

DARTMOUTH

SPRING 2005

# Engineer

THE MAGAZINE OF THAYER SCHOOL OF ENGINEERING



## FROM IDEA TO INVOICE

The pains and gains of entrepreneurial growth

>>NEW DEAN NAMED

>>DREW ENDY TH'99 ENGINEERS BIOLOGY

## FEEDBACK

NARDI REEDER CAMPION'S EXCELLENT ARTICLE, "Who Was Sylvanus Thayer?" [Fall 2004], in addition to teaching me much about Thayer the man, brought back memories about how a copy of his handsome bronze bust made its way to the school that bears his name.

The year was 1966-67 and I was proud president of the Dartmouth Society of Engineers, which had just been revived by then-dean Myron Tribus. Dean Tribus tried mightily to organize the Thayer alumni and to interest them in supporting their graduate school in a number of ways. One evening he called me at home with exciting news. Sylvanus Thayer had been elected to the Hall of Fame for Great Americans at New York University, and we had the opportunity to purchase a copy of the bust being created for this momentous event. The price was a paltry \$1,500, and surely I could raise this amount—possibly from 10 fellow alums at \$150 each. I accepted the challenge, and within a day or two the task was accomplished. Several months later the bust arrived and has ever since graced Cummings Hall.

But the story does not end there. Some weeks later my wife, Judy, phoned me at the office to say that a representative of the Dartmouth administration had called and that she had invited him to our apartment for drinks that evening. Our visitor turned out to be George Colton, longtime Dartmouth vice president of development and alumni affairs. George was courtly but eventually got around to the message he had come to impart: No one in the Dartmouth community was authorized to engage in fundraising without clearance from the central development office. My good intentions were appreciated, but in the future please make sure to go through proper channels.

In retrospect I can see that the gentle reproach was warranted. Nevertheless, whenever I visit Thayer School, the sight of that handsome bronze bust makes me smile.

Samuel C. Florman '46, Th'46

### FEEDBACK LOOP

Dartmouth Engineer welcomes letters to the editor.

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VOLUME 1 / NUMBER 2

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DARTMOUTH ENGINEER is published twice a year for the Thayer School community.

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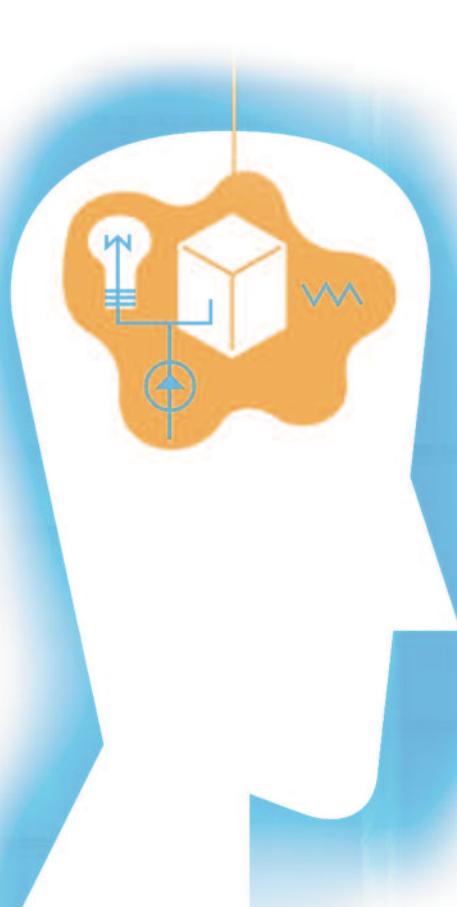
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Associate Professor Stuart Trembly, founder of ThermalVision Inc.  
Photograph by Chris Milliman

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Dartmouth campus photograph by Douglas Fraser.

# THE Great Hall

>>NEWS FROM AROUND THAYER SCHOOL



## Topping Out

(Above), left to right, Associate Dean Charles Wyman, Senior Executive Officer Lawrence McKinnon; Overseer Peter Fahey '68, Th'69, '70; M.E.M candidate Eleanor Alexander '04; Ph.D. candidate Douglas Van Cittert '99; Adjunct Assistant Professor Peter Robbie; Assistant Professor Christopher Levey; Interim Dean William Lotko; architect Fred Koetter; and Gilbane Construction Co. executive Douglas Butler with the signature beam. (Right) A flag and tree top out the roof of the MacLean Engineering Sciences Center.

## CONSTRUCTION

### Beam Team

ONE OF THE STEEL beams in the framework of the MacLean Engineering Sciences Center carries more than its share of the structural load. It also bears the signatures of scores of members of the Thayer School community.

Some 200 students, faculty, staff, and alumni signed the whitewashed beam before it was hoisted into place during a brief ceremony March 30. The festivities also included a "Topping Out" ritual, adorning the final roof beam with a flag and a live



tree, meant to bring good fortune to the building's occupants. A round of applause thanked the various construction crews who have been laboring on the project since July of 2004.

"It's a lot of fun to be at this

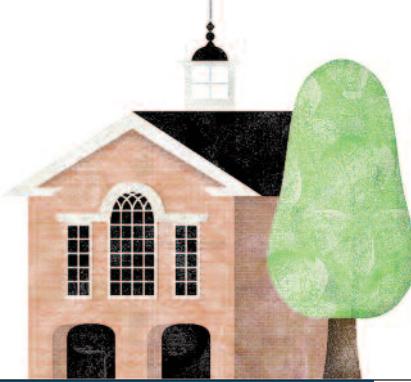
point," noted Interim Dean William Lotko. "The building has the DNA of Thayer School in its structure."

Architect Fred Koetter beamed as he viewed the building's skeleton. "It's always a dramatic moment," he said. "We enjoyed the engagement of the school and the College in this project."

The MacLean Engineering Sciences Center, named for major donors Mary Ann and Barry MacLean '60, Th'61, is scheduled to be completed in spring of 2006.

View construction progress at <http://engineering.dartmouth.edu/thayer/esc/index.html>.

# Interim Dean William Lotko on Joseph Helble's appointment as Thayer's dean: "He is the right leader for the School today."



## OVERSEERS

### Four New Overseers

THAYER SCHOOL'S Board of Overseers recently welcomed four new members. The 26-member board guides the planning of programs and approves the annual budget. Here's an overview of the new Overseers.

Clinton P. Harris '69, Th'70, P'04 is a managing partner with Grove Street Advisors, a private equity advisory firm. As a management consultant and partner with Bain & Company, he helped establish Bain's Japanese practice and opened the company's first office in Germany.

Christopher K. Hu '69, Th'70 is a partner at Morgan & Finnegan LLP, a New York City law firm specializing in intellectual property issues. Named a Sylvanus Thayer Fellow in May 2001, Hu has been active on Thayer School's Annual Fund Executive Committee for 10 years.

Thomas J. O'Neill '73, Th'74, P'05 is director, president, and CEO of Parsons Brinckerhoff construction services. He is a former member of Thayer School's Corporate Advisory Board.

Robert Copeland Fleming Jr. '78 is general partner and co-founder of Prism Venture Partners. A venture capitalist for more than 18 years, his technology focus includes business infrastructure software and systems, wireless communications, and telecommunications.

## LEADERSHIP

### UConn Prof Joseph Helble Named Dean

JOSEPH J. HELBLE, professor of chemical engineering and a member of the environmental engineering program at the University of Connecticut, Storrs, has been named the twelfth dean of Thayer School. He will assume the appointment in September.

"I'm honored and excited to join the Thayer School of Engineering," Helble said upon the April 4 announcement. "The Thayer School and Dartmouth are well known for their strong commitments to research and teaching. I am particularly impressed by the ability of the Thayer faculty to blend the two by incorporating the latest research, both from their labs and from the scientific community, into the classroom."

"We are delighted that Joe Helble will be joining Thayer School as its next dean and as a member of its faculty," says William Lotko, who has served as interim dean since July 2004. "It became clear during interviews that Joe's professional outlook and interests are well aligned with Thayer's aspirations and interdisciplinary style of engineering education and research. The broad consensus for his appointment among faculty, staff, students, overseers, and friends of Thayer School indicates not only that he is the right leader for the School today, but also that the School's various constituencies will be working together to ensure his success."

Helble earned his B.S. in chemical engineering at Lehigh University in 1982 and his Ph.D. in chemical engineering at MIT in 1987. He joined the UConn faculty in 1995. As department head he increased the number of Ph.D. candidates and doubled undergraduate enrollments in chemical engineering. His research interests include air pollution and nanotechnology.



#### Looking Ahead

Joseph Helble takes up Thayer's deanship in September.

## kudos

>> GlycoFi, founded in 2000 by Professors Tillman Gerngross and Charles Hutchinson, has been recognized by Scientific American as one of 50 technology businesses that have "exhibited outstanding technology leadership in the realms of research, business, and policy-making." GlycoFi is pioneering a technology to produce human-like protein for therapeutic use.

>> Professor Emeritus Graham Wallis has been elected chairman of the Nuclear Regulatory Commission's (NRC) Advisory Committee on Reactor Safeguards. Wallis, whose research focused on multiphase flow, has been a member of the committee since his retirement from Thayer School in 2001. At the NRC, he has been analyzing thermal-hydraulic computer codes and developing methods for evaluating uncertainties in the codes for predicting possible nuclear accidents.

>> Professor Bengt Sonnerup received a Group Achievement Award from NASA for his contribution to the success of Cluster, an international space exploration mission launched by the European Space Agency and NASA in 2000. Cluster's four orbiting probes relay information about solar winds and their effects on Earth. Sonnerup is a coinvestigator on Cluster's plasma spectrometer experiments.

**Work Load**  
Amit Gaind, left, and Dan Sack test the strength of the bridge they constructed in ENGS 33 (Solid Mechanics). Their combined weight: 335 pounds.



## ENGINEERS WITHOUT BORDERS

### Water Works

THE DARTMOUTH CHAPTER of the international service organization Engineers Without Borders (EWB) is working with counterparts in Louisiana State University, and Kenya to bring clean water to the Kenyan community of Nyamulu. The project is a response to villagers' requests for a sustainable, reliable source of safe water.

According to Dartmouth EWB co-chairs Katie Muse '05 and Hannah Murnen '06, the three chapters are handling different parts of the \$20,000 project. The Kenyans surveyed the area, LSU is focusing on pipes and reservoirs, and Dartmouth is designing a solar-powered pump with advice from Professor Dan Lynch and professional engineer Brian Klett '89. Five or six of the 15 Thayer School students working on the project expect to travel to Kenya this summer to implement the system.

EWB participants anticipate that the clean water project will have several social ripples, including reducing water-borne disease. Irrigation water will increase crop yields and open opportunities for raising livestock, creating new sources of employment and income.

The project is giving students experience in the human side of engineering. "It's important that the need arises from the community, rather than imposing your ideas. You have to be aware of the culture and environment," says Muse.

M.E.M. candidate Audi Okullo is giving fellow EWB members an invaluable view of life in Nyamulu. The village happens to be her home.



Left to right, Katie Muse '05, Audi Okullo, and Hannah Murnen '06

## Educational Costs

Thayer School's capital campaign goal:  
\$60 million.



### CAPITAL CAMPAIGN

## The Thayer Experience

YOU'VE PROBABLY HEARD about the Campaign for the Dartmouth Experience, the College's \$1.3 billion capital campaign launched in November 2004. If you're curious how Thayer School fits into that, read on.

Thayer School's \$60 million campaign goal addresses several critical needs:

#### **Chairs and Faculty Support— \$6 million**

To endow chairs, support curricular initiatives, and aid faculty recruitment.

#### **Dean's Venture Fund—\$4 million**

To provide early financial support to promising faculty research and creative student initiatives

#### **Laboratory Fund—\$3 million**

To keep instructional laboratories, computer-aided design studios, and workshops in step with advancements in computational science and engineering; and to support lab instructors.

#### **Technology and Liberal Education Fund—\$1 million**

To support Thayer School's development of courses to prepare all Dartmouth students—not just engineering sciences majors—to make informed decisions on issues involving technology.

#### **Thayer School Annual Fund— \$6.4 million**

To support the ongoing operation and programs of the school.

#### **Student Financial Aid—\$4 million**

To help Thayer School meet students' demonstrated financial need.

#### **MacLean Engineering Sciences Center—\$35.6 million**

Featuring integrated project labs, studio classrooms, multimedia computing systems, and next-generation research facilities, the MacLean Engineering Sciences Center will provide critical space for Thayer School's project-centered, interdisciplinary curriculum.

The campaign is progressing well. As of the end of March, alumni/ae and friends have already pledged more than \$36.6 million toward Thayer School's campaign priorities.

>> One of Professor Charles Sullivan's research teams won top honors in its division in the Efficiency Challenge 2004 international competition sponsored by the Department of Energy. The competition sought "cutting edge power supply designs that are not ready for the market, but are able to achieve outstanding efficiencies." Entering the category of 6-24 watt, 5-12 volt circuits typical of office phones, battery chargers, and computer peripherals, the team used advanced optimization techniques to construct a power supply that achieved an average of 88 percent efficiency over the range of test conditions. The team, led by Ph.D. candidate Jennifer Pollock, consisted of Ph.D. candidates Xi Nan, Satish Prabhakaran, and M.S. student Magdalena Dale.

>> M.S. candidate Lincoln Potwin took fourth-place honors in the American Society of Mechanical Engineers' 2004 "Old Guard Young Engineers" international competition. Potwin presented his research on an ultrasound scanning system for breast surface detection.

>> Engineering Sciences major Tom Zangle '05 received the College Student of the Year Award from the New England section of the American Institute of Aeronautics and Astronautics. AIAA member Alex Brucoleri '07 is a mentor for the 2005 Team America Rocketry Challenge sponsored by the Aerospace Industries Association. He has been mentoring high school students from Wolfeboro, N.H.

>> M.E.M. candidate Rebecca Wang and Kay Kochan, an M.S. exchange student from Germany, participated in the ninth annual "March Madness for the Mind" competition held in San Diego by the National Collegiate Inventors and Innovators Alliance. The students exhibited an active noise reduction module. Their project advisor is Associate Professor Laura Ray.

## STUDENT PROJECTS

### I Want One of Those!

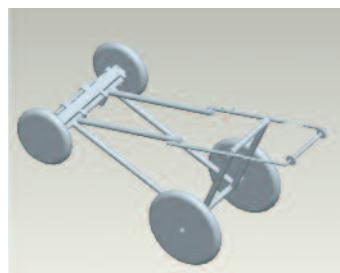


#### ▲ Gyrobike

Forget training wheels. The Gyrobike keeps beginners upright every time. The novel bike features a gyroscopic flywheel fitted into the front wheel. Inventors **Hannah Murnen '06**, **Augusta Niles '07**, **Nathan Sigworth**, and **Deborah Sperling '06** won the Phillip R. Jackson Award for most outstanding overall performance in last fall's ENGS 21 (Introduction to Engineering). M.E.M candidate **Jon den Hartog '03** was the team's teaching assistant.

#### Four-Wheel Jog ►

The four-wheeled "Better Jogging Stroller" improves on the stability and steering of three-wheeled models. A twist of the handlebar turns the front wheels right or left. ENGS 21 students **Jennifer Crist '07**, **Kevin Olds '07**, **Patrick Rodjito**, **Brenda Zarate '05**, and **Mike Hart '07** designed the stroller. The team's teaching assistant was M.E.M. candidate **Jeff Hebert '04**.



## CLASSROOM

### Substance of Civilization

"IF HUMANS HAD NEVER LEARNED TO SMELT METALS, we would still be living in caves."

That's what materials scientist Ron Lasky told the 60 students taking ENGS 5 "Materials, the Substance of Civilization." The course, one of several Thayer School offerings aimed at non-majors, gives students a glimpse of the interplay between technology and lifestyles. From the Stone Age to the Silicon Age, the interplay is more than a historical footnote. According to Lasky, "The foundation of civilization rests on humankind's ability to work with materials."

"Students usually don't realize the extent to which materials determine their everyday life," he says. "Almost anything we touch has been affected by improvements in materials: the clothes we wear, the objects in our houses and offices, the equipment we use, the materials we build with."

Marching chronologically through history, Lasky cites numerous examples of the societal impact of technological breakthroughs. "Tools and clothing enabled early humans to survive the ice age," he says. "The Romans' production of superior steel and their development and use of concrete and masonry created an empire. The gold rush accelerated the development of the western United States by generations. Sir Henry Bessemer's process for producing steel inexpensively in the 1850s led to railroads, enabled the industrial revolution, and made architectural innovations such as skyscrapers and elevators possible. Turning sand into silicon chips gave us the electronics/information age."



MATERIAL WITNESS Professor Ron Lasky demonstrates the modern version of a technology wrought from wood, sinew, bone, and feathers 40,000 years ago.

# sports

Even if none of the students enters engineering, Lasky hopes the course will stick with them. "I hope that as they view the world, they will never again take materials for granted," he says.

—Judith Hertog

## HISTORY'S TOP MATERIALS

By Professor Ron Lasky

- > 1. **Wood**—the most widely used building material from earliest times to today
- > 2. **Fired clay**—the first transformation of one material into another
- > 3. **Precious metals**—mainstays in the transfer of wealth
- > 4. **Smelted materials**—transforming several materials into a single material; heating copper-bearing minerals to produce copper was arguably the most significant technical development in all history
- > 5. **Glass**—used as early as 2500 B.C. for beads and 1000 A.D. for magnifiers, glass is ubiquitous in modern life
- > 6. **Petroleum**—beyond energy, a base for detergents, pharmaceuticals, chemicals, and plastics
- > 7. **Nuclear materials**—fission of uranium and plutonium led to nuclear power and weapons
- > 8. **Composites**—with tremendous strength-to-weight ratios, fiber-glass-epoxy carbon fiber-polymer, and other composites make cars, planes, and other products lighter
- > 9. **Silicon**—the foundation of computer and communications technology
- > 10. **Biological and nanomaterials**—today's groundbreaking materials

## In the End Zone

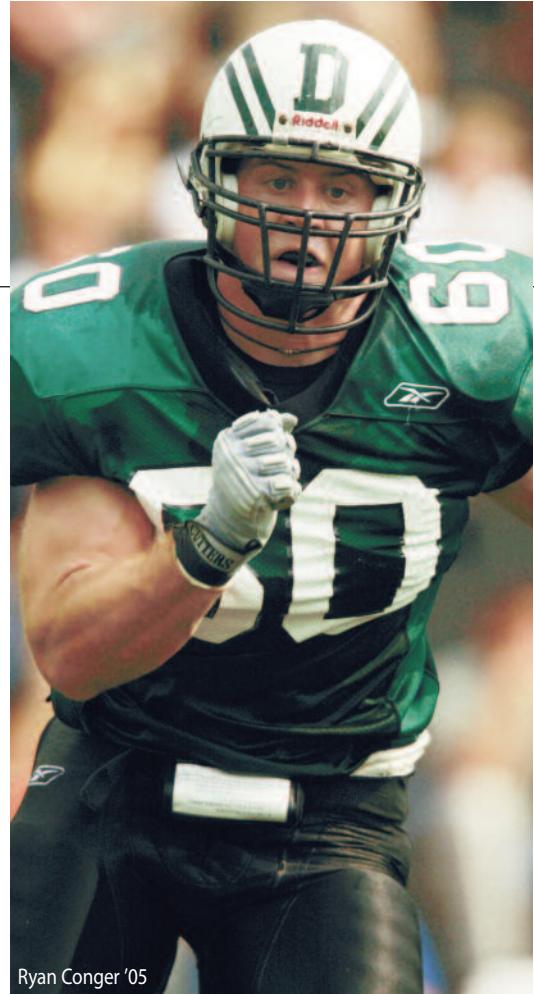
FOR ENGINEERING MAJOR Ryan Conger '05, senior year is more than the final leg of his undergraduate studies. It's also the end of his Dartmouth football career. A co-captain of the Big Green team, defensive end Conger started every game of his college career and was First Team All-Ivy his junior and senior years. He succeeded on Thayer School turf as well, serving as a teaching assistant for Professors Ursula Gibson in ENGS 1 (Everyday Technology) and William Lotko in ENGS 21 (Introduction to Engineering) and working in the ice lab with Professor Ian Baker and Research Associate Daniel Iliescu. Recently Conger spoke with Dartmouth Engineer about his senior year transitions.

**Q. What did it feel like to walk off the field at your last varsity game?**

**A.** In a word, bittersweet. During the week going into my last game I actually spent quite a bit of time thinking about how lucky I was to be on such a long, strange, and wonderful trip. Rather than being overcome with sadness, as I expected to be, I started to look back and actually appreciate the times I've had playing a game I love. When the time came, I was fortunate enough to spend the moment with my family, a few friends, an old coach, and of course my teammates. After playing football since I was nine years old, I was sad at the end of the last game, but I will always be happy for the experiences I have had playing such a great game.

**Q. How did you deal with the 2004 season 1-9 win-loss record?**

**A.** Unfortunately things didn't follow our plan for the season. It is heartbreaking to put so much time and effort into something and not reap the benefits of your labor. In the end we can look back on the season and we can say that we never gave up, no matter how poorly it seemed the cards were stacked against us. We put everything we had into it, and I feel that is the only way we should have done it.



Ryan Conger '05

**Q. You were known for visualizing games and plays. Is this how you approach engineering?**

**A.** I think almost any engineer would agree that there is a huge element of visualization in any problem solving. While the visualization is quite different between the two, I think they are closely related. Most people believe that football is almost entirely a physical game, but there is a tremendous amount of mental preparation that goes into it as well.

**Q. What's ahead for you in engineering?**

**A.** I plan on pursuing my B.E. and M.E.M. at Thayer in the future. Ultimately I think I'll pursue a career related with engineering, though I'm not sure how at this point.

**Q. Will you still play football?**

**A.** For the time being, I'm trying to pursue a career in professional football. I've been training for the NFL draft at home in New Jersey. I had some flexibility in my D-Plan that allowed me to take my winter term of my senior year off to devote my time and energy to pursuing a dream I have always had. Hopefully, things in that field will work out and I'll put off my graduate studies at Thayer for a few years.

# lab updates

## WIRELESS, WEARABLE TRIAGE GEAR

Associate Research Professor Sue McGrath, director of the Emergency Readiness and Response Research Center at Dartmouth's Institute for Security Technology Studies, is developing a wearable, wireless, mobile communication system that will help medics and emergency teams conduct triage in high-risk situations. Called Artemis (Automated Remote Triage and Emergency Management Information System), the system allows a team of hand-held computers to pass data wirelessly to one another and ultimately back to an emergency command center. Each Artemis unit can be worn on a belt and attached to GPS, vital-sign, or other monitors to gather and transmit critical data.

Last spring McGrath's team tested a prototype in an emergency training exercise in which rescuers freed an "injured" construction worker from scaffolding beneath Cape Cod's Bourne Bridge. The system outwitted interference from the concrete and metal in the bridge by bouncing signals between Artemis units, then back to the collector computer. The field trial led the team to improve the wireless networking, user interfaces, and software models. "Our experiments and exercises teach us a great deal about how the system could be used in actual emergency and battlefield conditions," says McGrath. She predicts that a commercial system could be available in two to four years.

The research is sponsored by the Department of Homeland Security's Office of Domestic Preparedness and by the U.S. Army Communications and Electronics Command Division. Papers by McGrath and other members of the team can be downloaded from [www.ists.dartmouth.edu/er3c/mission.php](http://www.ists.dartmouth.edu/er3c/mission.php).

## TAKING THE PAIN OUT OF JOINT REPLACEMENTS

Nearly half a million total hip and knee replacements are performed annually in the United States. Despite the high success rate of these procedures, an additional 60,000 surgeries are performed each year to replace failed prostheses. By analyzing failed prosthetic joints, the Dartmouth Biomedical Engineering Center for Orthopedics, headed by Professor John Collier, has greatly reduced the incidence of one cause of prosthetic failure, oxidation-related breakage of polyethylene bearings in artificial joints.

But many patients face another problem. The abrasive and adhesive wear of bearings in prostheses can cause microscopic particles of plastic and metal to migrate into the tissue surrounding artificial joints, causing an inflammatory, bone-resorbing reaction known as osteolysis. Collier and his colleagues are collaborating on a new research project to identify the factors that lead to this condition. Subjects will include both patients who have osteolysis and bone resorption and patients who are not experiencing resorption or infection despite

**LIFELINE**  
Professor Sue McGrath's remote triage information system will aid victims and rescuers.



loosened artificial joints.

After surgical removal of failed implants, samples of surrounding tissue are examined by pathologists, then sent to the Thayer School researchers to quantify and classify wear particles. By examining physical characteristics of the debris, patterns of wear on the removed prosthetic components, and tissue histology, the team hopes to identify conditions that lead to joint failure. Project goals are improved prosthetic joint design, better surgical techniques, and, ultimately, a decrease in the incidence of osteolysis-related joint failure.

Collier's team includes pathologist Justin Cates, orthopedist Michael Mayor, Ph.D.

candidate Doug Van Citters '99, Th'03, medical student Derek Jenkins '02, and undergraduate Katie Muse '05.

## SMART FOOTBALL HELMETS

A lightweight biofeedback system that measures the force of impact football players experience during head-on collisions is being field tested at three colleges this year. Thayer School Adjunct Professor Richard Greenwald, head of Simbex, the West Lebanon, N.H., company that is developing the Head Impact Telemetry System (HIT), says the patented invention can minimize the guess-work coaches apply every time a player goes down from a head-on collision.

HIT sensors embedded

## Explore more Thayer School research

<http://engineering.dartmouth.edu/thayer/research/>

inside a football helmet continuously measure the force of blows to the head and wirelessly transmit the information to a compact console on the sidelines. Coaches can view images and graphs detailing the magnitude, location, direction, and duration of each impact.

Data gathered last year from 38 Virginia Tech players indicate that hits to the head have an average force of 40g—40 times the force of gravity—and that impacts can reach as high as 180g, the kind of force involved in severe car crashes. Studies this year also include players from the University of North Carolina and University of Oklahoma.

While the National Football League has conducted lab research on concussions, Greenwald's device is the first to measure on-field head impact for a large number of players. "The HIT System allows us to track players' cumulative history over time," he says. "And that is important because most researchers believe that cumulative impacts—not just one impact—may be significant in terms of sustaining more concussions and also long-term cognitive deficits."

Research and development of the HIT System was funded by the National Center for Medical Rehabilitation at the National Institute for Child Health and Development at the National Institutes of Health.

### DOWN UNDER FOR NANOTECHNOLOGY

Two of Professor Ian Baker's students, James Hanna '02 and

Johnathan Loudis '05, traveled to Australia in March to use the University of Sydney's Local Electrode Atom Probe (LEAP) to examine experimental nanostructured FE-NI-MN-AL alloys developed at Thayer School. The University of Sydney is the only university in the world with a LEAP machine. According to Baker, who visited the Sydney facility last year, the students obtained composition profiles of the alloys by stripping off atoms one layer at a time. Dartmouth has filed a patent on the alloys.

### PUSHING FOR ALTERNATIVE FUELS

Professor Lee Lynd, whose research centers on developing biological alternatives to fossil fuels, is trying to rally support from the American public. In "Growing Energy," an article published by the Natural Resources Defense Council, co-

author Lynd argues that an aggressive plan for developing cellulose-based biofuels could end America's dependence on foreign oil by 2025. The paper can be downloaded from [www.bio.org/ind/GrowingEnergy.pdf](http://www.bio.org/ind/GrowingEnergy.pdf). Lynd also has initiated talks with the National Corn Growers Association, pointing out that corn and other sources of cellulose used in biomass conversion could provide a major new revenue stream for farmers.

### ICE ENGINEER AIDS NASA

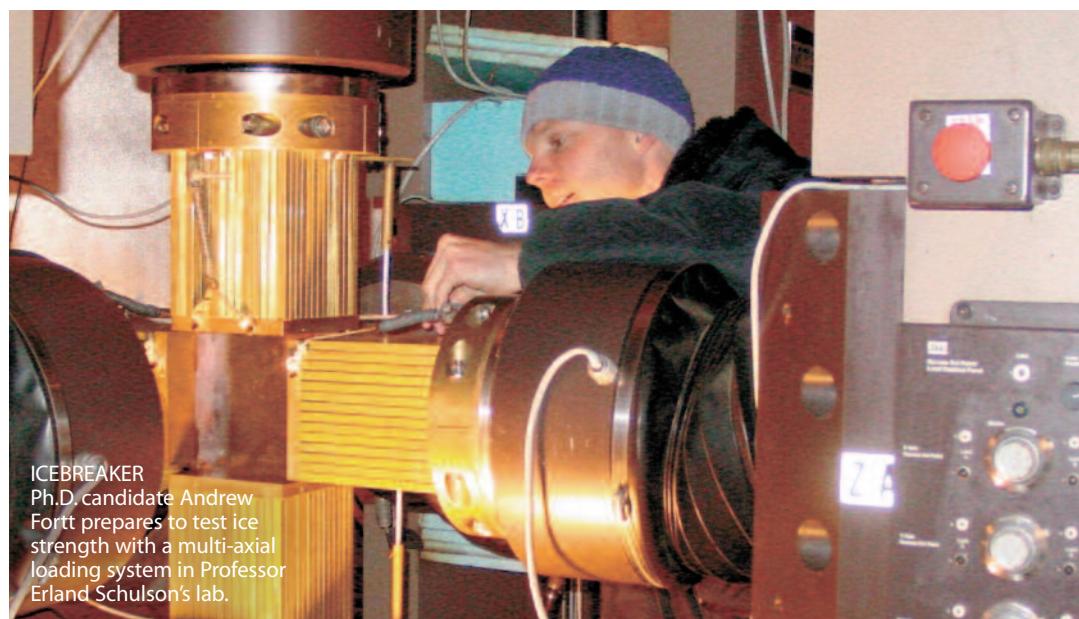
Professor Erland Schulson, director of Thayer School's ice research lab, is helping NASA's Space Shuttle Return-to-Flight Program analyze the ice that builds up on the shuttle's super-cooled external fuel tank. Because debris from Space Shuttle Columbia's external tank resulted in the loss of the orbiter, NASA wants to know

how much ice can accumulate on the tank without becoming a debris hazard.

NASA is simulating the conditions typical of launch days to see how much ice and frost build up on the external tank. The agency sends the ice to Schulson for strength and structural analysis. Using a multi-axial loading system, Schulson measures the force required to crush the ice, then returns the samples to NASA for ballistic impact testing.

The NASA work has expanded Schulson's research. "In our previous research we'd only ever tested poly-crystal ice samples," he says. "For NASA, we've now tested a single crystal form of clear, hard ice and discovered that it is extraordinarily strong."

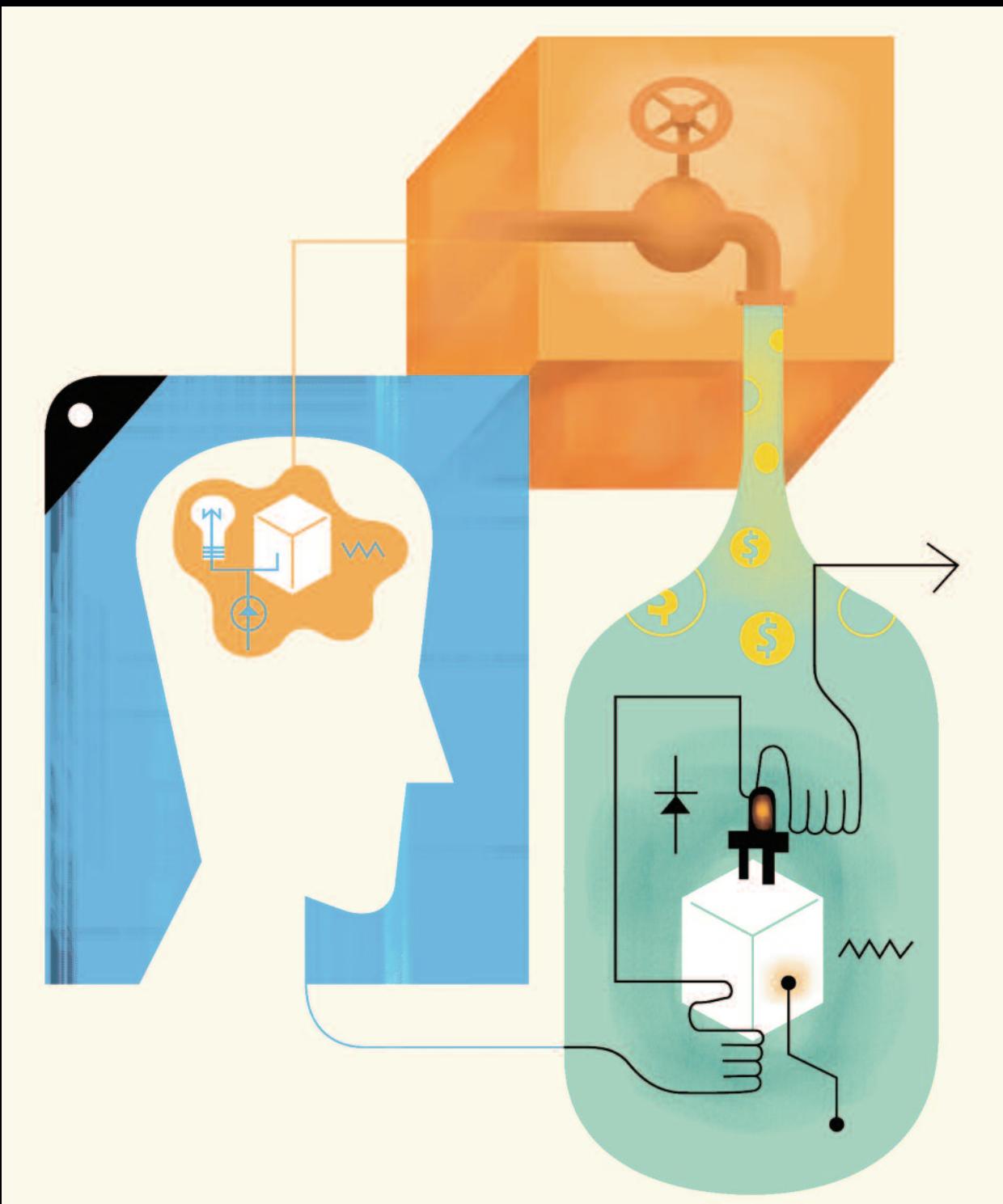
Ph.D. candidate Andrew Fortt and engineering research associate Daniel Iliescu are assisting with the analysis.



**ICEBREAKER**

Ph.D. candidate Andrew Fortt prepares to test ice strength with a multi-axial loading system in Professor Erland Schulson's lab.

# From Idea



# to Invoice

AS ENTREPRENEURSHIP GROWS AT THAYER SCHOOL,  
INNOVATORS ENCOUNTER PAINS AS WELL AS GAINS.

BY TAMARA STEINERT

**I**N THE EARLY 1990S A DARTMOUTH STUDENT approached Charles Hutchinson, then-dean of Thayer School, to ask him to support a new entrepreneurship club. The student explained that Dartmouth administrators had turned him down on the premise that entrepreneurship and the liberal arts were incompatible.

"I told the student that I couldn't disagree with that opinion more," says Hutchinson, founder of three successful companies, including, most recently, GlycoFi, a biotherapeutics firm located in Lebanon, N.H.

If there's any doubt that barriers toward entrepreneurship at Dartmouth are falling, consider this: In 2001 the College established an institution-wide equivalent of an entrepreneurship club, the Dartmouth Entrepreneurial Network (DEN). This resource for faculty, students, staff, and alumni attempts "to link the intellectual firepower of the university with the execution power of industry," says DEN's executive director, Gregg Fairbrothers '76.

Entrepreneurship, long a part of the Thayer School curriculum, is gaining momentum at all levels. Students in ENGS 21, the ever-popular introductory class, not only design solutions to real-world problems but write business plans as part of their final projects. Graduate students, particularly those studying for master of engineering management degrees, are encouraged to take an entrepreneurship elective at Tuck School of Business. In the late 1990s then-dean of Thayer School Lewis Duncan emphasized the need for students to understand how to take a project "from an idea to invoice." Even at the Board of Overseers level, entrepreneurship is on the agenda. E-ship, an ad-hoc group of overseers, is working to foster an entrepreneurial environment at Thayer School and Dartmouth to enhance the educational experience for students and faculty. Several overseers are also members of Angel Parvi, an independent, nonprofit organization founded by board chair John Ballard '55, TT'56 that invests in selected Dartmouth start-ups.

Even if institutional barriers to entrepreneurship are coming down, however, many Thayer School faculty and administrators contend that attitudinal walls remain. As Hutchinson describes it, "There's this mindset that anything that makes money is evil. And that's not too much of an exaggeration."

Critics of the entrepreneurial trend on campus worry that potentially lucrative research will receive higher insti-

tutional priority than less-profitable research. Others are concerned that teaching will take a backseat to business development, or that the free exchange of ideas will be hampered by the desire to protect trade secrets.

Interim Dean William Lotko acknowledges that these are serious concerns. "There is a tension, and I think we have to be vigilant," he says. However, engineering and entrepreneurship have always gone together in the sense that engineers create solutions of value to society, he says, and "the willingness to pay for something is one way our society recognizes that value."

While profit can be a motive for entrepreneurs, it's usually not the only one, says Fairbrothers. "Let's say some clinicians come to me with an idea for a new medical device. I'll ask them what the options for success are. Usually it comes down to wanting to see people using the device in practice. That's more important than whether they make a lot of money," he says.

"Many faculty who are involved in a start-up activity don't want to become a Bill Gates," adds Lotko. "What they want is to drive this technology out the door; then, when it becomes a full-fledged activity, they want to move on."

## AN EVOLUTION

For many people the tech boom of the late 1990s was their first introduction to the idea of university entrepreneurship. However, the entrepreneurial trend is the result of a long-term dynamic, not some sudden change, according to Hutchinson.

"Most of us in my generation were focused through our graduate programs on the big things like aerospace, trying to get somebody to the moon and those kinds of things, which were all funded by the government. So engineering schools just really fell away from their relationships with corporations," he says. Since the government retained ownership of intellectual property generated by federally sponsored research, researchers didn't have to be concerned with commercializing the products that resulted.

This dynamic changed in 1980 with the passage of the federal Bayh-Dole Act. Suddenly colleges and universities were not just producers of knowledge; now the government expected them to help move that knowledge from the lab to the living room. Many of the people who criticize colleges and faculty members for moving in an entrepreneurial direction aren't familiar with this responsibility, says Hutchinson.

"What Bayh-Dole said is, 'If you accept federal grant monies, you've got to commercialize the resulting technology. That's part of your job.' Very few people within the academic enterprise understand that," he says.

Bayh-Dole also prompted a philosophical shift in how people think about the value of research in the academy, says Fairbrothers. "In the post-Bayh-Dole model, research-based learning is about more than publishing. It's also about what the research community calls 'translation' or 'technology transfer,' wherein innovation is taken full-cycle into products and services that will benefit society," he says.

The most common way Dartmouth moves innovations to consumers is by licensing technology to outside companies, which then create and market the resulting products. However, in recent years researchers have been increasingly interested in forming their own small entrepreneurial ventures to commercialize their own technologies. The College sometimes issues licenses for the technology back to the inventor—an approach that is especially appropriate when the technology in question is so tied to the inventor that it can not easily

be developed without his or her involvement, explains College General Counsel Robert Donin.

According to Alla Kan, director of the College's Technology Transfer Office, the College usually receives upfront cash payments from licensees as a condition of licensing. However, she says, if a licensee is a cash-poor start-up company, the College might agree to take equity in the company in lieu of some of the cash payments.

When accepting an equity share, Dartmouth protects its integrity by placing special limits on its involvement in the company. "One of the things the College has said is we don't want to be a manager of the company," Donin says. To that end, the College limits its equity in a company to no more than 10 percent. College officials are also not allowed to sit on the boards of faculty companies.

At Thayer School the dean has the discretion to enter into cautionary agreements with start-up businesses based on research happening there, says Lotko. These agreements might allow a burgeoning company to use College space or equipment in exchange for equity. "One has to be careful that these are consistent with the tax-exempt and non-profit status of the institution and that they're aligned with our educational purpose," he says.

In recent years there also have been a growing number of faculty ventures that are part of the Small Business Innovation Research (SBIR) and Small Business Technology Transfer Award (STTR) programs. These federally sponsored programs provide grants to small businesses to investigate the commercial potential of new technologies. The STTR program requires companies to work in partnership with nonprofit research institutions. The funding for SBIRs and STTRs comes from the same government agencies from which academic researchers already receive grants, including the National Science Foundation, NASA, and the Department of Defense.

The SBIR and STTR programs have three stages: first, to demonstrate the feasibility of commercialization; second, to develop a prototype; and third, to actually take a product to market. Government funding is only provided through the first two stages. After that the company has to secure outside funding. According to Professor and former Dean Elsa Garmire, who is a member of the Thayer committee responsible for overseeing faculty business ventures, very few projects—maybe 1 percent—ever get to the third stage. "Most of the people on campus who get these SBIRs are not interested in making vast amounts of money. They've just found sort of a backdoor way of getting their research funded," she explains.

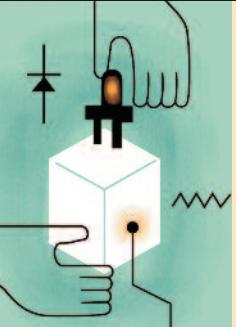
## ACADEMIC FREEDOM AND THE EDUCATIONAL MISSION

One of the most frequently cited arguments against entrepreneurial activity on campus is that the need to protect trade secrets will hamper the free exchange of ideas essential to the university environment. A veteran of both academia and the corporate world, Hutchinson doesn't buy it.

"With all due respect to my colleagues, there is nothing any more stifling and insidious than the peer-review system. It's an old-boy network," in which even "pure" researchers have to consider the political environment to get funding, he says. "We're all driven by that kind of dynamic. I'm not overly critical—the system basically works—but I think anytime anyone starts to think they're more pure than someone else, you've got a problem," he adds.

Lotko takes a more moderate view. "We do have to ensure—particularly where students are involved—that people are not restricted in

## Who Owns Intellectual Property?



Patents and copyrights are treated very differently in both intellectual property law and in College policy, says College General Counsel Robert Donin. Although the intellectual property created by an employee within the scope of work generally remains the property of the employer, the law has always included an exception for teachers, allowing them to keep the copyright to their works of authorship, such as books and musical compositions. Most colleges, including Dartmouth, have adopted this exception as part of their policies as well, says Donin.

However, since inventions generally involve more substantial institutional resources and are more readily commercialized, the College retains ownership of these items. Under this policy, faculty members are required to disclose new inventions to the Technology Transfer Office. College officials analyze the commercial potential of the invention and decide whether to retain ownership. If the College chooses to not exercise its option, ownership reverts to the inventor.

Should an invention eventually generate royalties, Dartmouth policy calls for a 50-50 split between the College and the inventor. Professor Victor Petrenko, whose research on the qualities of ice has resulted in eight patents, with 30 more in the works, describes this policy as "quite generous" compared to the policies of the College's peer institutions. The portion that comes back to the school first goes to pay the expenses associated with acquiring the patent and other marketing expenses. The College's portion of royalties is then split between the provost's office, the originator's school, the originator's department, and the originator's laboratory.

—Tamara Steinert

## So You Want to Be an Entrepreneur

The Dartmouth Entrepreneurial Network (DEN) recently sponsored a nine-week course for prospective entrepreneurs in the Dartmouth community. Here are some pointers from Tuck Professor and DEN Executive Director Gregg Fairbrothers '76.

publishing and expressing ideas and results that come out of their work," he says. "When an activity starts to take on that type of proprietary nature, we have to look at getting it off campus."

Protecting the teaching mission of the College is also a high priority. Dartmouth policy restricts the amount of time faculty members can spend on outside activities, whether it's consulting for outside companies or creating a business of one's own, to 20 percent of their time. Thayer faculty entrepreneurs are required to report on their activities to a College-wide committee on entrepreneurial activities, as well as to a similar Thayer group.

If entrepreneurship, like consulting, has the potential to distract from the classroom, it also has the potential to make a professor's teaching more relevant. "Engineering doesn't take place in the abstract," says Lotko. "One thing that really motivates students is when professors can talk about applying their skills in the real world. That's difficult to talk about with authority if you haven't experienced it yourself."

Professor Victor Petrenko, whose research into the structure and properties of ice has led to several licensing agreements with outside companies, as well as the formation of his own company, Ice Engineering LLC, concurs. "For 22 years I was just a basic science scientist, and I don't think I taught my students well," he says. "Now in my lectures I can provide numerous real-world examples. I actually am a better teacher."

Unlike industry, where the No. 1 priority is achieving a useful solution in a timely manner, academia encourages scientists to pursue research questions for years—sometimes for decades—in search of thorough understanding. "To be honest, many academics don't understand the compromise involved in getting a product out the door," Garmire says. "Many of our students are going to go into entrepreneurial situations, and they need to be taught by people who are familiar with that environment."

Professor John Collier '72, Th'77 hopes to give students a taste of how engineers work in the real world in ENGS 21. Only since he took over the class in the 1980s have students been asked to look closely at the economic side of engineering. Working as teams, students in the class have to identify a problem and potential solution, design a prototype, identify a market, and write a business plan.

"It's important for the students to have an idea of whether the solutions they've developed have any potential to be marketed," says Collier. "It forces you to figure out who your audience might be, what folks are willing to pay for your invention, and then how many of them there might be out there willing to buy it. Once you have those kind of numbers, you can go back and do an analysis: What would it cost me to produce it if I wanted to make this number of devices? That's really the crux of the matter."

According to Collier, such details bring the business side of engineering alive. "If you try to teach that in the abstract, the students have very little interest," he says. "If you put it in the context that they've already designed something that they've fallen in love with you have a very attentive audience."

Engineering student Jeffrey Grossman '06 took ENGS 21 during the spring of his freshman year and ended up being co-creator with four classmates of a patentable idea: a dripless gas nozzle. "Basically the theme for the class was to come up with something that would improve the transportation industry," he says. His team's background research revealed that dripping fuel and escaping gas vapor at filling stations

Continued on page 31



>>**1. Be prepared to work hard.** Entrepreneurship consists of 5 percent hearing, 10 percent seeing, and 85 percent doing. As John D. Rockefeller said, "The secret of success is to do the common things uncommonly well."

>>**2. Think about needs, not trends.** Ideas that fill needs automatically have users and buyers. Trying to create a new need is generally harder than innovatively addressing an existing need.

>>**3. Weigh the competition, both existing and potential.** There is always competition. Entrepreneurs often fall into the trap of thinking they have a unique market with no competitors. There is nothing wrong with competition—it means someone else thinks there's value in what you're doing. No competition may mean you're smart, but it may also mean a lot of other smart people have figured out the idea or market is not going to work out.

>>**4. Specify the compelling benefits of your solution.** Why is your idea better than your competition? Why will your idea be better than the competition over time?

>>**5. Pre-empt potential competition by filing for patents.** Another weapon is good execution; Microsoft built an empire on this concept.

>>**6. Share your idea through pitches.** Pitches help you distill the essence of your idea. Keep the pitch simple. Avoiding jargon or "geek speak" will help you reach the widest audience. Your pitch doesn't have to cover everything; the goal is to get people interested enough to come back for more.

>>**7. Build a prototype.** You'll become aware of the limitations in resources or materials that might not be evident on paper.

>>**8. Show the prototype to potential customers.** You'll get invaluable feedback on your product's appeal or ease of use. Finding people who are willing to pay you for your idea is the best proof of product you can give to potential investors—and to yourself.

>>**9. Don't get discouraged.** As Rosabeth Moss Cantor, editor of the Harvard Business Review, once said, "The middle of every successful project looks like a disaster."

—Genevieve Chan



entrepreneurial profs

# MINDING THEIR BUSINESS

## Professors Venture into New Markets

BY GENEVIEVE CHAN • PHOTOGRAPHS BY CHRIS MILLIMAN

**Y**ou've seen them around campus, in the Great Hall or in the laboratories in Cummings. You may have even sat in one of their classrooms and heard them lecture on the role of the engineer in today's world. But what sets the following individuals apart is that they are academics actively engaged in entrepreneurial ventures.

As professors they bring knowledge and resources to the companies they've started. As members of the new-venture community, they provide Thayer School students with insights into real-world applications of engineering, including the business challenges associated with new companies. Some professors call their entrepreneurial responsibilities "humbling." All share a collective belief: that in the process of bringing innovations to market, they have become better engineers.



**COMPANY** ThermalVision

**FOUNDER** Stuart Trembly, Chief Scientific Officer

**STARTED** 2002

**PRODUCT** System for reshaping the cornea of the eye through controlled, localized absorption of microwave energy. This is a safe, simple, low-cost, vision-correcting alternative to invasive laser surgery.

**STAFF** Two managers, one engineer

**INTELLECTUAL PROPERTY**

Dartmouth holds the intellectual property; company operates under an exclusive usage license; one patent issued, one patent pending

**EARLY FUNDING** STTR and SBIR grants; seed money from venture capitalist firm Borealis Ventures; awarded first prize in Greener Ventures business plan competition

**EXPERTISE** Associate Professor

Trembly was involved in a previous start-up. For business expertise he turns to Dartmouth Entrepreneurial Network founder Gregg Fairbrothers '76, Borealis investor Phil Ferneau '84, Tu'96, and Thayer overseer Ralph Crump '66A.

**ADVICE** "Trust your instincts when assessing people to work with in the business world."



**COMPANY** Ice Engineering LLC

**FOUNDER** Victor Petrenko,  
President and Chief Scientist

**STARTED** 2001

**PRODUCTS** A unique ice interface control technology modifies ice adhesion strength, prevents ice build-up, de-ices surfaces, and controls ice friction between any surface and ice or snow. Applications/products include bridge and power line de-icers, cross-country skis with electronically controlled traction, and a novel icemaker for refrigeration systems.

**WEBSITE** [www.iceengineering.com](http://www.iceengineering.com)

**STAFF** Four management employees, five research assistants

**INTELLECTUAL PROPERTY**

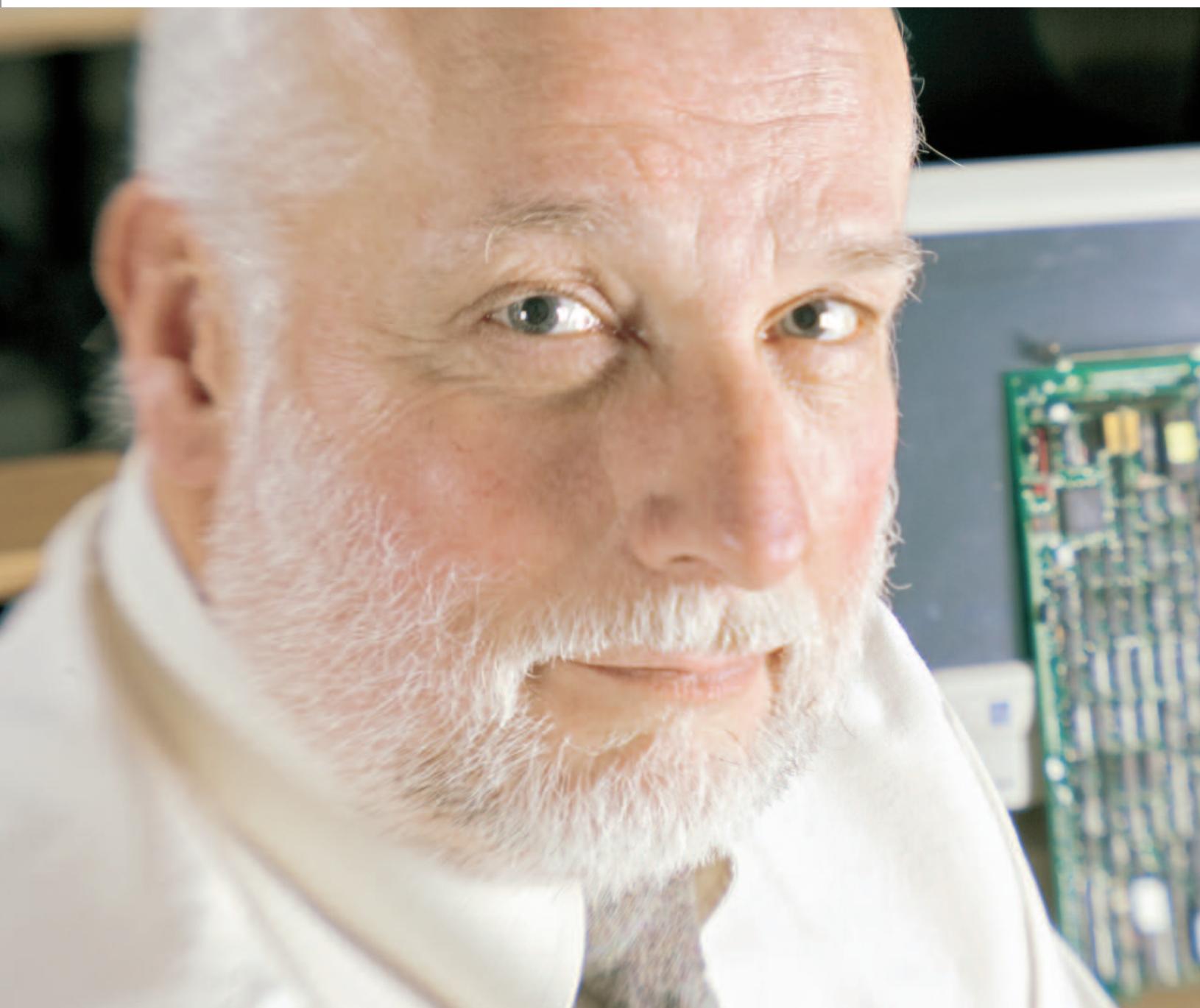
Dartmouth holds patents; Ice Engineering retains four exclusive field-of-use licenses

**EARLY FUNDING** Investments from previous patents, angels' investments, and early contract work

**EXPERTISE** Professor Petrenko co-wrote textbooks on ice physics and the physics of semiconductors. He holds 12 U.S. patents, 15 foreign patents, and has 20 more pending.

**THE UPSIDE** "After 22 years doing strictly basic science research, it's nice to do something that's really needed."

**THE DOWNSIDE** "As a founder, you take failures and setbacks personally. If you have five people on staff, you suffer five times as much."

**COMPANY** Ve-Design Inc.

**FOUNDER** Robert Graves, Chief Technical Officer

**STARTED** 1999

**PRODUCT** Software that allows design engineers to evaluate and optimize millions of design, sourcing, and manufacturing system alternatives in a fraction of the time it takes with existing tools. The goal is to

reduce the cost and time of bringing products to market.

**WEBSITE** [www.ve-design.com](http://www.ve-design.com)

**STAFF** Three expert engineers, one part-time engineer, CEO

**INTELLECTUAL PROPERTY** Patents held at Rensselaer Polytechnic Institute; company operates under an exclusive license from RPI

**EARLY FUNDING** NSF grant, customer contracts, prize money for business plans

**EXPERTISE** The John H. Krehbiel Sr. Professor for Emerging Technologies, Graves is co-director of Thayer School's M.E.M. program.

**ADVICE** "Make sure your technology is right, your concept is fitting, and your value proposition is well stated."



[entrepreneurial pros](#)



**COMPANY** Sound Innovations Inc.

**FOUNDERS** Robert Collier, Laura Ray, and Christopher M. Pearson Tu'02

**STARTED** 2004

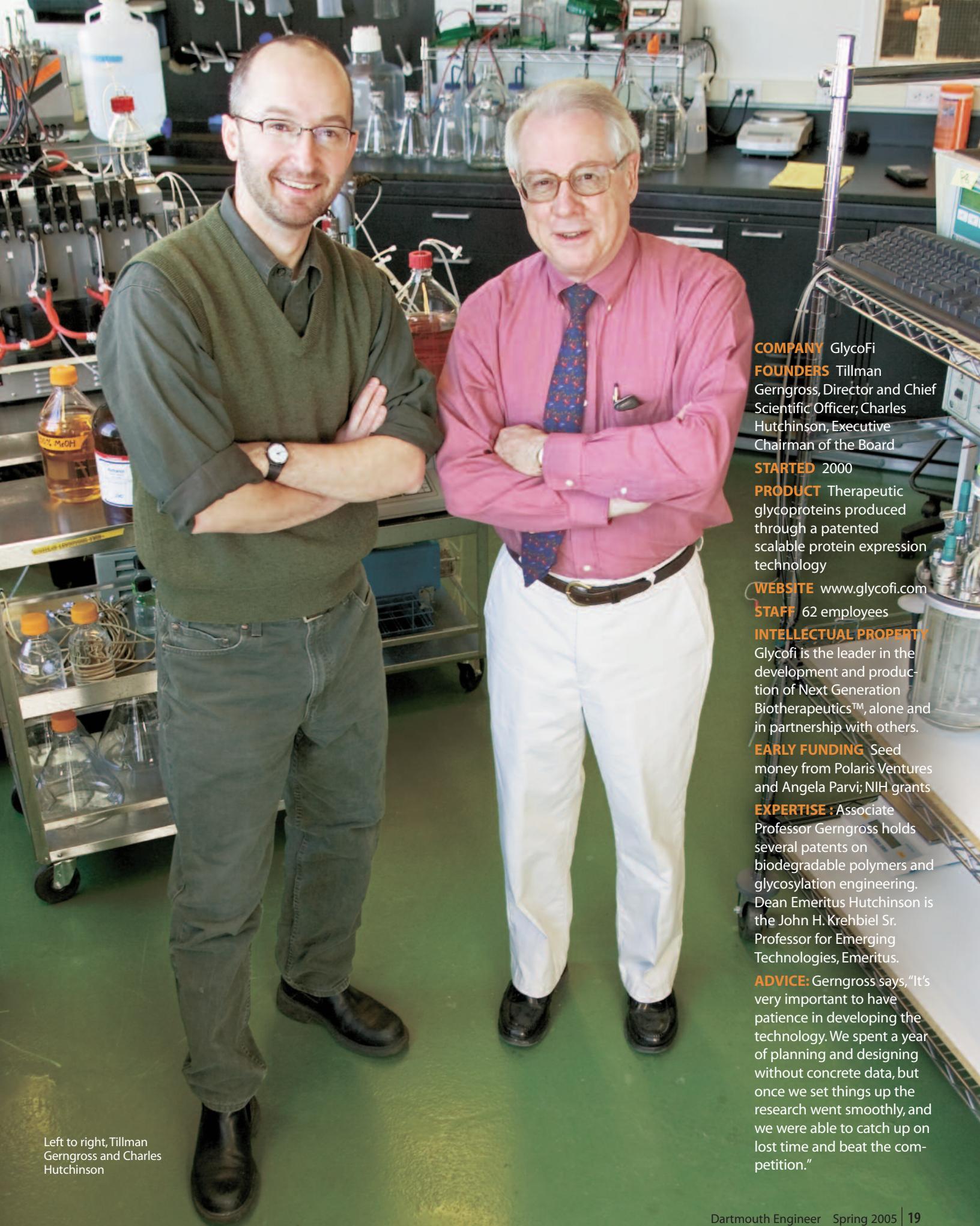
**PRODUCT** The next generation of aviation communications headsets. Using proprietary, patented digital signal processing methods for active noise reduction, the headsets cancel noise by producing diametrically opposed sounds. The headsets will enable communication while shielding users from ear-damaging noise levels.

**EARLY FUNDING** Product development contract with David Clark Company Inc.; U.S. Army and NSF research and development contracts

**STAFF** Tobin Deitrich Th'95, chief design engineer

**EXPERTISE** Adjunct Professor Collier specializes in acoustics, hearing protection, and environmental noise control. Associate Professor Ray researches control theory, dynamics, and computer-aided design and analysis. Deitrich is an electrical design and product development engineer.

**ADVICE** Collier on knowing your market: "Work closely with your end-users, focus on human needs, and be guided by real-world applications."



Left to right, Tillman Gerngross and Charles Hutchinson

**COMPANY** GlycoFi  
**FOUNDERS** Tillman Gerngross, Director and Chief Scientific Officer; Charles Hutchinson, Executive Chairman of the Board

**STARTED** 2000  
**PRODUCT** Therapeutic glycoproteins produced through a patented scalable protein expression technology

**WEBSITE** [www.glycofi.com](http://www.glycofi.com)  
**STAFF** 62 employees

**INTELLECTUAL PROPERTY**  
GlycoFi is the leader in the development and production of Next Generation Biotherapeutics™, alone and in partnership with others.

**EARLY FUNDING** Seed money from Polaris Ventures and Angela Parvi; NIH grants

**EXPERTISE:** Associate Professor Gerngross holds several patents on biodegradable polymers and glycosylation engineering. Dean Emeritus Hutchinson is the John H. Krehbiel Sr. Professor for Emerging Technologies, Emeritus.

**ADVICE:** Gerngross says, "It's very important to have patience in developing the technology. We spent a year of planning and designing without concrete data, but once we set things up the research went smoothly, and we were able to catch up on lost time and beat the competition."



entrepreneurial pros

Left to right,  
Tim Raynolds,  
Peter Robbie, and  
Paul Meaney



**COMPANY** Microwave Imaging System Technologies

**FOUNDERS** Paul Meaney, President; and Keith Paulsen

**STARTED** 1995

**PRODUCT** Noninvasive imaging system for better breast cancer detection and improved exam comfort.

**THAYER COLLEAGUES** Tim Raynolds, research engineer; Peter Robbie,

design consultant; Margaret Fanning, consultant

**PATENTS** Two patents, two patents pending, and one new provisional patent

**EARLY FUNDING** SBIR grants from the National Cancer Institute

**EXPERTISE** Associate Professor Meaney worked in the microwave technology industry for seven years before

getting a Ph.D. in biomedical engineering at Thayer School. Professor Paulsen earned his M.S. and Ph.D. in biomedical engineering at Thayer School and researches various imaging techniques.

**ADVICE** Meaney says, "Entrepreneurs must be willing to learn a lot of skills—such as dealing with regulatory bodies, accounting, and fundraising—outside the realm where they might be most comfortable."



**COMPANY** Synergy Innovations Inc.

**FOUNDER** Robert C. Dean Jr., President

**STARTED:** 1996

**PURPOSE** Creation of innovative ventures in nanotechnology, materials processing, thermal sciences, and energy sources

**LATEST VENTURE** NanoComp Technologies, which produces long carbon nanotubes for structural composites and electro-energy products

**WEBSITE**

[www.synnovations.com](http://www.synnovations.com)

**EXPERTISE** Known as the "Grandfather of Start-Ups in the Upper Valley," Dean has founded or co-founded eight high-tech companies: Creare, Hypertherm, Verax, Synosys (now PerSeptive Biosystems), Spectra, Synergy Research Corp, Simbex, and Synergy Innovations. These companies employ numerous Thayer School graduates. Dean is an adjunct professor.

**ADVICE** "Almost all watershed inventions begin with an individual act."

# Biology off the shelf

DREW ENDY TH'98 IS CONSTRUCTING  
A TOOLKIT FOR ENGINEERING LIVING SYSTEMS.

BY JON DOUGLAS '92

In the surrealist René Magritte's 1936 painting, *La Clairvoyance*, an artist paints a bird while eyeing an egg. The implication, as the title of the work suggests, is that the man is clairvoyant—that he can predict that the egg he's looking at will turn into a particular type of bird. But there are other ways to explain the painting. Perhaps the man has had experiences that allow him to draw the appropriate bird for the type of egg he sees. Or, if he knows enough about the general relationship between eggs and birds, he can draw the correct bird for any kind of egg that's on his table.

To Drew Endy, the different ways of understanding the Magritte painting mirror the transformation he underwent while studying biological systems for his doctorate in biochemical engineering at Thayer School. Endy was attempting to build a computer model that represented the behavior of bacteriophage T7, a virus that infects the bacteria *E. coli*. His computer simulation worked well to describe how T7 would grow in its natural state. But when he changed the organization of the virus' genetic material, the model couldn't predict the behavior of the new mutant virus. Endy was frustrated by his model's inability to explain what he was seeing in the lab. "This is one of the best-studied biological systems in the world. But, the most interesting predictions we made were always wrong," he says. It was as if the painter, faced with a new type of egg, suddenly lacked the knowledge to determine which kind of bird to draw.

After a detailed failure analysis, conducted once he left Thayer and moved to Berkeley's Molecular Sciences Institute, Endy eventually determined two key problems with the system whose principles he was trying to abstract. First, the functions of only 33 of the 56 genes of T7 were well understood, and second, "the architecture of the parts was screwy," as if the steering



**BUILDING BLOCKS** Drew Endy's vials of BioBricks form standardized parts for the new field of synthetic biology.



## The most interesting predictions we

It was as if the painter, faced with a new suddenly lacked the knowledge to determine which kind of

La Clairvoyance by René Magritte

wheel in a car were controlling the radio. The problems led him to the realization that it would be easier to study and model the virus if he built it himself. "We inherit beautiful living systems from nature. But natural living systems are not designed to be easy to understand and interact with. Engineered living systems could be designed that are easier to describe, model, modify, and predict," concluded Endy. "The question is whether or not engineered living systems will work."

Since joining MIT's biology and biological engineering departments in 2002, Endy has been leading the new field of synthetic biology to discover what is actually possible. In a key innovation, he has helped to establish an inventory of 1,205 "BioBricks"—snippets of DNA that can be used as standard biological parts. (The term BioBricks, coined by MIT colleague Tom Knight, is meant to evoke Legos.) To build new living systems, a biological engineer can deploy these components in various combinations, just as a mechanical engineer can pick up screws and bolts at the hardware store before constructing a new automobile engine. Funded by grants, BioBricks are available to researchers free of charge.

"Instead of discovering these proteins in the wild, you can go online and get one off the shelf. The whole collection is designed to work together," says Endy.

**ENDY SAYS THAT THE GOAL OF BIOLOGICAL** engineering isn't to create life from scratch, but to redefine biology as a technology platform for constructing useful biological systems. Suppose, for example, that a liver cell could be implanted with a counter that records how many times the cell divides. Then, once the counter reached 200, the cell could be programmed to kill itself. That could be a powerful tool to study—and perhaps, fight—cancer. Biological engineering could aid the development of nanotechnology, new

energy sources, better materials, and cheaper drugs, among other applications.

"Drew is bringing a new manufacturing technology into the conceptual framework of traditional engineering," says Thayer School professor Lee Lynd.

In an effort to get more people building with BioBricks, Endy has organized an inter-collegiate competition for students from MIT and several other schools, and he has taught a synthetic biology seminar during MIT's January intersession for the last three years. So far the most complicated biological machines anyone has designed are simple genetic circuits such as cellular clocks and bacteria that have been programmed to form patterns or swim in formation. Endy freely admits that many designs run into problems.

Fortunately, that doesn't faze him one bit. Endy says he cares much less about building any particular application than figuring out a technological platform that will let anyone build anything that the substrate of biology can physically support. To do this, he concentrates most of his effort on distilling the key principles of the nascent field.

"All of our engineering disciplines are so advanced that we take their foundations for granted," says Endy. "At no point during my engineering education did anyone sit down and teach me the core ideas that make engineering happen."

According to Endy, synthetic biology can learn at least three lessons from other fields of engineering, although each might need to be adapted to fit the unique nature of biological systems. The first lesson is to standardize parts. Up until about 125 years ago, Endy points out, you couldn't replace a screw or bolt in a machine without going back to the manufacturer who made it. Now all fields of engineering take standardized parts for granted. With BioBricks Endy is demonstrating that standardization works in biological engineering, too.

The second lesson is to decouple system design from fabrication. In civil engineering, for example, the architect of a structure is different from the contractor. The same principle can apply to engineered genetic systems: once students design a biological system, they send the information specifying its DNA off to a company for manufacture.

The final lesson is abstraction. For example, when computer engineers want to design a new microprocessor, they don't start by worrying about the inner workings of individual transistors or where the silicon for the chip is going to come from. Similarly, Endy posits, biological systems engineers don't need to understand the inner workings of a genetic inverter to make a cellular clock. Instead, they can simply take the inverter devices off the shelf and hook them together.

**IF ANYBODY CAN PULL BIOLOGICAL PARTS** off the shelf, however, it's possible that someone might use the technology to cause harm. Endy says that questions of biological risk are ever-present, and that building a constructive community is the best defense against terrorists or disgruntled researchers who might want to unleash harmful biological systems. "The question is: What more should we do to continue to foster a society of individuals who are developing and applying biological technology responsibly?" he says.

Endy is working to keep issues of ethics and risk front and center. When MIT hosted the First International Conference on Synthetic Biology last year, the 300 conferees discussed ethical considerations as well as current research in the field. Endy's synthetic biology competitions involve building "cool genetic machines," he says, not super strains of bacteria. And he's instilling a sense of accountability by requiring students to "sign" their BioBrick works with barcodes—though he's unsure if barcodes make it harder for the biological systems to function properly.

**made were always wrong.**

type of egg,  
bird to draw.

Endy's view that a responsible community can prevent misuse of technology grew out of a Thayer School seminar given by emeritus professor Arthur Kantrowitz. Kantrowitz had argued that the concept of sustainable development was inherently pessimistic, because if you talked about running out of oil, then you would. Although at the time Endy didn't buy Kantrowitz's argument, he came to realize that optimism is as much a self-fulfilling prophecy as pessimism. "It would be irresponsible to develop a new technology and not think about the consequences of success," says Endy. "We'll get as many people as possible informed and working together to minimize any risk."

Endy embraces the idea that biological engineering can be used to change "the human experience we get by default," but stresses the need to consider the consequences. For example, he envisions that synthetic biology will one day allow parents to design their children's genetic code to avoid disease. "I'd be perfectly happy to be able to reprogram myself," he says, "as long as I could reboot if something didn't work out right."

Endy recognizes that such grandiose visions for synthetic biology are mere speculation, not clairvoyance—considering that the most complicated genetic machines yet produced have just a few dozen components. But even as he grapples with the specter of new biological problems—such as unstoppable destructive errors in self-replicating machines—he's more and more confident that the widespread engineering of biology will eventually work. "I'm the sort of person who wakes up every day rethinking everything. But all of this doesn't seem as mysterious to me as it used to," says Endy. "There's a hint of light, way, way down at the end of the tunnel." □

Jon Douglas is a freelance writer based in Chicago.



## The Making of a Cellular Clock

As a Ph.D. candidate at Thayer School, Drew Endy dreamed of building a clock in a worm but couldn't figure out how to do it. Meanwhile, Princeton graduate student Michael Elowitz, now a biologist and applied physicist at CalTech, managed to construct a simple cellular clock. It took him two years. "We were all inspired by Michael's work," says Endy, "and have since been working to figure out how to engineer genetic clocks and other systems in much less time. Any electrical engineering undergraduate could make a simple electric clock in about five minutes. We want to be able to work just as fast."

An inverter—now available as one of Endy's standardized BioBrick parts—is the key to cellular clocks. As the term inverter suggests, what goes in is the opposite of what comes out. When the input signal—in this case, the rate at which RNA polymerase molecules move along DNA—for protein A is high, the output will be low, inhibiting the synthesis of protein B.

The cellular clock consists of three interlocking inverters, such that the production of protein A inhibits the synthesis of protein B, B inhibits C, and C inhibits A. Starting with a high level of protein A will produce a low output of protein B. In turn, this low input signal to B makes the output of protein C high. And finally, this high amount of protein C means that the output signal to A will be low. Running through the loop a second time completes the circuit. If the clock is engineered to produce a fluorescent protein only at a high level of A, it will blink on and off as it oscillates through the cycle.

### To Learn More

Follow Drew Endy's work at <http://mit.edu/endy/>  
See projects Endy has inspired at <http://rosalind.csail.mit.edu/projects/index.cgi>

For BioBricks, see the Registry of Standard Biological Parts at  
<http://parts.mit.edu/>

# Alumni/ae News

DARTMOUTH SOCIETY OF ENGINEERS

## The DSE and You

BY KATHRYN MILLER '97, DSE PRESIDENT

HELLO FROM the Dartmouth Society of Engineers. As president of the DSE, I'd like to invite you to take advantage of and get involved with the DSE.

The DSE is the best way I know to keep in touch with Thayer School and Thayer alumni/ae. Thayer graduates share a special approach to engineering. Although we might call ourselves mechanical engineers or chemical engineers, we know how to apply fundamental concepts to problems in different disciplines—and that differentiates us from our peers from other institutions. As a graduate student at MIT in chemical engineering doing research in a biological engineering laboratory, I constantly rely on my Thayer training. Many engineering schools consider the multi-disciplinary approach new; Thayer grads consider it standard.

The DSE provides opportunities for us to get together to talk about what we like most: engineering. At the DSE's 2004-2005 annual meeting, held in October in Boston, Professor Charles Wyman talked about his research progress toward achieving efficient conversion of biomass to ethanol. He gave a similar presentation in December at a DSE, Thayer, and Dartmouth Club event in Washington, D.C. In January professors Keith Paulsen and Brian Pogue discussed their research on alternative breast-cancer imaging techniques, including near-infrared hemoglobin tomography, at DSE events co-hosted by Thayer, Dartmouth Medical School, and the Dartmouth clubs of Los Angeles and the Silicon Valley.

I've enjoyed the opportunity to hear what our faculty are doing, and I've enjoyed reconnecting with classmates and meeting new alumni. When I am back in Hanover for DSE Executive Committee meetings, I look forward to the stories vice president Jolin Salazar-Kish '88, Th'91 tells about her Upper Valley contracting and rental business. Treasurer John Kennedy '53, Th'54 not only updates me on his work as a consultant on alternative-fuel vehicles, but also shares his tips on the best places to cross-country ski. I feel like I am back at Thayer, chatting with classmates around a table in the Great Hall.

If you would like information on how you can become involved with the DSE or how you can help host and plan a DSE event in your area, please call 1-877-584-2937, e-mail [DSEAlumniChapter@dartmouth.edu](mailto:DSEAlumniChapter@dartmouth.edu), or visit the Thayer School and DSE website at <http://engineering.dartmouth.edu/thayer/alumni-ae/DSE.html>.

## spotlights



Mike Collins '86

Forbes magazine recently featured **Mike Collins '86**, founder and CEO of The Big Idea Group, a New Hampshire-based company that helps inventors come up with the right idea at the right time for the right market. Sometimes Collins pays inventors an advance and a royalty, then turns their ideas into products he sells. Alternatively, he



Mike Adams '83

may license an idea directly to a manufacturer or a retailer, then split advances and royalties equally with the inventor. Collins' seven-person company also spearheads "idea hunts," challenging inventors to work on specific projects. "Ultimately, I'd like to have inventors anywhere in the world have a place to take their invention and get a good audience to review it," Collins told Forbes. Big Idea recently signed licenses for Game Time, an electronic timing device that gives video-game players a daily or weekly time allowance. The company is currently trawling for ideas for bike and power sports accessories. Visit the company online at [www.bigideagroup.net](http://www.bigideagroup.net).

**Mike Adams '83**, president of Bechtel Civil, an aviation, rail and infrastructure business, is work-



Burt  
Keirstead  
'76, Th'82

ing to make London's famed subway system a smoother ride for commuters and sightseers. Adams oversees the Bechtel-led team that is designing and building several billion dollars worth of upgrades to the Jubilee, Picadilly, and Northern Lines of the 140-year-old Underground. Adams described the project, which began two years ago, as one of the most complex improvement programs in the world. To minimize disruption to passengers, crews can only work when trains stop running between 1 and 5 a.m. "Already, people are starting to see cleaner stations and trains," said Adams. "And the new signaling system will shorten journey times and allow trains to run more frequently." See the project at [www.bechtel.com/briefs/1104/underground.htm](http://www.bechtel.com/briefs/1104/underground.htm).

**Burt Keirstead '76, Th'82** leads efforts at BAE Systems to support the Department of Homeland Security's initiative to protect commercial airliners from missiles. The BAE team was selected last August to build and test prototypes for anti-missile systems to defend U.S. commercial planes against shoulder-fired rockets. The missiles have been increasingly regarded as a serious threat

since the terrorist attacks of September 11, 2001. As missile defense program manager for BAE Systems in Nashua, N.H., Keirstead is heading a team that is developing a system that will fit into the belly of a jet. He predicts that missile protection systems will be installed on airliners during the next five to 10 years. "I think it's viable," Keirstead recently told The Wall Street Journal. "Clearly the technology supports it."

As chairman and chief executive officer of Network Computer Systems in Ghana, **Nii Narku Quaynor '72, Th'73** has helped several African nations adopt or strengthen Internet infrastructures. He chairs AfriNIC, the Regional Internet Registry for Africa, is African director of the Internet Corporation for Assigned Names and Numbers, and is a member of the United Nations Secretary General Advisory Group on Information and Communication Technologies. Quaynor also established the computer science department at Ghana's University of Cape-Coast.

**John D. Pavlidis Th'89** was appointed president and chief executive officer of R2 Technology, a medical software company headquartered in Sunnyvale, Calif. R2's Image Checker CT system is used in diagnosing and treating breast cancer. The December announcement followed Pavlidis' four years as president of the ultrasound division of Siemens Medical Systems.

Thayer School overseer **Charles Nearburg '72, Th'73, '74** was profiled in the September 2004 issue of Texas Driver Magazine. A road-racing and endurance specialist,



John Icke '59, Th'60

Nearburg has raced such speedsters as a Ferrari 333 SP and a Goy Racing Mustang and now often races one of the vintage cars he has collected and restored. Nearburg told Texas Driver that when he was deciding what to take in college, engineering was a natural fit because he wanted to "understand the things affecting a race car."

The Atlanta Journal-Constitution spotlighted **Eddie Amoakuh '83, Th'83, '85** in a December story about Right At Home, Amoakuh's home-care business for senior citizens. The Atlanta company provides companions for senior citizens who need help with tasks such as bathing and dressing so they can continue to live in their own homes. Right At Home employs more than 100 caregivers. "This is the right fit for me," Amoakuh told the Journal-Constitution. "My heritage is that in Ghana, our elders are not 'throwaways.' When I was a child, everyone was your mother, and your grandmothers vied to take care of you. Day care was never an issue. Nor was it a problem to take care of the elders when that time came. That's why I like this business so much."

The Wisconsin State Journal recently featured **John Icke '59, Th'60**, for his work as a volunteer docent at the Wisconsin Veterans Museum. Icke is the retired president of Icke Construction Co. of Madison. Almost a decade ago his company was working near the museum when he strolled in for his first look at the exhibits. "I walked through here and I thought, 'Wow! This is so awesome,'" Icke told the State Journal.

**W. Haskins Hobson '95, Th'96**, was elected to represent engineers ages 35 and under on the executive committee of the Missouri Society of Professional Engineers. The statewide engineering association promotes strong licensure laws and engineering ethics. Hobson works at Missouri's Department of Natural Resources Air Pollution Control Program.

—Jennifer Seaton

## Let Us Know

If you've seen news of Thayer School alumni/ae, please pass it along to Dartmouth Engineer. We welcome articles, press releases, and websites that feature the professional or personal accomplishments of Thayer School graduates

**E-mail:** [dartmouth.engineer@  
dartmouth.edu](mailto:dartmouth.engineer@dartmouth.edu)

**Write:** Dartmouth Engineer  
Office of Communications  
8000 Cummings Hall  
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Hanover, NH 03755

# thayer notes

alumni/ae news not available online



**Car Talk**  
Left, Ford's Kristen Morrow '92, Th'94 gave students career advice during fall term. Right, Tom Brady '66, Th'68 is restoring a '66 Ford Mustang.

alumni/ae news not available online

Get your Six Sigma Certification  
at Thayer School this summer  
<http://engineering.dartmouth.edu/other/sixsigma/>

alumni/ae news not available online

## OBITUARIES

**Desmond Canavan '60**, former assistant dean of Thayer School, died March 30 at age 92 in Hanover, N.H. Canavan led Dartmouth's Navy ROTC program before joining Thayer in 1962. He served as an admissions officer, counselor to foreign students, and liaison between the dean and overseers before his 1978 retirement.

**Stelios Orphanoudakis '71, Th'76** died March 18 at age 57 in his native Greece. A specialist in computational and knowledge-based vision, robotics, medical informatics, medical and diagnostic imaging, and intelligent image processing, he founded the division of Imaging Science at Yale School of Medicine, led the computer science department at the University of Crete, and chaired the board of the Foundation for Research and Technology-Hellas.

## Alumni/ae Directory

Thayer School's Development and Alumni/ae Relations Office is working with PCI, a publishing company, to produce the 2006 edition of the Thayer School of Engineering Alumni/ae Directory. The directory will include names, addresses, phone numbers, academic degrees, employment information, and e-mail addresses and will be available for alumni/ae purchase. Beginning in April, PCI will e-mail and send questionnaires to alumni/ae for updated information. If you prefer not to be listed in the directory, please contact Courtney Peschel '99, Th'00, '01 by e-mailing [cpeschel@dartmouth.edu](mailto:cpeschel@dartmouth.edu) or calling 877-584-2937 toll-free.

was one of the most significant problems facing the industry. "The approach we took was to create a membrane that could be opened by the flow of gasoline, but would stay shut when there were just a few drops," he explains. Although the team wasn't able to create a working model before the term ended, their research into existing patents revealed that there was nothing like their idea already on the books. With the help of one teammate's venture capitalist father, the dripless gas nozzle developed by the team currently is in the process of being patented.

The "real-world" focus of ENGS 21 has made the class Grossman's favorite at Dartmouth. "We saw what we were accomplishing, and it was really rewarding," he says.

This kind of entrepreneurship education works because it engages students viscerally, notes Fairbrothers. "If you're out there on the ridge yourself," he says, "your emotions kick in, and you remember and learn."

## THE OTHER SIDE OF THE COIN

Victor Petrenko's decade of research into the structure and adhesion of ice has the potential to make even a New Hampshire winter bearable. Technology he developed makes it easier to de-ice planes and power lines, increase car-tire friction on icy roads, and improve the performance of skis and other winter sports equipment. This research has produced 27 patents, with another 20 in progress. His technology also has been licensed to several outside companies.

Petrenko says that, had he understood what lay ahead when he formed Ice Engineering LLC in 2001, he probably wouldn't have made the leap. "I enjoy on the one hand seeing that some fundamental discoveries we made years ago can be transformed into useful products. But there's a bloody price we pay for it with financial pressure," he says.

One of the big challenges has been navigating the red tape associated with having a business on campus. The level of scrutiny, he says, is "very stressful."

"We all the time are under strong inspection by Dartmouth officials who suspect we are trying to use College facilities to do something for the company," he says. "In the past I kept a significant number of graduate students working on real engineering contracts. But now I have moved all the students away from practical applications because I am afraid I will be accused of misusing students."

Garmire, who helped write the policy on

commercial ventures at the University of Southern California before she came to Thayer School, is concerned about what she perceives as an excess of caution at Dartmouth. In addition to the Thayer committee, entrepreneurs are also accountable to another College-wide committee. In her estimation, this is both unnecessary and a detriment to innovation. She also thinks the College's policies suggest that administrators "don't really understand what goes on in a research lab."

"The policy says that research done for the company has to be completely separate from what you're doing as a faculty member. But usually when you're doing research for a company, it's fundamental research to advance the technology and meshes closely with projects that are funded by other means. Once it gets to a certain point where you actually have a product, that's when you need to move it into a separate space," she says.

Garmire is particularly concerned about the effect of excessive oversight of early-stage SBIR and STTR companies. College administrators who aren't familiar with these kinds of companies may unintentionally defeat the purpose for which the programs were developed—to promote free-wheeling innovation. She would like to see the College cede the oversight for these very embryonic companies to the Thayer oversight committee. "The point to be worried about keeping things separate is when people start to bring venture capitalists in," she says.

Neither Garmire nor Petrenko sees these issues as unique to Dartmouth. Like many other colleges and universities, Dartmouth is experiencing growing pains in dealing with increased entrepreneurial activity.

"The College is changing; I can see that. I think in a few years this won't be a problem. The change in mentality takes time," says Petrenko.

Regardless of whether faculty and students eventually become business owners, Fairbrothers reminds people that the ability to think entrepreneurially is in great demand in businesses and organizations of all kinds. "Entrepreneurs can be made; they're not just born," he says. "That doesn't mean everyone is interested or will succeed at being his or her own boss. But everyone can develop entrepreneurial behaviors and attitudes that can be valuable in many contexts—and make life a lot more interesting and fun." □

Tamara Steinert is a freelance writer based in Kansas.

# inventions

Former Thayer School research professor Sydney Alonso (left) and Cameron Jones '75, Th'77 (right), watch Dartmouth music Professor Jon Appleton play the Synclavier I.



## THE SYNCLAVIER

>> **INVENTORS:**  
**SYDNEY ALONSO**  
**CAMERON JONES '75, TH'77**

The Moog synthesizer, the prime electronic instrument of the 1970s, linked a piano keyboard to an analog computer—but it had no memory. Wanting something better, Dartmouth music professor and composer Jon Appleton turned to Thayer School.

The resulting Synclavier was the world's first digital synthesizer. Built in 1975 by Thayer

School research professor Sydney Alonso and programmed by then-B.E. candidate Cameron Jones '75, Th'77, the Synclavier pioneered digital sampling, hard-disk recording, and professional sound editing. It was just what Appleton wanted. "It did so many things, and the software was so beautifully integrated," he says.

Alonso and Jones left Dartmouth and went into business, founding New England Digital Corporation in 1977. The Synclavier rapidly became

the Rolls Royce of the music industry. Despite price tags ranging from \$75,000 to \$500,000, the Synclavier was the instrument of choice for Sting, Stevie Wonder, Frank Zappa, and many others. When jazz guitarist Pat Metheny asked how he could plug in, Synclavier engineers worked with him to develop a guitar interface.

Pianist Oscar Peterson's wish for better response led to the touch-sensitive keyboard. Lucasfilm's interest in the sound editor function resulted in a new soft-

ware interface that made post-production editing as easy as music recording.

Throughout the 1980s Synclavier led all comers. But as personal computers flooded the market with low-cost digital samplers and audio editing software, Synclavier sales faltered. In 1992 New England Digital Corporation closed its doors.

Today a hundred or so die-hard customers keep the Synclavier alive. Hardware and software are available at [www.synclavier.com](http://www.synclavier.com).



## RANDOM WALK

The Great Hall was transformed into a Martian landscape for a micro-rover competition in the fall-term course Machine Engineering (ENGS 76). Remote-controlled rovers navigated the red-planet terrain to retrieve rocks and other debris. Crouching, left to right, are competitors Ariel Dowling '05 and Narissa Chang '05. B.E. candidate Stephanie Johns, standing, judged the event.



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