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A Career Achievement

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Life sciences professor Brian Hedlund studies how life forms thrive in simmering hot springs in Nevada and beyond.

A Career Achievement

Meet several UNLV recipients of the National Science Foundation's prestigious CAREER Award, the highly competitive grant designed to establish leadership in education and research.

Story by Suzan DiBella

The research topics couldn't be more diverse: boiling hot springs, organic semiconductors, face recognition, hibernation ... and the list goes on.

The subjects may vary, but the projects all share one common attribute: They are being conducted by prominent UNLV faculty who are funded through the National Science Foundation's CAREER Awards.

These prestigious awards are presented nationwide to junior faculty who "exemplify the role of teacher-scholars through outstanding research, excellent education, and the integration of education and research within the context of the mission of their organizations," according to the NSF website.

A highly competitive grant award designed to establish a "lifetime of leadership in integrating education and research," the CAREER Award is considered a clear indication of achievement. A number of UNLV faculty have received this prestigious award through the years; here are the stories of just a few of the recent recipients.

Brian Hedlund Life Sciences

Boiling and near-boiling hot springs in northern Nevada – or, more specifically, the tiny creatures that thrive within them – are the focus of Brian Hedlund's NSF CAREER Award project.

Hedlund is especially interested in determining how creatures in the hot springs can exist at temperatures above the upper temperature limit of photosynthesis – 163° Fahrenheit (73°C). They don't rely on photosynthesis as a source of energy, as do virtually all creatures on Earth. Most organisms survive through photosynthesis either directly, as plants do, or indirectly, as animals do by ingesting plants.

In the absence of photosynthesis, some microorganisms, such as those in the hot springs, obtain energy by metabolizing chemical compounds humans consider foreign or toxic. For example, many microorganisms can eat chemical compounds such as hydrogen gas, hydrogen sulfide, carbon monoxide, or certain forms of metals, such as arsenic. In turn, they can "breathe" chemical compounds other than oxygen, such as salts like nitrate and sulfate, or gases such as carbon dioxide and nitrous oxide. These are the unusual organisms Hedlund studies in northern Nevada hot springs.

What is the impact of this research?

Not only does Hedlund's research tell us about these creatures, but it also expands knowledge of the diversity of life on Earth and strengthens understanding of the fundamentals of life.

It also may lead to important medical discoveries. Hedlund is working closely with private-sector partners to explore the possibilities.

"My closest partner is Lucigen Corp., a mid-sized company in suburban Madison, Wisconsin. We work together on a variety of projects, and I'm very optimistic that our research will lead to important products."

For example, Lucigen discovered an enzyme from a hot spring virus from Yellowstone National Park that may reduce the cost and increase the speed of diagnosis of certain viral diseases, such as flu, hepatitis, and AIDS. "There are some imperfections with that enzyme, so I'm helping them search for similar enzymes that might work better," Hedlund says. "We recently discovered many candidates in some hot springs in Nevada, and they are now being screened."

Another tangible impact: Hedlund has brought in more than $6 million in grant funding since he arrived at UNLV, mostly from NSF, NASA, and the Department of Energy. His largest project is the Tengchong Partnerships for International Research and Education (PIRE) project, which is a $3.75 million grant from NSF. The Tengchong PIRE project funds a team of researchers at eight U.S. universities and six partner institutions in China. (The Chinese institutions are funded by their own government, so the actual amount of funding is significantly more than $3.75 million.) This five-year project involves study of the microbiology of the largest geothermal field in China.

"We hope to integrate what we learn with what we know about U.S. hot springs to develop a more universal understanding of life at high temperatures," he says.

How did he become interested in this area of study?

"I've been interested in science since I was a child," Hedlund says. "In fact, my parents claim my first word was 'outside.' According to them, I used to stand at the back door and beg my parents to go outside so I could play with insects."

His interest grew through the years and inspired him to become a biology major. "What I learned in microbiology class about the diversity, abundance, and importance of microorganisms blew my mind and dramatically restructured my understanding of life," he says. "I continue to be humbled by the microbial world, and I feel very lucky that I get paid to study microbiology and to teach UNLV students what I learn."

How are students involved?

Hedlund has had approximately 30 undergraduates, several graduate students, and two postdoctoral fellows participate in his NSF CAREER Award project over the years. "It's hard to express how thankful I am to have worked with so many talented and dedicated people," he says. "These people have been incredibly productive. For example, more than 75 percent of the undergraduates have applied successfully for their own research fellowships and almost all have presented their research in at least one scientific meeting. More than 25 percent of the undergraduates have published research papers with me in peer-reviewed journals. A few superstar undergraduates have published several papers."

What other areas does he study?

"Virtually all of my research focuses on some aspect of hot spring microbiology," Hedlund says. "I'm very interested in how high temperature affects ecology, but the lab is also making great progress on the study of major new groups of bacteria and archaea that are completely new to science. About 50 percent of the microorganisms in the Great Boiling Spring, which is a major study site near Gerlach, Nevada, represent a phylum or class that has never been studied in the laboratory. These microorganisms are so different from anything known that we've started to use the term 'biological dark matter' to describe them."

How does he feel about receiving the NSF CAREER Award?

"The CAREER Award is a great honor," Hedlund says. "I feel very lucky to have received the award, and I'm extremely thankful to those who have supported me and my work over the years, particularly my lab team, my colleagues, and my family. I feel a strong sense of duty to make NSF's investment worthwhile. I try to do research that significantly impacts our understanding of life, and I work hard to contribute to our economy and inspire young people to live productive and exciting lives."

AARON MAYES

Psychology professor Jennifer Rennels explores what infants, such as one of her young subjects seen here, experience when looking at human faces.

Jennifer Rennels Psychology

Everyone loves to look at babies. But what do babies think when they look back at us? Jennifer Rennels hopes to find out through her CAREER Award research.

She examines how infants experience seeing faces and how this affects their preferences for different people.

Though it's challenging to know what babies are thinking, Rennels and her team gauge infant interest by determining what faces they tend to look at on a computer screen.

"In visual preference studies, we show infants' two novel faces that differ on one aspect – for example, gender – but are similar in all other aspects, such as emotional expression, age, race, attractiveness, or brightness/contrast," she says. "If they look longer at one face relative to the other, it demonstrates a visual preference for that face."

She notes the team can glean a surprising amount of information from their little subjects, including their ability to scan and categorize faces, as well as to recognize and prefer certain faces.

"Most people are surprised to learn that infants differ in their behavioral responses to individuals based on such facial cues," she says. "Person perception emerges very early in development and is heavily influenced by infants' experience with faces."

What is the impact of this research?

Understanding face perception and the stereotypes associated with facial cues is integral to understanding the social interactions people experience every day, Rennels says. Studying this process in infants provides insights into how and why stereotypes develop.

Within a very short period of time, individuals can assess a person's sex, race, age, attractiveness, dominance, and emotion, Rennels notes, adding that this assessment influences how individuals respond to, treat, and judge others.

Given the growing diversity of the American population, Rennels says, it is essential for people to understand factors influencing judgments and reactions to individuals based on group membership. Such information is critical in terms of raising awareness about diverse groups and ensuring that our communities are socially sustainable.

"Categorizing people is necessary before an individual can form stereotypes," she says. "Infants' facial recognition abilities and visual preferences for faces are related to face categorization skills. Understanding some of these precursors to stereotype development can therefore provide information about how and why stereotypes develop," Rennels says.

"Given the deleterious effects of many stereotypes, it is my hope the research findings can be used to raise awareness about these stereotypes and perhaps be applied to help reduce the negative outcomes of stereotyping."

Rennels has received more than $560,000 total in grant funding. Prior to receiving the NSF CAREER grant, she was funded by the National Institute of Child Health and Human Development. She also received two internal grants at UNLV, the New Investigator Award, and a College of Liberal Arts Center for Advanced Research Award.

How did she become interested in this area of study?

"When I was a graduate student, my mentor was investigating if infants could recognize an 'averaged' face, which is a mathematical average of faces, after being familiarized to several female or male faces," Rennels says. "With female faces, we found they could recognize the average, but despite numerous changes in methodology, we found no evidence that infants could recognize an average of male faces. These results suggest that infants were able to form a summary representation of female faces, but not male faces. I became very interested in exploring reasons for this; one very likely contributing factor is a real-world discrepancy in infant experience with female and male faces."

How are students involved?

This research and her other projects have provided scientific training opportunities for more than 100 undergraduate students since the project started.

"The nature of the research attracts diverse students to work in my lab," she says. "My graduate students and I have a strong commitment to providing a research environment in which all students feel valued and subsequently can benefit from their training."

Currently, six graduate students and 11 undergraduate students work in her lab. "Right now, we are collecting data for approximately 23 different research projects, so my students have a lot to juggle," she says, adding that they are very hard-working, dedicated to the lab, thoughtful about the projects, and eager to learn. "These research projects have provided each of my graduate students opportunities to 'honcho' projects, which means they assist with study design and setup, oversee undergraduate student training and data collection, conduct data analyses, and serve as authors on any presentations or published manuscripts resulting from the research. My graduate students are therefore gaining critical skills in managing a research project from beginning to end."

What other areas does she study?

"All my research is related to understanding face perception and/or stereotypes," Rennels says. With her graduate students, she conducts research on several areas: 1) factors that affect children's recognition of others' emotions and how emotion recognition affects children's decision-making in social situations; 2) how changes in self development affect children's face processing; 3) development of racial stereotypes and the most appropriate measures for tapping into children's concepts about race; 4) ways to reduce racial stereotypes in adults; 5) the relationship between facial appearance, personal attributes, and physical and mental health in adults and children; and 6) the relationship between a person's attractiveness and emotional expressivity and how and if it develops.

How does she feel about receiving the NSF CAREER Award?

"I was honored and excited to receive the award," Rennels says. "It has played a substantial role in my professional growth, my students' training, and our ability to conduct quality research."

R. MARSH STARKS

Dong-Chan Lee Chemistry

Dong-Chan Lee is a patient man. He has to be. He works at the molecular level.

Yes, he can envision his research someday leading to useful applications in electronics or renewable energy. But other scientists and engineers will be the ones to test and perhaps employ his research to develop these products.

Meanwhile, he is delighted to be in his lab, conducting research on the molecular building blocks that may one day enhance these applications.

Lee is conducting fundamental research on new ways of improving the properties of organic semiconductors. Semiconductors are used as key components in all electronics equipment – everything from radios to computers to digital displays.

Commercial semiconductors are typically made of inorganic material, primarily silicon, which has limitations in shape and flexibility. Organic semiconductors, on the other hand, are more flexible, lightweight, and easier to process than those made of silicon, and their properties can be easily tuned through synthetic chemistry.

For these reasons, organic semiconductors, which are typically carbon-based, are now being used to develop novel products, such as bendable TV screens and solar panels. However, there are still some challenges to address with organic semiconductors, primarily "charge transport," or the movement of electrons. Scientists are still grappling with this issue, as it limits the performance of organic semiconductor-based devices.

Lee is one of the scientists studying this area. His research focuses on improving the properties of organic semiconductors using a bottom-up approach starting at the molecular level. His work involves programming carbon-based molecules in a way that enables them to self-assemble into nanofibers that make better material for the creation of organic semiconductors.

What is the impact of this research?

Lee is establishing the concept for his research and has authored scholarly articles in several prestigious journals on the subject. He will soon collaborate with other scientists who will test the efficiency of devices based on his nanofibers; this will, in essence, assess the applicability of his concept and begin to indicate its value. If these nanofibers do facilitate charge transport more effectively than other materials, as he has postulated, they may be used in a whole host of applications, such as improved solar cells, organic LEDs, and transistors. While he acknowledges it is a long way off, if his concept is confirmed, it could make a significant contribution to the field of electronics.

Lee also seeks to expand the impact of his research through outreach into the high schools. Through his summer research programs, students from Basic High School have already participated in the NSF research project for two years. "This program has received positive feedback from both the students and the teacher," Lee says, noting that he hopes the program promotes interest in science among the students.

Lee has also received more than $850,000 in grant funding, including an internal seed grant designed to facilitate external grant acquisition.

How did he become interested in this area of study?

"Previously, I worked in two different areas that I connected for the current research: developing new organic semiconductors and self-assembly of organic molecules," he says. "After seeing the limitations of organic semiconductor research, I had a novel thought: Why not try programming organic molecules so that they self-assemble? This would create nanofibers that facilitate charge transport and could be used to improve the material for organic semiconductor-based devices."

How are students involved?

In addition to his summer research program for high school students, Lee has worked closely with more than a dozen UNLV students in his laboratory.

"I provide research opportunities to undergraduate students to enable them to experience cutting-edge science," he says. "I also provide mentoring and training to graduate students so that they can learn problem-solving techniques through research."

Research opportunities equip all students with analytical skills necessary for their future careers, Lee notes.

He also incorporates his research into his classroom instruction so that students can see how organic chemistry can be applied to create something useful in daily life. "This helps to motivate students and keeps them up-to-date on the real-life application of organic chemistry."

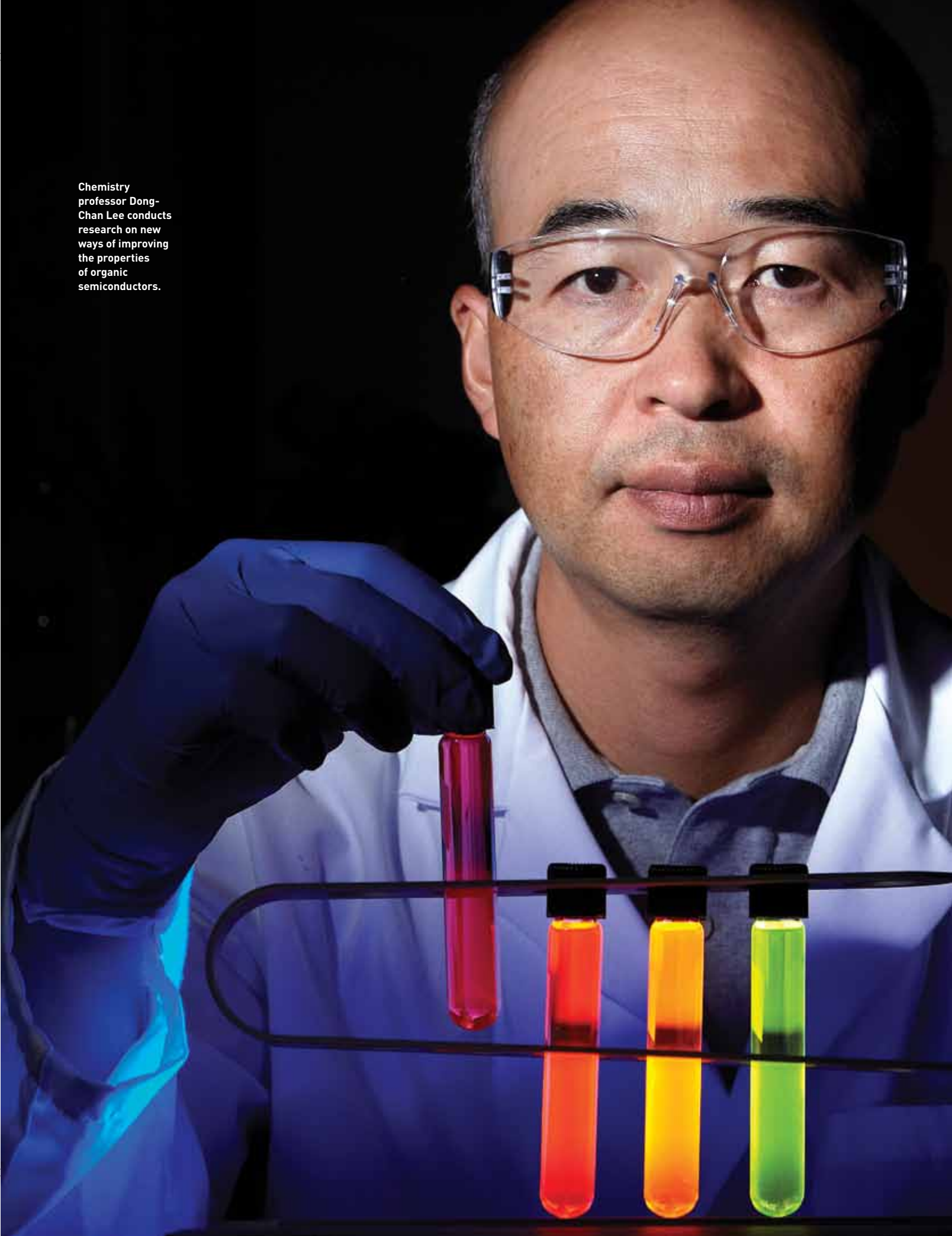
What other areas does he study?

"Resources are limited, and I am deeply involved in my current area of research," he says. "But I'm considering the notion of applying this concept to other types of electronic devices, such as sensors."

How does he feel about receiving the NSF CAREER Award?

"Lucky," he says with a smile, noting that he had heard it was important to speak with an NSF program officer before submitting his proposal, but he didn't have time to do so. He had also heard that it was rare to receive the CAREER Award on the first try. But he threw his hat in the ring along with scientists from some of the most prestigious institutions in the U.S. and received the award in 2009. He says he doubted himself at times as he was applying, but he was very grateful to see how fair the process was and to learn that his idea was validated. Since then, the NSF has asked him to become a reviewer for other NSF awards.

R. MARSH STARKS



Chemistry professor Dong-Chan Lee conducts research on new ways of improving the properties of organic semiconductors.

Frank van Breukelen Life Sciences

Frank van Breukelen's CAREER Award has enabled him to study protein metabolism in hibernating animals, which has some fascinating medical implications for humans.

During hibernation, animals' core body temperatures can fall below the freezing point of water, and their heart rate can be as low as two to three erratic beats per minute. Many fundamental processes are affected, including the ability to make and degrade proteins. "We've made significant strides in understanding how these processes are regulated and the consequences of this regulation," says van Breukelen.

Combining research and education was also an important part of his CAREER Award project. He and his team created a television show called "Desert Survivors" as a part of the project; the show focused on increasing scientific literacy in 5th graders.

What is the impact of this research?

"The medical implications of the study of hibernation are immense," van Breukelen says. "The physiological consequences associated with hibernation provide a natural model for the study of the effects of reduced blood flow similar to that seen during stroke or cardiac arrest, the loss of muscle and bone tissue during bed rest or limb immobilization, accidental hypothermia, organ transplant therapy, obesity, and kidney failure."

He believes that processes like extra-corporeal rewarming of blood during treatment of severe hypothermia might have been adopted sooner had the medical community sought lessons from the hibernator. "Hibernators shunt blood from the periphery as they arouse from hibernation. Only after significant rewarming has occurred does the peripheral circulation become re-established. Essentially hibernators do what extra-corporeal rewarming sets out to do."

He has received well over $1 million in federal funding as a principal investigator, and he was an integral team member on other projects that have garnered more than $17 million in federal funding.

How did he become interested in this area of study?

"As an undergraduate, I worked with a mentor who focused on what allowed hibernators to resist the muscle disuse atrophy normally associated with prolonged periods of inactivity," van Breukelen says, noting that he was intrigued by the larger notion of hibernation.

"At a biochemical and cellular level, virtually every process must be impaired in hibernation," he says. "This idea fascinated me, and I set out to acquire the skills to allow me to address the question of, 'How do animals even hibernate?'"

How are students are involved?

A large number of both undergraduate and graduate students work on van Breukelen's projects. "One of the graduate students, Peipei Pan, recently graduated and has five scholarly publications. Another undergraduate student, David Cotter, did excellent work and is currently an M.D./Ph.D. student at the top-ranked program in the country. All told, dozens of students have gone through the lab, and many have gone on to medical school or prestigious graduate programs."

What other areas does he study?

"My laboratory has a large number of current and completed projects," he says. "Fundamental to virtually all of them is a desire to integrate evolutionary perspectives into mechanisms that allow animals to survive in what we deem to be harsh environments."

Current projects include such diverse topics as protein degradation in freeze-tolerant frogs; gene expression in denning grizzly bears; the design and construction of a direct heat calorimeter to better assess the energy status of animals; and an "enormous collaborative project" on understanding the mechanisms of adaptation in a group of endangered fishes.

How does he feel about receiving the NSF CAREER Award?

"I feel lucky and grateful," van Breukelen says. "The funding success at NSF is extremely low, and the climate is exceptionally competitive. The CAREER Award is even more competitive. Receiving the CAREER Award is an affirmation from peers in the research community that one's research deserves support and recognition. With that support comes an immense feeling of responsibility to use the money effectively."

R. MARSH STARKS

Life sciences professor Frank van Breukelen's research on hibernation provides insights into a variety of human medical conditions, including accidental hypothermia, organ transplant, and kidney failure.

Civil and environmental engineering professor Sajjad Ahmad conducts research on how the flow of water in certain geographical areas is impacted by environmental and human factors.

Sajjad Ahmad
Civil & Environmental Engineering

Sajjad Ahmad's research brings a whole new meaning to the term "flow chart."

The civil and environmental engineering professor conducts research on how the flow of water into certain geographical areas, particularly the Colorado River Basin, is affected by various environmental and human factors.

As part of this research, he produces complex charts and diagrams depicting water infrastructure and then introduces variables to see how they will impact water resources. The variables that he analyzes include climate change, land use, population growth, and energy needs, among others.

"The major contribution of this research is a new theoretical framework, based on a systems approach," Ahmad says. "The goal is sustainable management of water resources that will reduce the vulnerability of water infrastructure to climate variability and change."

He is developing what he calls a "decision support framework" that will be used to evaluate the vulnerability of infrastructure to climate change. Water systems as well as flood control systems will be evaluated. He will also analyze different short- and long-term policies for sustainable management of water resources.

What is the impact of this research?

The theoretical contributions of his work, including the new approaches and modeling tools, will be useful for other researchers in arid regions around the world, he says.

"But locally, the results of the research and the policy recommendations will be useful primarily to water management agencies, such as the Southern Nevada Water Authority and the U.S. Bureau of Reclamation," he says.

His decision support framework will be used to explore important questions in Southern Nevada, including:

- What are the major short- (by 2020) and long-term (by 2035) changes expected in population growth, land use, energy and water demand, and water availability?
- How vulnerable is water infrastructure to climate variability and change?
- What are the most promising, sustainable, and cost-effective policies for water management in response to growth and climate change?

Ahmad has received approximately $1.4 million in grant funding for this research from both the NSF and the National Oceanic and Atmospheric Administration.

How did he become interested in this area of study?

"Floods were one of the frequent natural disasters when I was growing-up in Pakistan," Ahmad says. "I always wondered if something could be done to reduce the damage that they caused.

"Later, as an undergraduate major in civil engineering, I had the opportunity to visit several large dams that were developed to meet flood control, irrigation, and hydroelectric power needs," he adds. "This was the turning point in my life when I decided to do my graduate training in the area of water resources planning and management."

As time went on, Ahmad also developed a larger concern for the environment that still guides his interest today.

"Considering the population growth in the Las Vegas Valley and the limited water supply from the Colorado River," he says, "sustainable water management is a challenge for Southern Nevada, especially in the presence of climate variability and change. With my background in water resources planning and management, working to address this challenge is a natural fit for me."

How are students involved?

Though Ahmad's grant is fairly new, four graduate students have already been fully or partly funded through the grant, and two master's-level students have completed their degrees. Once the project reaches a certain stage, undergraduate students will also be involved. In the final year of the grant, the team will even include several high school students.

What other areas does he study?

"I study stream flow forecasting with long lead times – greater than one year," Ahmad says. "I'm also interested in the water-energy nexus. Our group is studying energy use in water and wastewater treatment plants and energy use in water distribution systems. We are also studying water conservation in semi-arid regions through desert landscaping, water-smart appliances, and water reuse."

Collaborating with colleagues at other institutions, Ahmad has also contributed to research on malaria control efforts in sub-Saharan Africa with his study of water ponds that provide breeding grounds for mosquitoes.

How does he feel about receiving the NSF CAREER Award?

"I am humbled by this honor," Ahmad says, noting that he is also grateful for the support of his colleagues Thomas Piechota and Jacimaria Batista, who provided guidance during the preparation of his proposal.

"The CAREER Award has allowed me to build an excellent team of students and researchers by providing a steady source of funds over five years," he says. "The results produced by our research group have advanced understanding of important issues and have paved the way to other awards and recognition."

Ahmad has also received the Graduate/Professional Student Association Outstanding Mentor Award, the College of Engineering Distinguished Researcher Award; the Barrick Scholar Award; and the Regent's Rising Researcher Award.

AARON MAYES