University of Minnesota

A MAGAZINE FOR ALUMNI AND FRIENDS OF THE INSTITUTE OF TECHNOLOGY | SPRING/SUMMER 2007

INVENTING TOMORROW

ENERGY ALTERNATIVES

Faculty research in the Institute of Technology fuels ideas for new forms of renewable energy >>

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Alumni rewarded for breakthrough ideas >>

INVENTING TOMORROW

Spring/Summer 2007
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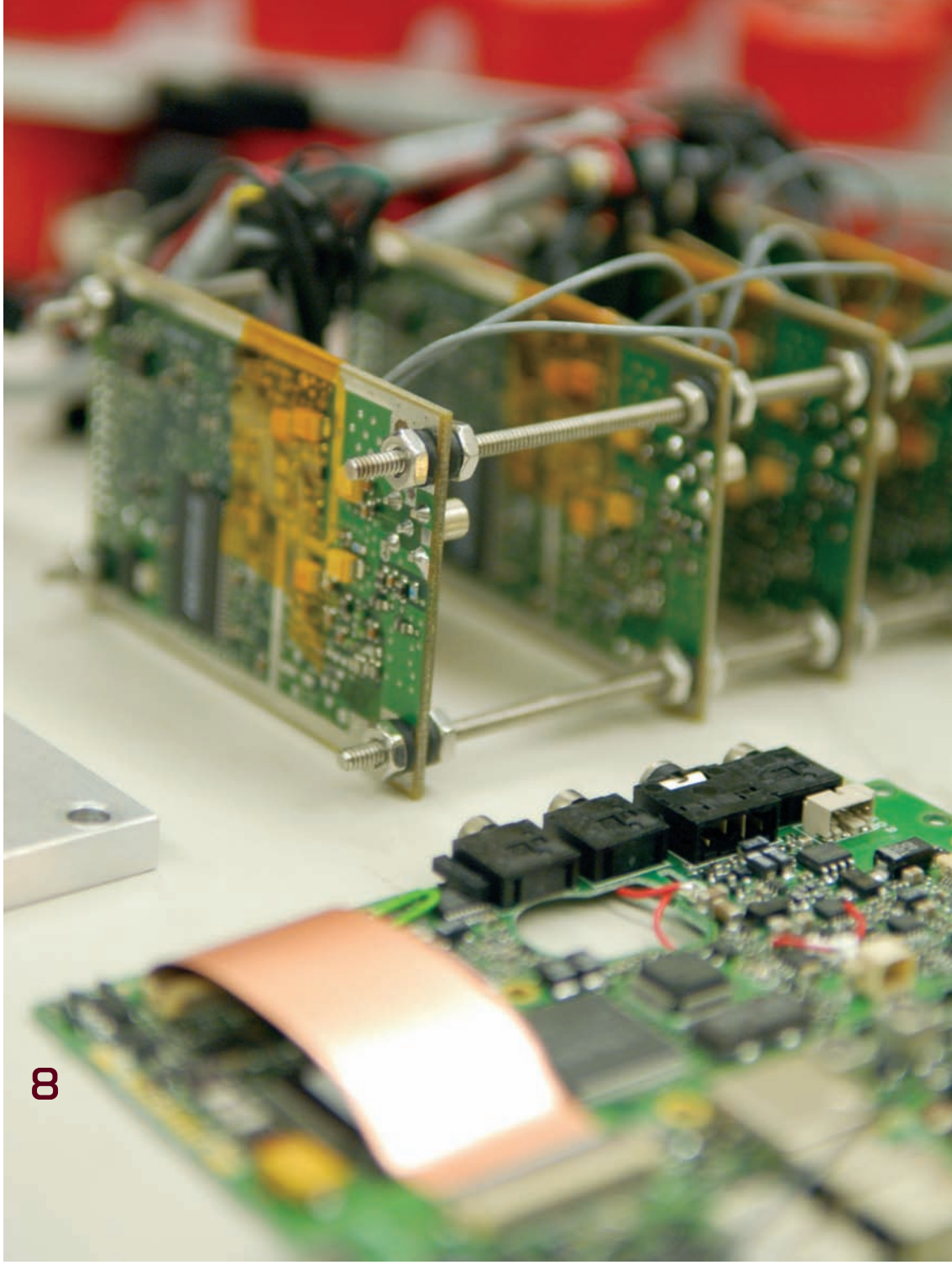


spring/summer **2007**

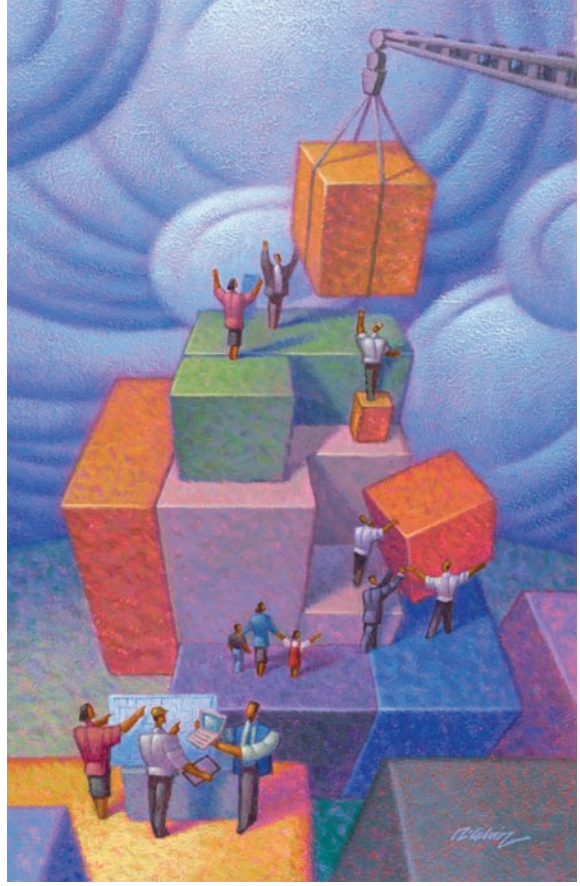
INVENTING TOMORROW

DEPARTMENTS

ON THE COVER

Professor Eray Aydil tests a nanowire-based solar cell in his lab. Aydil is just one of several Institute of Technology researchers working to develop new and improved renewable energy technology. • 12

PHOTO BY JONATHAN CHAPMAN



Our problem solving builds strong future

Solving open-ended problems is arguably the cornerstone of engineering and science

LIKE MOST ENGINEERS AND SCIENTISTS, I've always been curious. To the dismay of the adults in my life, I often liked to take things apart when I was a child and see how they worked. And sometimes, I was even able to get all the parts back together again.

During my time studying engineering at the University of Minnesota, I quickly learned how to tackle tough problems in my classes and in the research lab. These problem-solving skills served me well in adulthood as I began my professional career working as a research officer in the Mining Research Laboratory of the Chamber of Mines in South Africa. A few years later, working as a consultant to several mining companies, I developed computer software that helped engineers devise ways to mine deep underground ore deposits more safely and economically.

In more recent years as department head, associate dean, and now as dean, I use many of the same skills to solve problems every day regarding budgets, personnel, and administrative issues.

Solving open-ended problems is arguably the cornerstone of engineering and science. We recognize the problem, and quickly begin the research to find a possible solution.

Institute of Technology faculty, alumni, and students are working to solve some of society's greatest problems. This issue of *Inventing Tomorrow* highlights some of their potential solutions.

In our cover story "Alternative Energy," we highlight faculty and students who are researching various forms of renewable energy including solar energy, wind energy, biofuels, and hydrogen. Many of our faculty are recognized as national and international leaders in cutting-edge renewable energy research. As Minnesota works to comply with a new state law that requires 25 percent of Minnesota's energy come from renewable resources by 2025, the University of Minnesota and the Institute of Technology are poised to be at the forefront to lead the way for the state and the nation.

The "Breakthrough Ideas" story features Institute of Technology alumni who have won the first two years of the statewide Minnesota Cup competition, which seeks the state's brightest new business ideas. These two groups of alumni have invented a switch that could transform the fiber optics industry and environment-friendly brick pavers made from recycled materials.

In this issue's "Mini Marvel" story, a team of about 25 Institute of Technology undergraduate students from a variety of academic majors are getting their feet wet early on "real-world" research to find new ways to build a less-expensive, working mini-satellite. Faculty involved in the project note how truly amazing it is to see undergraduate students quickly grow to look, talk, and walk like engineers.

Other stories in this issue show the depth and breadth of the problem solving within the Institute of Technology. Not only are faculty and student researchers designing instruments to study the sun millions of miles away, they are working on research to solve traffic gridlock right here in our own city. They are finding innovative ways to study the human brain while others are researching new navigation and guidance systems that could potentially replace humans on board aircraft. Our faculty and students are conducting research on the nanometer scale trying to find new applications of nanotechnology while others are tracking stars that are 30 to 40 times larger than our sun.

I am proud to be a part of a college here at the University that includes so many faculty, students, and alumni who are truly driven to discover. Our state and our nation will have a stronger future because of the problems they solve every day. ■

U physicists help NASA 'follow the sun'

EVERY SO OFTEN, the sun flings a gigantic blob of hot gas in our direction, wreaking havoc with satellites and power grids and sending astronauts in orbit scurrying for the safety of their radiation shields.

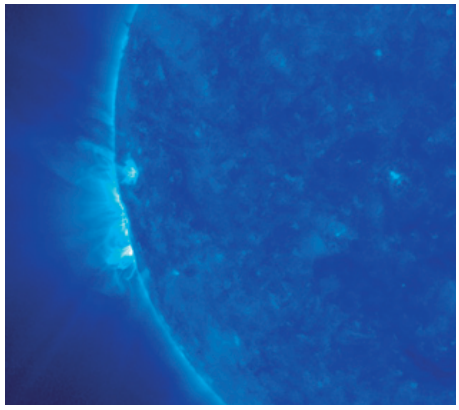
It has been hard to tell when one of these blobs of gas, or coronal mass ejections (CMEs), is brewing, or which ones are heading our way. But NASA's twin Solar Terrestrial Relations Observatories (STEREO) mission launched last fall will give researchers a new 3-D view of the sun that could help their predictions.

An Institute of Technology space physics team designed and built instruments that are currently traveling aboard the twin spacecraft of NASA's STEREO mission.

The instruments will detect waves of energy and charged particles emitted by the sun via processes that may help cause CMEs. The team's instruments will be able to track the shock wave that precedes a CME as it moves through space, with the goal of allowing scientists to see when one is coming to Earth.

NASA

An engineer looks on as the stacked STEREO spacecraft undergo a spin balance test before launch. University of Minnesota physicists designed and built instruments for the mission.



NASA

A close up of loops in a magnetic active region of the sun is one of the first images from the STEREO mission received in December 2006. This false color image of the loops from STEREO's SECCHI/ Extreme Ultraviolet Imaging Telescope shows the sun's atmosphere at a million degrees C. This powerful active solar region, AR903, produced a series of intense flares over a few days.

"As our society becomes more electronic and sophisticated, these outbursts become more disruptive," said Paul Kellogg, a retired physics professor who is part of the University's space physics team. "STEREO will allow us to see when one is coming to Earth."

The two spacecraft are being positioned into two different orbits, one in front of Earth and one behind. The two will orbit the sun from this perspective, separating from each other by about 45 degrees per year. Scientists expect the two to be in position to produce 3-D images in April 2007.

"It's all to understand and predict how the sun works," said University physicist Keith Goetz, the project manager for for STEREO WAVES. "We hope to get moving pictures of CMEs and solar flares. We want to be able to look at the surface of the sun and say, 'There's going to be an eruption-right there, in that spot.'"

Goetz, Kellogg, and other University physicists worked with researchers at the Paris Observatory to design and build the instruments.

—By Deane Morrison

IT launches new nano initiative

A NEW CENTER for Nanostructured Applications in the University's Institute of Technology will bring together researchers from across the University to focus on the emerging applications of nanotechnology to create devices and systems for energy, biomedicine, and information processing.

Researchers will use existing facilities and develop new relationships with industry. The center was initiated by Institute of Technology Dean Steven Crouch who secured funding from the University as part of the University's strategic positioning efforts to boost research.

Steve Campbell, a professor of electrical and computer engineering who also serves as director of the University's Nanofabrication Center, has been selected by Crouch as the director of the new center. Campbell has agreed to a two-year term as the center's first director.

"We expect the Center for Nanostructured Applications to increase the local, national, and international profile of the University in the important area of nanotechnology," Crouch said. "By bringing together researchers from medicine, biology, engineering, and the physical sciences to focus on the applications of nanotechnology we also intend to help University researchers become more competitive for federal research funding in nanotechnology."

In addition to research, the new Center for Nanostructured Applications will sponsor workshops, seminars, and conferences that will provide networking opportunities and bring top nano applications researchers to Minnesota.

Professor studies new-generation aerial navigation systems

NEW RESEARCH in the University's Institute of Technology explores methods of using the military's next-generation navigation and guidance technology to increase the effectiveness of navigation systems on aerial vehicles. The research holds the promise of developments in the world of unmanned flight.

Demoz Gebre-Egziabher, a McKnight Land-Grant professor in the department of aerospace engineering and mechanics was recently awarded a grant from the Lockheed Martin Corp. for his research.

His research will explore methods of using the military's next-generation navigation and guidance technology—the Joint Precision Approach and Landing System (JPALS)—to increase the effectiveness of navigation systems on Unmanned Aerial Vehicles (UAV). In addition, the research will explore how to use specially equipped vehicles as mobile data sources, broadcasting information that would enhance navigation and guidance performance of vehicles equipped with JPALS.

While JPALS technology is first and foremost a military program, research in this area could have a great effect in the area of commercial flight.

"This could have broad implications for future global positioning system-based navigation and precision landing systems that will be used in civilian aviation applications," Gebre-Egziabher said.

Lockheed Martin's recent grant is one of several that have provided support and kept the University of Minnesota at the forefront of JPALS-related research.

University faculty and students helped design this unmanned aerial vehicle. New navigation and guidance technology would be used to improve similar vehicles.

When operating at highest intensity, the NuMI beam line transports a package of 20,000 billion protons every two seconds to a graphite target.

PETER GINTER, FERMILAB

Physics research sets world record

ACCORDING TO THE 2007 GUINNESS BOOK OF WORLD RECORDS, the world's most powerful beam of neutrinos is the one that zips underground from the Fermi National Accelerator Laboratory outside Chicago to a 5,000-ton detector in the Soudan Underground Laboratory, a unique physics laboratory located in northern Minnesota and operated by the Institute of Technology's School of Physics and Astronomy.

Neutrinos are particles with the smallest mass, the weakest interaction, and no electric charge. Neutrinos change as they travel and their oscillations could explain why the universe exists. The University of Minnesota is playing a key role in the most precise experiment to capture their essence.

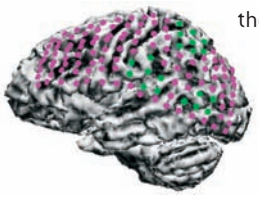
To study the properties of these elusive particles, researchers from 32 institutions, including the University of Minnesota, generate a beam of neutrinos at Fermilab and shoot them straight through the Earth to the 5,600-ton detector, located half a mile down in an old iron mine, where the layers of rock shield it from cosmic rays that would complicate the data. The neutrinos from Fermilab complete their 454-mile underground journey in just 25 thousandths of a second.

Research may hold key to brain activity

NEW FINDINGS about the electrical properties of the human skull by Bin He, a professor in the Institute of Technology's Department of Biomedical Engineering, may hold the key to more accurately diagnosing and monitoring epilepsy, comas, and other brain activity.

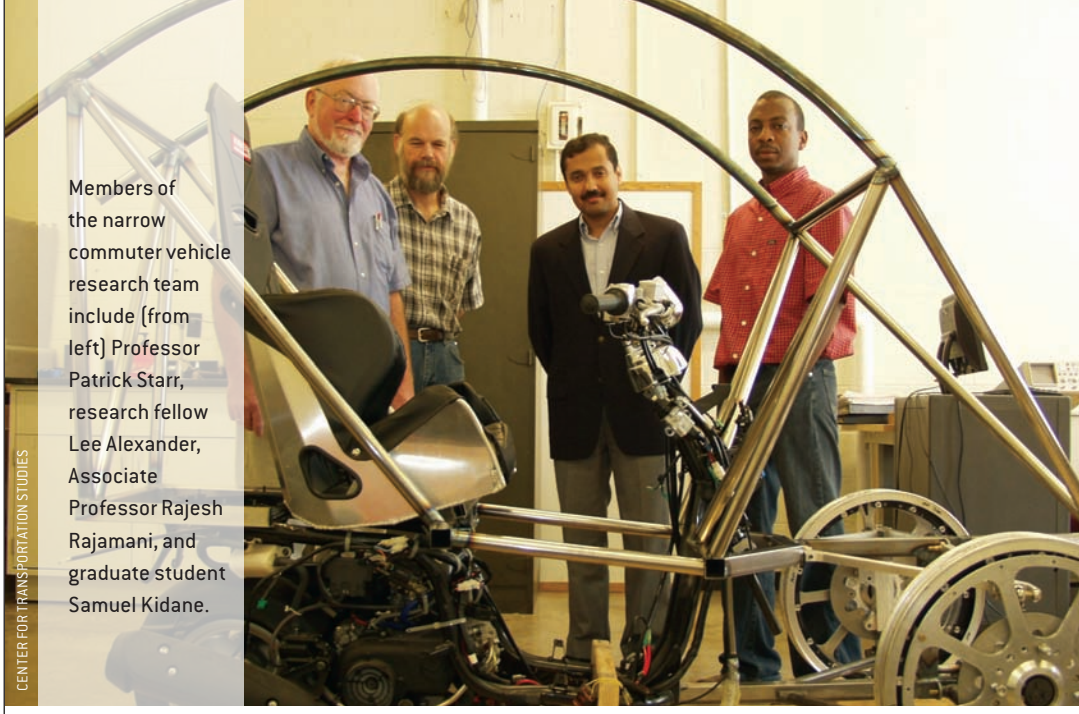
Knowing the conductivity levels of the brain and skull are key to techniques commonly used to scan brain activity. Professor He and his colleagues, including Yingchun Zhang, a post doctoral associate in the University of Minnesota's Department of Biomedical Engineering, and Wim van Drongelen, an assistant professor in the Department of Pediatrics at the University of Chicago, studied the human brain-to-skull conductivity of two children undergoing treatment for epilepsy.

With the help of sophisticated computer models developed in partnership with the University's Supercomputing Institute, and nearly 50 sets of electrical measurements, researchers found that the brain is surprisingly only about 18.7 times more conductive than the skull. Old data used for 30 years estimated that the brain was 80 times more conductive than the skull, while other more recent experiments suggested that the brain is 25 times more conductive.



"While the electrical conductivity of the brain is relatively well known, there has been a big disparity of findings on the electrical conductivity of the skull," He said. "Our group is the first in the world to develop a sophisticated computer model that can accurately compute the electrical field in the setting of simultaneous intra- and extra-cranial electrical recordings."

The new research offers more hope for future work in using non-invasive techniques to pinpoint areas of the brain responsible for seizures or other brain abnormalities. This would mean more "accurate surgical outcomes" in future brain surgeries, He said.



CENTER FOR TRANSPORTATION STUDIES

Members of the narrow commuter vehicle research team include (from left) Professor Patrick Starr, research fellow Lee Alexander, Associate Professor Rajesh Rajamani, and graduate student Samuel Kidane.

Researchers work to solve gridlock

YOU DON'T HAVE TO BE PARTICULARLY ASTUTE to have noticed that traffic congestion in the United States—at least in urban areas—is stressful and problematic at best; maddening and dangerous at worst.

If you think things are going to get better any time soon, think again. In fact, by 2010 freeway congestion in urban areas of all sizes throughout the country is expected to be double what it was in 1999.

An interesting solution may be on its way courtesy of researchers at the University of Minnesota's Department of Mechanical Engineering. They've been advancing the notion of a one- or two-passenger vehicle—about the width of a motorcycle—that's comfortable and safe to operate in any weather, releases fewer emissions with higher gas mileage, and might dramatically increase traffic capacity.

The University researchers have developed a narrow commuter vehicle—a little more than three feet wide—that would take up less than half the space of a standard automobile and could potentially be driven two abreast in a normal lane of traffic.

The research team—which includes Rajesh Rajamani, Lee Alexander, Patrick Starr, Max Donath, and Samuel Kildane—has been developing and refining a prototype narrow vehicle for about five years. Their current edition is a three-wheeled model with a driver-protective roll cage that seats one.

While other prototype narrow vehicles have been developed over the years, and some universities and companies in Europe are actively working on the concept, the University of Minnesota is unique in its research in the United States. "We are the only folks doing this," Rajamani said.

"A lot of work is going on to address safety," Rajamani said. "But nobody's really looking at how to address traffic congestion, even though it's getting worse every year."

One of the biggest challenges for University researchers has been providing lateral stability to the prototype vehicle during turns, since the vehicle is fairly tall relative to its width. When a driver steers to the left, for example, a normal vehicle would naturally lean to the right.

At a presentation on campus, Rajamani explained the engineering behind his new tilt-control system, controlled by a computer, which "helps the driver keep the vehicle balanced at all times," he said. When going around a curve, the steering system "figures out how much to tilt [into the turn], and it tilts automatically."

Many other challenges remain for the University researchers—chief among them safety and "the perception of safety," according to Rajamani. "People perceive anything small to be unsafe," he said.

The researchers' next step is to gain the additional funding needed to enhance safety features such as incorporating front and side air bags and developing collision-avoidance features. The research to date has been supported by the University's Intelligent Transportation Systems Institute and the National Science Foundation.

—By Rick Moore

FACULTY HONORS

Professor **Graham Candler** (aerospace engineering and mechanics) has received the American Institute of Aeronautics and Astronautics (AIAA) 2007 Thermophysics Award for his research on the flow field around high-speed spacecraft entering the atmosphere.

The National Science Foundation has recently awarded several Institute of Technology faculty members with prestigious Faculty Early Career Development Awards. Recipients include assistant professors **Abhishek Chandra** (computer science and engineering), **Kevin Dorfman** (chemical engineering and materials science), **Christy Haynes** (chemistry), **Mihailo Jovanovik** (electrical and computer engineering), and **Stergios Roumeliotis** (computer science and engineering).

Professor **Priscilla Cushman** (physics and astronomy) was appointed to the U.S. Department of Energy and National Science Foundation's Office of High Energy Physics Advisory Panel for a three-year term.

Professor **Ed Cussler** (chemical engineering and materials science) received the 2006 Gerhold Award, which recognizes outstanding contributions in research, development, or application of chemical separations technology.

Professors **E. Dan Dahlberg** (physics), **Vipin Kumar** (computer science and engineering), **Ellen Longmire** (aerospace engineering and mechanics), **Susan Mantell** (mechanical engineering), and **Fotis Sotiropoulos** (civil engineering) are among the members of a new advisory committee that will create a world-class interdisciplinary Institute for the Advancement of Science and Technology at the University of Minnesota. The goal of the institute is to increase communication and collaboration across science, medical, and engineering research areas.

Professor **Arthur Erdman** (mechanical engineering) received the Rutgers School of Engineering "Medal of Excellence" Award for Alumni Achievement in Academia.

The Association for Computing Machinery (ACM) has named Professor **Maria Gini** (computer science and engineering) and Professor **Joseph Konstan** (computer science and engineering) members of the initial class of ACM Distinguished Scientists.

Professor **Georgios Giannakis** (electrical and computer engineering) has been selected to serve as an Institute of Electrical and Electronics Engineers (IEEE) Signal Processing Society Distinguished Lecturer for the 2007 and 2008 calendar years.

Professor **Wayne Gladfelter** (chemistry), Professor **Vipin Kumar** (computer science and engineering), and Distinguished McKnight University Professor **William Tolman** (chemistry) have been awarded the distinction of fellow from the American Association for the Advancement of Science (AAAS).

Assistant professors **Christy Haynes** (chemistry), **Nihar Jindal** (electrical and computer engineering), **Marta Lewicka** (mathematics), **William Schuler** (computer science and engineering), and **Chun Wang** (biomedical engineering) are Institute of Technology faculty who are among 11 recipients of the 2007-09 McKnight Land-Grant Professorship, a program designed to advance the careers of the University's most promising junior faculty. The honor includes a research grant of approximately $30,000 in each of two years.

Professor **Bin He** (biomedical engineering) was appointed conference chair of the 2009 Annual International Conference of Institute of Electrical and Electronics Engineers (IEEE) Engineering in Medicine and Biology Society to be held in Minneapolis. The annual conference has had more than 2,000 participants and is a premier international conference in the field of biomedical engineering. He also has been elected vice president for publications of the organization for 2007-08.

Professor **Ken Keller** (chemical engineering and materials science) has been designated president emeritus of the University. Keller served as the University's president from 1984 to 1988. In August, Keller began a three-year leave of absence to become director of the Bologna Center of the Johns Hopkins School of Advanced International Studies.

Assistant Professor **Chris Kim** (electrical and computer engineering) received an IBM Faculty Partnership Award to support his work on analysis, measurement, and design techniques for Negative Bias Temperature Instability (NBTI) Tolerance.

Professor Emeritus **Thomas Lundgren** (aerospace engineering and mechanics) received the 2006 Fluid Dynamics Prize from the American Physical Society (APS). The award recognizes outstanding achievement in fluid dynamics research.

Professors **Zhi-Quan (Tom) Luo** (electrical and computer engineering) and **Nikolaos Papanikolopoulos** (computer science and engineering) were recently named Institute of Electrical and Electronics Engineers (IEEE) fellows.

Professor **Peter McMurry**, head of the Department of Mechanical Engineering, received the Fuchs Award at the 7th International Aerosol Conference in St. Paul. The Fuchs Award is considered the highest honor for researchers in the field of aerosol science and technology.

Associate professors **Ezra Miller** (mathematics) and **Beth Stadler** (electrical and computer engineering) received the McKnight Presidential Fellow Award, which singles out the most promising faculty who have just been granted tenure and promoted to the rank of associate professor.

Professors **Paige Novak** (civil engineering), **Christopher Paola** (geology and geophysics), and **Lanny Schmidt** (chemical engineering and materials science) are Institute of Technology faculty who are among the 15 founding fellows named to the University of Minnesota's new Institute on the Environment. Established in 2006, the institute will coordinate the University's breadth and depth of environmental resources to make it easier for researchers to share knowledge with each other and the public.

Christopher Paola (geology and geophysics) professor and director of the National Center for Earth-surface Dynamics (NCED) has been elected a fellow of the American Geophysical Union (AGU).

Professor **Serge Rudaz** (physics and astronomy) has been named as the founding director of the new, campus-wide University Honors Program.

Professor **Guillermo Sapiro** (electrical and computer engineering) was elected to be the first Editor-in-Chief of the new Society for Industrial and Applied Mathematics (SIAM) Journal on Imaging Sciences.

Professor **Michael Semmens** (civil engineering) is one of five University faculty and staff members to receive Fulbright Scholar Grants for special research projects in 2006-07. Semmens is at the Norwegian University of Science and Technology in Trondheim, Norway, researching advanced membrane processes for water and wastewater treatment.

Professor **Shashi Shekhar** (computer science and engineering) was selected as the recipient of the Institute of Electrical and Electronics Engineers (IEEE) Computer Society's Technical Achievement Award for contributions to spatial databases.

Professor **Bruce Wollenberg** (electrical and computer engineering) was named to serve on the new state task force on Plug-In Hybrid Electric Vehicles (PHEVs). The task force will develop strategies to encourage use of hybrid electric vehicles by the state.

Professor **Randy Victora** and Associate Professor **Jianping Wang** (electrical and computer engineering), together with their graduate students **Xiao Shen** and **Weikang Shen**, won the 2006 Information Storage Industry Consortium (INSIC) Technical Achievement Award for "pioneering work in the conception and experimental confirmation of exchange-coupled composite recording media." The University of Minnesota is the only university to receive this award three times.

Professor **Xiaoyang Zhu** (chemistry) was honored with the Brian Bent Memorial Lectureship in Chemistry at Columbia University.

Dean names department chair

PROFESSOR ROBERT GEHRZ recently was named the chair of the Department of Astronomy through June 30, 2010. Gehrz has been interim chair of the department since July 1, 2005. Gehrz's space infrared astronomy research has included programs conducted with the International Ultraviolet Explorer, Kuiper Airborne Observatory, Hubble Space Telescope, European Space Agency's Infrared Space Observatory, and the new Chandra X-ray Observatory. Gehrz has served as a professor at the University since 1985.

U of M astronomers create 3-D images of supersized star 5,000 light years away

A GROUP OF ASTRONOMERS led by University of Minnesota professor Roberta Humphreys have combined images from NASA's Hubble Space Telescope and the W.M. Keck Observatory in Kameula, Hawaii, to create the first three-dimensional images of one of the brightest supersized stars in the sky.

From these new images, astronomers have learned that the gaseous outflow is more complex than originally thought from VY Canis Majoris, a red supergiant star that is also classified as a hypergiant because of its very high luminosity.

The eruptions have formed loops, arcs, and knots of material moving at various speeds and in many different directions. The star has had many outbursts over the past 1,000 years as it nears the end of its life.

"With these observations, we may have captured a short-lived phase in the life of a massive star," Humphreys said. "We thought mass loss in red supergiants was a simple, spherical, and uniform outflow, but in this star it is very complex. VY Canis Majoris is an important star for understanding the high-mass loss episodes near the end of massive star evolution."

With these new images, the researchers have a complete picture of the motions and directions of the outflows and their spatial distribution, which confirms their origin from eruptions at different times from separate regions on the star, Humphreys said.

A multicolor image of VY Canis Majoris

HST/WFPC2

Humphreys and her collaborators, including U of M professor Terry Jones and U of M graduate student Andrew Helton, recently presented their findings at a press conference during the American Astronomical Society meeting.

Astronomers have studied VY Canis Majoris for more than a century. Located 5,000 light-years away, the star is 500,000 times brighter and about 30 to 40 times more massive than the sun, a size that is equal to Saturn's orbit. VY Canis Majoris is not visible to the naked eye.

The Hubble Space Telescope is a project of international cooperation between NASA and the European Space Agency (ESA). The Space Telescope Science Institute in Baltimore conducts Hubble science operations. The Institute is operated for NASA by the Association of Universities for Research in Astronomy Inc., Washington.

IT research receives defense act funding

INSTITUTE OF TECHNOLOGY RESEARCH on tiny "Scout" robots used to save lives on the battlefield and testing of high-speed aircraft designs have been designated to receive federal funding as part of the 2007 Department of Defense Appropriations Act recently approved by the U.S. House and Senate and signed by the President.

The Scout robot is currently being tested in search and rescue missions and military reconnaissance deployments.

The Institute of Technology's robotics research program, led by Professor Nikolaos Papanikolopoulous (computer science and engineering) received $1.95 million. The bill also allocates $2 million to the Department of Aerospace and Engineering's National Hypersonics Research Center led by Distinguished McKnight University Professor Graham Candler.

Jason Mintz, the Minnesat team student project manager, and Jim Pogemiller, a senior majoring in physics, work on last-minute adjustments to their mini-satellite. They are two of about 25 undergraduate students who participated in the University of Minnesota's first team to enter a nationwide mini-satellite competition.

mini marvel

University's first mini-satellite team is influencing an industry and launching a bright future for Institute of Technology students

WRITTEN BY **MICHELLE HASCHKA**

PHOTOS BY **JAYME HALBRITTER**

ASK ANY KID WHAT THEY WANT TO BE WHEN THEY GROW UP and astronaut is likely to make the list. Whether it's the appeal of exploring uncharted territory or the chance to bounce around sans gravity, space travel is mysteriously alluring.

Ellie Field admits she wanted to be an astronaut since she was 4 years old. She remembers dreaming of the day when she would be old enough to whiz through the atmosphere on a mission to Mars or the moon.

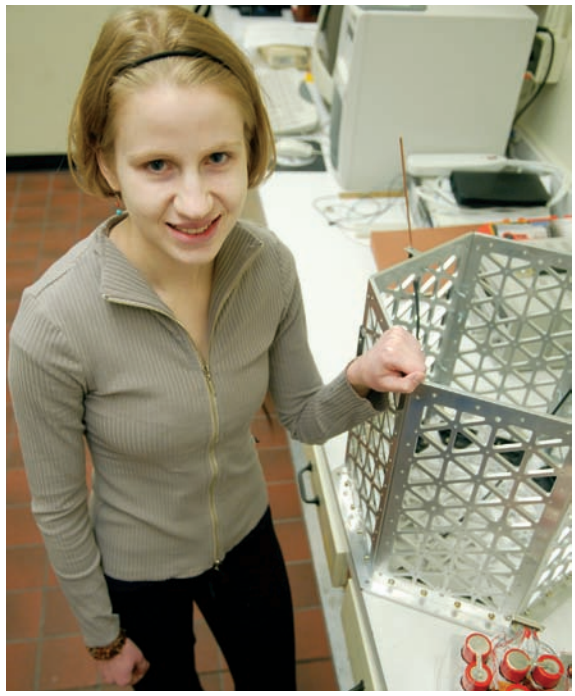
Fast-forward more than 15 years, Field is a sophomore studying aerospace engineering at the University's Institute of Technology. While her dreams of interplanetary travel have yet to be realized, she is already working on a spacecraft and is a pioneering member of a project that could influence the future of satellite design.

Field is part of a team of about 25 undergraduate students who embarked on a mission nearly two years ago to enter a nationwide student-run mini-satellite competition which culminates this spring. The University Nanosat-4 Program challenges students to design and build a working satellite, from initial concept to final working vehicle stage. The entry must meet a specific research goal, measure no more than 18.5 inches high or wide, and weigh less than 30 kilograms (66 pounds). The national winner gets a chance to see the fruits of their labor launched into space, with the $3 million launch tab picked up by the federal government.

BUILDING A BRIGHTER FUTURE FOR AEROSPACE ENGINEERING

Started in 1999, and run by the Air Force Office of Scientific Research, Air Force Research Labs, the American Institute of Aeronautics and Astronautics (AIAA), and the National Aeronautics and Space Administration (NASA), the University Nanosatellite Program aims to train the next generation of space professionals by providing a rigorous competition, while enabling small satellite research and development, integration, and flight test. Approximately 2,500 college students and 25 institutions of higher learning have been involved in the competition since its inception.

"Our primary goal is to attract students into the field of aerospace engineering and to give them experience working on real hardware," said Jeff Ganley, University Nanosat structural engineer at the Air Force Research Labs and University of Minnesota Institute of Technology alumnus (CE '94). "This project is not about paper designs. These are real satel-



"A lot of what works on the ground doesn't work in space, so we have to consider all the possibilities of what could happen in space."

—JASON MINTZ

Ellie Field, a sophomore studying aerospace engineering who is a member of the current Minnesat team, has been selected as the Minnesat student project manager for the next national competition which begins later this year and culminates in 2009.

University of Minnesota alumnus and former space shuttle astronaut Duane "Digger" Carey (Aero '81, M.S. Aero '82) talked with students last year about their mini-satellite prototype. Carey was one of about 20 University aerospace engineering alumni who came to the University last May to hear about the Minnesat project and give their support. Also pictured are Minnesat team members Azeem Khan, a senior majoring in electrical and computer engineering, and Jason Mintz, the project manager.

lites and after working on the project, students are qualified to work in aerospace."

The University of Minnesota's entry, named Minnesat, will compete head-to-head with satellites from 10 other universities around the country. According to the Air Force Research Labs, creating miniature spacecraft has many advantages, including inexpensive design, availability for mass production, reduced launch price, fuel economy, and low-risk cost. Because of the inexpensive nature of the project (when compared to the cost of building a commercial satellite), the program gives students a valuable learning platform while encouraging maximum innovation and creativity in small satellite design, development, and flight.

"We have students working on kinds of things that only students can work on—some of it is very 'out there' stuff. In turn, we get technology development that is high-risk and high-payoff," Ganley said.

The Nanosat Program has two distinct stages. The first stage, designing and building the satellite, culminated at the AIAA Student Satellite Flight Competition Review (FCR) in March. At the FCR, teams are evaluated on several criteria, including student participation/education, technical relevance/excellence, and flyability (meaning that the hardware meets strict quality assurance guidelines and spaceflight qualification practices). FCR judges are a distinguished panel of government and industry professionals.

The second stage of the Program begins for the one team whose satellite is deemed winner at the FCR. The mini-satellite is expected to be flight-ready by the time it is evaluated at the FCR (standards for spaceflight hardware and associated documentation are diligently maintained by teams every step of the way). During the second phase, the winning project goes through a series of tests to simulate the launch and outer space experience. Once testing is complete, the winning satellite will be launched into space.

> "Our primary goal is to attract students into the field of aerospace engineering and to give them experience working on real hardware."
>
> —JEFF GANLEY

INFLUENCING THE FUTURE OF SATELLITE DESIGN

This is the first time the University of Minnesota is participating in the competition. While teams from other universities that have participated in the past have the advantage of improving upon existing satellites, the Minnesat team built their model from scratch. In addition to learning the skills to build a satellite from the ground up, the team's experience is contributing to future University curriculum.

Demoz Gebre-Egziabher, a professor of aerospace engineering and mechanics and the principal investigator for the project, hopes that the Nanosat project will one day be required for all aerospace engineering majors. This goal is on the right track. The U of M recently was selected to participate in the next iteration of the competition—Nanosat-5.

"We are here to build an infrastructure in satellite design and space design into our department's curriculum," Gebre-Egziabher said. "We've started a program that we can integrate into the curriculum and build upon. And from the research aspect of the project, we will be a success. We have published papers, and whether or not we launch, I believe the Air Force will use our research."

Research is a key component in the competition

and differentiates each team's entry. The objective of Minnesat is to use the Global Positioning System (GPS) to determine the orientation of small satellites. Using GPS for navigation is not a new concept, Gebre-Egziabher said. It's currently used in large satellites and other projects. But to date, the concept has not been translated into a small scale, which is the goal of this project.

"We are trying to design and build something that is much smaller and less expensive than the current system. Because the satellite has to be ready to fly, we will have verified on the ground that this research is viable," Gebre-Egziabher said.

GPS antennas on each side of the satellite, eight in total, are an integral part of the project's success, said Jason Mintz, the Minnesat student project manager who completed a degree in aerospace engineering in December 2006. By taking two measurements at each end of the antennas and comparing the measurements, the team will be able to figure out the satellite's orientation. Mintz said this system has the potential to replace current systems.

In addition to the antennas, the finished mini-satellite features an aluminum hexagonal structure covered with solar panels. The team has built a variety of components for the satellite, including a communication system, a flight computer, and an internal health monitoring and control device.

"A lot of what works on the ground doesn't work in space, so we have to consider all the possibilities of what could happen in space," Mintz said. "Will computer chips freeze in a radiation environment? What if a chip stops working? How do we reset it? Basically we have to find a way to use materials designed to work on the ground and modify them by replacing parts so they will work in space."

TRANSFORMING STUDENTS INTO ENGINEERS

For the students, the project has essentially been a labor of love. Participation is completely voluntary, and team members don't earn traditional class credit for the work, instead, they squeeze it into schedules bursting with course work and part-time jobs, holing up in the team's office in Akerman Hall on evenings and weekends.

According to Mintz, the team has become quite close, which comes as no surprise given the fact that they usually spend seven to eight hours a day, five or six days a week on the project, and even more during crunch times. And because they are the pioneering members of the project, they have learned everything as they go.

"This project has been especially challenging because there's no precedent, and we can't go look up what other people did before us," Mintz said. "If we could go back and do it again, we could easily fix a lot of the mistakes we've made, both procedural type things and how to be more efficient."

Another challenge the team has faced is securing the appropriate resources to make their mini-satellite a success. Participating teams receive a budget from the sponsoring organizations, but Mintz said, teams are allowed to use any additional money they raise and as many donated materials as they can secure.

By leveraging the aerospace and mechanics department's existing relationships with local companies and alumni, the Minnesat team secured financial donations, as well as donations of parts, computer time, and help from local professionals. A donation from alumnus Richard DeLeo (Aero '46, M.S. '48), a retired vice president of Aeronautical Research at the former Rosemount Aerospace, as well as donations from companies such as Goodrich, Honeywell, Lockheed-Martin, and Tennent have helped the team improve their chances for success.

"The money that we're given to start really isn't enough to do everything, so we rely on donations from businesses," said Gebre-Egziabher, who also manages the team's budget. "We're always looking for more outside knowledge and resources that will help us continue to grow this program."

Gebre-Egziabher said throughout this process he has been continually amazed by how quickly the students became engineers and by the sheer volume of skills they acquired along the way. These skills, everything from giving presentations to working with vendors to wiring electrical systems, cannot always be learned in the classroom.

"One of the truly amazing things about this project is seeing how undergraduates have grown to look, talk, and walk like engineers," he said. "They are learning skills they never thought they'd have to learn to be successful aerospace engineers."

No matter the outcome of the competition, the University's first Nanosat team has found success. The students all contributed to a project with a real customer and a real finished product, while researching a topic that could change the industry.

"This is real-world engineering, and we are doing the same things we'd be doing if we worked for a company," said Mintz. "We get a big piece of the pie on this project because the team is so small. Instead of doing the same thing over and over again on a piece of the project, like you might do on other student projects, we get to work on a huge variety of things. That's something you don't often get to do as a student, other than at this University." ■

FOR MORE INFORMATION www.aem.umn.edu/proj-prog/nanosat/

"One of the truly amazing things about this project is seeing how undergraduates have grown to look, talk, and walk like engineers."

—DEMOZ GEBRE-EGZIABHER

A Global Positioning System (GPS) receiver is just one of many parts used by the Minnesat team to build their mini-satellite. While the concept of using GPS for navigation of satellites is not a new one, the concept has not been translated into a small scale, which is the goal of this project.

ENERGY *alternatives*

WRITTEN BY **RICHARD BRODERICK**

FACULTY PHOTOS BY **JONATHAN CHAPMAN**

Institute of Technology faculty play a key role in the state's commitment to renewable energy research

Glaciers melting. Monster storms ripping into the Gulf Coast. Inuit people unable to hunt seals for fear of falling through the thinning ice. And, now, the latest report from the Intergovernmental Panel on Climate Change has confirmed what almost everyone has already accepted is true: human activity—in particular the creation of greenhouse gases through the burning of fossil fuels—is playing the lead role in potentially catastrophic global warming.

Since 2003, the University of Minnesota's Initiative for Renewable Energy and the Environment (IREE) has been funding renewable energy projects responding to this pending crisis. Not surprisingly, many of these research projects are located within the Institute of Technology.

"If we are going to scale the mountain of replacing fossil fuels with renewable energy, we need a multi-front approach," observes IREE Director Dick Hemmingsen. "Institute of Technology research teams are playing a critical role in the University's efforts."

A closer look at Institute of Technology research reveals cutting-edge work on a wide range of renewable energy sources.

Current solar cells, like the one held here by Professor Eray Aydil, are usually made of silicon that require high temperatures and vacuum processing during production, all of which increase the cost. Aydil and his team are researching ways to apply nanotechnology to produce lower-cost, high-efficiency solar cells.

eray AYDIL

Harnessing the power of the sun

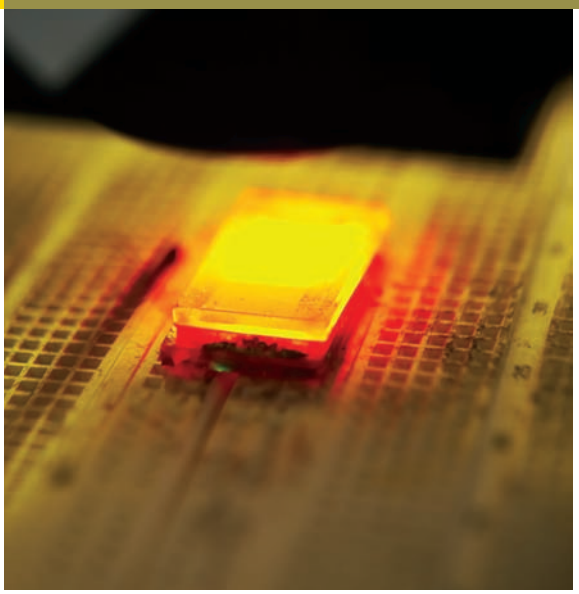
PROFESSOR ERAY AYDIL (chemical engineering and materials science) is not only undertaking research that could make solar-powered electricity inexpensive enough to compete against coal, natural gas and other fossil-fuels that currently drive the nation's electrical grid, he's helping to lay the foundation for breakthroughs by the next generation.

Aydil is researching ways to apply nanotechnology to solar-voltaic cells, which convert sunlight into electrical energy that can be stored for future use.

Currently, solar cells must be constructed from very high-grade materials—usually silicon—that require high temperatures and vacuum processing during production, all of which increase the cost. During production, conventional cells are doped with impurities that absorb light and convert it into positive and negative currents.

"We are aiming at architectures that are much less expensive," Aydil said.

To achieve that goal, Aydil and his fellow collaborators, professors Uwe Kortshagen (mechanical engineering), David Norris (chemical engineering and materials science), and Xiaoyang Zhu (chemistry),



Aydil and other researchers study how the nanowire-based solar cell absorbs different colors of sunlight and generates electricity.

are following two different, though related tracks. Both rely on nanotechnology.

One kind of solar cell they are developing employs nanowires coated with a light-sensitive dye; the other uses light-sensitive quantum dots, or nanoparticles, attached to nanowires. "The advantage of nanowires is that they have large surface areas and so can absorb a lot of dye or contain lots of dots that can convert sunlight into an electrical current," Aydil explained,

The other big advantage is cost. The architecture of both the dye-sensitized and quantum-dot cells is much simpler than conventional solar voltaic cells and potentially much easier to produce, Aydil said.

"Essentially everything is done in a beaker in a lab," Aydil said. "That could vastly reduce the cost of solar cells." And that, in turn, would speed the day when the sun becomes a major source of electricity to meet the world's growing demand for clean power.

In addition to Aydil's solar research in the lab, he's also helping bright young students reach their potential. This year, he volunteered to mentor a team of Hopkins junior high students participating in the FIRST LEGO League robotics competition, which focused on nanotechnology. The team won the Division II state championship for their presentation on nano-based solar cells and will represent the state at the World LEGO League Festival in Atlanta this spring.

"I hope the junior high students I mentored this year will come to research and study with me at the U in a few years," Aydil said.

The University currently has 150 graduate students and post-docs, including nearly 75 Ph.D. candidates, who are focusing their studies in renewable energy.

"At the University of Minnesota, we're not just researching renewable energy, we're training the workforce for tomorrow's renewable energy industry."

> "At the University of Minnesota, we're not just researching renewable energy, we're training the workforce for tomorrow's renewable energy industry."
>
> —ERAY AYDIL

jane DAVIDSON

Searching for the Holy Grail of solar power

NOT FAR FROM AYDIL'S LAB, Professor Jane Davidson (mechanical engineering) is working on another type of solar research that focuses on solar thermal energy.

Davidson began her work on solar energy in 1986 at Colorado State University, and over the past five years has been able to focus almost exclusively on solar. She is, she said, "fortunate that in the course of my career the subject has become popular. I have a real passion for it scientifically but also because of the role solar can play in creating a more environment-friendly world."

Currently that passion is channeled into two main areas of solar thermal research. In collaboration with several other Institute of Technology faculty—professors Susan Mantell and Francis Kulacki (both mechanical engineering) and Lorraine Francis (chemical engineering and materials science)—she is developing ways to produce lower-cost solar heating systems manufactured of plastic rather than of copper and glass. She and the other faculty are also addressing the scientific challenges to implementation. They are developing improved storage systems and methods to reduce scaling on the polymer surfaces of solar units. In addition, the team is working to determine the long-term durability of different kinds of polymers when exposed to hot, chlorinated water.

Davidson's second project takes her to the cutting edge of solar research: using solar heat to produce hydrogen from water.

"The Holy Grail would be if you could split water directly, using solar energy to separate the oxygen from the hydrogen," she said. But because of a number of reasons, this way of producing fuel isn't feasible. So she and Aldo Steinfeld (Ph.D. ME '89), a University alumnus and current professor at the Swiss Federal Institute of Technology, are working on a two-step water-splitting cycle using a solar reactor or furnace—an instrument that captures and concentrates solar energy, generating temperatures as high as 2500 degrees Celsius—to separate zinc oxide into zinc and oxygen.

The second step in the process, which is the focus of her research, involves hydrolysis: exposing the zinc to steam produces hydrogen and metal oxide, which is then recycled into the solar reactor to begin the two-steps all over again. The net reaction is water splitting—a "totally green" process.

"The problem with the second step—the reaction of zinc and water—is that zinc quickly forms a zinc

oxide layer that protects it from further hydrolysis. That's why zinc is used as a coating on iron and steel to protect against corrosion," she explains. Once that layer is formed, the rate of hydrogen production slows down.

Her answer to this dilemma is to use zinc nanoparticles in the second stage of the process. To that end, she and her research team have constructed a reactor that evaporates zinc in order to form zinc nanoparticles while simultaneously hydrolygizing the particles. The result? The researchers can retrieve almost all the potential hydrogen.

That's the good news. But there's still much work to be done. "We've achieved excellent results for conversion efficiency," Davidson said, "But what we're finding is that most of the hydrogen is being produced not from the nano aerosol but from zinc that has been deposited on the reactor walls. The recuperation of zinc oxide for recycling into the solar reactor is still something we're working on." Only when that puzzle is solved will the process become economically feasible.

Still, Davidson remains hopeful of the future, especially since, as she explains, "We have unique capabilities here at the Institute of Technology, with such a strong focus on energy and nanoscience.

"We'll be able to do it," she declares. "It's just a matter of time.

> "We have unique capabilities here at the Institute of Technology, with such a strong focus on energy and nanoscience."
>
> —JANE DAVIDSON

A reactor in Davidson's lab is used for the formation and hydrolysis of zinc nanoparticles in cutting-edge research to retrieve hydrogen energy in the process.

For the past five years, Professor Jane Davidson has focused her research on solar energy. Currently, she is channeling her efforts into two areas of solar thermal research.

Electrical and computer engineering professor Ned Mohan and his University of Minnesota colleagues are researching new technologies for converting and storing energy generated by wind turbines for usable electricity. Mohan is also researching ways to save energy by making motors and generators smaller and more efficient.

ned MOHAN

Leading the winds of change

SOUTHWESTERN MINNESOTA AND THE DAKOTAS have been rightfully described as the Saudi Arabia of wind power. The region's flat and relatively treeless landscape offers almost no resistance to the prevailing winds blowing steadily across the plains at mid-latitudes.

But before that potential can be fully harnessed, a number of daunting technical challenges have to be addressed, not the least of which is the reliability of the high-tech turbines whose blades and generators convert wind into electricity.

That's where Professor Ned Mohan (electrical and computer engineering) comes in.

Mohan is an inveterate tinkerer. Not long ago, he and a grad student went to a local hardware store and bought a number of fans, took them back to the lab, dismantled them, and discovered that even so-called "high efficiency" units operate at about 20 percent efficiency, tops. With some redesign work, Mohan and his graduate student Ranjan Gupta have pushed that efficiency up to 60 percent (and think they can do even better) while only adding a little to the overall price of the fan.

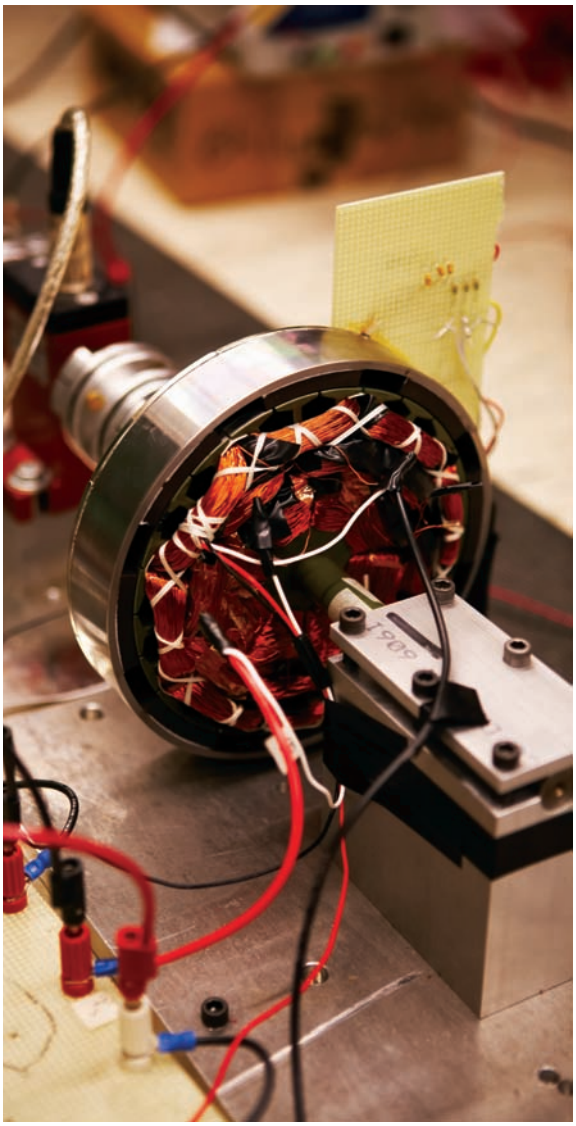
He has brought that same innovative spirit to the problem of windmills, whose bearings tend to demonstrate a disconcerting, and highly inefficient, tendency to wear out in relatively short order.

"You can imagine what a nightmare it must be to have to bring a windmill generator down from a height of 80 meters, repair it, and then put it back up again," he said. "It's a very costly affair."

The problem with windmill reliability stems from the stray currents released at the point where the constantly changing voltage generated by windmills—which is a function of wind speed—is switched at high frequency to synthesize a steady 60 Hz. In a nutshell, the stray currents flow through the windmill's bearings and destroy them.

To rectify that problem, Mohan and his post-doc collaborator, Krushna Mohapatra, have created an improved form of matrix converter, which is a matrix of switches that can synthesize a steady 60-Hz voltage from the variable-frequency voltage generated by the windmill. The University of Minnesota has filed a provisional patent application for this work and has awarded an Innovation Grant award to the researchers.

Matrix converters have been around for some 30 years, but have never been a big success because of their shortcomings of producing only 87 percent of the incoming voltage, without eliminating the stray currents. Mohan and Mohapatra have come up with a simple, elegant way to enable these converters to boost incoming voltage by as much as 150 percent while eliminating the stray currents that destroy bearings.



This motor created by graduate student Ranjan Gupta and Professor Ned Mohan is about three times more efficient than household fan motors currently sold in hardware stores.

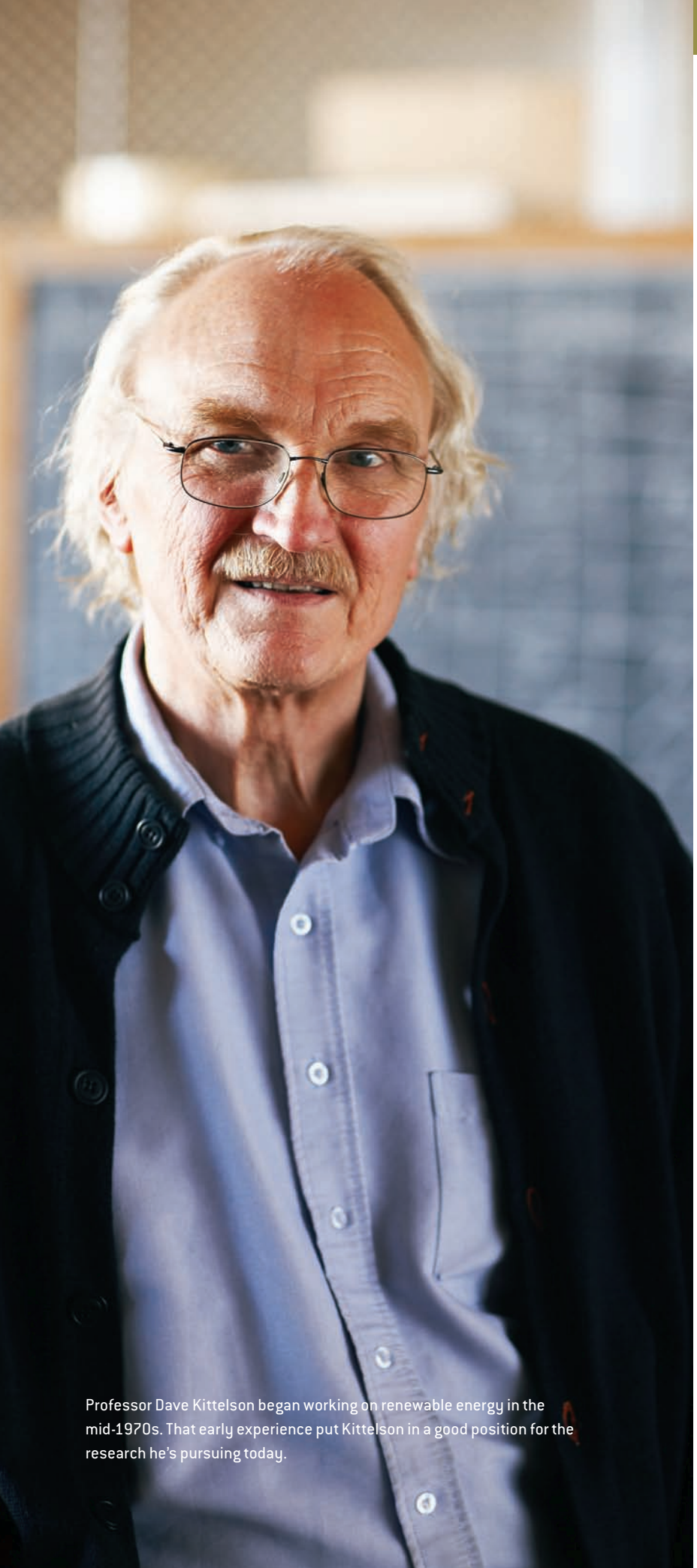
"In the past, generators were fed from only one side of the generator windings," he explains. "In our work we are feeding the generator windings from both sides.

"It's surprising that no one thought of doing this before."

In addition to its application to wind generators, Mohan's improved converter could also improve the reliability of any kind of three-phase electrical motor or generator in variable speed applications. But for now, wind power is the big potential payoff.

"What we're doing could put the wind industry into high gear," he declares. "And that's just what we need right now."

> "What we're doing could put the wind industry into high gear."
>
> —NED MOHAN



Professor Dave Kittelson began working on renewable energy in the mid-1970s. That early experience put Kittelson in a good position for the research he's pursuing today.

dave KITTELSON

Developing biofuels for a new generation

PROFESSOR DAVE KITTELSON is an old hand when it comes to renewable energy.

Kittelson (mechanical engineering), who heads the University's Center for Diesel Research, began working on renewable energy in the mid-1970s. "That was two or three energy crises ago," he quipped.

That first rash of concern led to the University's formation of the Steady Earth Center, charged with developing new forms of renewable energy.

"We were looking at cattails and all kinds of sources for biomass," he explains. Among other promising research, Kittelson was involved in experiments using hydrogen in gasoline engines and alcohols in diesel engines.

Though national support for renewables faded in the 1980s when the relative price of oil plummeted, that early experience put Kittelson in a good position for the research he's pursuing today.

The biodiesel program he helped launch more than a decade ago has continued to grow and branch out in search of new sources and applications of biofuels. For example, he is working with Professor Paul Strykowski (mechanical engineering), on developing ways of using less-refined forms of biodiesel, like raw plant oils, in engines and combustors. They are exploring processes that can convert unprocessed soy oil and restaurant grease (among others) into biofuels for transportation.

He is also working on a project with the Initiative for Renewable Energy and the Environment (IREE) to find ways of using ethanol, Minnesota's most common biofuel, in diesel engines.

Ethanol blends perform just fine in spark ignition engines of the kind that run well on gasoline, but not in diesel engines. That's unfortunate, because diesel engines operate at a higher level of efficiency than do gasoline engines, and generally last longer. But Kittelson thinks he might have the answer to this dilemma. Hydrogen.

In the renewable energy field, hydrogen is usually considered the promised land of renewables. It's clean-burning, but no one has found a way to produce and distribute hydrogen cheaply and efficiently (at least not yet).

Kittelson is not looking at hydrogen as a primary fuel but as an enhancer for ethanol blends. Mixing a small amount of hydrogen with ethanol results in a mixture that may overcome ethanol's shortcomings as a diesel fuel.

"We're testing this on a VW right now," he says.

"There's promise that the technique might lead to cleaner, more efficient engines using fuels that might not otherwise be suitable for diesel engines."

Hydrogen-enhanced ethanol is not the only biofuel Kittelson's investigating. He and other research teams also are looking into butanol, a biofuel that can be produced from sugar beets—which, like corn, the basis of ethanol, grow abundantly in Minnesota—and dimethylether, or DME, a fuel that can be refined from a waste stream of pulp mills. Kittelson sees this as "the biofuel of the future."

"While the end goal of our energy research has essentially remained the same over the years, today we have a better understanding of the negative consequences of fossil fuel use and have new technologies and tools to solve the problem," Kittelson said. "This leads me to believe we may really be able to find the key to creating widely used renewable energy sources this time around."

"While the end goal of our energy research has essentially remained the same over the years, today we have a better understanding of the negative consequences of fossil fuel use and have new technologies and tools to solve the problem."

—DAVE KITTELSON

Kittelson adjusts an instrument in his lab used to measure particle emissions from engines. The University of Minnesota's biodiesel program has continued to grow and branch out in search of new sources and applications of biofuels. Kittelson is currently researching ways to use ethanol in diesel engines, which are 25 to 30 percent more efficient than gasoline engines.

Professor Lanny Schmidt talks with Ph.D. graduate student David Rennard. Rennard is holding a catalyst that is used to convert biomass into hydrogen and biofuels.

lanny SCHMIDT

Working to end the Fossil Fuel Age

"THE STONE AGE DID NOT END because we ran out of stones," Regents Professor Lanny Schmidt has observed. Meaning, the Stone Age came to an end because humans happened upon a process to convert ore into metal and to shape that metal into tools that outperformed anything made from stone.

Schmidt (chemical engineering and materials science) is doing more than his fair share to see that the Fossil Fuel Age meets a similar fate.

Three years ago, his research team devised a feasible way to extract hydrogen from ethanol. This past year, he came up with a way to convert soybean oil and sugar water into hydrogen and carbon monoxide, or what is known as syngas, a basic ingredient in synthetic diesel fuel. When perfected the process could be applicable to a wide range of biomass sources – and could ultimately decentralize and therefore revolutionize the way America refines transportation fuels.

"Soybean oil and sugar water are prototypes," Schmidt said. In the end the range of possible biomass sources includes, "pretty much anything with a carbon base." In other words, everything from grass and trees to urban waste, though the latter presents challenges because it contains what Schmidt calls "high levels of crud."

"We'd have to research to see if such things would be compatible with our process," he said.

Schmidt's process uses an ordinary fuel injector to spray soybean oil or sugar water into a tube that contains a catalyst heated to 1000 degrees C. The combination of heat and oxygen tear apart the molecules. In just 1/100 of a second, the oil or syrup is converted into hydrogen and carbon monoxide. Not only is this faster than other methods of extracting hydrogen, Schmidt's technique also works for substances—such as soybean oil or sugar water—that only yield water vapor and "gunk" in other processes.

"For some applications, certainly farm equipment, I suspect we will be able to see a 100 percent replacement of fossil fuels," with fuels from biomass, Schmidt predicts. Already, he points out, America is relying on a combination of fossil fuels and biofuels (principally ethanol) for transportation, with the balance continuing to shift toward biofuels, a trend that will only grow because of cost and environmental considerations.

And with the cost and technology of bio-refineries not much different from those needed for an ethanol plant (a dozen or more of which are already located around Minnesota), the potential exists for the development of refineries almost anywhere there is a source or sources of biomass.

"The real world application of this process is close," Schmidt declared. "The application we are thinking of here is for small-scale biofuel refineries that would be distributed around the state. Rather than mega-refineries, the idea is to expand the number and sources of biofuel and build refineries with a range of biomass coming in and a range of biofuels going out," he explained.

"This would shift the whole way we think about fuel production," he said. "Biomass is distributed across the country. It would decentralize the whole transportation fuel industry. It's a revolutionary idea with the potential to change everything."

Who knows? Maybe it could even end the Fossil Fuel Age. ■

This catalytic reactor, which is only about two centimeters wide, uses an ordinary fuel injector to spray a renewable liquid material (such as vegetable oil or soybean oil) into a tube that contains a catalyst heated to 1000 degrees C. The combination of heat and oxygen tear apart the molecules. In just 1/100 of a second, the oil is converted into hydrogen syngas.

> "The application we are thinking of here is for small-scale biofuel refineries that would be distributed around the state."
>
> —LANNY SCHMIDT

Institute of Technology alumni have won the first two years of a Minnesota competition seeking the state's best aspiring entrepreneurs

>>>BREAKTHROUGH

Institute of Technology alumni John Berger and David Emmons were the winners of the first-ever Minnesota Cup competition in 2005. Their invention is an innovative, low-cost optical switch and attenuator for rerouting information carried on fiber-optic networks.

IDEAS

WRITTEN BY **KERMIT PATTISON**

PHOTOS BY **JONATHAN CHAPMAN**

SOME STUDENTS SPEND THEIR COLLEGE YEARS tossing Frisbees. John Berger and David Emmons built a machine to launch them—an exercise in four bar linkages optimizing the ratio between linear and angular velocity—but you wouldn't want to play catch with it.

"We demonstrated it by firing a Frisbee into a concrete wall. Believe me, the first two rows of the audience got up and moved back before our second throw," joked Berger.

Now the two mechanical engineering alumni are using their skills to launch another idea—a switch that could transform the fiber optics industry.

Meanwhile, another team of University of Minnesota Institute of Technology alumni are using their expertise to reinvent a simpler technology: the paving stone. VAST Enterprises is developing environment-friendly brick pavers from recycled tires and plastic bottles.

Both innovations have one thing in common: winning the Minnesota Cup, a statewide competition that honors promising innovations.

"We're looking for breakthrough ideas," said Scott Litman, co-founder of the Minnesota Cup. "We're also looking for concepts where we believe the entrants can take it into the marketplace and make it a success."

It's not surprising that the U's Institute of Technology alumni have swept the first two Minnesota Cup competitions. The college has spawned thousands of entrepreneurial startups as well as giant corporations such as Medtronic and Ceridian. According to a 2005 survey, Institute of Technology alumni have started 4,150 active companies with revenues of $90 billion worldwide.

"The University of Minnesota Institute of Technology has a long history as the primary science and engineering program in the state," said Mos Kaveh, associate dean for research and planning. "If you look at technology-oriented businesses, most of them are initially started by engineers and scientists, not businesspeople. You have to have the technical know-how that comes out of the engineering and physical sciences."

Berger and Emmons met during the 1974-75 school year in seventh-grade science class at what was then Fairview Junior High in Roseville. More than three decades later, they are still friends and now are business partners.

A SWITCH IN TIME

John Berger (ME '84, MBA '93) and David Emmons (ME '84) have been solving problems together for most of their lives. They met in seventh-grade science class and attended the same schools right up until they both graduated from the Institute of Technology in 1984. In addition to their Frisbee-launching device, they collaborated on a machine that turned pages for handicapped readers, an idea that was patented

Fiber optic lines have revolutionized telecommunications.

> "We always believed we had the best optical switch. Now we're confident the market timing is finally right."
>
> —JOHN BERGER

by the University.

"An engineering education is four years of problem solving," Berger said. "By the end, you're just a problem-solving machine. Everything you look at in life, you're thinking, how can I solve this?"

Their ultimate search for a solution began with a casual conversation. One day in the late 1990s they were discussing the growth of fiber optics, and Emmons mentioned an interesting problem he had encountered in a past job at ADC Telecommunications.

Fiber optic lines have revolutionized telecommunications but switching light from one fiber to another has been difficult because the lines are as fine as a human hair. As a result, fibers often must be attached to larger lenses and aligned by hand, a process that is labor-intensive and results in an expensive and space-consuming switch.

Was there a way to "build a better mousetrap"? Berger and Emmons started brainstorming. They designed a switch with optical fibers bundled onto two armatures that moved in arcs. The switch could be programmed to "remember" the location of each opposing fiber and position them in optimal alignment. Without the expense of lenses and manual labor, the switch would cost much less than competing technologies.

It seemed like an idea whose time had come. At the time, the dot-com industry was booming and the installed capacity of fiber optic lines was doubling every three months. They applied for patents and considered quitting their day jobs.

Then the boom went bust.

"We mothballed it to be honest," said Emmons, who holds 25 U.S. patents. "We joked that when all these other dot-com startups were going out of business our competitive advantage was our burn rate—we were bleeding slower than everybody else."

In 2005 when the aftershocks of the dot-com bust had calmed, Berger's wife, Caroline, heard about the new Minnesota Cup competition and prompted Emmons and Berger to dust off their idea. They polished their business plan, put together a compelling presentation and beat 600 other entrants. "The Minnesota Cup was a great third party validation, a fabulous experience for us," said Berger, who also has an MBA from the University of Minnesota and works at Fiserv's Personix division, a leading source for plastic card manufacturing and personalized print/mail services. "It really re-energized the whole effort."

The $25,000 prize helped them recoup a portion of the $100,000 in personal funds they have invested so far. It also provided them with advisory services from Wells Fargo and the Maslon law firm, media exposure, and an opportunity to network with people who have provided invaluable help.

Emmons recently left his job with Proctor & Gamble's PUR Water Filter brand to devote himself to the startup full-time. He and Berger are looking for venture capital or a corporate partner to help fund the remaining development and qualification testing.

"We're in it for the long haul," says Berger. "We always believed we had the best optical switch. Now we're confident the market timing is finally right."

And another problem will be solved.

PAVING A NEW WAY

A few miles away, Troy Achterkirch (ME '94) demonstrates a solution to a very different problem.

He stands on what appears to be a traditional brick patio. In fact, the pavers are made out of recycled tires and plastic bottles and weigh only about a third as much as brick or concrete. He stoops, removes a few bricks from their grid-like base and rearranges them into a new pattern as quickly as a card dealer

(From left to right) Institute of Technology alumni Andy Vander Woude, Steve Smith, and Troy Achterkirch are part of a team of business partners who have created an alternative to the traditional paver using 99 percent recycled materials. Their idea helped them win the 2006 Minnesota Cup competition.

shuffling a deck.

"You can do any different sort of patterns that you want," Achterkirch said. "It pre-aligns everything for you."

Things are snapping into place for his company, too. VAST Enterprises—a startup of five people, most of them Institute of Technology alumni—has created an alternative to the traditional paver using 99 percent recycled materials. Last year, the company became the second winner of the Minnesota Cup, and now the startup is preparing to ramp up manufacturing and distribution in time for the spring season.

"Our product addresses many problems with one solution," says Steve Smith (ME '94 and M.S. MOT '04), another member of the team. "We make an eco-friendly green product out of recycled materials. It's lighter, better performing and looks better than traditional concrete pavers."

> "Our product addresses many problems with one solution."
> —STEVE SMITH

The idea took hold a few years ago when Achterkirch, the general manager of Thermotech injection molding facility in Hopkins was approached by a colleague, Steve Thorkelson, who had an idea for easing the back-breaking labor of installing pavers. The two developed a prototype and decided to bring in more expertise by tapping into a network of Institute of Technology alumni.

Achterkirch contacted Smith, a college friend who was working at Victory Motorcycles, a division of Polaris. In turn, Smith recruited Andy Vander Woude (M.S. MOT '04), a colleague from the Institute of Technology's master's program in Management of Technology (MOT). At that time, Vander Woude was working as director of product marketing at the security firm Fargo Electronics. Later, they rounded out the team by recruiting George Solnitzky, a veteran of the construction and real estate industries.

"One of the smart things we did was to put together a team that was very complementary in our strengths in different areas," says Vander Woude.

They spent last year engaged in research, seeking patents and developing a business model. They decided to initially focus on the green building industry—a fast-growing area of the construction business. Their invention offers a new use for the 300 million tires scrapped per year in the United States. Each square foot of patio uses the equivalent of about half a car tire and six gallon milk jugs (used as a binder).

The materials will cost more than traditional pavers, but reduced labor will make the total price of installation roughly equal, says Vander Woude. The bricks, which come in a variety of colors, snap into a base as easily as LEGOs. Afterwards they are locked in place with sand just like traditional pavers.

Their idea already has won kudos. The pavers will be featured on an upcoming episode of "Landscape Smart" on HGTV. Last year, VAST won the second Minnesota Cup competing against more than 600 entries. After they unveiled their concept to the competition judges, they pointed out the window at a patio that had been assembled during their 15-minute presentation. Litman, one of the judges, said the VAST team made a compelling case that "they not only have a great product but something that will really move the needle."

Smith and Vander Woude recently began working at VAST full time after quitting their day jobs. As they sit inside their new offices along the banks of the Mississippi River in Northeast Minneapolis, they're betting that the paving stone—a technology that hasn't evolved much in the last few thousand years—is ready for a retread.

Smith explained, "The fear of not doing this was greater than the fear of doing it and failing." ■

FOR MORE INFORMATION see www.vast-enterprises.com

> "One of the smart things we did was to put together a team that was very complementary in our strengths in different areas."
>
> —ANDY VANDER WOUDE

The VAST pavers, which come in a variety of colors, snap into a base as easily as LEGOs. Their idea already has won kudos. The pavers will be featured on an upcoming episode of "Landscape Smart" on HGTV.

DAVE & CAROLYN CLEVELAND PRESENT THE MINNESOTA CUP™

2007 Minnesota Cup

Let the Innovation Begin

THE THIRD ANNUAL MINNESOTA CUP competition will accept entries from the end of March through the end of May. The contest seeks "the next great entrepreneurial success story in our state" and has drawn more than 600 entries each year for the past two years.

Entries will be judged on innovation, commercial viability and quality of presentation. Five finalists will make presentations to a panel of executives, investors and entrepreneurs at a final event in the fall.

The winner will receive $25,000 in seed capital and advice from the Wells Fargo Advisory Board (made up of leaders in finance, accounting, legal and management support services).

Second and third place winners will receive $5,000 and $2,500.

There also is a separate category for student entrepreneurs with a $5,000 prize. Entrants must be full-time students and have less than five years of professional work experience.

FOR MORE INFORMATION, see www.breakthroughideas.org

Kim Dockter
Director of External Relations

Alumni giving reaches new levels

An investment in the Institute of Technology is an investment in our quality of life

OVER THE PAST YEAR, Institute of Technology alumni and friends have made a substantial investment in the college's students, academic programs, and research. Our benefactors have more than doubled last year's gift totals. Not only is this strong level of support encouraging, it is an endorsement of the teaching and research the college carries out every day, which enhances the quality of all our lives.

As of the end of February, with four months remaining in this fiscal year, Institute of Technology alumni and friends have committed nearly $23 million to support student scholarships, fellowships, faculty, research, and academic programs. Alumni gifts for scholarships and fellowships alone have quadrupled.

These gifts are especially important because the University matches the award from all new endowed scholarship and fellowship fund commitments of $25,000 or more on a one-to-one basis, doubling the impact of their gift for student support. Corporate matching gifts may also be used to meet the minimum threshold and pledges may be paid over a five-year period.

Among gifts that have pushed the Institute of Technology to record support levels are the following:

Harold (ME '49) and Phyllis Conrad who recently endowed the Harold and Phyllis Conrad Mechanical Engineering Fellowship with a gift from their Individual Retirement Account (IRA). A provision in recent federal legislation, effective through 2007, allows individuals age 70-1/2 or older to direct a charitable distribution from their IRA, up to a maximum of $100,000, with no penalty as long as that money goes directly to charity. What's even better—the Conrad's fellowship award will be matched dollar-for-dollar by the University.

Also taking advantage of the opportunity to make a gift directly from her IRA is Phyllis Branin (ChemE '47) who added to the Phyllis B. Branin Fellowship Endowment in Chemical Engineering, which she established in 2004. Considered one of the trailblazers for women chemical engineers in the 1940s, Phyllis was employed by General Electric. As a retiree, she is eligible to receive a company match for her gifts to her fellowship, all of which is matched by the University.

Rich Kruger (ME '81), Executive Vice President of ExxonMobil Production Company, wanted to "give back" as a way of saying thank you for the outstanding education he received. He recently made a gift to endow the Richard M. Kruger Scholarship Fund, which will provide scholarships for Institute of Technology students. Rich was able to take advantage of ExxonMobil's matching gift program as well as the University match.

With a deep commitment to the Institute of Technology and a gift of $4 million, an anonymous donor recently established the Gemini Chair. The purpose of the chair is to help the Institute of Technology provide students with an opportunity for training in basic business and entrepreneurial skills with an eye for the technical and engineering marketplace.

Every day great things are happening at the Institute of Technology. Students and faculty are working steadfastly to discover new and more efficient sources of alternative energy; more effective ways of protecting our environment; lifesaving medical devices and drugs; safer buildings, bridges, and infrastructure; and a plethora of inventions for the future.

An investment in the Institute of Technology is an investment in our quality of life in Minnesota and on a wider scale, our nation and the world. Your gifts, large or small, are essential to our ability to carry on this strong tradition of excellence and innovation. ■

IT named the 'Top Producer' of alumni gifts

THE INSTITUTE OF TECHNOLOGY recently received a "Top Producer Award" given to the college with alumni and friends contributing the highest gift total during the University's Promise of Tomorrow Scholarship Drive.

A record 44,860 University of Minnesota alumni and friends made gifts and pledges during the three years of the scholarship drive, helping achieve the $150 million goal.

During the scholarship drive, $37 million was raised for graduate student fellowships, including an anonymous gift of $10 million for fellowships in the Institute of Technology.

Engineering entrepreneurs

AN ANONYMOUS GIFT of $4 million will establish the Gemini Chair in Engineering Entrepreneurship the holder of which will teach a course for Institute of Technology undergraduate students to help them broaden their leadership capabilities, business knowledge, and entrepreneurial skills.

"To maintain our programs in the ranks of the world's finest and to continue to innovate with increased impact for our graduates, we need to prepare students for success in all aspects of their careers," said Massoud Amin, who directs the U's Center for the Development of Technological Leadership (where the Gemini Chair will reside).

IT receives $10 million bequest

THE INSTITUTE OF TECHNOLOGY recently announced that it has received an anonymous $10 million bequest. The deferred gift will be used to set up a permanent endowment to fund graduate student fellowships.

The University estimates that the endowment will fund about 15 to 25 graduate fellowships each year to help graduate students pay for education and living expenses.

"This generous gift is a critical step in securing the future of the Institute of Technology," said Steven Crouch, dean of the Institute of Technology. "Through these fellowships, we will be able to maintain our stellar reputation and continue to attract the best and brightest graduate students. These graduate students are a key part of the research engine that drives our university."

"This gift will make the U of M more attractive to the most talented and creative students—women and men who have many options for their graduate education," said University President Robert Bruininks. "Attracting these high potential students will be key to our aspirations to become one of the top three public research universities in the world. They also will be focused in areas that many observers, including the National Academies and the Business Roundtable, have identified as critical to our country's ability to compete in a global economy."

The Institute of Technology currently enrolls about 2,500 graduate students. Student support in the form of fellowships and scholarships continues to be a top fundraising priority within the Institute of Technology and the University of Minnesota.

Alumni tour Arizona telescope

A group of Institute of Technology alumni recently toured the Large Binocular Telescope (LBT) Observatory. The facility, located on Mt. Graham (elevation 10,700 feet) east of Tucson, Ariz., is an international collaboration involving University of Minnesota Institute of Technology researchers. The LBT is the most-technologically advanced ground-based optical telescope in the world. Data from the LBT is used to research the origins of the universe, dark matter, quasars, black holes, and star formations. This tour was one of several alumni gatherings around the country in cities such as Naples, Fla.; Phoenix and Tucson, Ariz.; and Austin, Texas in which key faculty within the Institute of Technology shared their research and expertise with alumni.

DEVELOPMENT TEAM

The Institute of Technology's experienced development team can help you determine your best options for supporting the college. They can give you information about college programs with funding needs that match your interests and that best fit your financial situation.

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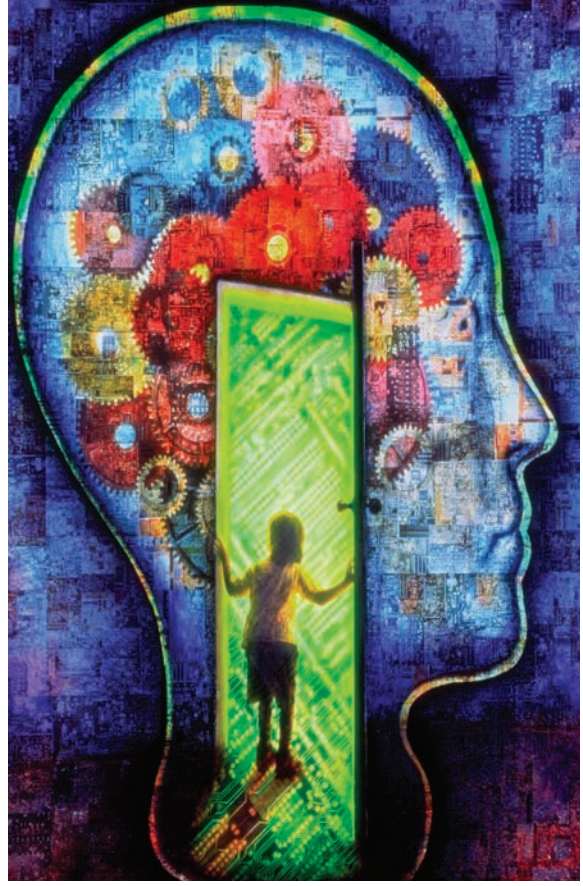
TO MAKE A GIFT

To support a project you've read about in *Inventing Tomorrow* or to designate a gift for any purpose, you may contact a development officer directly or call 800-587-3884 for more information.

DAWN SPANHAKE
ITAS PRESIDENT

ITAS helps all ages marvel at the world



As a mom, I have had the joy of watching my son constantly learn about, appreciate, and marvel at the world around us. It has made me aware that at some point in my life I stopped asking the "why" questions and started focusing on my very practical "to-do" list.

But having a 5-year-old has given me a reason to look at things from a new perspective. I've begun to appreciate all that I have yet to learn and have realized how much I can teach others around me. This new perspective has helped me to see that we all need to be more like 5-year-olds—wonder out loud how things work and then excitedly share what we've learned with others. The Institute of Technology Alumni Society (ITAS) can help you do just that.

There's never a better time than now to put down your 'to do' list and make your 'to learn' list

Reaching out to younger students is a fun and rewarding way to share your excitement about science and engineering. Providing opportunities for children to experience science and engineering at a young age is essential if we want them to consider a career in these areas.

The ITAS K-12 Outreach Committee sponsors award-winning programs for children. Get involved and watch the magic unfold. Volunteer as a mentor or coach to work with middle school kids participating in the FIRST LEGO League robotics competition. Bring your children or grandchildren to the ITAS-sponsored TechFest at The Works, a nonprofit hands-on science and technology museum. You'll be amazed at how much fun learning and experiencing science and engineering can be when you see it through the eyes of a child.

Even when these young people graduate from high school and enter the University, our work needs to continue. The ITAS Student Relations Committee is leading one of the University's top mentor programs with about 300 mentors and students involved. This program could not be successful without the dedicated volunteers who reach out and support our students, and the many students who teach their mentors a thing or two.

It is also important that we do not lose the passion for learning in ourselves. ITAS provides many learning opportunities just for you. The Public Lecture Series, coordinated by our Alumni Relations Committee, features top Institute of Technology faculty sharing their research on today's relevant issues. This year we sponsored lectures on renewable energy in Minnesota and new research in fluid power.

Our Corporate Relations Committee coordinates the ITAS premier event of the year—the Science and Technology Banquet. The banquet not only provides an opportunity for you to hear from world-renowned leaders in technology, but the funds raised through this event provide scholarships to our students.

If you're still looking for another way to learn and share, you can become involved on the ITAS board. As a board member, you can help us enhance our activities, reach out to students and alumni, and work with the Institute of Technology leadership, faculty, and students. Just contact us, and we'll find a place for you.

ITAS is working hard to coordinate many opportunities for you, but you don't have to stop there. The Institute of Technology and the University of Minnesota have a variety of opportunities for you to consider. Take advantage of the breadth and depth of knowledge at the University to expand your understanding of the world around you. Check out the IT Web site at www.it.umn.edu for news and events and sign up for mailing lists announcing activities in areas that interest you. Learn what students are doing and where you can use your expertise to help.

There's never a better time than now to put down your "to-do" list and make your "to-learn" list. See you at the next event! ■

IT public lecture in May focuses on rebuilding New Orleans

REBUILDING THE HURRICANE PROTECTION system in New Orleans and restoring the public's trust in the infrastructure is the focus of an upcoming Institute of Technololgy Public Lecture. "Rebuilding After Katrina" is at 7 p.m. Wednesday, May 16, at the University of Minnesota's Coffman Memorial Union Theater, 300 Washington Ave. SE. The event, sponsored by the Institute of Technology Alumni Society, is free and open to the public.

The event features Institute of Technology alumnus Craig Johnson (M.S. CivE '79), vice president of Stanley Consultants and the senior project manager for Task Force Guardian.

The U.S. Army Corps of Engineers formed Task Force Guardian (TFG) to restore New Orleans' hurricane protection system to pre-Katrina protection levels by June 1, 2006, the beginning of the next hurricane season. Under national and international media scrutiny, TFG managed 59 construction projects by 26 contractors in just eight months. The $800 million effort included miles of new floodwall, levees, scour repair, and several gated closure structures.

After the lecture, a panel of Institute of Technology faculty and alumni who have been involved in hurricane protection and recovery from Katrina will answer questions from the audience.

For more information, call 612-626-9354 or visit http://it.umn.edu/katrina.

TechFest draws 450 visitors

BRAD STAUFFER

Institute of Technology alumnus Philip Anderson (CivE '77) and his grandson Austin Palmer share some laughs with Goldy Gopher at TechFest 2007, an event that celebrated National Engineers Week. More than 450 children and family members visited The Works museum for the event. The day's activities focused on an electrical engineering theme. TechFest 2007 was sponsored by the Institute of Technology Alumni Society, the Society of Women Engineers, and corporate sponsors Digital River, Faegre and Benson, Hutchinson Technology, General Mills, Malt-O-Meal Co., and McDonalds.

Alumni Honors

John Franz (Chem Ph.D. '55) recently was named a 2007 inductee of the National Inventors Hall of Fame for his discovery of the non-toxic popular weed killer Roundup®. He will be honored at a special ceremony in May. This year's inductees also include the inventor of the automotive airbag, the developer of vaccines for childhood diseases in developed countries, and the creator of the Ethernet.

Robert P. Hammer (Chem Ph.D. '90), a Professor of Chemistry at Louisiana State University, has been named by Scientific American magazine as one of the 2006 Scientific American 50, the magazine's prestigious annual list of research leaders. Hammer made the list because of his research in the basic science of Alzheimer's Disease published recently in the *Journal of the American Chemical Society*.

Jay Knutson (Physics '73, M.S.'75, Ph.D. '78), chief of the Optical Spectroscopy Section of the Laboratory of Biophysical Chemistry of the National Heart, Lung and Blood Institute at the National Institutes of Health, has been elected to The Johns Hopkins University Society of Scholars. Knutson is a leader in the development of laser-driven high-speed optical instruments and techniques that have allowed researchers to make advances in the fields of biology and medicine.

E. Dianne Rekow (Math, Physical Science '66, ME '70, ME M.S. '82, D.D.S. '83, BME Ph.D. '88) has been elected president of the American Association for Dental Research. She is currently chair of the Department of Basic Science and Craniofacial Biology and director of Translational Research at New York University College of Dentistry.

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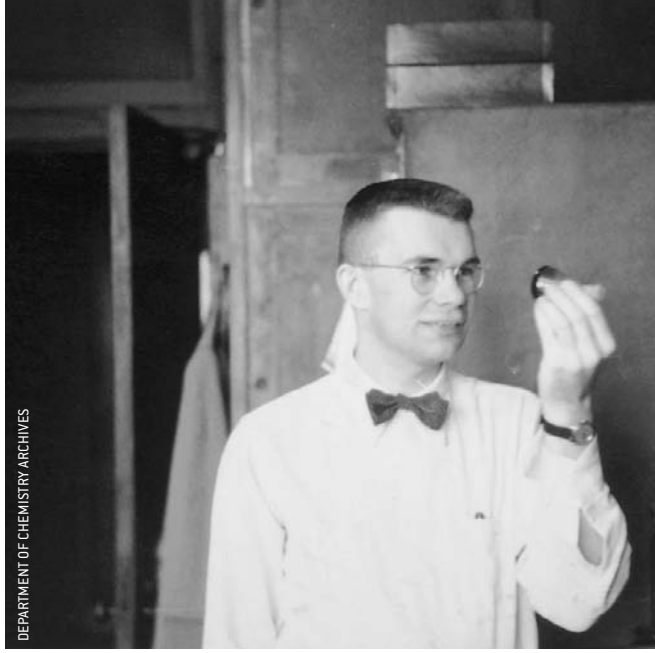
Prof shows the "Way" to good chemistry



DEPARTMENT OF CHEMISTRY ARCHIVES

After 54 years in the classroom and lab, Professor Wayland E. Noland shows no signs of letting up

WHEN CHEMISTRY PROFESSOR WAYLAND E. NOLAND started his teaching career at the University of Minnesota, Harry S Truman was president, "Singin' in the Rain" was a hit new movie, and the price of a first-class stamp was 3 cents. A lot has changed since then, but even at age 80, Noland's passion for teaching and his love of the University are as strong as ever.

"There have always been top-notch students in my classes from the start," Noland said. "I have very pleasant memories of some of them going back a long way. Some are already retired. Now, that's hard to take sometimes," he said with a laugh.

When Noland first arrived at the University in 1951 after earning a Ph.D. at Harvard (degree was awarded in 1952), he served as a duPont post-doctoral fellow in physical-organic chemistry. A year later, he was appointed assistant professor. His focus has shifted to synthetic organic chemistry, and he has been teaching and researching in Smith Hall ever since. "I guess I like it well enough, and I leave well enough alone," he joked of his impressive tenure.

The estimated 12,000 students who have passed through Noland's classes, his numerous research students, and his faculty colleagues, would probably disagree about leaving well enough alone. According to Jeff Roberts, chair of the Department of Chemistry, "Way is quick to welcome new faculty, staff, and students to our department, and to get to know them."

Roberts points to last year's graduation ceremony as an example. After quietly shaking hands with Roberts and other administrative heads, degree candidates greeted Noland with unprecedented warmth and affection as he sat on the stage. "It was a telling and humbling experience," Roberts recalled.

Roberts also said Noland is like a living time capsule. "He has a long and prodigious memory, and he keeps track of people when they leave the department," Roberts said. "Whenever any of us has a question about something that happened in the 1950s or later, Way is there to answer it."

Even after his 54 years in the classroom and lab, Noland shows no signs of letting up. Known for his blackboard lectures, he believes that face-to-face student-teacher interaction still beats technology-enhanced learning. It's hard to argue with success. Last year, Noland received the Charles E. Bowers Faculty Teaching Award for exceptional teaching in the Institute of Technology.

Noland's commitment to students goes beyond those in his classes. He has also helped dozens through his endowed fellowships and scholarships in the Department of Chemistry. "My gifts have always been to help students become better students and better citizens as a result of their education at the University," he explained.

Roberts agrees. "He is totally student-centered," Roberts said. "Way constantly reminds us that faculty are here primarily to serve and teach our students, whether in the classroom or the research lab."

Noland's former students haven't forgotten his dedication. About 200 of those former students from across the country, faculty and staff colleagues, and current students, celebrated Noland's 80th birthday earlier this academic year at a party organized by the

JONATHAN CHAPMAN

In honor of Professor Wayland Noland's 80th birthday, a commemorative miniature bobblehead doll was created in his likeness—complete with suspenders. "That's very clever," Noland said of his springy-necked likeness. A limited supply of the bobbleheads are still available and will be distributed on a first-come, first-served basis. To have one sent to you, send an e-mail to pruden@umn.edu with the subject heading "Bobblehead."

DEPARTMENT OF CHEMISTRY ARCHIVES

THEN
(Left) Chemistry Professor Wayland Noland began teaching at the University of Minnesota in 1952. He's pictured here as a young assistant professor in 1954. (Right) Smith Hall has become like a second home to Noland. He's pictured here in his lab in the early 1980s.

NOW
(Below) Today, at age 80, Noland's commitment to teaching and the University is as strong as ever.

University's Chemistry Department.

It all seemed like a bit much to the self-effacing Noland. "It wasn't something I sought, but I always look forward to seeing my former students," he says of the party, which organizers dubbed "Wayfest."

The celebration included a morning lecture program, a river cruise, and even a bobblehead doll created in Noland's likeness. "That's very clever," Noland said of his springy-necked likeness. "It makes it fun."

Roberts said the event also had a more serious side. "Way's length of service to the University, his dedication and efforts on behalf of chemistry students, and his selflessness are extraordinary," he said. "I hope that everyone who attended his birthday party was able to reflect on what Way has to teach us about kindness, loyalty, and service."

Thanks to Noland's endowed scholarships and fellowships, his extraordinary service, and his influence on countless alumni, Noland has left a deep impression on the U. Despite his preference for a low profile, he does hope to leave a legacy at the institution where he's dedicated well over half his life.

"One lives on in the memories of the people with whom that person has been associated," Noland said. "I hope that I will, in a favorable way, live on in the memories of the people I've been associated with and those I have helped." ■

STEVE ANDERSON contributed to this story.

"I hope that I will, in a favorable way, live on in the memories of the people I've been associated with and those I have helped."

—WAYLAND E. NOLAND

PATRICK O'LEARY

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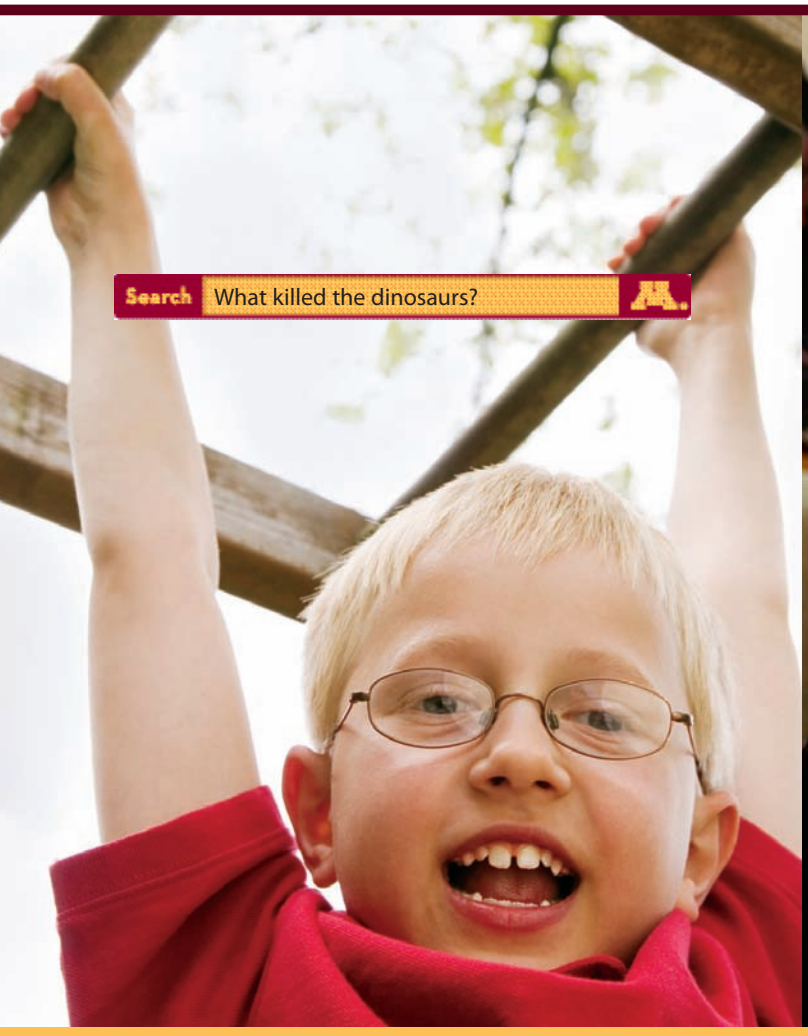

UNIVERSITY OF MINNESOTA
Driven to Discover℠

Search Results Meteorite collision with Earth

University of Minnesota geology professor Donna Whitney is involved with an international team of researchers who have analyzed sediments from the Atlantic Ocean floor to show that the effects of a single meteorite impact obliterated most of the Earth's animal species 65 million years ago.