What if all of America's highways could be covered with a solar roof, powering automobiles equipped with electric antennae like bumper cars? What if we could think like plants, and learn to photosynthesize fuel? What if the smallest man-made materials could solve one of the planet's biggest problems—how to wean our society from fossil fuels forever? The answers to questions like these may one day lead us away from petroleum dependence. That's why today, the Division of Mathematical and Physical Sciences (MPS) in the College of Letters and Science is actively engaged in new fundamental research to unlock our energy future.

"Energy efficiency and weaning ourselves off fossil fuels are necessities," says Winston Ko, dean of the division. "Innovation in this area is key."

Across campus, UC Davis is investing in energy efficiency and innovation. To address today's immediate issues, the UC Davis Energy Efficiency Center, founded in 2006, works with utilities, government agencies and companies to find solutions in greener building, food production and transportation.

At the other end of the spectrum lies fundamental research—the inventive thinking, theorizing and testing that advances our understanding of science and nature, and suggests new solutions to the energy prob-

**SPECIAL ISSUE**

This is your spring issue of College Currents, the College of Letters and Science magazine. This eight-page version of the magazine is inserted into UC Davis Magazine. This is a way for us to be more financially conscious and contribute a little more to saving our environment. Like it? Don't like it? Let us know at currentsseditor@ucdavis.edu.

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**ALSO INSIDE:**

**BACKYARD JUSTICE**

**APOCALYPSE: PAST AND FUTURE**

**ANOTHER DEPRESSION?**

**FOOD FROM THE CENTURIES**
lem. Much of this pioneering work is taking place in MPS. “We’re investing in long-term research that will help permanently wean the world from fossil fuels,” says Ko.

Here are just a few examples of groundbreaking efforts underway in MPS.

**SOLAR MAVERICKS**

What does physics professor Gergely Zimanyi have in common with Despereaux, the movie mouse? Commitment to a cause, a willingness to be unconventional . . . and very big ears (metaphorically speaking, in Zimanyi’s case).

In 2006, Zimanyi was lunching with a prominent friend at a national physics conference. His friend had just returned from Washington, D.C., giving testimony to Congress on alternative energy. At the time, only a handful of academic physicists worldwide were interested in solar energy as a research topic. Zimanyi’s friend said that physicists were missing the boat. “He said physicists should really be looking at solar energy more intensely, and told me about some great new research. My ears got bigger than those of Despereaux the mouse. I realized this was an important area few physicists were investigating, when this was maybe the biggest challenge of our times, both scientifically and morally. I dropped everything else and jumped on it.”

The work that inspired him was a discovery in 2004 by Los Alamos researcher Victor Klimov. Klimov found that a single solar photon could excite as many as seven electrons when absorbed by a solar cell. This finding represented a break with the most fundamental solar energy conversion paradigm: “one photon in—one electron out.” His insight suggested that solar cells could become far more efficient than anyone previously suspected. “Based on the old paradigm, Bill Shockley, founder of Silicon Valley, inventor of the transistor, concluded that the theoretical maximum for solar efficiency is 31 percent. You just cannot do better by the laws of nature—everybody believed that. Until now,” Zimanyi explains.

Today’s solar cells capture maybe 20 percent of the incident solar energy, and are creeping ever so slowly toward the 31 percent maximum. But in experiments with nanomaterials, Klimov demonstrated that the efficiency of solar energy conversion might go as high as 65 percent.

Fascinated, Zimanyi began his own theoretical work studying these nanomaterials. But he knew theory alone wouldn’t turn on the lights. “I do theoretical model calculations, but to explore this stuff properly, you need to use computers and do experiments as well. So, with colleagues here in Davis we formed a solar collaboration.”

One key partner is chemistry professor Giulia Galli. “She has a most impressive expertise and does very powerful computer calculations on nanostructures,” he says. The collaboration grew with time to involve professors Susan Kauzlarich and Delmar Larsen from Chemistry and Sue Carter, associate professor of physics at UC Santa Cruz.

While the collaboration has no formal name, Zimanyi jokingly refers to the group as “the solar mavericks,” because of their unconventional research. “There are maybe 100 people worldwide working on this. Two years ago, there were fewer than 10.”

While results from this line of thinking may be a decade away, the rewards could be incalculable. “The solar energy falling on a 100-mile-square area could satisfy all the energy needs of the United States,” Zimanyi says. “We just have to figure out how to capture it more efficiently and bring it to the end-users.”

In true maverick fashion, Zimanyi imagines solar
cells covering the federal highway system, electric cars zipping by underneath this solar roof, constantly charged as their collectors scrape the roof of this “solar highway.” “Like bumper cars—without the bumping, of course,” he says. Zimanyi laughs while he suggests the idea—but this kind of out-of-the-box innovation may one day solve the energy problem. “Really, we need a new type of thinking,” he says.

R. DAVID BRITT: THINKING LIKE A PLANT

Next time you tell someone you just want to “veg out,” think twice: When it comes to extracting energy from the sun, plants are much busier and more effective than humans. That’s why chemistry professor R. David Britt and his group, the Photosynthesis and Redox Systems Energy Center (PARSEC), are exploring one of the most basic chemical reactions on earth—photosynthesis—in the hopes of creating sustainable solutions for our energy future.

“We’re trying to understand how nature does, with incredible efficiency, things that man-made technology has not been able to reproduce,” says Britt.

Sure, everybody knows that plants make food from light. And a lot of people understand that, specifically, plants convert carbon dioxide into sugars and starches, while helpfully emitting oxygen as a byproduct. But what are the actual mechanisms at work? Similarly, plants need nitrogen (“Without nitrogen fertilizer, the planet wouldn’t be able to support the current population,” Britt notes). But it takes a massive amount of energy for humans to produce fertilizer—a need that the lowly peanut has ingeniously circumvented by evolving to provide a home for nitrogen-fixing bacteria.

“These little clusters work so exquisitely. How does nature make those things?” Britt asks.

To explore such questions, Britt and his students use magnetic imaging to follow the path of electrons as they move from one molecule to another, from water to CO₂, for example.

While PARSEC is dedicated to pure research—“we’re focused on trying to understand the natural systems,” Britt says—its results could have far-reaching implications for the future of fuel. “On one hand, you could think about actually using organisms as an energy source. On the other, you could take what you learn from nature and make a synthetic system inspired by biology. Or a hybrid system, with the biological and synthetic blended together.” While Britt is not currently working directly on such applications, he is on the scientific advisory board for a CalTech/MIT group that’s attempting to build an artificial photosynthetic system. “You could put it on the roof of your house and you’d make hydrogen gas, instead of electricity, which you could put in your hydrogen-powered vehicle,” he says.

BUILDING A BETTER GARBAGE CAN

If you plan to throw away a toxic substance, you’d better make sure you’ve got a pretty good garbage can to put it in. Even if that substance changes dramatically over the decades, the garbage can still needs to do its job. To ensure this, you need to understand how its material might react with different substances and how it behaves under a wide variety of circumstances. Similarly, if you want a device to last a long time, you must know that it is stable and does not corrode.

To address such issues, scientists and companies around the country turn to Chemist R. David Britt (in blue) in the PARSEC lab with research assistants
geology professor Alexandra Navrotsky, head of the Peter A. Rock Thermochemistry Laboratory at UC Davis. This unique lab, occupying some 5,000 square feet in the Chemistry Annex building, uses a wide variety of calorimetric (energy measuring) techniques to measure the properties of various materials. Understanding the properties and behavior of materials under a variety of circumstances has important implications for energy efficiency, Navrotsky says.

“The ability to deal with energy efficiently to a large extent is governed by the materials that one can use for extracting energy and using energy,” she says. For example, commercial fluorescent light bulbs on the highway can now last a decade. But the gas inside the light tubes might react with the aluminum oxide from which the lamp is made. Depending what type of gas is in the tube, that reaction can produce a residue that blocks the light. To avoid this, a lighting company funded a project to determine the thermodynamic parameters for certain compounds involved in the process, to create the most efficient, longest-lasting street lights.

Similarly, skyrocketing fuel prices over the summer led to new discussions about nuclear power. “In all the various energy scenarios saying the world needs new energy, most are saying that for the next 50 years, nuclear energy has to be part of the mix,” Navrotsky says. “That raises the problem of creating more efficient nuclear reactors and solving the nuclear waste disposal problem.” So the lab has been exploring the stability of the corrosion products of spent nuclear fuel. “It’s like building a better garbage can that doesn’t leak.”

These are all very different applications, she says, “but what holds them together is this—if your light has to last 20 years instead of two, if you want fuel cells to last five years, you want everything to function properly at the right temperature during all that time. Thermodynamic data are essential to answer these questions,” she says.

**KEEPING THE VISION**

When might the world see results from these innovative approaches? That depends partially on the price of oil, says Zimanyi. “When oil was $147 a barrel this summer, alternative fuels seemed like an important national priority. With oil at $42, national priorities are focused in the financial sector. Without a national commitment, this kind of thing could remain the hobby of 30 professors in a few universities working for decades.” On the other hand, if public or private supporters throw themselves behind innovative energy solutions, the time frame may be much shorter. “If the government says we really want solar energy to happen and we create a ‘Manhattan project’ with thousands of people in big national labs working to make this happen, this could work in ten years, maybe less.”

UC Davis and MPS are irrevocably committed to creating a sustainable planet. “Fundamental research today is vital to our energy future,” says Ko. “Only innovative research and development will lead to important gains in energy technology and policy.” He points out that private support is helping MPS attract new talent and keep its labs competitive. One new trend is for donors to endow a lab or faculty member for a given number of years, which helps cover start-up costs, attract top researchers and lay a foundation for important advances. Ultimately, he says, support for energy research is support for a viable future. “Universities are the hub of innovation. The United States must be good at this to solve our energy issues and advance the overall good of the nation.”
ERRORS IN TENNIS CALLS MOVE RESEARCH OFF THE COURT

Was the ball in or out? Countless debates are sparked by tennis fans watching the sport. Now, new research led by David Whitney, an associate professor at the Center for Mind and Brain and Department of Psychology, shows that professional tennis referees are vulnerable to an optical illusion when they see balls bouncing on or close to a line.

The error occurs when the brain’s perception of the world lags a few milliseconds behind the actual event. While the brain is processing the image of a moving object received from the eyes, the object has already moved on. Whitney and his team reviewed a random set of 4,457 points from the 2007 Wimbledon tournament. When a ball bounced in the direction it was already moving, the referees were more likely to perceive that it landed off the line—even if it didn’t. Eighty-four percent of the 83 wrong judgments observed were errors in which the ball was called “out” when it was actually “in.”

Most of the time, a referee’s call is accurate, says Whitney, and both players and referees can have the same perceptual bias with bouncing balls. The research has applications across a broad spectrum of fields, not just athletics, says Whitney. “These experiments shed light on how the brain processes information. This knowledge can help us design better artificial visual systems and can also be applied in areas like computer science, medicine, and data visualization, where the limits of visual processing are centrally important.”

FOOD FROM THE CENTURIES

One of the most universal aspects of human life is food. This past month, the Tasting Histories Conference brought together a wide variety of experts to explore the social, historical and environmental aspects of what and how we eat. The program, held at the new Robert Mondavi Institute of Wine and Food Science, highlighted connections between scholars in the humanities and sciences, and the innovations of regional farmers and producers. Attendees included scholars, scientists, growers and farmers, and members of the public.

“Tasting Histories was a rare convening of the leading international scholars of food and culture, one that provided us a bird’s eye view on how food helps us think about history and how history helps us think about food,” explained Carolyn De La Peña, director of the UC Davis Humanities Institute and author of the forthcoming book Empty Pleasures: The Making and Marketing of Artificial Sweeteners. “Even more intriguing was the opportunity to combine these scholars’ insights into patterns in food ways across time and around the world with the perspectives of regional food growers and culinary artisans who have themselves helped to shape food ways and food history through their own innovations and entrepreneurship.”

NOT FROM SPACE: CLUES ABOUT LIFE ON OTHER PLANETS

Understanding life on Earth and other planets requires in-depth research. Literally. Last summer, graduate student Bekah Shepard descended British Columbia’s Pavilion Lake in a one-person submersible to map and sample “microbialites”—formations of living microbes and minerals thought to be similar to some of the earliest forms of life on Earth.

Pavilion Lake, which is about 213 feet deep, is unique in its diversity of microbialites. Shepard, who studies with geology professor Dawn Sumner, co-investigator on the Mars Science Laboratory rover, piloted the “Deepworker” submersible as part of a multiyear effort to map and sample the lake’s microbialites and their billion-year-old fossils. Undergraduate student Natalie Stork was also part of the research team. Shepard was joined by Canadian astronaut Dave Williams, now a professor of surgery at McMaster University, and NASA astronaut Michael Gernhardt. The expedition was led by Darlene Lim from NASA’s Ames Research Center. The submersibles, provided by Nuytco, Inc., will also be used later this year, as the team’s efforts resume this summer.

Bekah Shepard, a graduate student in geology
A NEW MEANING FOR APOCALYPSE

What would you do if the end of the world were near? Throughout history, rumors of apocalypse have exerted a powerful effect on individuals in society.

John Hall, a professor of sociology at UC Davis, was on ABC News last summer, discussing the next apocalyptic phenomenon, the end of days as predicted by some cultures for 2012. He said most movements predicting civilization’s end reflect a larger anxiety about the current state of society. “Terrorism, 9/11, ecological disasters, floods and earthquakes . . . there is a sense that modern civilization has had its run.”

His book, Apocalypse: From Antiquity to the Empire of Modernity, will be released in the summer of this year. It’s an unusual subject, Hall says. “For most of us, ‘apocalypse’ suggests the cataclysmic end of the world. Yet in Greek ‘apocalypse’ means ‘revelation’ and the real subject of the Book of Revelation is how the sacred arises in history at a moment of crisis and destiny. With origins in ancient religions, the apocalyptic has been a transformative force from the time of the Crusades, through the Reformation, the French Revolution, and modern communism, all the way to the present day ‘Islamic Jihad’ and ‘War on Terror.’”

STEPS TO NEW FRONTIERS

Physicists may be two steps closer to unlocking the secrets of the universe, thanks to two major projects led by UC Davis physicists that recently passed key milestones.

First, the world’s largest particle collider (the Large Hadron Collider or LHC) circulated beams for the first time in September of last year. Millions observed the event. Tech giant Google posted an LHC logo on its search page on the day it went live. The 17-mile collider, located at the Swiss-French border at the European Center for Nuclear Research (CERN), will smash beams of protons into each other, testing fundamental theories of physics and shedding light on the nature of matter.

The first beam circulation was celebrated throughout Davis, as many UC Davis physicists were part of the project from its inception nearly two decades ago. They assembled with other Northern California scientists involved in the project at a reception in San Francisco the evening of the go-live date, talking remotely to one of the scientists present at the CERN facility, where the first beam was circulated.

Winston Ko, one of the physicists working on the project and dean of the Division of Mathematical and Physical Sciences, was delighted that the pioneering UC Davis team could be a part of the experiment. “It is a great thrill to see this milestone of LHC so successfully reached. We can now look forward to at least 15 years of exciting physics results that will enable us to substantially advance our understanding of the fundamental structure of the universe.”

The second project is the Large Synoptic Survey Telescope (LSST), a project massive in size and in global support as well. Director J. Anthony Tyson, a professor of physics at UC Davis, attended the unveiling of the single-piece primary and tertiary mirror blank cast for the LSST. The cast creation was “perfect,” according to project astronomers and engineers. Once completed, this will be the world’s largest two-surface optical mirror made from one substrate.

The telescope, being built in northern Chile and set to go live in 2014, requires three large mirrors to give crisp images over a record large field of view. The two largest of these mirrors are concentric and fit neatly onto a single mirror blank. The single-piece primary and tertiary mirror blank emerged from a giant furnace oven at the University of Arizona’s Steward Observatory Mirror Lab. Team members gathered to celebrate the major milestone; the project has 26 institutional members and many supporters including Microsoft’s Bill Gates, former Microsoft executive Charles Simonyi, Google’s Eric Schmidt and former Google executive Wayne Rosing. The project is also funded by the National Science Foundation and the U.S. Department of Energy.

For more information on these and other projects in the Department of Physics, please refer to the spring 2008 edition of UC Davis Magazine, “Cosmic Convergence.”
Gail Goodman, a distinguished professor of psychology and author, and acting professor of law Donna Shestowsky, have found that adults are easily fooled when a child denies that an actual event took place, but they do somewhat better at detecting when a child makes up information about something that never happened.

“The large number of children coming into contact with the legal system—mostly as a result of abuse cases—has motivated intense scientific effort to understand children’s true and false reports,” said Goodman. “The seriousness of abuse charges and the frequency with which children’s testimonies provide central prosecutorial evidence makes children’s eyewitness memories important considerations. Arguably even more important, however, are adults’ abilities to evaluate children’s reports.”

Two studies by psychology professors specializing in Asian American studies offer important insight into conflict, suicide and family integration.

The first study involves research centering on suicide in Asian Americans. Researchers at UC Davis found that Asian Americans whose families experience a high degree of interpersonal conflict have a three-fold greater risk of attempting suicide when compared with Asian Americans overall. The risk is tripled even among those who have never had a diagnosis of depression.

“Because of the great emphasis in harmony and family integration in many Asian cultures, family conflict is an important factor to consider when studying suicidal behaviors among Asian Americans,” said Stanley Sue, a professor of psychology and Asian American Studies and one of the study’s authors.

The second study also looks at mental health issues in Asian Americans. Nolan Zane, a professor of psychology and Asian American studies, and Lauren Berger, a psychology graduate student, studied Chinese-Caucasian, Filipino-Caucasian, Japanese-Caucasian and Vietnamese-Caucasian individuals and found that biracial Asian Americans are twice as likely as monoracial Asian Americans to be diagnosed with a psychological disorder. However, the overall lifetime prevalence for the biracial group was no greater than that of the general U.S. population.

“Up to 2.4 percent of the U.S. population self-identifies as mixed race, and most of these individuals describe themselves as biracial,” said Zane. “We cannot underestimate the importance of understanding the social, psychological and experiential differences that may increase the likelihood of psychological disorders among this fast-growing segment of the population.”

Henry Wedler (left), chemistry and history student and the Hach Scientific scholar of the year.

NO STOPPING HIM

“The thing is, no one can see an atom.” These are the words from the undergraduate student who won the $6,000 Hach Scientific Foundation scholarship this year, an award that gives students a leg up in their future work in the field of chemistry. Henry Wedler is not only a talented chemist chosen from a field of extremely capable students for the scholarship—he is also blind. When he was 5 years old, he started to ask his parents how everything worked, and naturally gravitated to science for his answers.

“From there on, there was no stopping my fascination with science and my passion to study it,” said Wedler.

Wedler attributes his interest in chemistry to an “inspirational” chemistry teacher who took it as a personal challenge to ensure that Wedler learned chemistry just as well as her sighted students. After a year of high school chemistry under her guidance, Wedler knew that the field of chemistry was more theoretical than visually applied, and has passionately pursued it as the area he would like to enter when he graduates as a double major in chemistry and history.

“I feel extremely lucky to have received it, and to get this incredibly valuable help with funding my education,” he said. “I will do everything in my power to put it to the best possible use.”

Wedler plans to become a chemistry teacher, and hopes to make science and math less daunting to students who see them as difficult subjects.

DETECTING THE TRUTH

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HARMONY, IDENTITY AND CONFLICT IN ASIAN AMERICANS

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Nolan Zane, above left, and Stanley Sue, professors of psychology and Asian American Studies.

Henry Wedler (left), chemistry and history student and the Hach Scientific scholar of the year.
BACKYARD JUSTICE

The “not in my backyard” aspect of society applies to decisions about public health and environmental protection (such as landfill locations and flood controls) but rarely enters into a conversation about environmental legislation. To close the gap between academic institutions, community-based organizations, and agencies engaged with environmental injustices, UC Davis has created the Environmental Justice Project, housed at the John Muir Institute of the Environment. The director of the program is an associate professor of American Studies, Julie Sze. Her prize-winning book, Noxious New York, is about the culture, politics and history of environmental justice activism in New York City within the larger context of privatization, deregulation and globalization.

“Environmental justice is so interesting because it’s about the backyard,” said Sze. And yet these communities are often rendered “invisible” by race, class and gender, she says. Broad federal legislation on environmental issues, such as air and water quality, fails to address local or local-scale issues. The environmental justice movement challenges the marginalization of affected communities and seeks to represent their interests on local, regional, state and federal scales.

When Sze teaches, she gets feedback from students who are unaware of issues of environmental injustice or inequality within their own cities, states and regions. And building on academic research, the project seeks to work in communities to solve the issues that are particular to those environments. “The dynamics of power—whether in a large city like New York City or in the rural context of the Central Valley of California—are very similar,” she says.

The project recently launched “25 Stories,” anecdotes about environmental justice. To read the stories and learn more about the project, visit: http://ej.ucdavis.edu.

A NEW DEAL

Are we in another Great Depression? That’s what many have been asking, including the media.

Eric Rauchway, professor of history and author of The Great Depression and the New Deal: A Very Short Introduction, has found himself front and center in media across the globe. Rauchway has commented on the many ties between the Great Depression and the New Deal and today’s legislative efforts to solve the financial crisis. His work was picked up by The New York Times and National Public Radio, and he made an hour-long appearance on C-SPAN in February.

Rauchway says those who worry that the crisis may evolve into another depression can take some heart. “So far the crisis hasn’t spread as badly as it did in the 1930’s,” he told National Public Radio. “In 1933, when President Roosevelt took office, more than a quarter of the country was unemployed, and half were employed less than full-time.”

SAVING LANDMARKS IN SAN FRANCISCO

Mark Kessler, assistant professor of design, was awarded $7,000 from the American Institute of Architects to teach a design studio class in which students would document, analyze and develop designs to reuse threatened industrial buildings in San Francisco.

“In American cities, developers and governments continue to propose large-scale projects to achieve economic growth and neighborhood revitalization,” Kessler said. “These projects, no matter how ‘green,’ consume new materials and often involve tossing away existing structures. A new idea of progress is emerging, one paradoxically predicated on an acceptance of finite resources.”

The students presented their work in December at the San Francisco Planning Department. Their presentations were well-received, and the preservation coordinator at the department suggested that the best buildings be considered for landmark nomination.

“Several of the planners remarked that our approach—the focus on a particular building type that is disbursed throughout the city—can be legitimately applied to other building types that are threatened by development,” said Kessler. “We discussed the possibility of working together in the future, so that the students’ efforts inform the planning and preservation process.”