Spring 2015

# Research Frontiers, Spring 2015

University of Arkansas Fayetteville. Office of University Relations

The mission of the World Trade Center Arkansas is to connect Arkansas to the world by providing international trade services to Arkansas companies, agricultural producers and entrepreneurs, and by educating students in global commerce.


WORLD TRADE CENTER®
ARKANSAS
UNIVERSITY OF ARKANSAS

3300 Market Street • Suite 400 • Rogers, Arkansas 72758
Phone: +1-479-418-4821 • Website: www.arwtc.org

UNIVERSITY OF ARKANSAS
ARKANSAS
*A natural for business*

UNIVERSITY OF ARKANSAS

# RESEARCH FRONTIERS

researchfrontiers.uark.edu

Spring 2015



UNIVERSITY OF ARKANSAS

# Gearhart, Gaber Paved the Way for Research Growth

Success seemed inevitable under Chancellor G. David Gearhart's leadership at the University of Arkansas. But change is also inevitable. The chancellor is retiring in July, and the next issue of *Research Frontiers* will be the first since 2008 without his name at the top of the masthead. As he leaves his post, so does Sharon Gaber, our provost and vice chancellor for academic affairs since 2009. She will assume the presidency of the University of Toledo this summer.

Great things are happening at the University of Arkansas. They would not have been possible without the steady hands of Chancellor Gearhart and Provost Gaber. We wish them well.

Among the highlights:

- We were elevated to the highest possible classification by the Carnegie Foundation for the Advancement of Teaching – becoming one of just 108 schools with this distinction, bestowed for increased accomplishments in research and productivity.
- Further, our research expenditures have exceeded $120 million for four consecutive years.
- We've added more than 300 faculty, many of whom are already competing for national grants such as the Faculty Early Career Development Program award through the National Science Foundation, known as a CAREER award. Eight of our professors since the beginning of 2012 have received the grant, one of the highest honors given by the foundation to junior faculty members.
- Faculty scholarship at the U of A since 2008 has also resulted in fellowships with the National Endowment for the Humanities and the Mellon Foundation. Our professors have also been elevated to fellows of the American Association for the Advancement of Science, the Institute of Electrical and Electronics Engineers, the National Academy of Engineering and the National Academy of Inventors.
- The University of Arkansas Honors College – established by the historic $300 million gift to the university from the Walton Family Charitable Support Foundation – celebrated its 10th anniversary in 2013. The Honors College provides outstanding educational opportunities for some of the brightest, most academically gifted undergraduate students in the state and country.
- Our doctoral fellowships – created by that same $300 million gift – are attracting some of the top graduate students in the nation.
- We awarded an all-time high of 200 doctoral degrees in 2013, up from 144 in 2008. In 2014, we surpassed 4,000 enrolled graduate students for the first time.

The research community at the University of Arkansas eagerly anticipates a new chancellor and provost who will help guide us to our goal of becoming one of the top 50 public research universities in the United States by 2021 – the 150th anniversary of the founding of our institution.

James Rankin

By Jim Rankin
Vice Provost for Research and Economic Development


University of Arkansas ***Research Frontiers*** is published twice a year by the Office of University Relations in the Division of University Advancement.

Questions or comments should be sent to:
Editor, *Research Frontiers*
Davis Hall
1 University of Arkansas
Fayetteville, AR 72701
or sent by e-mail to
rfeditor@uark.edu

**Chancellor**
G. David Gearhart

**Provost**
Sharon Gaber

**Vice Provost for Research and Economic Development**
Jim Rankin

**Associate Vice Chancellor University Relations**
Laura Jacobs

**Editor**
Amy Schlesing

**Writers**
Amanda Cantu
Matt McGowan
Camilla Shumaker
Michelle Parks
Kalli Vimr
Bob Whitby

**Art Director**
Eric Pipkin

**Photographers**
Russell Cothren
Matt Reynolds
Logan Webster

**Webmaster**
Chris Nixon

**Deans**

*Graduate School and International Education*
Kim Needy

*School of Law*
Stacy Leeds

*University Libraries*
Carolyn Henderson Allen

*J. William Fulbright College of Arts and Sciences*
Todd Shields

*College of Engineering*
John English

*Sam M. Walton College of Business*
Eli Jones

*Dale Bumpers College of Agricultural, Food and Life Sciences*
Michael Vayda

*College of Education and Health Professions*
Tom Smith

*Fay Jones School of Architecture*
Peter MacKeith

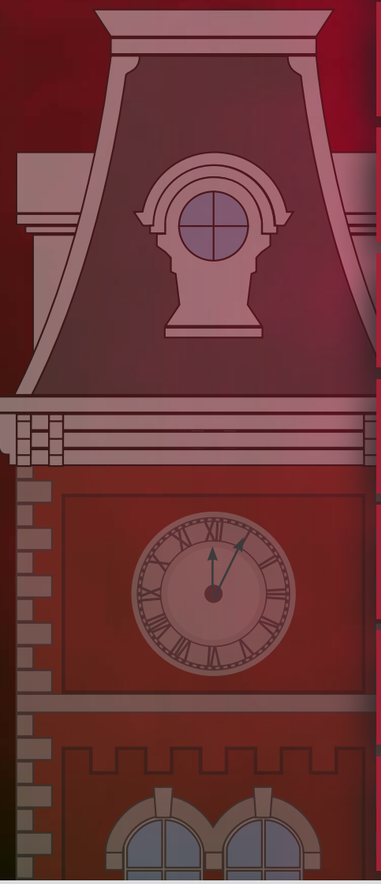
*Honors College*
Curt Rom


To see more stories about University of Arkansas research, visit http://researchfrontiers.uark.edu/

15-117

# CAREER Award

A grant made by the National Science Foundation and National Institutes of Health through the Faculty Early Career Development Program, better known as a CAREER award, is one of the highest honors given to junior faculty members in the fields of science, technology, engineering and mathematics. Recipients are selected based on high-quality research and the integration of that research with university education initiatives.

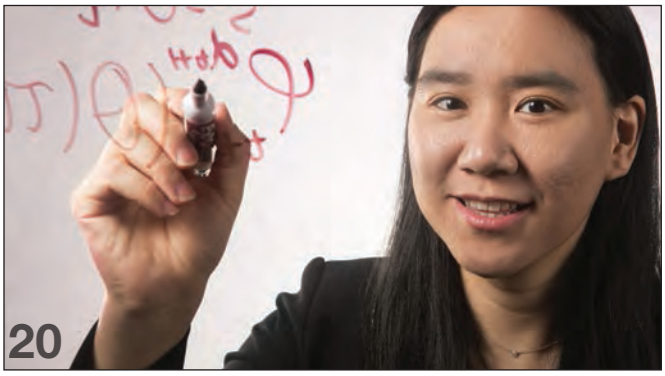


| | | | |
|---|---|---|---|
| 2015 |  | **Kartik Balachandran**<br>Biomedical Engineering<br>College of Engineering | |
| 2014 |  | **Burt Bluhm**<br>Plant Pathology<br>Dale Bumpers College of Agriculture, Food and Life Sciences<br>University of Arkansas Division of Agriculture | |
| 2013 |  | **Nan Zheng**<br>Chemistry and Biochemistry<br>J. William Fulbright College of Arts and Sciences | |
| 2012 |  | **Julian Fairey**<br>Civil Engineering<br>College of Engineering | |
| 2011 |  | **Xianghong Qian**<br>Chemical Engineering<br>College of Engineering | |
| 2011 |  | **Shui-Qing "Fisher" Yu**<br>Electrical Engineering<br>College of Engineering | |
| 2010 |  | **David Zaharoff**<br>Biomedical Engineering<br>College of Engineering | |
| 2007 |  | **Min Zou**<br>Mechanical Engineering<br>College of Engineering | |
| 1998 |  | **Paul Thibado**<br>Physics<br>J. William Fulbright College of Arts and Sciences | |
| 1996 |  | **Lin Oliver**<br>Physics<br>J. William Fulbright College of Arts and Sciences | |
| 2015 |  | **Jing Yang**<br>Electrical Engineering<br>College of Engineering | |
| 2013 |  | **Gregory Dumond**<br>Geosciences<br>J. William Fulbright College of Arts and Sciences | |
| 2013 |  | **Feng Wang**<br>Chemistry and Biochemistry<br>J. William Fulbright College of Arts and Sciences | |
| 2012 |  | **Colin Heyes**<br>Chemistry and Biochemistry<br>J. William Fulbright College of Arts and Sciences | |
| 2011 |  | **Fangzhen Tang**<br>Geosciences<br>J. William Fulbright College of Arts and Sciences | |
| 2010 |  | **Douglas Spearot**<br>Mechanical Engineering<br>College of Engineering | |
| 2008 |  | **Jak Chakhalian**<br>Physics<br>J. William Fulbright College of Arts and Sciences | |
| 2000 |  | **Laurent Bellaiche**<br>Physics<br>J. William Fulbright College of Arts and Sciences | |
| 1996 |  | **Ingrid Fritsch**<br>Chemistry and Biochemistry<br>J. William Fulbright College of Arts and Sciences | |
| 1994-95 |  | **Min Xiao**<br>Physics<br>J. William Fulbright College of Arts and Sciences | |

**The following faculty received a CAREER award at another institution and brought the award with them to the University of Arkansas:**

**2007 Suzanne Striegler**, Department of Chemistry and Biochemistry, J. William Fulbright College of Arts and Sciences; **2006 Xintao Wu**, Department of Computer Science and Computer Engineering, College of Engineering; **2000 Julie Stenken**, Department of Chemistry and Biochemistry, J. William Fulbright College of Arts and Sciences, **Ranil Wickramasinghe**, Department of Chemical Engineering, College of Engineering; **1997 Susan Gauch**, Department of Computer Science and Computer Engineering, College of Engineering; **1991 Jon Gauch**, Department of Computer Science and Computer Engineering, College of Engineering







UNIVERSITY OF ARKANSAS
# RESEARCH FRONTIERS

## Features



## Departments




### On the Cover:

Matt Covington, assistant professor in the Department of Geosciences, works his way through a cave in the Hansbreen Glacier in Svalbard, Norway. Photo by Jason Gulley. Story on page 14.

Member University Research Magazine Association

# Old Habits Die Hard for Wheat Growers

Photo submitted

U.S. wheat growers resist converting to a more profitable method of farming because of ideology – their personal beliefs about organic farming – rather than technical or material challenges, according to a new study co-authored by Jeff Murray and a team of international colleagues.

Organic wheat production over the past 30 years has consistently yielded higher profits for producers compared to conventional wheat farming methods that rely on chemical pesticides, herbicides and synthetic or chemical fertilizers. Organic farming relies on crop rotation, animal and plant-based fertilizer and other biological-based processes for pest control. And the higher profit margin for organic wheat farmers is without the government subsidies on which conventional wheat farmers rely.

The team found that a producer's beliefs or opinions about what is the right way to farm might not match the most efficient or lucrative method of production.

"Across our data, we found expressions of ideological tensions embedded in the different strategic orientations to agriculture," Murray said. "One would think that obstacles to the expansion to organic commodity production are mostly technological or material, but instead it's the intensity of these ideological tensions that impedes the transition to a more economically strategic orientation. And likely, until these tensions subside, the transition will remain in a stage of crisis."

The findings show that individuals may be less committed to the most efficient or most economical way of doing business, and more committed to cultural or cognitive forces.

"When approaching strategic change, managers might have greater success if they recognize that potentially conflicting ideologies are in play," Murray said.

**Jeff Murray**, R.A & Vivian Young Chair, Department of Marketing

Sam M. Walton College of Business

Published: *Journal of Marketing*

Funding: U.S. Department of Agriculture

For more: **http://goo.gl/3qA7FC**

# Biologists Capture, Document Elusive Northern Saw-whet Owls in Arkansas

Kimberly Smith and Mitchell Pruitt captured and documented for the first time two Northern Saw-whet Owls wintering in the Ozarks.

The elusive and small birds are rarely found this far south, with only a dozen sightings reported in the state over the last 55 years. The researchers used recordings of the saw-whet owl call and fine-gauge nylon mist nests to capture the birds before banding them and releasing them back into the wild.

During winter, northern saw-whets are usually silent and difficult to locate, so little is known about their winter distribution. However, recent successes at banding stations in Missouri and Alabama caused Smith and Pruitt to suspect the birds might also migrate to Arkansas. The researchers banded the birds to track their migratory pattern, which will help biologists determine where the birds are wintering.

"An interesting thing about saw-whets is some of them migrate south every year, even when there's plenty of food up north," said Pruitt, who will use the experience and research for his honors thesis. "This year food must have been abundant because capture rates have been down across the country. But some birds have trickled through."

Two weeks after the initial capture, Smith and Pruitt captured another adult female at the Ozark Natural Science Center.

"The fact that we were able to capture two birds in the same place within two weeks of each other is really incredible, given that this owl has only been seen in Arkansas about a dozen times in the last 55 years," Smith said. "Even more unbelievable is that we have had three owls respond to our tape recording at the science center, suggesting that this owl might be much more common in Arkansas than previously thought."

**Kimberly Smith**, Professor, Department of Biological Sciences

J. William Fulbright College of Arts & Sciences

**Mitchell Pruitt**, Undergraduate Student, Department of Crop, Soil and Environmental Sciences

Dale Bumpers College of Agriculture, Food and Life Sciences

Honors College

For More: **http://goo.gl/BVhfJk**





# The Significant Benefits of School Field Trips

Education researchers found that field trips to cultural institutions have significant benefits for students beyond educational aspects.

"We found that students who attended a school tour at Crystal Bridges demonstrated stronger critical thinking skills, displayed higher levels of tolerance, had more historical empathy and developed a taste for being a cultural consumer in the future," Jay Greene said. "We also found that these benefits were much larger, in general, for students from rural areas or high-poverty schools, as well as minority students."

The team announced the results of a study analyzing the impact of school field trips to Crystal Bridges Museum of American Art in Bentonville on students in grades K-12. Greene, Brian Kisida and Dan Bowen surveyed nearly 11,000 students and 500 teachers at more than 120 schools.

Kisida said, "This research is the first large-scale, randomized, controlled trial measuring what students learn from school tours of an art museum."

The study is part of a larger research initiative that Greene and Kisida are pursuing to shed light on the effects of arts and culture in education. The research offers implications for everyone from parents to policymakers.

"Our research suggests that students actually retain a great deal of factual information from their tours, as students who received a tour of Crystal Bridges were able to recall details about the paintings they had seen at very high rates," Greene said.

For example, 88 percent of the students who saw the Eastman Johnson painting, *At the Camp – Spinning Yarns and Whittling*, knew when surveyed weeks later that the painting depicts abolitionists making maple syrup to undermine the sugar industry, which relied upon slave labor. Among students who saw Thomas Hart Benton's *Ploughing It Under*, 79 percent could recall that it is a depiction of a farmer destroying his crops as part of a Depression-era price support program.

"Culturally enriching field trips are in decline in public education, and museums across the country report a steep drop in school tours," Greene said. "This research shows that the trips have significant benefits and particularly for disadvantaged students. These results should be an important consideration in the assessment and distribution of resources."

Photo by Russell Cothren

**Jay Greene**, (above left) Twenty-First Century Chair in Education Reform, College of Education and Health Professions

**Brian Kisida**, (right) Senior Research Associate

**Dan Bowe**, Doctoral Student in Education Policy

College of Education and Health Professions

Publication: *Education Next*

For More: **http://goo.gl/NbxL4G**

# Developing Safer and More Efficient Nuclear Fuels

Mechanical engineer Paul Millett is leading a study on strategies to minimize swelling in metallic nuclear fuels as a way to improve the safety and efficiency of nuclear reactors.

"Almost all current nuclear energy reactors operate with ceramic fuels," Millett said. "But as an alternative, metallic fuels have generated significant interest because they have much higher thermal conductivity, meaning the temperatures in the reactor are far lower than with ceramic fuels."

Fuels in metallic form, however, have a tendency to swell significantly during operation, which limits the efficiency of power generation. The swelling is a caused by gas elements such as helium and xenon that are produced by the atomic fission process and cluster to form gas-filled bubbles within the fuel.

Millett is the principal investigator on the $786,407 grant from the U.S. Department of Energy. He will work with researchers at the Georgia Institute of Technology, Texas A&M University and the Idaho National Laboratory, using advanced computer simulations and experiments to get a better understanding of the micro-scale processes that lead to volumetric swelling in metallic fuels.

Most importantly, the researchers will explore how to design fuels that are resistant to swelling.

**Paul Millett**, Assistant Professor, Department of Mechanical Engineering

College of Engineering

Funding: U.S. Department of Energy

For More: **http://goo.gl/77ElQX**

# Economic Driver: Arkansas Research and Technology Park Contributed $522 Million to Economy since 2003

The Arkansas Research and Technology Park pumped nearly $55 million into the state economy in the 2013-14 academic year and more than a half billion since 2003, according to the Center for Business and Economic Research at the University of Arkansas.

"These findings confirm the measurable impact of the Arkansas Research and Technology Park on the state and regional economy," said Phillip Stafford, president of the University of Arkansas Technology Development Foundation, which manages the research park.

According to the Center for Business and Economic Research, the research park ended fiscal year 2014 with 38 public/private affiliate companies and 196 employees, resulting in a total employment impact of 385 jobs statewide.

Last fall, in a separate analysis, the center's researchers determined that the research park has had an economic impact of more than a half-billion dollars since construction on the park began in 2003. The center found that labor income associated with the tenant companies totaled $189.5 million from 2005 to 2014, and the research park's overall economic impact on the state from 2003 to 2014 totaled $522.9 million.

The mission of the University of Arkansas Technology Development Foundation is to stimulate the knowledge-based economy in Arkansas through partnerships that lead to new opportunities for learning and discovery, that build and retain a knowledge-based workforce and that spawn the development of new technologies to enrich the economic base in Arkansas.

Photo by Russell Cothren

In the last decade, the research park has grown to encompass six cutting-edge facilities in south Fayetteville, including the Genesis Technology Incubator, the Innovation Center and the Enterprise Center, which each support emerging technology companies that contribute to Arkansas' knowledge economy. The park also features the Engineering Research Center, the High Density Electronics Center and the National Center for Reliable Electric Power Transmission, which combined house laboratories where U of A researchers investigate such areas as solar energy, the power grid, sustainable pavement design and cancer treatment.

The park's partners include the city of Fayetteville, the Northwest Arkansas Council, the Arkansas Economic Development Commission and the Arkansas Science and Technology Authority, among others.

**Phillip Stafford**, President, University of Arkansas Technology Development Foundation

For more: **http://goo.gl/yD4x14**

**http://goo.gl/58e9Cn**

# Researchers Receive Patent for Method to Simplify Pharmaceutical Protein-Development Process

The U.S. Patent and Trademark Office has issued a full patent for protein manufacturing technology developed through research at the University of Arkansas.

The new method will simplify the pharmaceutical production of proteins used in drugs that treat a variety of diseases and health conditions such as diabetes, cancer, arthritis and macular degeneration, said Ellen Brune, a 2013 doctoral graduate of the university and primary researcher on the project. Her start-up company, Boston Mountain Biotech, is working to shorten development time so that new drugs can get to patients faster.

The former process of protein development used is complicated, time-consuming and expensive.

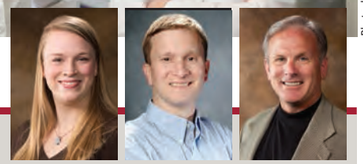
The patent, titled "Separatome-based Protein Expression and Purification Platform," was assigned to the board of trustees of the University of Arkansas and the University of Pittsburgh.

Boston Mountain Biotech – a Genesis Technology Incubator client at the Arkansas Research and Technology Park – holds the exclusive license to market the trademarked Lotus purification platform.

Brune's research received more than $1 million in research grants through the National Science Foundation and Arkansas Biosciences Institute. Boston Mountain Biotech was established through the National Science Foundation Innovation Corps program.

In addition to Brune, other inventors named on the patent are Bob Beitle, professor of chemical engineering and associate vice provost for research and economic development at the U of A; Ralph Henry, Distinguished Professor of biological sciences at the U of A; Mohammad Ataai, professor of chemical engineering at the University of Pittsburgh; and Patrick Bartlow, a scientist at Janssen Research and Development, a subsidiary of Johnson & Johnson.

Photo by Matt Reynolds



**Above:** Ellen Brune, left, and McKinzie Fruchtl of Boston Mountain Biotech

**Ellen Brune**, 2013 Doctoral Graduate, Department of Chemical Engineering

**Bob Beitle**, Professor, Department of Chemical Engineering and Associate Vice Provost for Research and Economic Development

College of Engineering

**Ralph Henry**, Distinguished Professor, Department of Biological Sciences

J. William Fulbright College of Arts & Sciences

Funding: National Science Foundation, Arkansas Biosciences Institute

For More: **http://goo.gl/ztLQfD**

# Engineers Receive NSF CAREER Awards for Research to Improve Wireless Devices and Fight Heart Valve Disease

Engineers Jing Yang and Kartik Balachandran have been awarded Faculty Early Career Development Program grants through the National Science Foundation.

Yang received a $500,000 grant to continue developing sensing and transmission systems for energy-harvesting, wireless sensor networks.

Energy-harvesting, wireless sensor networks are systems that include collaborating embedded devices, such as sensor nodes, that are capable of sensing, computation and communication. They are often used for application-specific analysis, such as environmental monitoring in homes or factories. The sensors perform long-range communications that are impossible or impractical to implement with the use of wires.

These networks use energy from the ambient environment – including solar power, but also sources such as vibration and wind – to collect and transmit vast amounts of data. However, they struggle to maintain reliable collection, transmission and analysis of data because the energy supply for this process can be random, scarce and inconsistent.

Yang is working on a set of algorithms that will lead to the design of new systems that can dynamically and intelligently allocate scarce energy to collect and transmit the most informative data samples.

Balachandran received a $500,000 grant to further his research in heart valve disease.

Balachandran's research focuses on understanding the multi-scale relationship between structure, architecture and mechanics related to the biological behavior of cells and tissues in disease processes.

The award will allow him to study the role mechanical forces and cell shape play in dictating endothelial-mesenchymal transformation, a process involved in fetal development and also in diseases such as heart valve disease and cancer.

Balachandran will focus on the role of endothelial-mesenchymal transformation in causing heart valve pathologies, and insights from this project are expected to yield new therapeutic strategies to treat valve disease.

The grants, better known as CAREER awards, are one of the highest honors given by NSF to junior faculty members. Recipients are selected based on high-quality research and the integration of that research with education initiatives in the context of the university's mission.

**Jing Yang**, Assistant Professor, Department of Electrical Engineering

College of Engineering

**Kartik Balachandran**, Assistant Professor, Department of Biomedical Engineering

College of Engineering

Funding: National Science Foundation Faculty Early Career Development Program

For more: **http://goo.gl/VmlGQZ**

**http://goo.gl/bVh8R1**

# Researchers Use NIH Grant to Study the Interplay of Brain Function that Controls Thoughts and Actions

The National Institute of Neurological Disorders and Stroke of the National Institutes of Health has awarded $375,000 to researchers who are investigating the interplay of two types of signaling in the brain.

The constant exchange of chemical and electrical signals among neurons in the cerebral cortex is responsible for our thoughts and actions. Understanding the interplay of these two types of signaling is essential for insight into neurodegenerative diseases like Alzheimer's and Parkinson's as well as healthy brain function.

Under the grant, Woodrow Shew, a biophysicist, and Julie Stenken, an analytical chemist, will develop new tools to measure changes in the electrical signals caused by carefully controlled and measured changes in chemical signals within a neuronal circuit.

The expertise of Shew's group is in measuring the electrical signals of neurons during sensory information processing using implanted microelectrode arrays. Stenken's research group specializes in precise control and measurement of chemicals in the brain using microdialysis implants.

Combining the tools and skills of the two labs promises to advance the frontiers of brain research in new directions that would be impossible without such interdisciplinary collaboration. "With microdialysis probes we can control exactly how much acetylcholine or other chemical is released and can therefore affect the localized chemical gradient in different ways," Stenken said.

Neuroactive chemicals play an important role in practically every aspect of brain function. The production and distribution of Acetylcholine in the brain is tied to Alzheimer's, for example. This work could expand knowledge on Parkinson's, depression and more.

"We expect that this is just the beginning of a long term collaborative effort to get a deeper understanding of how the spatial patterns and dynamic changes in the chemical environment in the brain impacts how our senses work," Shew said.

**Julie Stenken**, Professor, Department of Chemistry and Biochemistry, Twenty-First Century Chair in Proteomics

J. William Fulbright College of Arts and Sciences

**Woodrow Shew**, Assistant Professor, Department of Physics

J. William Fulbright College of Arts and Sciences

Funding: National Institute of Neurological Disorders and Stroke, National Institutes of Health

For more: **http://goo.gl/xHu09T**

# Study of Ocean Upwelling Off the California Coast Uses Data from Land and Sea to Gauge Ocean Health

Photo submitted

Researchers used tree-ring chronologies to reconstruct 600 years of data on ocean upwelling along the West Coast of North America to find indicators of the ocean's health.

Upwelling is the rise of cold waters carrying nutrients from deep in the ocean to warmer zones near the surface. Scientists monitor coastal upwelling because it is an important control on the productivity of critical marine ecosystems. But their efforts have been impeded by lack of data data from previous centuries.

The study, published in *Science*, demonstrated that the recent levels of increased variability happened only twice in the past 600 years and are associated with weak upwelling, which has a negative impact on marine productivity.

David Stahle co-authored the study and produced tree-ring chronologies of blue oak trees that depend on precipitation caused by the same atmospheric conditions that cause winter upwelling. Several other scientists contributed to the study, which was led by Bryan Black, assistant professor of marine science at the University of Texas Marine Science Institute.





# Particle Performance in 3-D Printing

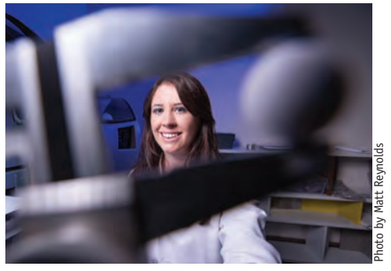


Photo by Matt Reynolds

Geotechnical engineer Michelle Bernhardt is using computer modeling to study how particles react to displacement and stress, an important step in understanding particle performance in 3-D printing.

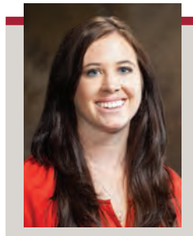
Bernhardt was using a simulation process to study particle movement and drew the attention of the National Institute of Standards and Technology, a technology agency within the U.S. Department of Commerce, which has awarded Bernhardt a three-year grant for $340,035.

In her project, Bernhardt will develop discrete element method simulations that can be used to examine the metal powder behavior in direct metal laser sintering devices, one of the techniques known as additive manufacturing.

"Additive manufacturing processes build a 3-D object such as a metal part layer by layer," Bernhardt said. "This particular type of printer spreads a layer of metal powder across a build surface and a laser sinters the metal layer by layer, creating a 3-D object. Discrete element modeling captures the movements and interactions of each powder particle. The National Institute of Standards and Technology is interested in finding out how the powder particles are distributed when the printer arm moves the powder across the build surface, and whether that is going to change the properties of the material that is actually made."

The simulations will be used to examine the initial packing of the powder, as well as the density and size distribution across the build surface with and without a 3-D object present, Bernhardt said. Each of these factors affects the quality of the built part and understanding how the powder is distributed on the build surface will help link the build conditions with the characteristics observed in the final product. From a manufacturing standpoint, this information will also help increase the quality control of various build conditions, she said.

"There are a lot of aerospace and other applications where you want to make sure the printed part is going to behave like you expect and that the engineering properties are the same each time it is printed," she said.



**Michelle Bernhardt**, Assistant Professor, Department of Civil Engineering

College of Engineering

Funding: U.S. Department of Commerce National Institute of Standards and Technology

For More: **http://goo.gl/J30anq**

The research documented long-term changes in the variability of marine upwelling in the California Current system, which during the winter lifts deep, cold and fertile oceanic waters into sunlit surface layers of the ocean. This process fuels vast phytoplankton blooms that provide food for fish, seabirds and marine mammals. The atmospheric conditions that control winter upwelling also control onshore precipitation and tree growth by guiding the storm track into or around the western United States.

For more than 30 years, Stahle has taken core samples from trees and examined the chronology of their rings to reconstruct past climate and help explain the societal impact of drought. This study of marine productivity expands on the scientific applications of his research – focusing on the flow of the Sacramento River, San Francisco Bay salinity and ancient blue oak trees in California, which have already been used to develop high-quality reconstructions of precipitation.

In addition to the tree-ring chronologies, the analyses also used direct measurements of phytoplankton productivity and the growth of marine birds and fish.

The researchers also relied on three indices of physical variables to characterize winter climate caused by the California Current: the Northern Oscillation Index, a new index of climate variability based on differences of sea level pressure in the north Pacific; the Bakun Upwelling Index, the standard measure of the volume of water that upwells along the coast; and sea level measurements at San Francisco.

"The annual growth data gleaned from fish, seabirds and blue oak trees are highly correlated and demonstrate a remarkable degree of connectivity across the coastal interface," Stahle said. "Taken together, the data not only provide a long historical context for interpreting modern variability in observational records, but may also inform decisions about managing coastal ecosystems."

**David Stahle**, Distinguished Professor, Department of Geosciences

J. William Fulbright College of Arts and Sciences

Published: *Science*

For More: **http://goo.gl/9KOX3Y**

Photo by Don Shreve

# Building Art

## *Understanding Frank Lloyd Wright through research and construction*

By Michelle Parks

Last September, a group of students in the Fay Jones School of Architecture journeyed to a nearby airport hangar where Frank Lloyd Wright's Bachman Wilson House lay in pieces on the ground. They wanted to get a peek at this significant work of architecture that Crystal Bridges Museum of American Art acquired and moved to Bentonville, Arkansas, from its original site in Millstone, New Jersey.

The home and a pavilion designed by University of Arkansas architecture students are under construction on the museum grounds.

"This was a Frank Lloyd Wright house, and it was just a pile of lumber," said Gregory Herman of that day at the hangar. "It really takes the reconstitution and the genius of the architecture to give it its spirit. When it's disassembled, by and large, it's just a pile of lumber."

Herman is an associate professor of architecture in the Fay Jones School — named to honor Fay Jones, the school's first dean, long-time professor and Frank Lloyd Wright apprentice. Last fall, Herman and his students prepared interpretive materials for this Wright home that would be accessible, understandable and enlightening to the public.

Herman's studio project is one of two projects connected to the Bachman Wilson House that architecture students developed last year in the first collaboration between the Fay Jones School and the museum.

The spirit of Wright's architecture — and its tie to nature — left a deep imprint on Jones and other Arkansas architects, even though Wright never designed a building in the state.

Photos by Don Shreve

"It is surprising, considering the influence Wright had on Fay Jones and other faculty here," Herman said.

The Bachman Wilson House is unique in that it was designed in the later part of Wright's career and built just five years before his death in 1959. "So, it really reflects the end of his career, but also that he was still very much a productive architect well into his 80s," Herman said.

Arguably America's most famous architect with more than 500 completed design projects in his lifetime, Wright might best be known for the Guggenheim Museum in New York City, and Fallingwater, a home in rural southwestern Pennsylvania.

The students focused on Wright's residential designs for the project and traveled to the Avery Library at Columbia University in New York City to research Wright's works on paper.

## Relation to the Landscape

Wright's later work, including the Bachman Wilson House, reflects his unique vision of American democracy. Indeed, the term Usonian means "of or relating to the United States." In the 1920s Wright designed a Utopian, agrarian, American community called Broadacre City. It was to be filled with Usonian-style homes, a truly original American residential design intended to be affordable with the option of being constructed, at least in part, by the owners.

"They were spatially adventurous and suggested new ways of living through spaces that had multiple uses and were overlapping — which is a hallmark of a lot of Wright's work anyway, but really was modernized in the Usonian houses," Herman said.

With the Usonian style, the "organic sensibility" of a structure — its relationship to the landscape — was key. The furnishings and any ornamentation were part of the architecture, often with built-in pieces, such as couches, benches, bookshelves and dining tables. In the Bachman Wilson House, the dining table wraps around an interior wall.

At the Avery Library, students filtered through Wright's wide variety of approaches to Usonian houses to develop a basis of comparison for visitors to Crystal Bridges. They wanted to show how the Bachman Wilson House fit along a "continuum of thought" for Wright and his Usonian houses. "It's part of a critical mass of exploratory designs," Herman said of this house.

"The care and craft that went into the preparation of the drawings, which people don't see, are just exquisite. And you can also see that in Fay Jones' work," Herman said.

Usonian homes were typically single-story structures; the Bachman Wilson House is one of the few homes from his late period that is two stories. The footprint of the Bachman Wilson House shrank to reduce the cost of construction. There are two bedrooms and a bathroom upstairs, with a balcony that overlooks the living space.

Designed on a 4-foot grid plan, the house features a large expanse of glass, lots of wood inside and out and concrete block — used in a way that is "downright comfortable, rather warm even," Herman said.

The defining ornament of this house is the pattern of perforated wood panels that covers the band of windows just below the ceiling line. These clerestory windows protect privacy while providing light. The pattern of the panels — 72 panels stacked three high — casts dramatic shadows into the space.

Andrew Schalk, a fifth-year student, said the research of Wright's work reinforced his own ideals about architecture, such as economy of space, sustainability and affordability. He also was relieved to see how many iterations of a design this revered, prolific architect would create — as often happens in the students' design studios.

"The point of their research was to inhabit the design ethos of Wright and to present the material so it would be understandable and desirable, even artful," Herman said. "We are a design school, after all."

Students drew, diagrammed and analyzed Wright's work and built what Herman calls a "Buick of a model," showing the site at Crystal Bridges where the Bachman Wilson House is being reassembled, along with a viewing pavilion that other architecture students designed and built.

Students used digital fabrication technologies to create the pieces for the model. While the entire model was a group project, Grant Gilliard made the model of the pavilion, and Kyle Heflin made the model of the Bachman Wilson House, including interior detailing and furnishings.

"The house itself is a work of art," Herman said.

Working with a limited space at the museum, the students integrated an exhibit into the model's walnut base with sliding panels and drawers containing details about the Bachman Wilson House design and Wright's Usonian style that could engage and enlighten visitors of all ages.

"I think the model on its own helps you understand the building, but it doesn't help you understand what Wright was going for, and that's what the drawers are about," Schalk said.

The model, situated in the Crystal Bridges lobby next to the museum's Great Hall, will serve as a prelude to experiencing the viewing pavilion and the Wright house.

## Veined Leaves and Dragonfly Wings

Months before the model was built, other students had already begun work on a viewing pavilion to be perched just a few yards away from the site of the Bachman Wilson House along a hillside trail at Crystal Bridges. Nearly 30 students worked with Santiago Perez in three studios over the course of 2014 and early 2015 to design and build the pavilion.

Perez, an assistant professor and the 21st Century Endowed Chair in the Fay Jones School, sought to integrate design, fabrication and installation with this single project. "What I've tried to do in the DesignFab Lab is to break down the barriers between design technology and production, and to create a place where innovation can take place without barriers," Perez said.

This pavilion project allowed the students to be hands on through the design and development process. In a typical design studio, when students draw a line for a structure, it matches up perfectly with the connecting lines.

"Well, in the real world, wood shrinks and expands, and steel, when you weld it and heat it, it also distorts," Perez said.

They had to adjust their project to deal with changes to the site over the last year. "That whole accelerated process was only made possible through digital modeling," Perez said. "While the conceptual designs were being developed, we were also coming to terms with what actually could be fabricated in the lab by producing a mock-up."

The pavilion is an open-air structure with cedar frame and decking, polycarbonate panels and steel pieces. One wall arches over the structure to become the roof and features a unique geometric design found in nature — similar to the details of veined leaves and dragonfly wings.

Called a Voronoi pattern, the geometric design creates a plane of polygons that also happens to be a strong pattern for the distribution of forces on a surface, Perez said.

Photo by Santiago Perez

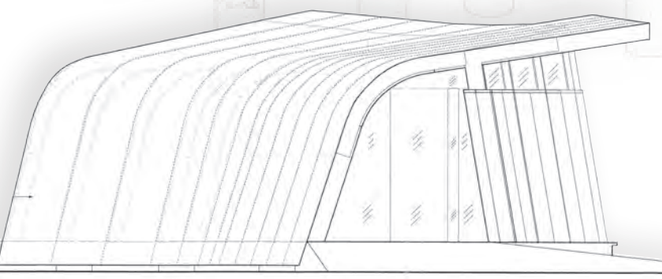
**Opposite page:** Architecture students integrated an exhibit into the base of their detailed site model, with horizontal and vertical panels that slide out. One (shown at top) contains a three-dimensional plan, or horizontal cross-section, of the Bachman Wilson House. A second provides interesting facts about Frank Lloyd Wright and the Usonian style.

**Above:** The Voronoi pattern used for the pavilion roof and one wall is similar to structural patterns found in nature – from the veins in leaves to dragonfly wings.

Photo by Michelle Parks


Photo by Santiago Perez

**Above:** A detail of the pavilion model. **At right:** The pavilion wall that faces Crystal Bridges is made from steel panels and floor-to-ceiling windows, and it echoes a design element of the Bachman Wilson House. Unlike Wright's design, however, this pavilion uses a highly customized geometry with no right angles. The pavilion's design also references the museum where it's located. The translucent panels that cover the pavilion call attention to minimalism and some artwork found inside the museum. The use of cedar wood framing hints at the architecture of the museum itself, designed by Moshe Safdie.



They used digital modeling software to create a Voronoi pattern, and projected it from a two-dimensional plane onto the three-dimensional surface of the pavilion that arches and curves.

The students had to figure out how to take idealized patterns and designs and make them work with real materials as well as they worked on paper.

The pattern continued to evolve as students worked with the steel material. "The ideal pattern broke down, and the new pattern had artifacts and geometric lines that were discontinuous," Perez said.

"We used the digital modeling to derive the angles, but then the limits of the machine that we had in the shop basically required that the students calibrate by hand the angle on the machine," Perez said.

That summer studio, with its six-day work schedule, left Molly Evans physically exhausted but mentally satisfied. Now a third-year student, she learned to write the code to direct the computer-controlled plasma cutter on how to cut the steel. She enjoyed the intimacy of working directly with the materials that came from learning to cut and weld steel and helping to build wood joists for the pavilion deck.

The experience influenced her design approach by teaching her the importance of conveying information through drawings.

"Learning how to detail and being able to see the process of the 1:1 scale has changed the way that I view design as a whole," Evans said. "The process is just as important as the product."

Students in the fall semester studio picked up the project where the summer class left off. They worked to solve the issue of "drift" — the difference between the design and the realities of construction. They recalibrated the project, which required remaking some of the thin-gauge steel panels that make up the curved wall.

"They were the ones that finally absorbed this drift between the ideal and the real. And that was fascinating to watch," Perez said.

As Kirsten Henson, a fifth-year student, worked in the fall studio, she learned how to weld and to use saws and benders.

"I think it was the most eye-opening experience as far as architecture because it taught you how things are really put together," she said. "You can draw anything on paper, but that doesn't mean it's going to work."

Henson and her classmates finished the pavilion to about 90 percent complete at the site by the end of the semester, and a professional contractor in Rogers, Arkansas, was hired to complete the work this spring.

Today's architecture graduates have to navigate between design as a conceptual process and design as a technical process, Perez said.

"I see these studios as a bridge between academia and the professional life of the alumni, and giving them a chance to determine to what extent they want to encounter material in their careers," he said.

Perez is thrilled by the physical legacy this project leaves for these students. The museum anticipates opening the exhibit to the public in late summer.

"For those alumni that come back to Fayetteville to visit, they'll be able to go to that completed structure and walk through it with their family and friends, and explain how that was part of their design education," he said. ■

**Connections and Intersections:**

## Fay Jones and Frank Lloyd Wright

The lives of Fay Jones, an Arkansas native and award-winning architect, and his mentor Frank Lloyd Wright intersected for the first time in 1949, when Jones bumped into Wright at the American Institute of Architects' convention. Wright was there to receive the AIA's Gold Medal, the highest award in American architecture, given in recognition for a significant body of work of lasting influence on the theory and practice of architecture.

Jones and Wright remained in touch throughout the next 10 years, until Wright's death in 1959. When Jones was still an architecture apprentice, he and his family spent a summer at Taliesin, Wright's institute and design studio near Spring Green, Wisconsin. Then, in 1958, Jones convinced Wright to speak at the University of Arkansas, where Jones taught architecture courses. In 1966, the university appointed Jones as the first chair of the Department of Architecture. The School of Architecture was established in 1974, with Jones serving as its first dean. In 1990, Jones received the AIA Gold Medal – the only one of Wright's disciples to receive this coveted award also held by their mentor. Jones died in 2004, and the school was renamed in his honor in 2009.

In 2014, Crystal Bridges Museum of American Art in nearby Bentonville, acquired one of Wright's Usonian-designed homes, the Bachman Wilson House, which was threatened by regular flooding of the Millstone River in Millstone, New Jersey. The home is being reassembled on the grounds of the museum and will open to the public this summer. It will become the only building in Arkansas designed by Wright.

An innovative digital exhibit titled "Fay Jones and Frank Lloyd Wright: Organic Architecture Comes to Arkansas" explores these two notable architects. Crystal Bridges Library and Archives and University Libraries' Special Collections collaborated on the online exhibit. Gregory Herman, associate professor in the Fay Jones School of Architecture, contributed an essay and advised on the project, and the David and Barbara Pryor Center for Arkansas Oral and Visual History at the university provided an interview with Fay Jones' late wife, Gus. The digital exhibit consists of nearly 150 photographs of the two architects' work, families and colleagues; correspondence; lectures; musings and writings; and other media.

University of Arkansas Libraries Special Collections

Frank Lloyd Wright, left, speaks with student Bill McCartney, center, and Fay Jones, right, during his visit to the university in 1958.

"Despite all of the current shortcomings with online exhibitions, one cannot argue against the incredible value such sources add for scholars and researchers, and the University of Arkansas and Crystal Bridges Museum should be praised for their bold decision to advance this discourse," wrote Evan Rawn in *ArchDaily*, one of the world's leading architectural websites.

The exhibit can be viewed here: **http://digitalcollections.uark.edu/cdm/landingpage/collection/joneswright**

**Santiago Perez**, Assistant Professor and the Twenty-First Century Endowed Chair

Fay Jones School of Architecture

**Gregory Herman,** Associate Professor

Fay Jones School of Architecture

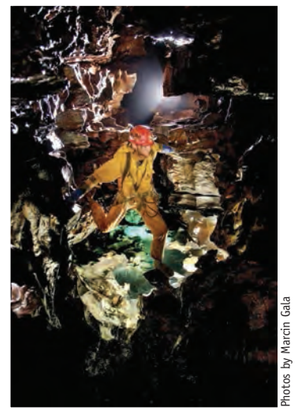
# Studying Hydrology *from the* Inside Out

*By Bob Whitby*

Snow still blankets the ground on this 30-degree February afternoon as Matt Covington prepares to crawl through mud beneath the earth's surface. The empty parking lot at Blowing Springs Park in Bella Vista, Arkansas, allows him to suit up without attracting attention. First he dons long underwear, followed by a neoprene wetsuit and a pair of dark green coveralls — a sacrificial layer intended to prevent the wetsuit from being shredded on sharp rocks. He tops it off with a helmet, boots and gloves. He's ready.

Photo by Matt Reynolds





Photos by Marcin Gala

**Previous page:** Professor Matt Covington of the Department of Geosciences pauses outside Blowing Springs Cave in Bella Vista, Arkansas, where he gathers data on water temperature and carbon dioxide levels. **This page:** Covington explores Sistema J2, a cave system in Oaxaca, Mexico believed to be among the deepest in the world.

Covington, an assistant professor in the University of Arkansas' Department of Geosciences, and his assistant Alex Breeding, a senior geology major, are making a monthly visit to change batteries and download data from devices placed throughout the 8,000-foot long cave. The devices gather data on air and water temperature, as well as carbon dioxide levels for a variety of research projects Covington oversees with his undergraduate students. The cave is a laboratory you have to wriggle into.

The pair open the locked gate that keeps casual spelunkers out and hoist themselves over a flat, waist-high rock. They drop down into a running stream and belly-crawl through the muddy water. Headroom is tight at first, but the cave opens up further in, where they'll walk through chest-high water to access their equipment.

It would be a stretch to call this just another day at the office. Like many professors, Covington spends most of his time teaching. Caves are both a profession and an avocation for him. He's managed to do what many of us only dream about: Combine his work and his hobby.

Covington studies the mechanical and chemical processes of erosion and the relationship between springs and the internal structure of aquifers. Such relationships are most complex in karst topography, which is characterized by sinkholes, underground drainage systems and caves. Understanding the intricacies of karst can help municipalities manage water resources and deal with the hazards of pollution and spills.

As a caver and adventurer, he's been on expeditions probing the world's deepest caves in places as far flung as Mexico, Peru, Sumatra and China. He's discovered and mapped caves, camped underground for days, scuba-dived in lakes hidden deep in the earth and put himself through physical trials only the truly obsessed would endure. In 2008, while exploring Lechuguilla Cave in New Mexico, he fell and broke his arm two days into an eight-day trip when an anchor popped loose during a climb. He set his own arm deep in that cave and passed out from the pain. When he awoke, Covington climbed for 13 hours through the cave to make it out without calling in a rescue team.

"I just like being outside," he says. "But the thing that is particular about caves is the exploration aspect. It is really about the only thing an average person with an average budget can do and explore new places that people haven't seen before. My other options would be going to space or the bottom of the ocean. And even the bottom of the ocean is mapped."

## Diving into Speleophysics

Covington grew up camping and hiking in Northwest Arkansas and credits his family with cultivating his love of the outdoors. He's also a third-generation University of Arkansas faculty member; his grandfather, Jess Covington, was the chair of the journalism department, and his father, David Covington, was a professor of engineering.

With that lineage, it was almost a foregone conclusion that he would do his undergraduate work in Fayetteville. He graduated in 2002 with bachelor degrees in philosophy and physics.

While he meshed with qualitative principals of philosophy, Covington was also drawn to the quantitative nature of physics. He was good at the math and enjoyed building the predictive models physicists employ to perform research. With quantitative research in mind, he went on to the University of California, Santa Cruz, and, studying galaxy mergers, earned his Ph.D. in physics.

He was a year away from finishing that degree when a thought occurred to him: Geology can be quantitative too. It's a field often considered qualitative because it attracts people who like science but not necessarily math. But once Covington realized that didn't have to be the case, the light bulb clicked on.

"There was a day when I was sitting in a lecture on galaxy formation and the guy was talking about a statistical technique he was using, and somehow it hit me," he recalls. "I wondered if I could use that technique to think about how caves form."

That moment led to Covington becoming one of only six speleophysicists — cave physicists — in the world.

While on a break from an astrophysics conference in Germany, Covington traveled to Slovenia to find Franci Gabrovšek, a geologist he'd met at a caving conference in Texas. Gabrovšek had a background in physics.

"We talked all day about being a physicist studying caves," Covington recalls. "He convinced me that it wasn't crazy."

Covington's geology training was limited to a few classes he'd taken as a grad student, however. He was willing to head back to grad school and earn a second Ph.D., but instead landed two

National Science Foundation Earth Sciences Fellowships, one studying karst hydrology in Minnesota and the other at the Karst Research Institute in Postojna, Slovenia.

When a faculty position came open in the University of Arkansas' Department of Geosciences, Covington readily applied.

"Normally when you are getting an academic position somewhere, it's not in your hometown," he says. "It's wherever you can find one. I had seen enough of the rest of the world and was happy to come back here to live close to family."

## Water on the Move

A relatively large amount of U.S. water resources, perhaps 20 percent, are found in aquifers that contain caves. That poses a water management problem.

"They are basically like pipe systems that run through an aquifer that allow water to travel very quickly over long distances possibly in difficult-to-predict directions," says Covington.

Aquifers are underground water sources contained in porous rock and are often intersected by caverns or underground streams that move water quickly through an area. Aquifers also depend on the filtering effect of the layers of soil and porous rock above them to clean the water. But caves create pathways for water and, like a pipe, can move it and any contaminants that water may contain along too fast for filtering to take effect.

So understanding how caves form and predicting where they take water can be beneficial to resource managers.

At Blowing Springs, Covington is focused on the dynamics of carbon dioxide. He's interested in how the cave's airflow patterns influence the level of carbon dioxide in both the air and water. Carbon dioxide is a catalyst for dissolution of rock, and levels of it vary greatly by season. Covington's data shows that carbon dioxide levels are up to 10 times higher in the summer than the winter.

That helps him understand how and when caves erode. It's a line of research that hadn't been much explored until now.

"No one has collected a dense enough data set to say much about it," he says.

Until recently, it wasn't easy to even collect data on carbon dioxide levels in water. Covington had to modify an air sensor by wrapping it in a waterproof membrane to get the data he wanted.

"For the first time, we have study data of $Co^2$ concentrations in cave water," he says.

## The Thrill Isn't Gone

Turning an avocation into a living is risky. What if you end up burned out on both?

"I wondered if it was dangerous to my hobby and my career," he says, "like caves are just not going to be fun anymore."

Instead, science has given him a new way of seeing the world underground, one that involves mathematical modeling rather than pushing physical boundaries. And there's satisfaction knowing that time spent rappelling down waterfalls, squeezing through cracks and wading in knee-deep mud could have real-world implications. Being on the team that lays claim to the world's deepest cave will be an achievement akin to conquering the world's tallest mountain. Understanding the hydrology of karst topography could mean safer water supplies for cities around the world.

But, like a mountain climber who becomes a guide to extend his days at elevation, Covington still feels the tug that got him hooked in the first place. In 2013, on a trip to J2, a deep cave in Oaxaca, Mexico, Covington spent most of his time collecting data instead of probing for passages that would extend the cave's known depth.

"It was a little bit sad for me," he recalls. "I was no longer out there at the edge. I was working, measuring the sizes of potholes and trying to download data from my data loggers. It was still fun to be down there, but it was a change."

He hasn't given up exploration entirely. He plans to return this summer to Slovenia for another look around a cave he discovered there while on a Sunday afternoon hike.

"My relationship to caves and caving has changed," he says. "There are good things about that. Expedition caving is hard on your body. Science is a way I can still interact with caves in a much less physical way. It is more sustainable." ■


Photo by Tom Johnson


Photo by Marcin Gala


Photo by Jason Gulley


Photo by Peter Bosted


Photo by Jason Gulley

**Top left:** Covington dives in a Florida spring. **Middle:** "Luxurious Camp 3" in Mexico's Sistema J2 cave system; Covington climbs in the Hansbreen Glacier in Norway. **Bottom:** Formations in Lechuguilla Cave, New Mexico. **Above:** Sunlight streams through an opening as Covington climbs the Hansbreen Glacier.

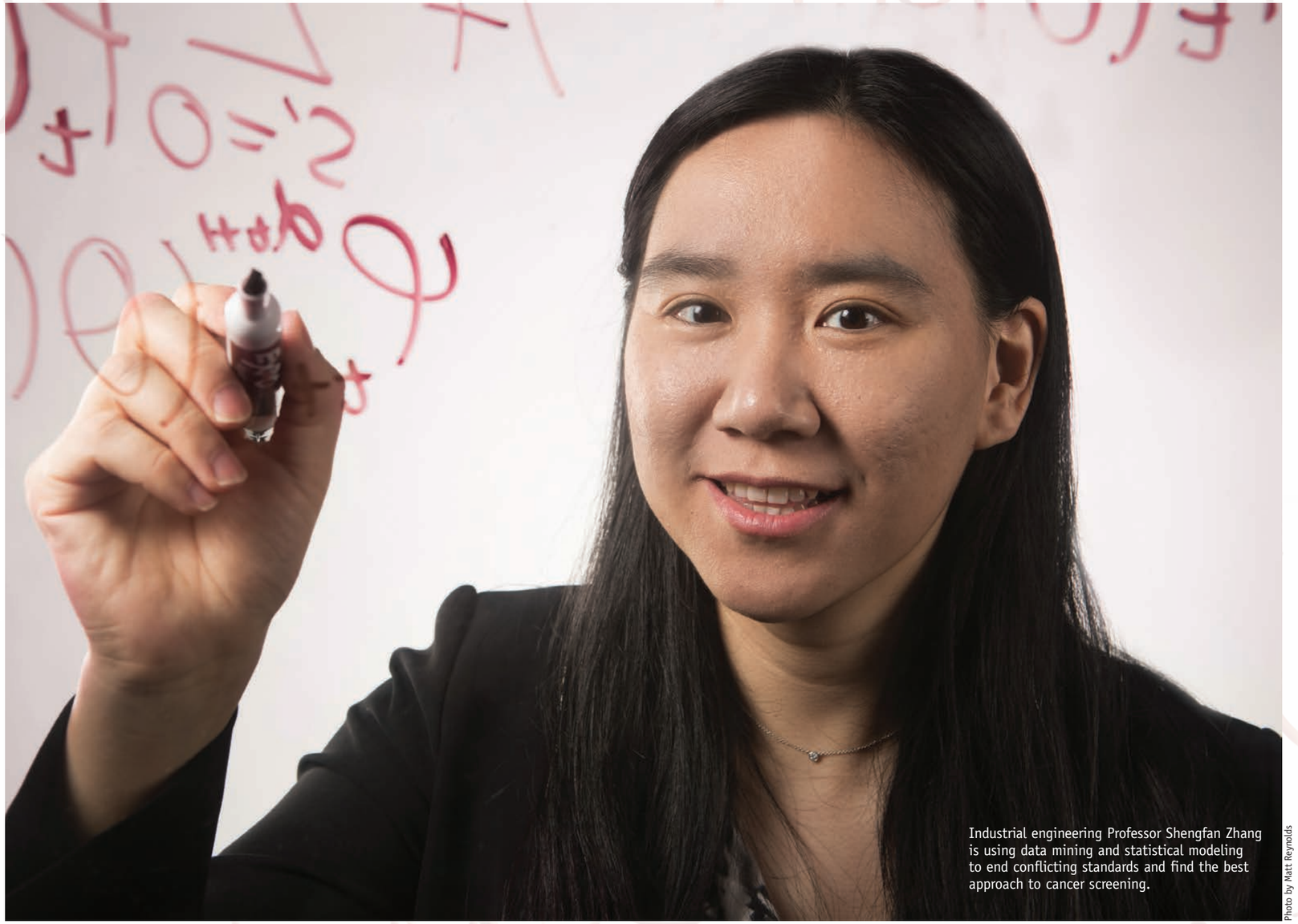
**Matt Covington**, Assistant Professor, Department of Geosciences

J. William Fulbright College of Arts and Sciences

For more, watch the video at:
**http://bit.ly/scientistcaver**

# Data:
# A New Weapon Against Breast Cancer

By Camilla Shumaker



Industrial engineering Professor Shengfan Zhang is using data mining and statistical modeling to end conflicting standards and find the best approach to cancer screening.

Photo by Matt Reynolds

Breast cancer trails only melanoma as the most common cancer, and it has one of the highest cancer-related death rates. Early detection and proper treatment are proven to increase the chances of survival, yet experts disagree on age and frequency standards for cancer screening.

That conflicting guidance can be confusing for patients — and could lead to to some women skipping screening altogether.

Industrial engineering professor Shengfan Zhang is using data mining along with statistical and computational modeling techniques to solve this puzzle. By plugging survey data into formulas, Zhang is able to identify the best general approach to breast cancer screening. Her ultimate goal is more ambitious: To create a personalized system of breast cancer screening, one in which a doctor and patient sit down together and work out a customized plan based on the patient's risk factors, preferences and the approach the data say works best.

"Right now, there's only one protocol for everyone," she said. "But we know that this doesn't work. One size does not fit all. A physician should work with a patient to come up with the best option."

## The Problem with Mammograms

The importance of screening is found in the numbers. One in seven women will develop invasive breast cancer in her lifetime. Currently, the only effective way to screen for breast cancer is to get a mammogram, but there are several factors that make mammograms less than perfect. And the questions of when and how often are still being debated.

Frequency matters. Mammograms expose patients to X-ray radiation, which is in itself a risk factor for cancer. Zhang cites research concluding that each exposure to radiation increases a patient's cancer risk by about 1 percent, and the cumulative increase in risk over a decade of screening is 5 percent for each breast.

Mammograms don't give clear results; they produce images that must be interpreted by clinicians. Sometimes the interpreter can miss a malignancy, resulting in something called a false

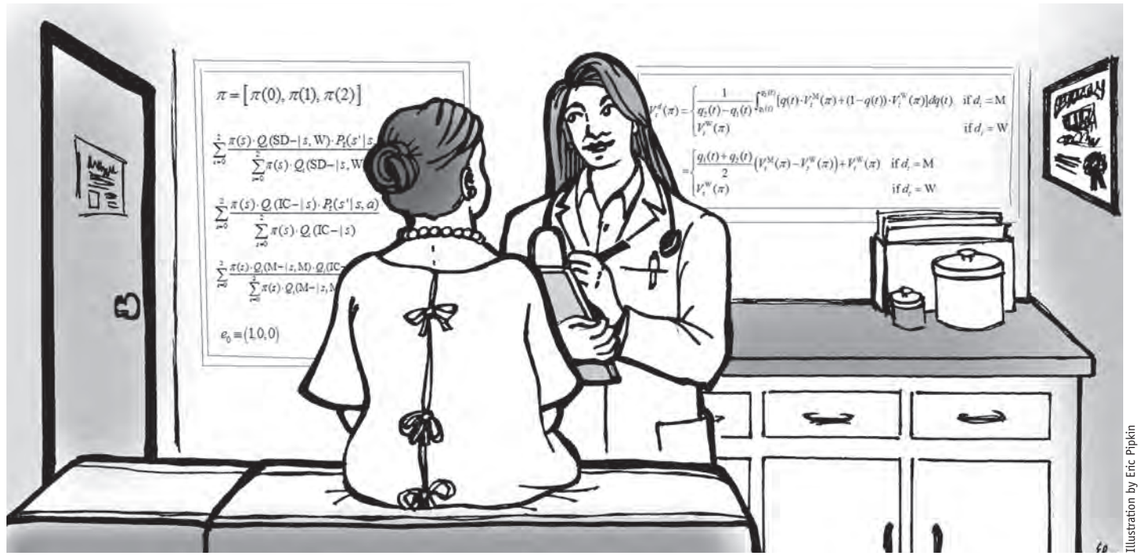



Illustration by Eric Pipkin

negative. The danger of this is obvious — the treatment that is so vital to a woman's survival does not happen. Another danger is called interval cancer, or cancers that appear between screenings and grow undetected for months before another test is administered.

Less obvious are the risks associated with false positives and overdiagnosis. In the case of a false positive, the woman is told she has a possible tumor that turns out to be nothing. Overdiagnosis occurs when cancer is detected and treated, but the treatment is unnecessary, because the cancer would not have been a risk to the woman's health. In both these cases, the patient undergoes treatments that cause stress and physical side effects and don't result in any benefit.

For these reasons, experts disagree on when and how often women should get mammograms. The American Cancer Society recommends yearly screening starting at age 40. On the other hand, the U.S. Preventative Services Task Force recommends screening every two years starting at age 50.

## The Question

Zhang and her graduate student, Mahboubeh Madadi, set out to identify which screening policy had the best balance of risks and benefits, but they also had to consider two other factors: Age and adherence to screening recommendations.

Age presents a paradox when it comes to cancer screening. While the risks of developing breast cancer increase with a patient's age, breast cancers are less aggressive in older women and tumors are more responsive to treatment. Because of this, survival rates for breast cancer actually increase with age. In addition, the accuracy of mammograms also increases with age, because tissue in the breasts becomes less dense.

Zhang and Madadi also considered the degree to which women were likely to follow the policy. While the American Cancer Society and the Preventative Services Task Force crafted their recommendations under the assumption that women would faithfully follow them, the reality is that most women do not. According to data from the Centers for Disease Control and Prevention, more than 75 percent of women older than 40 had five or fewer mammograms between 1996 and 2009 — considerably below the screening level recommended by the American Cancer Society.

Zhang and Madadi set out to answer a complicated question: Which screening policy would work best overall and for individual women, given that women skip screenings, the risks associated with mammography and the age-related variables in both breast cancer incidence and risk?

First, the researchers had to establish what they mean by "work best." They decided to measure outcomes in two ways. They considered how a screening policy affected a patient's chance of dying from breast cancer. They also examined how the policy would affect quality of life by measuring a patient's remaining quality-adjusted life years.

## The Process

Industrial engineers use mathematical tools to analyze data and optimize processes. Zhang and Madadi used several different statistical and operation-research methods for their project.

In an earlier study, they had predicted how adherent different groups of women would be to a screening policy. They considered many different factors, including age, race, education, insurance coverage, family history, body mass index, eating habits, exercise habits and the subjects' overall knowledge of breast cancer and mammography. The researchers determined the rate of adherence for women in different circumstances based on data collected by the Health Information National Trends Survey, which asked women if they planned to get a mammogram.

With this data, Zhang and Madadi predicted the likelihood that the general population would follow a policy.

Next, they used a method called the partially observable Markov decision process to evaluate different policies for three different cases: The general population, an individual patient and an imaginary population that would follow each policy to the letter.

The Markov decision process is a tool that models decision making in situations where the outcomes are results of both a decision and random chance. It shows relationships between different states and the actions that lead from one state to another. The type of Markov decision process used by Zhang and Madadi is called partially observable because the true health state of a patient is not fully discernable — a woman may have cancer but this is not known with certainty until the cancer is detected. In this case, the researchers had to consider three possible states at the same time: A woman could have early stage cancer, advanced stage cancer or she could be cancer free. At any point in the process, a patient's state was a combination of the probability she had cancer and the probability she didn't.

"The partially observable Markov decision process is used in many different areas, from robot planning and control to infrastructure maintenance problems," Zhang said. "It is natural to apply this type of modeling to health care because of the uncertainty in disease and human behavior and the partially observable nature of the patient's true condition."

When a woman is due for a screening, she has the choice to undergo screening or skip the procedure. The decision she makes can lead to several different consequences. She could continue to have no symptoms, she could detect symptoms before her next screening, she could get a false negative result and then develop symptoms, or she could get a false positive result, which would lead to further testing that shows no sign of cancer.

If a patient gets a screening with true positive results, she moves out of the screening decision process and into treatment. By modeling the interaction between these states and actions for different groups of women, the researchers developed a realistic idea of which policy would lead to lower mortality and the best quality of life.

The results of their research suggest that adherence plays a big part in how well a screening policy works. Zhang and Madadi found that on average, women who follow screening policy recommendations have higher quality of life and lower mortality risk. But they found a big difference between the imaginary group that followed the policy exactly and the more realistic group that sometimes skipped screenings. For the perfect group, the U.S. Preventative Services Task Force policy resulted in the higher quality-adjusted life years, suggesting that having a mammogram every other year is a good way to balance the benefits and risks of screening.

However, the realistic group and the individual cases fared better on the American Cancer Society policy, which recommends screening every year. Zhang explained that according to these results, screening policies should be more like speed limits, which are often set low with the expectation that many drivers will exceed them. Perhaps policy makers should account for the fact that patients will not follow their guidelines and set them a higher than necessary to make up for that.

## The Next Steps

Zhang plans to refine and build on this research in the future. She wants to revise her formulas to account for the fact that negative experiences with screening — like a false positive — could affect the way the patient follows a screening regimen in the future. She would also like to incorporate patients' attitudes toward risk into her model. Risk-averse patients would be less likely to deviate from a policy, while risk-seeking individuals might be more comfortable taking chances with their screening schedules.

Zhang is currently working with Madadi to address overdiagnosis, which is considered by some to be the most important disadvantage of cancer screening. The goal of their research is to refine the screening program to reduce incidents of overdiagnosis. In addition, another graduate student, Fan Wang, is looking at a decision process that accounts for the different risks associated with false positive and false negative results.

"I am interested in conducting research that will have a significant impact," explained Zhang, whose personal experience with family health issues motivated her to focus on health-care research. "In the field of medical decision-making, I can use my expertise to help patients and physicians make efficient and effective decisions that will lead to better health. In addition, I believe data-driven decision modeling can provide insights to health-care policy makers." ■

**Shengfan Zhang**, Assistant Professor, Department of Industrial Engineering

College of Engineering

**Mahboubeh Madadi**, Graduate Student, Department of Industrial Engineering

College of Engineering

Photos by Matt Reynolds

# Everything is Relative

## When You're Down to Your Last Dime

By Matt McGowan


That last dollar in your wallet carries more weight than just spending power. It affects the way you feel about purchases, which can be valuable knowledge for marketers and consumers alike.

Marketing researcher Robin Soster found that spending our last dollar leaves us less satisfied with the product, and it has very little to do with the product purchased. Her research shows that consumer satisfaction is affected by the depletion of a person's finances. If you bought the exact same item when you had $100 in your pocket (or bank account) rather than $1, then you *would* like it. Or like it more.

"For most people, parting with money causes discomfort," Soster said. "This resonates with nearly everyone's experience, and a lot of research has confirmed it. Our research shows that letting go of that last dollar is especially painful, and as this pain increases, satisfaction with the product purchased decreases."

Soster teaches consumer behavior with a research focus on mental accounting – how we think about costs and benefits.

Lately, her focus has been on "pain of payment," an expression used by researchers in the fields of marketing and economics to describe the nearly ubiquitous discomfort consumers experience when they spend money. The results have significant implications for the effective timing of consumer marketing incentives such as sales and coupons.

In "The Bottom Dollar Effect: The Influence of Spending to Zero on Pain of Payment and Satisfaction," published in the *Journal of Consumer Research*, Soster and co-authors Andrew Gershoff at The University of Texas at Austin and William Bearden at the University of South Carolina extend a few basic and empirically documented phenomena, namely that consumers associate spending with psychological pain and that they make spending decisions differently during periods of economic paucity compared to times of abundance.

Knowing that many – if not most – people usually spend rather than save those bottom dollars, Soster and her colleagues asked: Does a purchase when a budget is approaching exhaustion bring the same degree of happiness as when the same purchase is made when the budget is flush?

The researchers predicted people with fewer remaining dollars would feel more payment pain than those with resources left over. This pain, in turn, would lead to less satisfaction with the purchase.

The predictions were based on prior research of reference points, which suggested that people might use their available resources as a reference when making spending decisions. People with larger budgets perceive costs as smaller, while the very same costs are perceived as larger for those spending the last of their resources.

"Since we predicted pain of spending to be the primary driver for the bottom-dollar effect," Soster said, "we looked at situations that might increase or reduce this pain."

In two pilot studies, adults were given a budget and spending simulation. Participants were told that their budgets had dwindled to various levels – $10, $22, $34, $46, $58, $88. The researchers then informed the participants that they were to purchase a $10 movie ticket.

The researchers asked questions about spending and found that respondents' aversion to spending grew as their budget balances declined.

The researchers' next study looked more closely at the influence of bottom-dollar spending on product satisfaction. Soster and colleagues used a virtual film festival in which half of the participants exhausted their budgets with the purchase of the final film, while the other half had money left over after the film's purchase. While all participants watched the same three films, those who spent the last of their budgets on the final film didn't enjoy the film as much as those with money leftover.

"While the purchase of the third film reduced all participants' balances by the same amount, satisfaction was attenuated only for those whose budget balance was reduced to zero," Soster said. "We believe that these differences in satisfaction were driven only by the pain associated with spending one's last dollar. The product *feels* more costly, even though it wasn't, and this feeling, not the quality of the actual movie, determined how satisfied they were."

In the next study, to further explore whether this pain was the driving force behind differences in satisfaction, the authors had participants earn the resources spent in the film festival. Some participants felt as though the earning tasks were difficult; others perceived them as easy. In this study, resource availability influenced satisfaction when tasks were viewed as difficult, but not when tasks were perceived to be easy.

"If it is especially easy for me to recoup my resources, spending seems to be less painful," Soster said.

In another experiment, bottom-dollar spenders who were told their resources would be replenished soon felt less spending pain. Their satisfaction was unaffected — despite spending their last dollar.

Surprisingly, the bottom-dollar effect also arose for participants with plenty of resources remaining, if they were told that their budgets would not be replenished for a long time. Even though these participants had not spent their bottom dollar, their pain of payment was higher and satisfaction was reduced when future resources were uncertain.

What happens when people receive "free" money – unanticipated work bonuses, gifts from family members, or income tax refunds? The researchers found that these windfall gains stemmed the bottom-dollar effect, since spending no longer exhausted budgets.

The findings matter, Soster said, because beyond the obvious possibility of placing ourselves in the uncomfortable position of having to go without basic necessities for a while, there may be other reasons to wait until we're financially flush before making a purchse.

"Although waiting a day or two for one's paycheck may be a difficult exercise in self-control," she said, "our findings suggest that this waiting may actually increase happiness."

Regardless of whether consumers choose to follow this advice, simply understanding the bottom-dollar effect may help mitigate the pain of spending and its subsequent influence on satisfaction, Soster said.

Lessons from her research may be even more important for retailers and marketers. Both want to avoid situations in which consumers feel like they've received a "bad deal," which makes them less likely to buy a product again.

In light of this, Soster said companies might consider adjusting their promotional strategies. For example, heavy advertising might yield greater sales at the beginning of the month, after many people have just been paid. This strategy could also apply to seasonal events, such as Christmas, when many people exchange gifts, or in early spring when people have just received their income-tax refunds.

Conversely, at the end of the month, when budgets have likely dwindled and consumers are more likely to be approaching their bottom dollar, marketers might find special pricing incentives and coupons more effective strategies.

*"Our research shows that letting go of that last dollar is especially painful, and as this pain increases, satisfaction with the product purchased decreases."*

Photos by Matt Reynolds

"In other words, anything that accommodates the potential for fluctuating payment pain may not only increase sales, but also satisfaction," Soster said. "In fact, these types of incentives may work in a manner similar to windfall gains — preventing or at least easing, any pain associated with bottom-dollar spending." ■

**Robin Soster**, Assistant Professor, Department of Marketing

Sam W. Walton College of Business

# Flushing Out Facts About the Stomach Flu

By Amanda Cantu

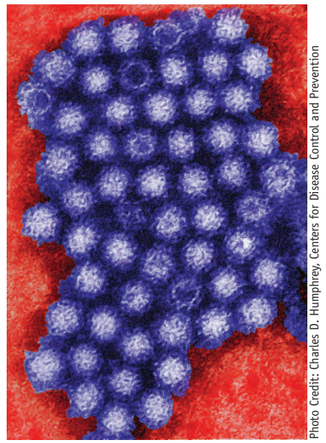


Photo Credit: Charles D. Humphrey, Centers for Disease Control and Prevention

Your head is pounding. Your stomach is in knots. Your entire body aches as the fever spikes. And the worst is yet to come.

You have the human norovirus, the stomach flu also known as gastroenteritis, the most common foodborne illness in the United States. Symptoms can be severe and last from 24 to 48 hours, and there is currently no cure.

Sabastine Arthur, a graduate student in cell and molecular biology, wants to change that by putting an end to norovirus infections.

Human norovirus is difficult to study because it cannot be reproduced in a lab. So Arthur's first step is to find a way to study the virus in a laboratory setting. The only way currently to learn more about the virus is through human volunteer studies — which are cost prohibitive and complicated to conduct — or to identify viruses that mimic the human norovirus that can be used as surrogates.

Arthur focused his research over the last two years on the Tulane virus and porcine sapovirus as potential surrogates for the human norovirus study. If he is able to successfully establish that these viruses are the most suitable surrogates to use in this endeavor, it will open the door for scientists to begin exploring possible control strategies for preventing contamination and infection.

Relatively little research has been conducted on Tulane virus and porcine sapovirus in the United States. Arthur's research is helping scientists learn more about the viruses by adding literature and data to the field and validating existing research.

"It is difficult to propagate the viruses so that we get high yields, which makes it challenging to create a standard protocol to produce the virus in the lab," Arthur said.

Though there have been some obstacles in the lab, there have been plenty of noteworthy discoveries for Arthur as well.

"One of the most interesting things I have come across is how cells grow. Sometimes they grow over five days and sometimes over three days," he said. "There are many inconsistencies."

This was Arthur's first time studying viruses, so he relied on Tulane virus and porcine sapovirus experts at the Centers for Disease Control and Prevention in Atlanta and The Ohio State University to keep him on the right path by ensuring he follows proper protocols.

Perhaps the most significant support Arthur has received throughout the process, however, has been from his adviser Kristen Gibson, assistant professor of molecular food safety and microbiology with the University of Arkansas System Division of Agriculture and the Department of Food Science in the Dale Bumpers College of Agricultural, Food and Life Sciences.

"Dr. Gibson is ever-ready to listen and to allow me to do what I think is right; and when I am wrong she directs me to the right course," he said.

Gibson was one of the reasons Arthur chose the University of Arkansas. He learned about her research pursuits while exploring graduate programs and found that his interests aligned well with hers. Arthur, a native of Ghana, came to the University of Arkansas in 2013, after completing a bachelor's degree at the University of Cape Coast in his home country.



University of Arkansas
Student **Research**


Photo by Matt Reynolds

Sabastine Arthur and his adviser, microbiologist Kristen Gibson, work in the lab on a cure for the human norovirus — the common stomach flu.

Arthur has published his research in the journal, *Food and Environmental Virology* and anticipates two more articles going to print before he completes his master's degree this May. Additionally, his research earned him first prize in the food science category at the University of Arkansas' 2014 "From Abstract to Contract: Graduate Student Research Poster Competition" and first prize at the 2014 Arkansas Association for Food Protection Educational Conference. His overall academic character resulted in his being nominated for the Dale Bumpers College of Agricultural, Food and Life Sciences distinguished Master of Science scholar in 2015.

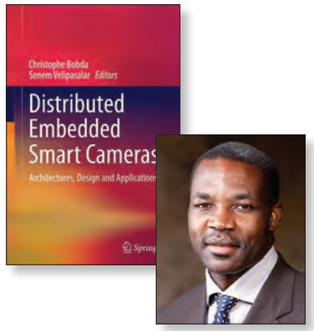
Gibson attributes her student's success to his work ethic and the enthusiasm she shows for research.

"He is highly motivated and very passionate about what he does," she said, "which is why he has been able to accomplish so much in a short period of time." ■

**Kristen Gibson**, Assistant Professor, Department of Food Science

Dale Bumpers College of Agricultural, Food and Life Sciences

University of Arkansas System Division of Agriculture

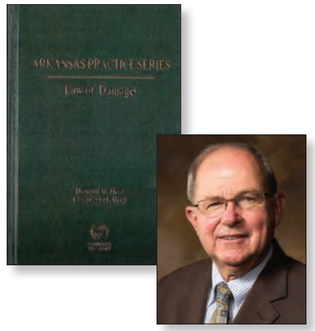



Senem Velipasalar, ed.; **Christophe Bobda**, ed., Associate Professor of Computer Science and Computer Engineering, *Distributed Embedded Smart Cameras* – Springer

The textbook covers the architecture, design and applications of a new wave of smart cameras that analyze video data internally and thus limit the amount of data that needs to be sent to remote servers.

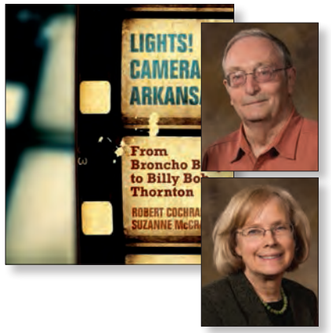

**Margaret Jones Bolsterli**, Professor Emerita of English – *Kaleidoscope: Redrawing an American Family Tree* – The University of Arkansas Press

The book is the story of the author's discovery that her great-great-great grandfather was a free mulatto who owned an antebellum plantation near Vicksburg, Mississippi, and it is the story, too, of the rise and fall of the family's fortunes in Mississippi.




**Howard Brill**, Vincent Foster University Professor of Legal Ethics and Professional Responsibility – *Arkansas Law of Damages (6th Ed.)* – West Publications

Completely rewritten for the first time in more than a decade, the volume covers both the general principles of damages and the damages relating to substantive principles of the law.

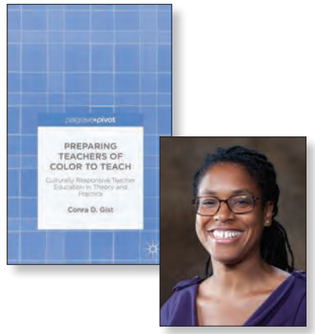



**Robert B. Cochran**, Professor of English; **Suzanne McCray**, Vice Provost for Enrollment and Associate Professor of Higher Education – *Lights! Camera! Arkansas!: From Broncho Billy to Billy Bob Thornton* – The University of Arkansas Press

The book traces the roles played by Arkansans in the first century of Hollywood's film industry, from the first cowboy star, Broncho Billy Anderson, to Mary Steenburgen, Billy Bob Thornton and many others.


**Matthew T. Feldner**, ed., Associate Professor of Psychology; Kimberly Babson, ed. – *Sleep and Affect: Assessment, Theory, and Clinical Implications* – Elsevier Publishing

Sleep research is discussed from a neurobiological, cognitive, and behavioral approach, and sleep and emotions are explored across the spectrum of mental health from normal mood and sleep to the pathological extremes.

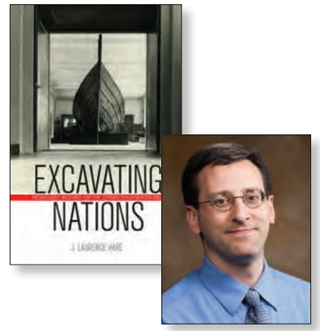



**Conra D. Gist**, Assistant Professor of Childhood Education – *Preparing Teachers of Color to Teach: Culturally Responsive Teacher Education Programs in Theory and Practice* – Palgrave Pivot

The book explores how teacher educators and teacher education programs design pedagogy and support structures to foster the learning and development of teacher candidates of color.








**J. Laurence Hare**, Associate Professor of History – *Excavating Nations: Archaeology, Museums, and the German-Danish Borderlands* – University of Toronto Press

Hare traces the history of archaeology and museums in the contested German-Danish borderlands from the emergence of antiquarianism in the early 19th century to German-Danish reconciliation after the Second World War.

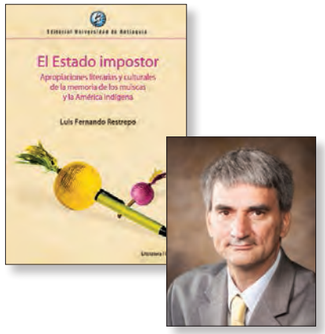

**Jennifer M. Hoyer**, Associate Professor of German – *The Space of Words: Diaspora and Exile in the Work of Nelly Sachs* – Camden House

Hoyer offers the first sustained critical analysis of Sachs' largely unanalyzed pre-war poetry and prose, as well as the first analysis that examines structural and thematic ties between the pre-war works and the Nobel Prize-winning post-war poetry.


**Peter MacKeith**, Dean of the Fay Jones School of Architecture – *SOM Journal 9* – Skidmore, Owings & Merrill

The *SOM Journal* is an ongoing review of architecture and design history, theory and criticism sponsored by Skidmore, Owings & Merrill (SOM), one of the largest and most influential architecture, interior design, engineering and urban planning firms in the world.

MacKeith led the international jury process and oversaw the editorial content for *SOM Journal 9.*

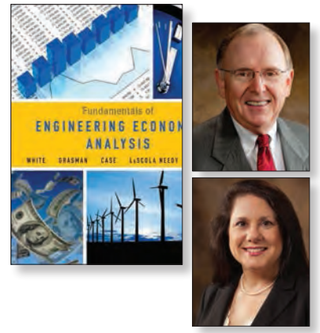



**Luis F. Restrepo**, Professor of Spanish, Latin American and Latino Studies, Comparative Literature and Cultural Studies – *Impostor State: Literary and Cultural Appropriations of the Memory of the Muisca and Indigenous America* – Universidad de Antioquia Press

The book examines the literary and artistic representations of the conquest of what is now Colombia, from the colonial period to the present, particularly in relation to current efforts of the indigenous communities to receive cultural and political recognition from the Colombian state and society at large.


**Sergio Villalobos-Ruminott**, Associate Professor of Spanish and Latin American Studies – *Sovereignties in Suspense: Violence and Imagination in Latin America* – La Cebra

Starting from the Chilean dictatorship (1973-1989) and focusing on the literary, visual arts, constitutional, social sciences, film productions and intellectual debates triggered by the Chilean coup, the book links the last four decades of Chile and Latin America's history under the assumption of an epochal change which implies the transference from state sovereignty to corporations.




**John A. White**, Chancellor Emeritus and Distinguished Professor of Industrial Engineering; Kellie S. Grasman; Kenneth E. Case; **Kim LaScola Needy**, Dean of Graduate School and International Education and Professor of Industrial Engineering – *Fundamentals of Engineering Economic Analysis* – John Wiley & Sons

This textbook provides streamlined topical coverage with a modern and rich presentation, and features a wealth of real-world vignettes to reinforce how students will use economics in their future careers as well as to drive student motivation and interest.

# Echoes from the Past: Preserving the Voices of the Ozarks

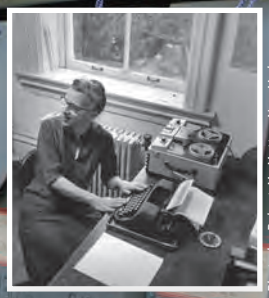


Photo by Robert M. Mottar, New York

Photo by Russell Cothren

Photo by Matt Reynolds

Tim Nutt and Lora Lennertz with the collection today. Above right: Mary Celestia Parler in her office in Old Main. The wealth of information documented in the Folklore Collection includes more than just the audio files and their transcripts — there are photographs like this one, musical notations, and class reports chronicling life in the Ozarks. When funding becomes available, these materials will also be offered digitally.

By Kallisto Vimr

Mary Celestia Parler made it possible for some Arkansans to hear the voices of their grandparents for the first time.

Parler began the University of Arkansas Folklore Project in 1949. She and her students spent 16 years trekking across the Ozarks collecting more than 4,000 audio files – folksongs, folk tales, instrumentals and countless conversations. Descendants of her subjects are naturally fascinated by these recordings, finding familiar voices among the hand-labeled boxes of tapes.

Professor Robert B. Cochran of the English Department, the original steward of the collection, recognized the value of the recordings and what they offered listeners. He worked with the University Libraries' Special Collections to find them a permanent home in the collection.

The University Libraries later appointed Lora Lennertz, director for academic and research services, to direct the campaign to preserve the tapes digitally, broaden access to their content, and capture for posterity an entire era of Ozark Mountain culture.

## A Collection in Peril

Researchers and archivists had known for some time that the tapes were deteriorating – the magnetized reel-to-reels were demagnetizing and the collection could be lost. In 2005, Special Collections sponsored a conference to discuss preservation options and gather support from researchers. The conference caught the attention of the Happy Hollow Foundation, which signed on to fund the audio preservation. The digitization of the transcripts was funded by a grant from the Arkansas Humanities Council.

"The project is really about bringing these songs out of their boxes, off of creased tapes, and out into the public," said Tim Nutt, head of Special Collections.

The scope of the project broadened over the next several years to include the transcripts Parler and her students carefully created. The audio files captured voices generations old in dialects that have faded in time and are unfamiliar to many listeners today. The fully searchable transcripts are often critical to the understanding and use of the songs, Lennertz said.

## Metadata Makes the Collection More Visible

The tapes and their transcripts convey a riveting story, but it was only part of what they could tell. Lennertz worked with Deb Kulczak, music cataloger and metadata expert, to create a sophisticated web of descriptors that made the collection more searchable.

The original collection guide limited searches to the name of informant or title of the song, leaving many songs unfound and unheard. Now users can search for the student transcriber's name, the first line of a song's chorus, and the location of the recordings, alongside poetically rich themes, keywords, places, or even fictional people.

The past comes alive through this extensive collection, for descendants, students, and scholars alike. And digital preservation has protected not just the voices and vernacular of the Ozark Mountains, but a chronicle of a field of study. Now this important work is linked across the Internet to other collections like it, making connections that many living in the isolated mountain communities of the 1950s were unable to make themselves. Lennertz said, "With this collection, we are far better able to 'walk in the shoes' of both the Arkansans and the folklorists of the last century."

**Ozark Folksong Collection**
**http://goo.gl/OCKtLn**