real synergistic energy. That's what I thrive on here at Thayer. There's a certain amount of rigor and content that must be communicated clearly and understood so that students are advancing knowledge rather than reinventing the wheel during their careers. But the part that's most fun for me is walking into the unknown with the students — we tackle design problems for which I don't know the answer, and we discover solutions together.





CONNECTIONS
Professor Diamond, left,
Ph.D. candidate Paolo
Giacometti, seated, and
Alison Stace-Naughton '11
are designing a system to
measure brain function.



SPHERES OF INFLUENCE
Professor Griswold, left,
works with Ph.D.
candidate John Lamppa
on protein therapeutics.

KARL GRISWOLD

My formal training is in chemistry and biochemistry. What inspired me to dive into engineering was seeing how powerful biomolecules are in their native environment and envisioning what might be accomplished if you could tap into that level of performance in solving practical real-world problems. We take proteins out of their natural context and use them to solve problems that may or may not relate to the tasks for which they originally evolved. The amazing functionality of biomolecules provides the capacity to revolutionize a huge variety of practical applications.

One of the things I love about biomolecular engineering is that it has the potential to impact virtually any field. My research group is currently focused on potential medical applications of proteins and how they can be used as therapeutic agents. For example, we're interested in the emergence and spread of drug resistance among bacterial pathogens. Drug resistance is a subject with which almost everyone is familiar. If you asked someone on the street, they've likely heard of antibiotic resistance and even the controversy about whether or not antibiotics should be put in hand soap (I think that's a bad idea). My lab is working to develop new antibacterial proteins with the ability to combat drug-resistant infections.

It would be wonderful if the field of protein engineering could generate solutions to the big medical issues that are facing the world. I *hope* that over the next 10 years protein engineering might develop cures for a broad spectrum of cancers, cures for diseases such as multiple sclerosis, and even reagents that allow us to effectively treat drug-resistant bacterial infections while reducing the tendency for those bacteria to rapidly evolve resistance. But even with the amazing rate of innovation, progress is still slow. So what I *expect* to happen over the next 10 years is that protein therapeutics are going to make further inroads in areas such as cancer diagnostics and cancer therapy where they're already having an impact. Ultimately, engineered proteins will help reshape the treatment of many other diseases as well.

Academics and teachers have the capacity to exponentially amplify their ability to impact society by virtue of the fact that when you become a teacher, you're no longer a one-person team. For the vast majority of people, the greater impact of an individual's career in science, technology, and engineering may be less about what you yourself accomplish and more about what is accomplished by the people who study under you. I very much hope that my own research will someday make its way into the clinic and be used to treat patients. If my group doesn't generate a cure for cancer or a treatment for drug-resistant pathogens, however, my expectation is that someone I interact with at Thayer might continue on and do so as part of his or her own career.

JIFENG LIU >

I want to apply science to our everyday life, explore the world, and understand the rules of nature. Engineers experiment with these rules to benefit humankind. It's just like playing chess, but you don't know the rules at the beginning. Scientists try to find out the rules, but it's engineers who apply the rules and become good players for the benefit of everyone.

There are two aspects and goals in my research: One is to produce renewable energy, and the other is to try to reduce the energy consumption of information technology. We hope that with our research we can produce solar cells that are less expensive and more efficient so that they can be deployed widely in the world to offset the consumption of fossil fuels.

Few people realize how much energy is consumed in the information industry since the invention of computers and the Internet. The Internet is one of the fastest growing technologies in the information age. The data flow on the Internet is growing by 40 percent per year, which basically doubles every two years. I'm trying to apply photonic technology to information technology to reduce the overall energy consumption. This would make information technology more sustainable, what some people refer to as green IT.

Teaching is not just about giving information to students; it's actually a great motivation to do some rethinking. A smart student can ask you very interesting questions, so you better be prepared for those and really start to look into all aspects of your own learning. Sometimes we can get some new ideas from such thinking. My personal style is to help students think about themselves as explorers and innovators. We engineers want more people to understand the importance of engineering and science to society. The more people we educate, the more we influence the world.



REZA OLFATI-SABER

My dad influenced me to become an engineer since I was a little boy. He was head of my hometown's telecommunications department in Iran. He used to take me to the central part of the phone company back in late 70s, when everything was still electromechanical and you could see 10,000 selectors moving in one large room. Later he bought me all the elements of a basic circuit so I could connect the battery to a motor and to a light bulb and turn that on. And on paper he showed me the flow of currents that goes through the circuit. At the time, these were all games to me, but I think he was trying to get me interested in electrical engineering. He succeeded.

During my postdoc at Caltech I tried to understand how birds flock. The lessons I learned

from observing and modeling them allowed me to understand the fundamental problems involving design and how to analyze thousands or millions of interacting elements.

One of my main objectives is to come up with the first intelligent transportation system. Cars don't necessarily need drivers. They could move autonomously. You could use your car in an autonomous mode in which you basically give it a GPS destination and the car gets you there without colliding with other cars or pedestrians or getting lost or going through unusually long routes. It could avoid traffic, take shortcuts, and do all sorts of things you might not actually know about because you don't know the congestion in other parts of the city. You could use the car in fully manual mode or semi-autonomous mode, where you just pick the speed or your favorite lane on the highway and leave the rest of the driving decisions to the car.

If most of us began to use these automated cars, we could create a much safer transportation system that is not prone to the human mistakes. In five to 10 years this could be an automatic feature on luxury cars. In 15 to 20 years it could be on all cars.

It's challenging to teach any kind of engineering class when all the students don't have the same interest. Some of them like the science part more, some of them like the building more. The majority of the students at Dartmouth are very hands-on. They could essentially build just about anything they want.



INTERACTIONS

Left to right, Ph.D. candidates Parisa Jalalkamali and Dingkun Du, Professor Olfati-Saber, and M.S. candidate Peng Wang Th'08 discuss miniature mobile robots.



KOFI ODAME

I've always been creative. As a child I liked to paint and draw a lot, and then as I went through school it turned out that I had an affinity for solving analytical problems. Engineering turned out to be a very nice blend between creativity and solving analytical problems.

I'm very interested in health and in artificial intelligence. I'm looking at the way our neural systems work and applying that to engineering and to a more potent artificial intelligence. The idea is to have extremely intelligent computers that are very power-efficient and yet very small. One of my current projects has to do with a cochlear implant that is controlled by the brain's electric signals. The idea is to have electrodes that are sitting on a patient's skull record EEG signals, and decipher these signals to determine what the patient wants to hear.

My vision is to create sophisticated yet cheap electronic intelligence that can fit in the palm of your hand. Such technology could enable a more decentralized model of healthcare delivery, which would allay the rising cost of health care in the United States. Even more critically, decentralized healthcare delivery might present the only practicable option in remote parts of the developing world. Imagine computational ability that is so cheaply available that a nurse in a village in Ghana can input a blood film to an "intelligent" camera phone, which then makes a preliminary diagnosis of malaria or some type of hematological condition.

Engineering is a discipline that deals with a lot of balance and a lot of trade-offs. Given a particular problem, there is no one absolutely correct solution. Each solution to any given problem has its own positives and negatives, and when you consider any solution, you need to carefully go through the list of all the different advantages and disadvantages of that solution. Teaching engineering forces you to go through this process methodically because you're trying to convince a class of students that one solution versus another is better. When you go through this process, you can come up with better solutions — or your students can come up with better solutions.

PROBLEM SOLVERS

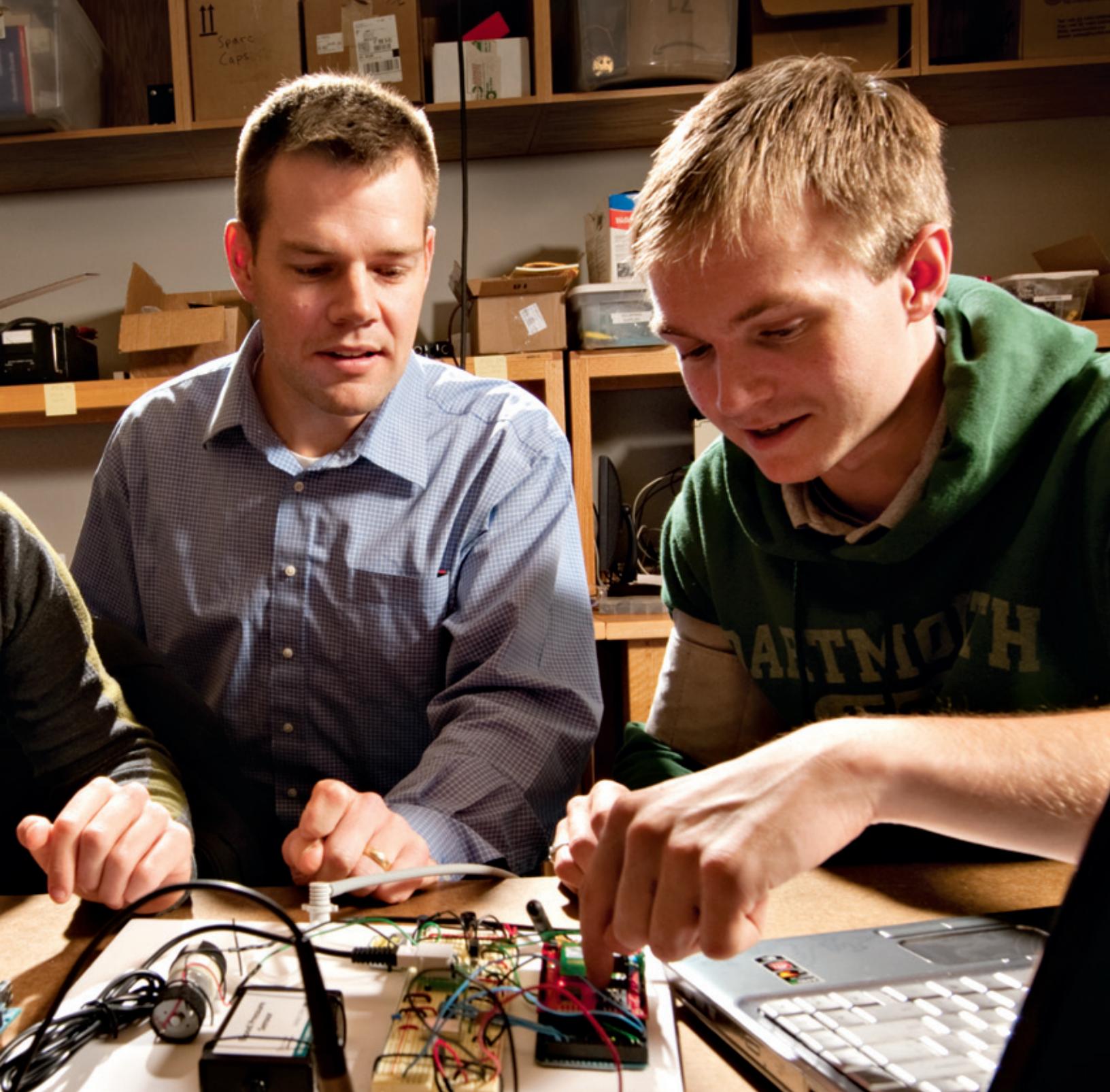
BELOW: Professor Van Citters examines a wireless blood pressure monitoring system that B.E. candidates Jeff Spielberg '10, left, and Adam Strom '10, right, are designing.
LEFT: Professor Odame, right, with Andrew Ceballos '12.



DOUGLAS VAN CITTERS '99 TH'03 '06

I always liked to take things apart — it was part of my nature. In preschool I took apart the telephone and nobody knew about it until I showed up with all the pieces. In elementary school I was doing mechanic work with my father. In high school I started doing my own mechanic work. I loved seeing how things worked and started developing some of my own — I hesitate to call them inventions — but they were solutions. When it was suggested that I explore engineering as a major in college, I jumped on it. But it wasn't really until ENGS 21 with Professor John Collier that I figured out what engineering really was.

I'm trying to decrease the cost of healthcare and increase its efficacy in the field of artificial joints in orthopedics. I'm starting with artificial knees. There are currently roughly one million artificial knees and hips being implanted annually in the United States, and 10 percent of those are for failed joints. I'm trying to examine the failures and determine why they failed and what we can do to improve the materials and design. It's all very materials-driven at this point. If we can understand the chemistry and the mechanical or wear mechanisms of these devices, we can then understand the failure mechanisms and



perhaps improve overall outcomes for patients. My dream is a commoditized artificial knee. I'm not so naive to think that there will be a one-size-fits-all, one-size-works-for-all, but it would be wonderful if we could have a small selection of devices that worked for the vast majority of patients. In the next 10 years, as we try to address the demands of the growing population, I don't think we are going to have enough surgeons to accommodate the need for artificial joints. Further, I don't know if society can bear

the financial burden; it's a very expensive surgery. If a device is developed with appropriate but inexpensive materials, and you can decrease implantation time, cost savings will follow. You could improve access to the procedure, ensure a positive outcome for the patient, and hopefully, you would decrease the financial burden on the individual and society.

The thing that's most fun about teaching is doing the problem solving day in and day out. I teach students how to solve problems effi-

ciently. I rarely give them answers — that's not my job. I really love to walk them through the problem-solving process and show them how to use science and math to better society. The enjoyment is watching somebody actually understand what's really important and what's fun about engineering.

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

A PROFESSORIAL
PICK OF
OUTSTANDING

ENGS 21



HANDS ON

Left to right, Chloe Ruiz-Funes '13, Alan Salas '13, Yuan Shangguan '13, and Philip Royer '13 assemble robot parts they made during orientation to ENGS 21.

PROJECTS



BY KAREN ENDICOTT

PHOTOGRAPH BY DOUGLAS FRASER

FOR DECADES THAYER SCHOOL'S "INTRODUCTION to Engineering" course has been a favorite with students — engineering majors and non-majors alike. That's because ENGS 21 (a.k.a. ES 21) isn't just any intro course. In 1961 Professor Robert Dean, now a veteran entrepreneur and an adjunct professor, turned a three-year-old course about the theoretical foundations of engineering into a hands-on experience of doing engineering. Continuing to evolve over the years, ENGS 21 gives students the means to design solutions to real-world challenges, build working prototypes, develop business plans, and present results to a professional review board.

"The goal is to give students a set of skills that allows them to tackle a problem and an opportunity to work in a group," says Professor John Collier '72 Th'77, who first taught the course in 1984.

Before taking ENGS 21, many students have never even drilled a hole. "At the end of term every student knows how to use a lathe, milling machine, band saw, drill press, use hand tools, solder wires, build circuits, and do CAD, and a lot of them have done rapid prototyping as well," says Collier. "You've taken students who have an interest in building things and set it up so they have the skills to do it."

The group experience magnifies the effect. "The sum of what a team is able to learn and do is greater than what any one individual is able to do," says Collier.

The results have led to patentable and marketable products. Dean Spatz '66 Th'67 co-founded the company Osmonics based on his ENGS 21 work (see "Inventions," page 32). An innovative 2004 ENGS 21 project called the Gyro-bike won a *Popular Mechanics* Breakthrough Award in 2006 and is now for sale at thegyrobike.com. Other great ENGS 21 ideas with commercial potential have fallen by the proverbial

wayside as students move on to other interests.

Choosing favorites from the many projects students have done over the year doesn't come easily for Collier or the other faculty members who rotate teaching ENGS 21, Professors William Lotko and Ian Baker.

"It's hard to select one or a few because I love all of my children the same," says Lotko. "My faves are as much — maybe more — about the teams' process as the widget."

"They're all really good projects, and the students learn a ton," Collier says. "When I pick projects that are impressive to me, it's where the group came together and worked effectively

and where they were able to demonstrate a whole bunch of skills. Part of what appeals to me is the students who get so caught up in what they're doing, they're determined to make it succeed even though it takes an enormous amount of time and energy for that to happen."

But what impresses Collier the most is the lasting effect of the course. "The thing that is so stunning is if you go back 30 years and you ask students what their ES 21 project was, they can tell you what it was and most can tell you who was on their team. I don't know anyone who doesn't remember what their ES 21 project was."

For the record, Collier recalls his own: "Carl

Long was our faculty advisor, and Russell Stearns was running the course. The topic was something like improving living conditions for migrant workers. Our project was being able to reconfigure the inside of a room. We wanted to make wall panels that would snap together and press against the ceiling and floor and have power in them so that you could reconfigure a room. It was pretty simple back then, but I still remember doing it."

Read on to see a few of the projects Collier, Lotko, and Professor Peter Robbie, a frequent faculty collaborator in ENGS 21, can't help but admire.

A FEW OF OUR FAVORITE THINGS

PROFESSOR JOHN COLLIER • PROFESSOR PETER ROBBIE • PROFESSOR WILLIAM LOTKO



GYROBIKE

Students: Left to right above, Hannah Murnen '06 Th'07, Deborah Sperling '06 Th'07, Nathan Sigworth '07, Augusta Niles '07 Th'08

What It Is: a bike stabilizer so beginners can learn to ride without having to use training wheels

WHY IT'S A FAVE:

Collier: Here were four students who knew nothing about how to build anything at the start, yet they enjoyed each other's company tremendously and they supported each other and developed considerable fabrication skills. They

tackled something they knew very little about, worked well as a team, were determined to succeed, and actually demonstrated the effectiveness of their device by teaching several children of Thayer staff how to ride a bike in an afternoon.

Robbie: The group's key insight came from empathy with childhood fears about learning to ride a bike. Training wheels don't teach kids how to lean and steer into turns. The Gyrobike lets them do just that. The students patented the Gyrobike and started a company [now run by CEO Daniella Reichstetter Tu'07].

BOAT TRAILER

Students: Left to right below, Eric Fitz Th'05, Monica Thomas Th'05, Peter Rice Th'06, David Fouche Th'05, Spencer Boice Th'05

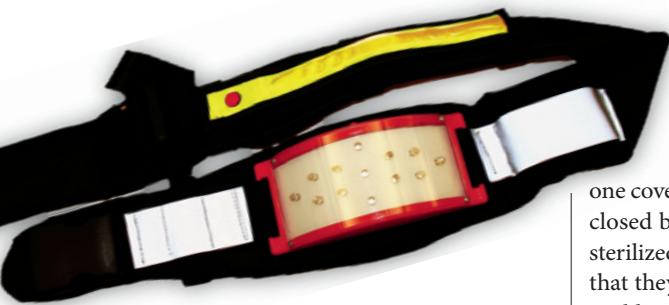
What It Is: retractable "landing gear" for boats

WHY IT'S A FAVE:

Collier: This group of dual-degree students from Colby was determined to make a full-sized, functional prototype of a boat that had wheels that were like the landing gear of a plane. When approaching shore, the push of a button would electrically lower the wheels. A tongue would be connected to the front of the boat and to a vehicle and one could then tow the boat right out of the water with no trailer, so there's nothing to store on shore. The boat is its own trailer. This was a very challenging project in that the system was complex and the boat needed to remain watertight. The group worked relentlessly and made a fully functional system out of aluminum and then demonstrated it by videotaping it entering and being towed back out of the Connecticut River.

Robbie: This project was an insane amount of work and a great example of attempting a really creative, counterintuitive solution.





NIGHTRUNNER

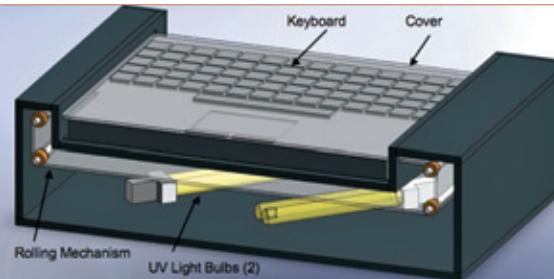
Students: Abraham Clayman '07, Daniel Harburg Th'09, Sanderson Hull '09, Michal Jablonski '09 Th'10, Alex Lippai '09

What It Is: a lighting system attached to a belt

WHY IT'S A FAVE:

Collier: The group was determined to make a light that would permit running at night through the woods. Their functional prototype was so well finished that when they demonstrated it, the reaction was: Okay, where did you buy this. It looked like the real deal.

Robbie: This was an excellent project that showed sensitivity to the discomforts of runners using headlamps caused by poor visibility, disorientation from bobbing light, and lack of a consistent visual reference. The group performed original human factors research to determine that the waist moved much less than the head and was therefore a superior location for mounting a light. Their prototype was a comfortable multiple-LED belt with a rechargeable battery and a safety light on back.



SANITIZING KEYBOARD COVER

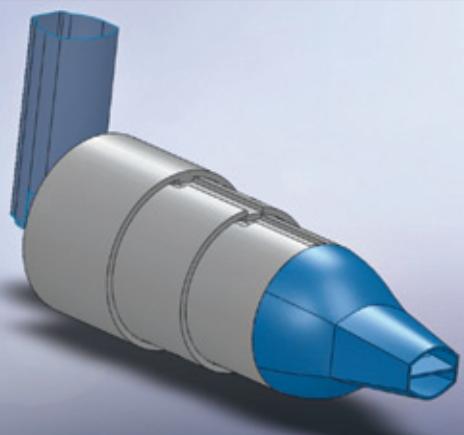
Students: Sean Currey '11, Elizabeth Kemp '11, Heather Kluk '11, Yolanda Lin '11

What It Is: a keyboard cover cleansed by UV light after each use

WHY IT'S A FAVE:

Collier: This group had no idea about how UV lights kill off bacteria, and they had never put together a mechanical or electronic system. Further, they began, like many groups, with little fabrication expertise. They used a pair of silicone covers for a keyboard that had room for every key. They hooked these together and moved them with a tractor-feed system. When

one cover was over the keys, the other was in a closed box under the keyboard, where it was sterilized with UV light. One big challenge was that they had to index the covers exactly. The problem turned out to be really daunting. They beat on it and beat on it and beat on it until they finally came up with a way of making it work. And they actually did the cell-culture work to show that short-duration exposure to UV light killed off all the bacteria.



TAKE-A-BREATHER NEBULIZER INHALER FOR ASTHMATICS

Students: Zakieh Bigio '10, Elizabeth Dain-Owens '10, Catherine Emil '10, Sarah Feldmann '11, Sarah Rocio '10

What It Is: a collapsible, portable nebulizer

WHY IT'S A FAVE:

Robbie: They designed and tested an improved mouthpiece and spacer for the metered-dose inhaler used by millions of asthmatics. This was a difficult project that required collaboration with several physicians and solving multiple problems in a single integrated solution. The design includes a nebulizer that collapses to a small, easily carried form and a novel two-way valve that allows the patient to hold the device in his or her mouth while breathing normally. The students set a high bar for themselves with a project that required sophisticated medical knowledge and complex CAD and prototyping.

Lotko: They even ran SolidWorks flow simulations to study and optimize flow patterns in the device. They also developed some sophisticated bench-top test procedures to evaluate the effectiveness of the device.



SPOTTER-FREE WEIGHT-LIFTING BENCH

Students: Eric Chaves '05, Dan Jackson '05, Lance Martin '05 Th'06, Colin Murray '04 Th'05 '06

What It Is: a device for using free weights without a spotter

WHY IT'S A FAVE:

Robbie: The students created a weight bench with an adjustable piston allowing weightlifters to safely lower themselves below a catch bar when they need an assist. This is a wonderful example of the creativity of thinking in opposites.



ROLL-A-YAK

Students: Lauren Harad '12, Sarah Jewett '12, Sam Streeter '13, Max Van Pelt '11

What It Is: a keel weight that makes capsized kayaks easier to right

WHY IT'S A FAVE:

Robbie: The students understood the terror most people have about being upside-down in a kayak. This solution really works: It lowers anxiety levels so that users can learn more quickly and easily how to perform an Eskimo Roll.

Lotko: I really liked the simple model and scale prototype they developed to test and optimize their initial concept. The full-scale version works extraordinarily well, and it is such an exquisitely simple solution.



CUSTOM KEYBOARD

Students: Left to right above, Renee Foisy '88, David Lindahl '86, Christoph Mack '88, Corey Brinkema '86, Susan Smith '86, Patrick Walsh '88
What It Is: a piano customized for a musician with a specific physical disability

WHY IT'S A FAVE:

Collier: Back when the course was small I would pick a topic and immerse the students by taking them to meet folks who had problems. One year I took them to Crotched Mountain Rehabilitation Center for young people who have disabilities. We toured around and everyone met with the kids. This group of potential engineers and a musician met Maureen Gaynor, a girl with cerebral palsy in a wheelchair who had a head stick — a band around her head with a pointer coming out of it — and a board with letters on it, and "yes" and "no" and a couple of words. You would ask her questions and she would move her head to point. Her use of her hands was very limited. With the help of an assistant they asked her: If we could help you do any one thing, what would you like to do? Her answer was: play chords. She had a toy-like piano, but she didn't have enough control to play chords. They decided they would make her a piano. They talked to Casio and got them to donate an electronic organ. They tested her ability to move and realized one hand had much more control than the other and that she could only put her hands out to the sides. They did lots of testing with Maureen and got the angle of the keyboard just right and the size of the keys right. The students went to the wood shop at the Hopkins Center and made this whole electric piano case out of cherry so it looked like furniture. Here at Thayer they tested the tactile feel of all the different plastics, picked the most appealing, and then machined each key individually and hooked each up electronically to the organ. Toward the end of the term one member of the group took the piano down to Crotched Mountain, set it up, and set up a video camera. Maureen rolled over to the keyboard and began to play "Silent Night." It was phenomenal! When the students gave their

presentation to the review board and showed the video, everyone sat there staring. The students were expecting applause, and we were dumbfounded, thinking: How did that happen? The applause came loud and long after we realized how sensational the group had succeeded. None of the students and none of the review board members had any idea that the girl understood music and could play with the right equipment. Recalling that one really brings tears to my eyes.

Editor's Note: Maureen Gaynor is now a musician and writer. Her music and video-rich blog are at myspace.com/501471630.



DRIPLESS GASOLINE NOZZLE

Students: Mark Christman '06, Jeff Grossmann '06 Th'07, Max Guimond '06 Th'06, Juliana Lisi '05 Th'06, Meredith Lunn '06 Th'07
What It Is: a slit membrane cap for a gasoline nozzle to prevent dribbling gasoline when removing the nozzle from your gas tank

WHY IT'S A FAVE:

Lotko: Although it seemed like a simple, but maybe not terribly important, project at first, the team's research revealed the cumulative environmental impact of dripped gas at the nation's filling stations — and EPA plans to require spill-proof gas nozzles to be installed at all gas stations. A few calls to nozzle manufacturers found that they had no solution yet. The manufacturers even asked the Dartmouth students to call back if they found a good one. With this knowledge, the problem and the team's efforts took on a whole new dimension. How hard could it be to design and develop a simple end cap or flap for a gas nozzle? Much more challenging than anyone on the team imagined. They first had to become venturi nozzle experts — the solution couldn't undermine its ability to shut off automatically. It had to be robust and durable, and its viability had to be demonstrated by tests in a powerful solvent — gasoline. The students climbed the learning curve fast. The importance, feasibility, and novelty of their final design earned a pending patent, which Meredith developed over the summer on the team's behalf.



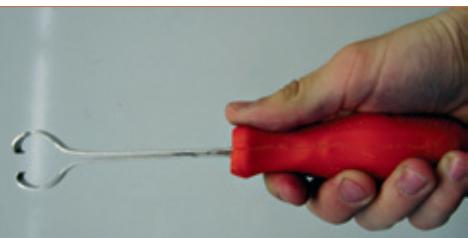
CODED LIGHT SWITCH

Students: Michael Bush '11, Eric Durell '11, Michael Lewis '11, Thomas Mandel '11, Paul Seebacher '11

What It Is: a switch that enables power when a valid ID card is inserted

WHY IT'S A FAVE:

Lotko: Dartmouth dormitory life presents a rich and sometimes abundantly obvious need for engineering solutions that can improve how things are done. A cursory walk down the hall of any dorm shows that too many lights are left on with no one in the room. Can an engineering fix modify behavior? No other ES 21 presentation ever attracted the interest of so many Dartmouth administrators and facilities staff. This simple but ingenious device makes use of the Dartmouth ID card. (But which one of the three different kinds of ID tags — magnetic stripe, bar code, or radio frequency ID — should one use?) With a card reader in each dorm room linked to central computers, the reader validates that you have authority to enable power in the room. Heading out to dinner? You won't get far without your ID, so you need to pull it out of the reader and disable power. Try to jimmy the reader with a generic card, electronic validation won't let you.



OARLOCK TOOL

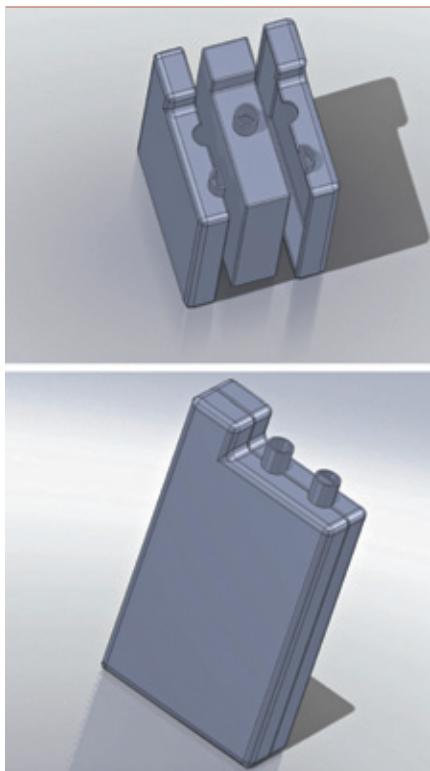
Students: Stephanie Crocker '12, Erin Dauson '11, Wiley Dunlap-Shohol '12, Ruth McGovern '12, Eric Packer '12

What It Is: A hand tool for adjusting the height of oarlocks

WHY IT'S A FAVE:

Lotko: It won't reach the mass market, but ask any rower on the Connecticut River on a cold April

morning how much fun it is with bare hands to change the spacers for the oar lock position on a shell. They will verify a compelling need for a better way. Rumors of the device development spread rapidly across campus well before its design had even crystallized. When I met a professor and recreational rower at a frat row BBQ that spring, her main interest in our conversation was about the ES 21 team she heard was developing a new spacer removal tool. Specialized pliers adapted to a new spacer design developed by the team, the device takes the pain out of spacer removal. Its final presentation would have gone exceedingly well if the team had not dropped the tool in the Connecticut River during testing days before the presentation and before floatation material (anticipating exactly this circumstance) had been finalized.

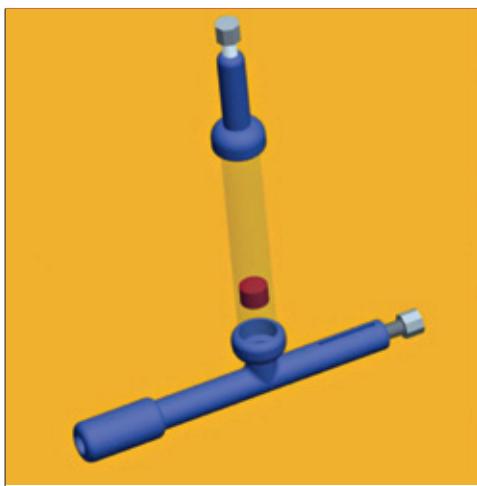


VACCINE DELIVERY SYSTEM

Students: Satoshi Harris-Koizumi '12, Merritt Jenkins '10, Aidan Nelson '12, Grayson Zulauf '12
What It Is: an ice pack designed to prevent vaccines from freezing

WHY IT'S A FAVE:

Robbie: The group identified the weak link in the temperature control mechanism used in vaccine transport systems currently used in developing countries and then created a simple, effective, and affordable solution for use in areas without access to electricity.



TONETUBE

Students: Andreas Baum '07, Bruce Corliss '08 Th'09, Alexandria Fecych '07 Th'08, Frederick MacDowell '07, Scott Newbry '08

What It Is: a blow tube with feedback indicator to train brass musicians to maintain constant airflow

WHY IT'S A FAVE:

Lotko: The students connected with users immediately, identified a compelling problem common to them, and conceived and developed a simple solution. Their analysis of the performance of the device was superb, and their follow-up with users demonstrated viability and significant interest in their device. Buoyed by their engineering success, Parke and Scott pitched a plan to the Club of Dartmouth Entrepreneurs for production and sale of the device. They won the club's 2005 E-ship competition among a field of 18 entrants, including Tuck and



Dartmouth Medical School students.

AEROMOD

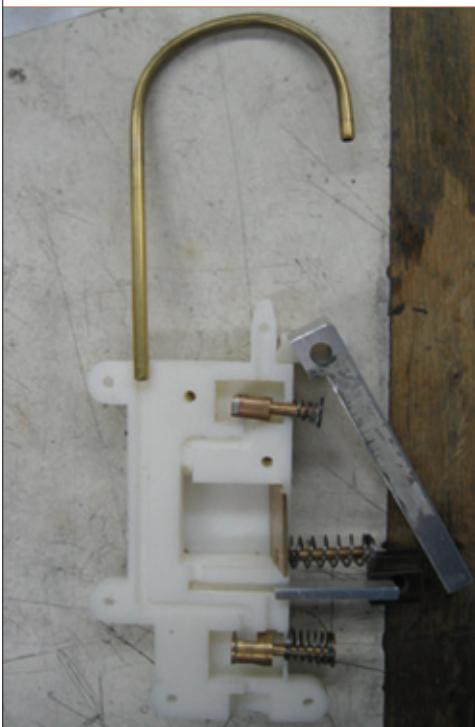
Students: Derek Brand '09 Th'10, Eric Mann Th'10, Ignacio Rueda '09 Th'10, Kyle Sherry '09 Th'10

What It Is: an aerodynamic cover for a pickup truck bed to reduce drag and increase fuel efficiency

WHY IT'S A FAVE:

Lotko: Some ES 21 groups connect with potential users so effectively, develop and test a so-

lution to a problem so thoroughly, and present the concept and results so professionally that professors sometimes wonder who's teaching whom. This group's expertise and polish (and camaraderie) stood out at every stage of the process. The final product, a sloped Tonneau cover extending from the top rear of the cab to the top rear of the pickup bed, was even endurance-tested by Eric on the way home to Mammoth Lakes, Calif.



EFFICIENT DRINKING FOUNTAIN

Students: Elizabeth Asher '09, Josh Bronston '06, Patrick Hamon '08, Sarah Parkinson '09

What It Is: a drinking fountain faucet that wastes less water

WHY IT'S A FAVE:

Lotko: Did you ever wonder or even notice what fraction of the water goes down the drain when someone drinks from a water fountain? That point did not miss the collective eye of this engineering team. Part anthropologist, part scientist, and part engineer, they quantified the waste (the efficiency of state-of-the-art fountains is typically less than 40 percent), determined why so much water goes down the drain, and designed a faucet extension that would meet the needs of students who carry water bottles but can't seem to fill them very efficiently at standard-issue fountains.

Karen Endicott is the editor of *Dartmouth Engineer*.

Alumni News

spotlights

WORLD CLASS
Sproxil founder Ashifi Gogo Th'09 was awarded \$10,000 by the Clinton Global Initiative.



Ashifi Gogo Th'09 was awarded \$10,000 by the Clinton Global Initiative to develop his anti-counterfeit drug technology venture, Sproxil. During the Global Initiative's annual meeting in September, Gogo presented an update on Sproxil's progress. The mobile phone-based service enables customers to confirm a medication's authenticity via text messaging. By the end of 2010 the service was available for up to 2.5 million items in Nigeria. "This is a genuinely remarkable accomplishment," former President Bill Clinton remarked after Gogo's presentation, adding that "putting people in charge of their own healthcare" is "empowering." You can watch Gogo's full presentation at sproxil.com. The company also earned the People's Choice Award at the 2010 Accelerate Michigan Innovation Competition and an honorable mention at IBM's SmartCamp, which highlights start-ups that are making the planet smarter.

With counterfeit drugs making up about 10 percent of the global market, Gogo isn't the only grad developing mobile phone solutions to the problem. **Nathan Sigworth '07**, who had his first entrepreneurial success as co-inventor of the Gyrobike, the ENGS 21 project that is now for sale commercially (see page 22), and his former Dartmouth roommate, **Taylor Thompson '08**, co-founded PharmaSecure in New Delhi, India. The company announced that the pharmaceutical firm Unichem has bought 70 million PharmaSecure codes to verify the quality of its products. Customers check the code via text messaging. "Putting the codes on the market, having the consumers authenticate, this is all building a very, very valuable network and communications platform with consumers," Sigworth told *The Christian Science Monitor* in December.

Drew Wenzel '08 Th'10 is living at the intersection of technology and business. To get there Wenzel, who

now works on green building designs at Google's headquarters in Silicon Valley, needed a solid engineering education and a firm understanding of the business world. He needed a master's in engineering management (M.E.M.), a degree that is gaining popularity among students and employers, the *Financial Times* reported in an article on the rise of the business-savvy engineer (ft.com/home/us, search careerist Thayer). "The M.E.M. gives you the ability to speak both languages," Wenzel told the paper. The degree is "for engineering grads who know they don't want to spend their entire careers in design or in a lab," Thayer Dean Joseph J. Helble explained to the *Financial Times*. "They want to do broader, systems-based engineering by identifying promising new product lines. They want to create a vision for the technology in the broadest business sense." More students than ever are following Wenzel's path: Applica-

tions to Thayer's M.E.M. program have doubled in the past five years to more than 250 applications for 50 spots.

"Recalling the events on a small Pacific atoll in 1945, I am reminded how camaraderie can spring up in the unlikeliest situations," **Sam Florman '46 Th'46** wrote in *The New York Times* (nytimes.com/2010/09/04/opinion/04florman.html) on the anniversary of Japan's surrender to the Allies on September 2, 1945. Florman described his first engineering experiences after leaving Thayer School. As one of the newly commissioned ensigns in the Navy Civil Engineer Corps, he began the voyage across the Pacific to join one of the Seabee battalions being mustered for an invasion of the Japanese mainland — only to arrive the day before the surrender. Now it was time to rebuild a country, or at least Truk, an atoll in the Caroline Islands that had served as headquarters for the Japanese fleet and was now a pile of rubble. Flor-



PEACE OFFERING

Sam Florman '46 Th'46 stands beside a note of friendship a Japanese officer gave him after World War II.

man was put in charge of one of the less imposing projects: building a small earthen dam on a mountain stream for the American military's water supply system. Florman was assigned three Seabees and about two dozen Japanese men and their lieutenant. He recalls how both sides faced off the first day until he ceremoniously unrolled the drawings he had prepared. Soon some were driving stakes while others attacked the earth with shovels and picks. "Within a few days the two groups had settled into an efficient working routine interspersed with episodes of playfulness," he remembers. "The anticipated generation-long era of fear and hatred seemed to have been reduced to mere days." The crew completed the project in several weeks and planned a dedication ceremony — where the Japanese lieutenant presented Florman with a small ceramic statue and a note of friendship. "The Thayer experience was a won-

PET PROJECTS
Tom Brady displays plastic packaging products made at his company Plastic Technologies Inc. in Bowling Green, Ohio.



derful preparation for work in the Seabees," Florman, now the chairman of the Kreisler Borg Florman General Construction Co. in Scarsdale, N.Y., tells *Dartmouth Engineer*. "The hands-on activity — field trips, drafting, surveying, lab work with concrete, metals, water in flumes and pipes — was memorable. Joe Ermenec's thermodynamics classes, which started with a problem on the board every day, were a preparation that stood me in good stead for any theoretical challenges that life was to present."

He's done it again: Dallas-based racer and businessman **Charles Nearburg '72 Th'74** made history at the Bonneville Salt Flats in his *Spirit of Rett* streamliner, breaking a 45-year-old land-speed record and also setting the fastest single-engine car record in history with an average speed of 414.5 mph. On September 21 the *Spirit of Rett*, named for Nearburg's late son, made back-to-back speed runs under the watchful eye of FIA officials, breaking the 409-mph record set by the Summers Brothers' *Goldenrod* in 1965. According to FIA rules, the team must make a first run out, service the car in one hour, and then make a return run in the opposite direction. "We didn't realize that an FIA record required you to beat it by 1 percent," Nearburg told BangShift.com. "After finding that out we changed gears, tune-up, and a bunch of stuff just hoping we could make it go that fast."

FASTER THAN EVER
Charles Nearburg '72 Th'74 made racing history at Bonneville Salt Flats.



ASK THE EXPERT

The Expert: Tom Brady '66 Th'68

Should we avoid plastic bottles because of waste and safety concerns?

IF YOU DRINK SODA OR USE LIQUID LAUNDRY DETERGENT, chances are you've purchased polyethylene terephthalate (PET) bottles designed and manufactured by one of several companies Tom Brady '66 Th'68 founded and runs, including Plastic Technologies Inc. (PTI), Preform Technologies, and Phoenix Industries International — the largest producer of recycled PET for packaging in this country. With plastic bottles such a ubiquitous part of modern life, *Dartmouth Engineer* asked Brady, who earned his Ph.D. in plastic materials engineering from the University of Michigan, for his take on recycling and safety. Here are his views:

PET is the most recyclable packaging plastic. When you recycle most plastics, the molecular chains break apart and become shorter. However, PET has a unique chemistry that allows the shorter chains to grow back together during the recycling process, so you can recycle PET forever if you remove the non-PET contamination. Modern recycling processes accomplish that extremely well.

Today in this country, about 30 percent of the PET used for bottle applications is recycled. Much of that recycled PET (RPET) goes into fiber for clothing and carpet and other items, but increasingly RPET is being used in food packaging, the highest value application.

All plastics are recyclable in principle. PET (#1) and high-density polyethylene (HDPE, #2) are the most commonly recycled plastics because they are the most intensively used plastics. The other numbered plastics are used less frequently. The economic feasibility of recycling depends on having a large supply available.

More than half of the RPET in this country is shipped to China. Ships that would otherwise return empty to Asia can offer low shipping rates compared to shipping within the United States. The limited supply of RPET in this country keeps the price of RPET close to virgin PET.

There will always be a market for recycled plastic resins. The world will eventually have to begin reusing all materials when raw materials become increasingly difficult to find and therefore more expensive to use. At some point there's going to be a whole industry around not just waste disposal and recycling, but around reusing all materials as a mined resource.

BPA has nothing to do with PET. BPA (Bisphenol A) is one of the two components you put together chemically to make polycarbonate, a material that's tough and is used to make shatter-resistant products. Polycarbonate has been used in packaging applications that require heat resistance, such as in baby bottles and sports bottles. Studies have shown that BPA can be extracted from polycarbonate plastic articles, and there is some evidence that BPA can act as an estrogen mimicker, so eliminating polycarbonate from food packaging is prudent. Polycarbonate is no longer used in baby bottles and water bottles.



SMOOTH RIDE

Peter Stone '61 Th'62 drives an air cushion vehicle he developed with Bruce Johnson '61 Th'62.

► just one question

Q. What was your most memorable project at Thayer?

In our post-senior year Thayer students did a few weeks in the field in a house in Etna, N.H. Our classes were in surveying, and our fieldwork was to make a plan of the road that went past the house we were staying in. I was a saver of all my college papers. Some 50-plus years later my daughter Jean '74, a graduate of Thayer (in one of the first classes for women) who was married and had a young daughter, bought a lot on the same street that I had surveyed many, many years earlier. Her husband has built a house on the lot during a nine-year period. They vacation there now in winter and summer. It is really a small world.

—Charlie Weinberg '42 Th'43

"Structural Engineering" in 1951: On the first day we met our professor, John Minnich. He explained that on the first day of deer season he might be in late, with the dean's permission. "But never been in later than noon!" he bragged. What we thought originally was that we had

a New Hampshire farmer as professor, but John turned out to be the most brilliant, logical instructor we ever had. He made structural engineering come alive! But the most memorable event was the trip to Corbin Park Hunting Preserve in mid-New Hampshire. John owned 1/20th of the fenced park stocked with game animals of all sorts: deer, German boar, and who knows what else. We went in a surplus GI open truck with a winch we used several times to extricate us from the piled-up snow. Then for lunch, prepared by John's wife, we partook of deer burgers, elk burgers, and boar burgers! Being from Hawaii, it was an unbelievable opportunity for me. Two years later, I had the pleasure of taking John fishing, where he caught his first marlin, and only then, got horribly seasick.

—Peter Nottage '50 Th'51

From 1960 to 1962, my friend and lab partner Peter Stone '61 Th'62 and I worked on a unique air cushion ve-

hicle. Our advisor was Bob Dean. We built a 3-foot model with a model aircraft engine and tested it in the Dartmouth gymnasium guided by a wire. It went like a bat out of hell, and we were encouraged to continue. We obtained funding from the U.S. Army research and engineering division in Ft. Eustis, Va., and spent the summer of 1961, just after I got married, building a full-scale working version. Pete lived on the base, and my wife and I lived in a trailer park. We built the device on the Ft. Eustis base, but were unable to complete it during the summer, so the Army trucked it up to Hanover, where Pete and I finished it during our fifth year in mechanical engineering. It was powered by a 45-horsepower Nelson aircraft drone engine and weighed somewhat more than 1,000 pounds. We made a number of modifications, including stripping off excess weighty parts, and ran it on the lawn behind Thayer School. We discovered that air cushion vehicles are very slippery devices, and the least little grade will send it sliding downhill. We then added some light stabilizing wheels that could be removed and replaced with fins for water travel, and thus we could steer it on the ground and in the water. The Army guys then came up to Hanover with a camera crew and we plunked the device into Mascoma Lake and

they chased it with a rented outboard. We had great fun doing this project, and it got a bit of attention in the press. After completing this project and graduating, I went on to Polaroid and designed cameras for a living. Peter went on to Harvard Architectural School, became an architect, and eventually ended up teaching architectural design at the college level in Florida.

—Bruce Johnson '61 Th'62

As my fifth-year project I "designed" a two-phase flow heat exchanger for a nuclear power plant. The cooling medium was powdered coal that was to be lofted into a fluidized bed by air. The coal was to collide with vertical pipes that were exchanging the heat from the nuclear reactor coolant (which I believe was liquid sodium). The coal was thus heated and gave off "coal gas," which would have been distributed in a manner similar to natural gas today. Looking back on the experience I can see why my project grade was not as stellar as I'd hoped. Seems to me my design failed to provide for many things, especially maintenance. On the other hand, my learning was immense, as both the thermodynamics and various mechanical aspects required quite a bit of knowledge (much of which I did not have at the start of the proj-

**STACKING UP**

Bill Downey '74 Th'77 and Stephen Matzuk Th'77 created an isokinetic stack sampler.

ect). Graham Wallis was my advisor and provided help when asked, but I just should have asked more questions and dug deeper. I received a real-world lesson from that project.

—Steve Brenner '63 Th'64

One of my most memorable projects was a combined Thayer-Tuck project where we were asked to redesign (the Thayer part) the Gillette razor with market considerations (the Tuck part) in mind. We thought that having a blade that would set Gillette apart as opposed to a heavy-handled razor was the right trajectory. However, we did not think of multiple blades (now five). I have followed the industry ever since and have seen that our ideas were partly prescient.

—Lee Chilcote '64 Th'65

Three projects come to mind: ENGS 21, where we designed and partially built an energy-storing bicycle; ENGS 22, where I designed and built an air-bearing seismograph; and the Thayer B.E. plus M.S. program, where I designed a hand-written character recognizer (someone else implemented it).

—Mark Tuttle '65 Th'66

Although there were a number of interesting projects during my time at Thayer School, there are three that really stand out, and they share a common thread: All three taught me a valuable life lesson and all three could have easily killed me. Number three on my list is a project that never happened. During my freshman year, the professor asked us to investigate parawing gliders. NASA was studying the parawing as a way to return manned capsules from space. While tossing gliders off the top of the football stadium, I actually calculated the size of glider I'd need to launch myself and worked out how to guide it. But I never jumped. Several years later, seeing pictures of hang gliders out in California, I real-

ized that to innovate takes more than good engineering; it takes courage, and success is only for those willing to take the risks. Number two on my list is my fifth-year project to design and evaluate the world's worst lawn mower. (It wasn't intended to be—it just turned out that way!) I actually built a prototype, and when it self destructed and the blade went flying inches from my head, it occurred to me that the first step in any engineering project ought to be to analyze the potential risks. At that time, risk evaluation was not being taught at Thayer—another good idea ahead of its time. The number one project was not the result of any course and was not approved by any professor. One of my fraternity brothers and fellow engineering majors found an old drone engine and propeller in the basement of Thayer. Another frat brother and fellow engineering major was a professional water ski jumper. So, naturally, it was obvious to them that we needed to build an air sled on skis and run it up and down the frozen Connecticut River! They let me join the group, and after weeks of sleepless nights and countless challenges that stretched our inventiveness and engineering capabilities, we were racing up and down the river—no helmets, no seatbelts, no fear. Though running it was fun, it turns out the real excitement was in accomplishing that crazy goal, so after a few runs the sled was dismantled and the engine put back where it was found. The lesson we learned is that a small group of dedicated people free from restrictions and "good common sense" could accomplish amazing things. For me, Thayer was always about amazing things. Every day was a magic show with the professors teaching us how to do the tricks.

—Pat Bremkamp '68 Th'69

"How do you play if you can't

move?" With that question, Professor Paul Shannon began the first class of ENGS 21 in the fall of 1965, but only after making us wait for five minutes before he said anything. We wondered: What was going on? Professor Shannon explained: How can a physically handicapped child play with toys made for the commercial market? Can toys be successfully adapted for use by children with special needs? That was our ENGS 21 project assignment. We visited the Crotched Mountain School for children with disabilities in southern New Hampshire to understand the nature of the problem and try out our ideas. For many, it was our first encounter with children with severe physical disabilities. My project team decided to take an existing toy—an electronic slot car game—and redesign the control unit so that handicapped children could steer the slot cars, adjust their speeds, and even flip them out of the slots. We named our team TREPHCo: Therapeutic Recreational Engineering for the Physically Handicapped. We learned as a group. Made mistakes. Tried again. And eventually built a slot car unit that could be controlled by some of the handicapped children. In the process, we were introduced to a systematic approach to problem solving. This was not only my most memorable project at Thayer; ENGS 21 was among the best courses I took as an undergraduate and was a lifetime experience.

—Dennis Drapkin '68 Th'69

As part of a structural analysis class, I wrote a program in 1972 that simulated the performance of a cross-country ski. At that time, it occurred to neither the professor nor myself that the work was probably marketable. My hope is that this no

longer happens at Thayer School, and that work with commercial value is always encouraged even though it might conflict with the goals of academia.

—Mark Totman '71 Th'72

Editor's Note: Thayer now encourages entrepreneurship for students at all levels of study. See engineering.dartmouth.edu/entrepreneurship.

In our first semester in the master's program at Tuck, **Stephen Matzuk Th'77** and I collaborated on a project for ENGG 196, "Introduction to Design Methodology," to develop an isokinetic stack sampler. As an undergraduate engineering student, I spent two semesters as an engineering intern working on environmental air pollution remediation at a major chemical company. I had used equipment to sample effluents in emission gases from chemical reactors. To get an accurate measurement, the velocity in the sample probe had to be adjusted to match the velocity in the emission stack. This was done by using a pitot tube in the emission stack to find stack velocity, measuring the sample rate through the probe, calculating the velocity in the sample probe, and manually adjusting flow rate through the sample equipment to match these two velocities. We proposed to create an automated system to match the gas velocity in the sampling probe to the gas velocity in the effluent stack. The design that resulted consisted of two major devices: first, we created a novel differential sampling probe; second, we created an inventive pneumatic-electronic-mechanical feedback system to control the flow. We successfully created a proof-of-concept prototype, though we knew it was well short of optimizing the design for a potential product. The most critical lessons we learned had nothing to do with engineering. We learned the value of collabora-



ROBO-TEAM

From left, Margaret Martei Th'08, Laura Weyl Th'08, Andrew Herchek Th'09, and Anders Wood Th'08 won a machine engineering class competition.

tion to solve problems. Our advisors — Professors Hooven, Converse, Grethlein, and Dean Long — each made essential suggestions. And we were well matched to solve this problem: Steve covered the electronics and I covered mechanical design. We learned about the real-world engineering process: No matter how obvious the need appears or how clever our first guess at a solution may be, our proposal was only accepted when we were halfway to solving the problem. Since that class, both of us have gone on to pursue independent careers in new product development — Steve as a patent lawyer and me as president of Technology Consulting Group, providing market research, strategic planning, and new product development.

—Bill Downey '74 Th'77

The most memorable project for me was from ENGS 21. We were charged with developing products for energy efficiency. Our team conceived of and built exterior auto closing shutters to insulate windows in homes located in cold climates. We built a small model of a house and demonstrated the shutters closing and the improved insulation and draft reduction. We did our testing at the Cold Regions Research and Engineering Laboratory. While ENGS 21 was most memorable, I have several runners-up. I remember putting small-scale integration (SSI) chips together to simulate a clarinet, only to have a short in the breadboard and the whole project fail. I worked for 36 hours straight to rewire the whole thing. It is ironic because all that circuitry and more can now fit on a tiny chip smaller than the 30 or so chips I had on the prototype. Other comical memories are doing a superconductivity experiment one afternoon when Friday beers were being served. We thought we might super-cool our beer by dangling it over the liquid nitrogen only to have it explode on our

experiment. The silicon did superconduct, and the beer slushie wasn't too bad after we cleaned it all up. Additionally, the bridge-building project haunts me from time to time, especially when I go over rickety, small suspension bridges.

—Anne (Davidson) Barr '83

The best project I ever worked on was for a class that was both a Thayer and Tuck class. The class operated as a consulting firm and was assigned to review and solve a problem in the community. For our particular class, the town of Brownsville, Vt., asked us to look into the Mt. Ascutney expansion that was planned in the 1984-to-1985 timeframe. For my portion of the assignment, I reviewed the engineering plan for the sewage treatment system and also the traffic analysis that had been done. Other class members looked into tax implications, environmental impact, social impact, pollution, and a number of other elements that were of concern to the residents of Brownsville. The culmination of the class was a presentation at the Brownsville town meeting. It was televised locally. This class cemented my interest in becoming a consult-

ant, which I have been now for my 26 years following Dartmouth graduation in 1984.

—Howard Jones '84

Without a doubt the bridge contest was my most memorable project. Our team won for least deflection and was dead last for projected deflection — never did quite get the math behind it! I still have the bridge on my shelf at home. Another memorable project was my B.E. project to build a fluids-flow apparatus for the fluids lab. I toured Thayer with my four sons last year and saw it was still in use! I do remember lots of interesting projects, such as the plan by Bob Donaldson '84 Th'85 to attach an out-of-whack car engine to the base of tall communications towers so the vibration would inhibit ice build-up. No idea if it worked, but I loved Bob's creativity!

—Doug Kingsley '84 Th'85

I'd have to say that my two most memorable projects from the time I spent at Thayer School — the Women in Science Project and the Dartmouth Project for Teaching Engineering Problem Solving — were both very much influenced by the

ENGS 21 engineering problem-solving approach and the whole entrepreneurial environment fostered at Thayer School.

—Carol Muller, Assistant Dean 1987-92,
Associate Dean 1992-96

My most memorable project at Thayer was my B.E. design project, completed with Samantha (Scollard) Truex '92 Th'93 Tu'95, Kristen (Morrow) Johnson '92 Th'94, and Bruce Northrup Th'94. Our project involved redesigning a boat hatch that could be opened in multiple directions, depending on the direction of the wind. What was most memorable to me about the project was less the outcome than the process and the teamwork involved. It was truly a collaborative effort with a group of people I really enjoyed spending time with and learning from.

—Sue Roberts Th'93

It is fun to sit back and remember all those great Thayer School projects, but if I had to choose the most memorable, it would have to be our B.E. design project. Linda Blumberg '95 Th'96, Tony Mamone '96 Th'96, Brian Spence '95 Th'96, and I worked on this gem: designing environmentally and behaviorally appropriate "toys" for captive polar bears at the Brookfield Zoo in Chicago. I am aware that there was much debate outside our group regarding the true engineering value of our project, but as far as we were concerned it was perfect. We applied our well-honed Thayer School problem-solving skills to building a device that encouraged the bears to work for their food, as they would in a more natural environment. Unfortunately, our best solution — just release some live seals into the polar bear pool — didn't meet the parameter that the solution had to be palatable to zoo visitors.

—Pam Brockmeier '95 Th'96

I had a great experience with ENGS

CALLING ALL PATENTS
Thayer School is creating an exhibit of patents that developed from Thayer undergraduate or graduate student coursework. If you've been issued such a patent, please send the names of the inventors and the seven-digit patent number to fearn.pate@dartmouth.edu.

21. We did a project — Bike Buddy — that involved careening down an icy hill on a bike connected (through our contraption) to someone in the project. It was crazy.

—**Jay Bruce '96**

My ENGS 21 project somehow ended up with me on top of Balch Hill, along with project-mates **Erin Morse '02 Th'03**, **Derek Hansen '02**, and **Abby Faulkner '02 Th'03**, skinning a moose. Rewind a bit: Our theme was safety innovations, and our group chose to tackle the largely unrecognized but serious problem of moose-vehicle collisions. Moose unfortunately possess the potentially lethal combination of enormous mass, windshield-level height, and a general lack of concern for traffic whizzing by at highway speeds. After reading in some obscure journal that moose fur is known to fluoresce when exposed to UV light, we sought to investigate this as a possible key to our solution. We were "lucky" enough to find a nearby butcher shop that had recently received a road-kill moose and was more than willing to part with the hide for the low, low price of \$20, with the caveat that it wasn't entirely cleaned. So that's how we found ourselves up on Balch Hill stretched out on tarps over a reasonably disgusting former moose, trying our best to clean the hide to a sufficiently sanitary level. The best (or worst?) part was the look on other hikers' faces when they unwittingly wandered over to our secluded area to see what interesting thing was going on over there. So cut to a few days later and — surprise! — we did not observe any noteworthy glowing of the moose fur under UV light, journal claims notwithstanding. So our ultimate solution involved a series of heat-sensing infrared sensors and warning lights deployed alongside particularly dangerous highway areas frequently trafficked by our favorite half-ton mascot of the Granite

State. I think one of our friends might still have a pair of moose-hide mittens somewhere, too.

—**Tom Nichols '02 Th'04**

My most memorable projects at Thayer were both team-based design classes. In "Machine Design" we had to build a machine that could create a Lincoln Log cabin. Since we were constrained in degrees of freedom, we built a clutch into our car that allowed us to have another motion. The clutch was driven by the crane arm. When the crane arm was up, the motor would drive the wheels and move the car around. However, when the crane arm was down, the drive motor was disengaged from the wheels and drove the crane arm out and in to give us precise control when placing the logs. It miraculously ended up working as we had designed it. My team members, **James Lamb '04**, **Jon Kling '04**, and **Chad Steinglass '02 Th'04**, were a blast to work with. A close second to this project was the CAD/CAM class, where our final project was to build a tricycle. We pushed the limits a little bit and ended up designing a Potty-Training Trike, where the seat doubles as a toilet. When the kids were invited in to test drive the trikes, one of the girls saw it and immediately ran away to her mommy crying. I guess it was too much for her to understand how those two worlds could be combined. However, one of the little guys loved it and pedaled all over the Great Hall.

—**Brian Mason '03 Th'05**

ENGS 21 started about two weeks after 9/11. My group of **James Lamb '04**, **Jon Kling '04**, and **Andra Pool '03** wanted to do something that would benefit firefighters. We learned that although their outer clothing provided protection against flames, the material did not breathe well, and many firefighters suffered from hyperthermia while combating fires.

At our first presentation, our solution involved having firefighters wear mini-refrigerators. We quickly learned about the value of the design and redesign process to ultimately come up with a device to monitor the firefighter's body temperature and serve as an early warning system for hyperthermia.

—**Erik Dambach '04 Th'05**

As a junior in the dual-degree program we ended up having five of us from Colby College on the same team — I worked with **Spencer Boice Th'05**, **Eric Fitz Th'05**, **Dave Fouché Th'05**, and **Monica Thomas Th'05** — and we ended up being referred to as the "Colby Mafia." We won the Jackson Prize for our internal boat trailer, which Leonard from the machine shop described as a \$500 boat with F-16 landing gear. With our design you no longer needed a separate trailer for your boat. You would drive the boat right up to the edge of the water and then, with a press of a button, the wheels would deploy out of the bottom of the boat and out of the front would come the tow hitch, which you would then just connect to your car. It would eliminate the hassle of having to store the trailer when the boat was in the water, and could also help in point-to-point trips: All you needed in the new location was a car with a hitch; no need to move the trailer around.

—**Peter Rice Th'06**

Editor's Note: See page 22.

My most memorable and glorious project from Thayer has to be the mechanical design project **Margaret Martei Th'08**, **Laura Weyl Th'08**, **Andrew Herchek Th'09**, and I completed in "Machine Engineering" (ENGS 76) in fall 2007. The goal of the project was to design a robot that would pick up as many walnuts as possible in the allotted time on a course built in the Atrium. Our robot then competed against the robots of other

teams. As the one with the most points at the end of the round, our team won! The project may be my most memorable project because our team won, but it was also great because our robot began as just raw materials: sheets of metal, wheels, and gears. Then, using CAD and mockups, we designed a beautiful, fine-tuned machine and built the whole thing in the machine shop.

—**Anders Wood Th'08**

I feel like all of my projects were so memorable — I loved every one! My two most favorite are ENGS 76 ("Machine Engineering") and ENGS 190/290 [now ENGS 89/90]. ENGS 76 was probably the most fast-paced class I've ever taken; however, by the end, I felt as though I had learned and accomplished so much. I also feel it was the first true "engineering" project because you design and build the robot from the ground up, which allows you to really learn about the process and take ownership of the results. ENGS 190/290 is phenomenal preparation for the real world, as you have the opportunity to work on an actual project that has real potential. I did a project with Jetboil, in which we redesigned one of its camping cookstoves. I still can't believe that we got to speak with the CEO regularly, access proprietary information, learn about the manufacturing process, and come up with different innovations so that we could design a system that will actually be marketed! Now that I am studying at another university (I have a Fulbright to study sustainable energy at the Technical University of Denmark), I realize just how unique an experience that was. I think this type of learning really prepares Thayer students for the workplace and gives them the tools to innovate new procedures or products and present their ideas in a persuasive and effective manner to all types of audiences.

—**Emily Koepsell '09 Th'10**

inventions

PURE GENIUS

Students Dean Spatz '66 Th'67, right, and Chris Miller '66 Th'67 decontaminate water through reverse osmosis.



REVERSE OSMOSIS APPLICATIONS

>> INVENTOR: DEAN SPATZ '66 TH'67

Reverse osmosis (RO) wasn't invented at Thayer. Eighteenth-century French physicist Jean Antoine Nollet gets the credit for that. However, two centuries after Nollet's discovery, RO was still not much more than a laboratory phenomenon until a Thayer student project helped create a new multi-million dollar RO industry.

By way of review, RO is a process by which a solvent such

as water is purified of solutes by being forced through a semipermeable membrane through which the solvent, but not the solutes, may pass," according to the American Heritage Dictionary.

When Dean Spatz '66 Th'67 arrived at Dartmouth, commercial applications for reverse osmosis systems were in their infancy. In ES 21: "Introduction to Engineering," Spatz and Chris Miller '66 Th'67 were given a jar of brackish water and told to find a way to make it potable. The pair came up with a prototype for an RO purification system. They ramped up their undergraduate

project into graduate-level research that eventually led to Spatz winning contracts from the Department of the Interior to develop low-pressure reverse osmosis systems. Spatz also thought up new applications for the emerging technology. Shortly after getting his degree from Thayer, for example, he built a reverse osmosis system for a friend's maple sugar operation to separate the maple sugar from the sap.

In 1969 Spatz co-founded an RO company, Osmonics, with longtime Thayer Overseer Ralph E. Crump (see "Inventions,"

Summer 2010). The company had just two employees, Spatz and his wife, Carol, working out of their garage in Minnetonka, Minn. The husband and wife team did everything themselves, from rolling membrane elements to mailing press releases. Their first machine was sold to the Mayo Clinic for kidney dialysis. The second went to a car wash for a rinse water system. From these humble origins, the company grew into a world leader in reverse osmosis filtration. In 2003 General Electric bought Osmonics for \$275 million.

—Lee Michaelides



RANDOM WALK

Thayer's Master of Engineering Management (M.E.M.) students have a newly improved space to call their own. The second-floor complex in the Murdough Center — which physically links Thayer School and Tuck School of Business, the M.E.M. program's educational partners — has been redesigned to better serve program growth. The 15-month-long program, which prepares engineers for the realities of business, has doubled over the last few years from 25 to more than 50 students per entering class. According to M.E.M. assistant director and M.E.M. grad Ross Gortner Th'04, the new digs represent a kind of coming-of-age for the 21-year-old program. In his student days, he says, "I could be sitting up in the third floor of Cummings and my buddy could be three floors below in the sub-basement in his office. But now we've got a centralized location where all of the M.E.M. students can come together after class. They can collaborate. They've got small conference rooms to work in if they want to work in small groups. And the administrators and the faculty are all over here, too. We have a very nice home."

Photograph by Douglas Fraser

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