Spring 2006

Research Frontiers, Spring 2006

University of Arkansas Fayetteville. Office of University Relations

UNIVERSITY OF ARKANSAS

RESEARCH FRONTIERS

SPRING 2006

Understanding Aquifers

Investigating Water Rights

Improving Water Quality

Sculpting Streams

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A Message from the Chancellor:

I was fortunate over the holidays to travel to India to meet with and address business, government, and higher education leaders. It provided an opportunity for me to see personally the factors at work in the acclaimed best-selling book, "The World Is Flat," by Thomas Friedman.

Friedman writes that with the growing application of technology and the redoubled commitment to education by emerging powers like China and India, our world is growing more connected and more competitive than ever before. University of Arkansas graduates will be applying for many of the same jobs that graduates of the hundreds of universities in India will. In order to compete with the best students from around the world, UA graduates must be prepared to travel internationally, act locally, and think globally.

As this issue of Research Frontiers illustrates, UA students have at least one competitive advantage. They are learning from world-class professors and researchers who are committed not only to thinking globally, but also to acting with the benefit of Arkansas and the world in mind.

In a meeting with India's president, Dr. Avul Pakir Jainulabdeen (APJ) Abdul Kalam, he discussed the challenges facing his country: illiteracy, the role of women, the caste system and infrastructure needs. Regarding the latter, he cited roads and airports, utilities, medical care, and water quality and distribution. (To gain further insight regarding his research vision, visit his web site at http://presidentofindia.nic.in/.)

At an international conference he keynoted, Dr. Kalam challenged the engineers and scientists present to perform research on issues of global significance, e.g., forecasting and designing for massive hurricanes and tsunamis; energy conservation and alternative forms of energy; predicting and designing for earthquakes; and managing the world's water supply.

Coincidentally, this issue of Research Frontiers is about water. It is simply remarkable to read of the groundbreaking work UA researchers are doing in this field not only in Arkansas and the surrounding regions but in locations around the globe. Among the stories you'll find inside:

- The unique collaboration between Community Design Center Director Stephen Luoni and Marty Matlock, associate professor of biological and agricultural engineering, and their colleagues. Their work is improving the health of local streams and leading to the development of Arkansas' first "green" neighborhood.
- The development of the Savoy Experimental Watershed. Savoy is a "premier water quality research collaborative" – a 3,000-acre outdoor laboratory consisting of meadows, forests, and rivers, which enables multidisciplinary teams of researchers to study groundwater behavior.
- The construction of a water filtration system at a church in Zaragoza, a small village in Colombia. Civil engineering associate professor Thomas Soerens is raising money to provide more filtration systems to Zaragoza and the surrounding areas.

Stories like these renew my pride in the University of Arkansas, its students, faculty and staff. Our researchers make a profound, positive difference in our world and they teach our students to do the same. Their work does more than make the University of Arkansas a nationally competitive, student-centered research university – their work serves Arkansas and the world.

Sincerely,

John A. White
Chancellor

You Had To Be There: The Word Before It Becomes Text

By Barbara Jaquish

When medieval literature professor William Quinn hears slam poetry or rap music, he hears something old and familiar, "a revival of aesthetics that have been dismissed since Skelton," a Tudor court poet from the time between Chaucer and Shakespeare. Looking at the relationship between literature and how it is produced over the centuries leads Quinn to wonder whether living in a post-print period "puts us in sympathy with the pre-print world."

As a Chaucer scholar, Quinn has focused on how a work of literature intended for oral performance changes when it is recorded in manuscript form. With a fellowship from the National Endowment for the Humanities, Quinn participated in "The Handwritten Worlds of Early Modern England," a summer institute at the Folger Shakespeare Library in Washington, D.C. There he joined a diverse group, including some of the foremost scholars worldwide, to discuss research and analyze manuscripts, many coming from the Folger's extensive holdings.

"The institute gathered people from solitary cloisters. It was therapeutic: people doing narrowly focused work could share and achieve a broader textual and theoretical understanding of their own research," Quinn said. "I came away from the institute with better-informed questions."

He also benefited from the critical perspective of two of the world's leading manuscript authorities, Julia Boffey and A. S. G. Edwards. Since no existing manuscript of Chaucer's work was directly corrected by Chaucer himself, Quinn speculates from the evidence on the page about the author's intention and the oral performance that may – or may not –have preceded the written manuscript. Quinn is well aware that his speculations "need the skeptical admonitions of a primary bibliographer."

Oral performance produces words without the permanence of text. It has an element of improvisation, Quinn says, "like a trapeze artist without a net," that is lost when the words are written down. The process of producing a manuscript can shape the reader's understanding of a work, and the direction of a poem can be changed by how it is presented.

When The Legend of Good Women is presented as a free-standing work, it could be read as sentimental. The sense of the poem is quite different if it is read as a palinode, a poem that recants or retracts something from a previous work. Quinn has examined the Legend as a palinode to Troilus and Criseyde, originally performed by

Image thanks to The Parker Library, Corpus Christi College, Cambridge, http://www.corpus.cam.ac.uk/parker/index.php.

Chaucer for Queen Anne and her courtiers. In that context, it can be seen as a comic work, rich with the irony and double entendres that can be conveyed by tone or gesture during an oral performance.

As the presentation of literature changed from oral to manuscript to print, standards also changed. Punctuation had to be developed, beginning with quotation marks to indicate who is speaking and exclamation points to suggest intensity. Without a phrase like "he said sarcastically," there were no sign posts to indicate ironic or sarcastic tones, so the text becomes more difficult to interpret.

Revision can be another area of sympathy between pre-print and post-print eras. While manuscripts can show revision notes in the margins and can be corrected using wax or gesso and lacquer, we lose access to clues about the author's thinking when writers create and revise on computers. An oral work, whether an entertainment by Chaucer for the royal household or a slam poem performed for a raucous crowd at a campus bar, can be revised with each performance. And in that case, as Quinn noted in his study of The Legend of Good Women, to fully understand what the writer/performer intended, "you just had to be there." ■

Frontispiece from *Troilus and Criseyde*: While Chaucer was thought to have once recited some form of *Troilus and Criseyde* at court, the frontispiece is a highly stylized image that has sparked debate on whether it depicts Chaucer and whether it establishes him as a court performer.

UNIVERSITY OF ARKANSAS
RESEARCH FRONTIERS

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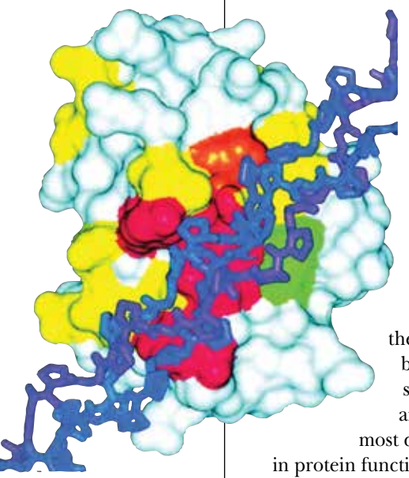
UA Center for Protein Structure and Function Receives $10.2 million



The Center for Protein Structure and Function has received a $10.2 million award from The National Institutes of Health National Center for Research Resources. This new five-year grant, the largest competitive research grant ever received by the University of Arkansas, will provide funding to continue the center, which was established in October 2000 with a $9.6 million NIH grant.

Proteins do nearly all the work in the cells of our bodies, ranging from brain function and nerve transmission to metabolic energy production and muscular contraction. Moreover, most diseases are associated with defects in protein function. Future advances in the diagnosis and treatment of human disease will depend upon better understanding of the thousands of proteins that are encoded within the genomes of humans and human pathogens. The center seeks to contribute to this fundamental understanding through detailed investigations of the molecular structure and function of proteins that play an important role in human disease.

More than 20 faculty members and 30 graduate students, postdoctoral students and technical staff work as multidisciplinary teams in the center to develop innovative approaches to biomedical research in protein structure and function. David Vicic, Matt McIntosh and Bob Gawley will develop new synthetic methods to prepare compounds that block chemokine receptors to provide a potential treatment for HIV infection. Robyn Goforth, Suresh Kumar and Ralph Henry will study the protein targeting process, which sends a protein to its correct location in the cell. Joshua Sakon, Kathryn Curtin and Michael Lehmann are studying protein interactions in the extracellular matrix, with the goal of developing a novel drug delivery system. Denise Greathouse, Grover P. Miller and Roger Koeppe II will examine the structure and function of membrane proteins, which play a crucial role in nerve transmission in brain and muscle. Kumar and Sakon will study the fibroblast growth factor signaling complex, which plays a key role in cell growth and wound healing. Frank Millett and Bill Durham will develop a new laser-excitation method to study how electron transfer in the mitochondria is used to produce the energy needed by a cell. ■

Discussion of Women and Minorities in the Contemporary South

Political scientists and polling directors in 12 Southern states debated the political, social, educational and economic status of women and minorities in the contemporary South as part of the New South Consortium Inaugural Conference.

Topics explored included what the Katrina relief effort says about race, poverty, and contemporary Southern politics; an evaluation of the last 50 years of desegregation; which Southern states have the best living standards and why; and what the future holds for women and minorities in the South.

The group's members discussed how they can work together in the future to conduct research and polls on questions important to the South.

"We looked at questions of public health, such as obesity being a serious Southern problem, at environmental concerns which are becoming a Southern problem because so many industries are locating here but Southern states don't often have the infrastructure or legal protections to prevent substantial environmental damage," said event co-sponsor Todd Shields, director of the Blair Center in Fulbright College.

The Blair Center and the department of education reform founded the consortium, which is composed of 12 Southern universities that annually conduct public opinion surveys. The consortium provides the researchers an opportunity to collaborate on their findings and share them with the public.

Conference panelists included Kirby Goidel, Louisiana State University; Debra McCallum, University of Alabama; Mary Stutzman, Florida State University; James Bason, University of Georgia; Ron Langley, University of Kentucky; Steve Shaffer, Mississippi State University; Robert Stevenson, University of North Carolina, Chapel Hill; Bob Oldendick, University of South Carolina; Michael Gant, University of Tennessee; Brian Cannon, Texas Tech University; and David Urban, Virginia Commonwealth University.

"Neither scholars nor policy leaders have sufficient information about the attitudes of Southerners to be confident about how certain policy decisions will impact the region," said Shannon Davis, event co-sponsor and director of research in the College of Education and Health Professions. "This is particularly true with regard to how we work to provide Southerners with quality public education, affordable housing and health care."

The coordinators plan to publish a book based on the efforts of this conference. ■

The Role of Courts in Autism Special Education Disputes

A law professor studied legal disputes between the parents of autistic children and public school districts regarding the adequacy of the child's individualized education plan, and found that the courts often prefer to make decisions based on proper procedure rather than the appropriateness of the plan.

Terry Jean Seligmann published her findings in the paper "Rowley Comes Home to Roost: Judicial Review of Autism Special Education Disputes," in the University of California-Davis Journal of Juvenile Law and Policy. The title comes from a 1982 Supreme Court case, Board of Education v. Rowley, in which the court directed reviewing courts to defer to the local school district's expertise in any dispute over teaching methods.

In the 20-plus years since then, numerous autism special education disputes have appeared in courts, and Seligmann believes that the courts must take a more proactive role in deciding whether or not a school has created an appropriate educational plan for an autistic child.

"School districts and states are the education experts, not the courts," Seligmann said. But courts must look at the foundations of an individualized education plan so that whatever the school district suggests is not automatically accepted.

"If the courts never question whether a plan is sound, then school districts may begin to behave differently," she said. "They might begin proposing only low-cost methods rather than ones that promise real educational benefits, but come with a higher price tag.

"Ultimately, the court should be trying to figure out if a child is really getting an educational benefit" from a particular plan, short of becoming educational experts, she said.

Seligmann cited several things courts can examine to make this determination. First, they can determine if the program is designed specifically and individually for that child. Then, they can determine if the people making decisions about a child's evaluation and program are qualified to do so and knowledgeable about the specific situation. Third, the courts should examine the facts, including the child's educational history, to determine whether or not the program has provided or is likely to provide an educational benefit for the child. ■

"Ga" Use Points to Shift in Japanese Politics

Tatsuya Fukushima, assistant professor of Japanese, believes that a simple word – "ga" – points to a political shift in Japan.

He has studied the language used by Japanese prime ministers and believes linguistic differences point to changes evidenced by recent elections in Japan.

Fukushima's paper, published in the Journal of Language and Politics, examines the linguistic patterns in domestic and international press conferences of three different Japanese prime ministers.

Fukushima studies the use of the Japanese conjunction "ga" and its different meanings in spoken language. The dictionary defines "ga" to mean "but." However, the word serves five different functions in Japanese speech.

"The meanings are very subtle," Fukushima said.

In Japanese culture, "ga" can be used to reflect sensitivity to the needs of others, to create a sense of harmony and consensus within a group, Fukushima said. But using "ga" ambiguously also can obscure the speaker's own agenda, leaving the listener to interpret the speaker's meaning. Frequent users of "ga" who use the word to mean many different things have this orientation.

People who use "ga" infrequently with little variance in meaning tend use more "straight talk" in their speeches, Fukushima contends. Historically, political candidates in Japan who use "ga" infrequently have generally been less popular nationally.

There are situational differences between domestic and international press conferences in Japan. Domestic press conferences receive scrutiny from fellow party members, who may publicly disagree with the prime minister. At foreign press conferences, the Japanese leaders have more freedom to speak their minds.

Ryutaro Hashimoto had the lowest "ga" frequency of the three prime ministers. His successor, Keizo Obuchi, was a consensus builder who used "ga" frequently both domestically and internationally.

When Fukushima examined the use of "ga" by Prime Minister Junichiro Koizumi in the first six to eight months of his administration, he found that the leader used "ga" in domestic press conferences, but not in international press conferences.

"In international press conferences, his 'true colors' emerged – there was a total absence of 'ga,'" Fukushima said.

The re-election of Koizumi as prime minister indicates that traditional values based on harmony and consensus may be changing.

"His selection was the threshold of a new and potentially long-term trend in Japanese politics," Fukushima said. ■

Chicken Fat Fuels Potential as Diesel

In the future, fat shaved off chicken breasts and other parts may power automobiles that emit less pollution.

Chemical engineering researchers associated with the Mack Blackwell Transportation Center have developed an optimized method of converting chicken fat into biodiesel fuel. This could lead to using chicken fat – a plentiful, accessible and low-cost feed stock – as an inexpensive supplement to petroleum-based diesel fuel.

Photo by Russell Cothren

"We're trying to expand the petroleum base," said Brian Mattingly, a graduate student in the department of chemical engineering.

Mattingly is working with R.E. Babcock and Ed Clausen, professors of chemical engineering, and Michael Popp, associate professor of agricultural economics.

"Biodiesel additives are cleaner and better oxygenated," Babcock said. "They burn better, create less particulate matter and actually lubricate and clean things like cylinders, pistons and fuel lines."

For these reasons, interest in the use of biological resources for alternative diesel additives has risen, but large-scale U.S. production of biodiesel fuels has not occurred for economic reasons.

Researchers have turned to chicken fat as a less-expensive alternative: It is available at low costs and has high-yield potential. However, the presence of free fatty acids in raw chicken fat has limited yields of biodiesel from these less-refined raw materials.

Mattingly worked high-quality fat and feed-grade fat. High-quality chicken fat costs more than feed-grade fat, but both cost less than alternatives, Mattingly said.

He created biodiesel fuel by subjecting each grade of chicken fat to a one-step and multiple-step conversion process. Both processes produced biodiesel fuel, but the single-step process could not convert free fatty acids into fuel.

Popp said it is too early to say that producing biodiesel fuel from chicken fat is economically feasible, but chicken fat shows a great deal of promise given today's fossil fuel prices and available subsidies. Popp will evaluate the yield information from Mattingly's study ■

Employment Circumstances Influence Responses to 'Psychological Contract Breaches'

In most work situations, employees respond to perceptions of unfulfilled employer obligations by bad-mouthing the employer, skipping work or finding a new job. But Vikas Anand and Anne O'Leary-Kelly, management professors in the Sam M. Walton College of Business wanted to know how workers with limited employment options react to these perceptions, which are known as "psychological contract breaches" in labor-management relations

The researchers conducted in-depth interviews with "job-constrained" foreign workers in the United States and discovered that employee responses to psychological contract breaches vary depending on employment circumstances.

"If there are (psychological contract breaches) in a traditional work setting, employees get angry, tend to be less motivated and are more likely to leave their jobs," said Anand. "In our study, the job-constrained workers were highly motivated. In fact, in many cases, work became the one thing that gave them joy. They were immersed in their jobs."

The workers' employment circumstances help explain their response to breaches. The researchers interviewed 60 contract employees, all software engineers from India. The workers were recruited and hired by "bodyshoppers," U.S.-based firms that hire foreign software engineers and arrange for visas that allow them to work in the United States. Only sponsoring employers can apply for these temporary visas on behalf of alien workers.

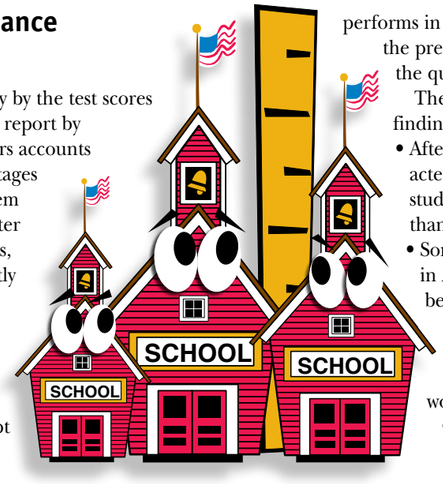
Bodyshoppers assign or rent their employees to work on short-term projects with American corporations. The workers, or contractors, are at the mercy of the bodyshopper, who controls the visas.

The contractors must remain with a bodyshopper for three to six years before they can acquire a green card for permanent residence. During this time, their options for changing or improving the situation are limited.

Because of these constraints, contractors do not challenge employers directly. Instead, the contractors immerse themselves in their work and tolerate their employers throughout the visa-application process.

The interviews revealed five predominant coping strategies contractors use to put up with bodyshoppers: detachment, selective social comparisons, lowered expectations, hope and cynicism, and social buffering. ■

Report Rates Performance of Arkansas Schools



Schools often are judged solely by the test scores their students receive, but a new report by University of Arkansas researchers accounts for the advantages and disadvantages students bring to school with them – and the report suggests that after adjusting for these characteristics, Arkansas students perform slightly better than the national average on standardized tests.

Researchers in the UA department of education reform have created The School Performance Index in an attempt to disentangle school quality from student advantages and disadvantages.

Accountability tests are often used to assess the quality of schools. Schools with high scores are thought to be "good schools," while schools with low scores must be "bad schools." However, test score results are only partially a reflection of the quality of school instruction; they also reflect the advantages and disadvantages that students bring to school.

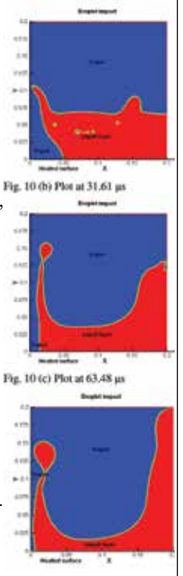
To develop the School Performance Index, researchers controlled for student characteristics, community characteristics and resources and then predicted how well each school should be performing given this input. The difference in how well or poorly the school performs in reality when compared with the prediction gives the estimate of the quality of the school.

The authors note five key findings:

- After controlling for student characteristics and resources, Arkansas students perform slightly higher than the national average;
- Some schools and school districts in Arkansas perform substantially better than we would expect given their student characteristics and resources, while others perform substantially worse than expected;
- School performance on the Iowa Test of Basic Skills is not substantially affected by the spending of the district;
- School performance on the Iowa Test of Basic Skills is not substantially affected by the size of the school or district; and
- School performance on the Iowa Test of Basic Skills is substantially affected by the percentage of African American students, the percentage of students who qualify for free or reduced-price school lunch in the school, household income, educational attainment of residents, the percentage of Hispanic students, and percentage of married families in the district.

To see the full report, please visit http://www.uark.edu/ua/oep/SPI_Full_Document.pdf. ■

Staying Cool: Research Shows How Spray Cooling Works



From top to bottom, these computational images show the impact of a single droplet on layers of vapor and water created by a heated surface.

Heat is a critical obstacle to developing smaller electronic devices. Engineering researchers have developed computer models that explain the complex process of spray cooling, a method used to remove heat from microsystems in computers and other electronic devices. The research could lead to development of smaller microscopic electronic systems, circuits and chips.

Panneer Selvam, professor of civil engineering and director of the Computational Mechanics Lab, created computational models of the impact of spray cooling on heated surfaces and found that the complex interaction of conduction and convection are the major phenomena of spray cooling.

Conduction is the transfer of heat through matter by communication of energy from particle to particle, and convection is the circulatory motion that occurs in a fluid due to variation of the fluid's density and the action of gravity. Selvam also discovered that density of individual droplets affects the droplet's ability to cool a heated surface.

"Spray cooling has been used in the computer and electronics industries for several years," Selvam said. "But an overall theoretical understanding of the process is limited because of the complex interaction or tension between liquid, vapor, gravity and droplet impact. We have contributed to a better understanding of this process."

This research will help engineers design high-powered electronic devices in radar used by the military. Space agencies like NASA could use Selvam's research to design efficient, system-level hardware for lasers and communication equipment in space shuttles and vehicles that perform research missions to Mars and Venus. ■

SPRING 2006
STUDENT RESEARCH

World Traveler Finds Way to Help Through Biomedical Research

By Megan Webb

Shelly Kaufman has spent time with the homeless in Toronto. She has traveled to Kenya and met people with AIDS and malaria. She has been to Estonia and an isolated mountain community in Mexico.

Even from a young age growing up in Bartlesville, Okla., Kaufman wanted to experience other countries and cultures.

"I knew that increasing my knowledge on other cultures would increase my knowledge of the world," Kaufman said. As her perspective of the world expanded, Kaufman also began to see the needs for and limitations of health care abroad.

As she began her education as a freshman at the University of Arkansas, these images of suffering remained strong in her mind.

Kaufman, now a junior biophysical chemistry major, has found her place, not overseas, but in the laboratory. She believes that the best way she can help other people is to apply her intellect toward medical research.

"I am passionate about improving the international human experience," she said. "I think that there is nothing better than improving the health of these people."

Kaufman began learning the basics of organic chemistry research techniques the summer after her freshman year. In the fall of her sophomore year, Kaufman applied for an honors college undergraduate research grant. By January 2005, she had begun her own project in natural product synthesis, a branch of organic chemistry.

Scientists have discovered that the chemical toxins of certain deep-sea plants have shown potential activity against various types of cancer. Scientists isolate the molecules within these toxins and identify which molecules have promising biological activity. For example paclitaxel, or taxol, is a plant product that halts rapidly dividing cancer cells.

However, the rare sources of these natural products can be difficult to locate and costly to retrieve. Synthetic organic chemistry attempts to generate these limited products efficiently and economically.

Kaufman is part of a research group led by Matt McIntosh, an associate professor in the chemistry department. The research group, composed of five graduate students and four undergraduate students, works to synthesize biomedically important compounds and to develop new organic chemistry reactions. Individually, Kaufman is working to develop new reaction pathways toward specific molecular structures.

Between her own classes and teaching organic chemistry drills, Kaufman spends her time in the laboratory, methodically developing the procedure to synthesize an important substructure of a larger molecule. Kaufman sees the value in developing a small piece to a much larger puzzle.

"Although it is not total product synthesis," Kaufman said, "my contribution allows for the creation of more than I could ever do on an individual basis."

Photo by Russell Cothren

Kaufman hopes that the development of the five-step synthetic pathway will lead to the more efficient synthesis of anti-cancer therapies. Kaufman's piece of the puzzle, a vicinal amino alcohol substructure, is commonly encountered in several natural products that have promising biological activity.

Once an entire molecule has been synthesized, it is sent to the National Cancer Institute. The National Cancer Institute has identified 40 cancer lines, and the synthesized molecule is tested on each line.

"In her third year, Shelly already has more research experience than most students have in their entire undergraduate career," said McIntosh. "She has done so well academically and in the lab that she will be able to apply her solid background in synthesis to biophysical chemistry."

"Research in natural products chemistry has given me an extensive background in the development of chemotherapeutic compounds and has fueled my interest in medical chemistry," she said. Kaufman eventually would like to work for a medical research hospital.

"I really want to do groundbreaking research," Kaufman said. "I don't want to do science for science's sake. I want to be that person who takes theory from the research bench to the patients."

Kaufman's desire to translate research to patient care means that she needs to master both disciplines. She plans on pursuing both a doctorate in medicine, and in natural product synthesis or molecular biology.

"People are so much more important to me than the science behind what heals them," Kaufman said. "But a practical application of that science is healing. Improving quality of life."

"I know that my mind is made differently," Kaufman said, smiling. "I see things differently. I see things long-term. When I'm not understanding chemistry, I feel like I am not accomplishing those goals that are before me."

In June 2005, Kaufman was one of three undergraduate students to present her research at the National Organic Chemistry Symposium in Salt Lake City. She also was selected as one of four University of Arkansas finalists for the Barry M. Goldwater Scholarship for the 2006-2007 academic year.

"I feel I've been given the tools to do what I'm shooting for," she said. "I can dream bigger and make bigger dreams a greater reality." ■

SUSTAINING
Life by Discovering How
GROUND & WATER

Interact

A child's globe shows the planet with clearly divided land and water. But spin it, and the blue, green and tan blur. While our experience of life on earth may seem to conform to the static globe, with water in the blue place and land in the green and tan places, reality is closer to the spinning blur.

by Barbara Jaquish

We know oceans, lakes, rivers and streams. Yet that earth we know, dry ground, terra firma, is not so dry or firm as we might believe. We may owe the water we drink or the food we eat to rain that fell on land, lakes or rivers thousands of years ago, rainwater that lies beneath our feet, trapped below a clay strata or filling the spaces between grains of sand.

Ground water is a source of sustenance for people, agriculture and industry worldwide, and as populations grow and economies develop, we increasingly draw on those stores of water beneath the surface. Our needs for water grow each year. But ground water is a finite resource, one that in some places is strained to the limit.

"Ground water" is more than just a term for water that resides below. The word can also imply a relationship between the water and the surfaces of soil, sand and rock that it touches. The water and the ground interact in complex and little-known ways. Discovering how ground and water interact in the dark places we cannot readily observe may be key to planning how to live in a sustainable manner with the finite amount of water available here on earth.

At the University of Arkansas, an eclectic cadre of researchers from all corners of campus – geosciences, civil engineering, biological sciences, soil sciences, chemical engineering, biological and agricultural engineering, and more – is doing something to understand the world of water below, the minerals and microbes it carries, how it renews itself and its relationship with surface water.

"The overriding concern, my greatest concern, about water is sustainability," said Phillip D. Hays, associate research professor in geosciences, whose academic appointment is shared with the U.S. Geological Survey and the National Water Management Center of the U.S. Department of Agriculture.

"We assign a lot of value to water, but we don't necessarily have an understanding of how to allot and most wisely use what we have," Hays observed. "We need water to survive, and we can't behave as though we can grow and expand exponentially, because we are limited by a finite resource."

He notes that population growth and economic expansion in areas as divergent as China and Northwest Arkansas increasingly strain that finite resource. In the western United States, "water wars" have been a common problem, and we are beginning to see such signs of stress in formerly water-rich states like Arkansas, Rhode Island and Georgia.

Ralph K. Davis, associate professor in geosciences and director of the Arkansas Water Resources Center, has seen first-hand the effects of over-use of an aquifer. In the 1980s, he worked for several years in Kansas with a system commonly known as the Ogallala Aquifer, which has been recognized as troubled for decades. That aquifer extends from western Kansas through west Texas and has been extensively "mined," leading to its significant decline. In an area that receives no more than 20 inches of rain each year, the aquifer is recharged – that is, replenished by drainage through the soil – at about half an inch a year. He calls the area from Dodge City to Garden City in Kansas "one great feedlot" where usage far exceeds the recharge rate.

The road enters the Savoy Experimental Watershed, 3,000 acres of forest, meadows and river with a typical karst landscape. Undergraduate Chris Hobza observes a water seep discharging a heavy flow of water.

Photos submitted

Researchers use a weir (above) to aid in measuring water discharge. Van Brahana, top center, installs a weir at Tree Seep. Jozef Laincz, doctoral student in environmental dynamics, far right, measures water quality as it comes from the seep. Doctoral student Tiong Ee Ting, near right, introduces E. coli into ground water through a barrel, as Ralph Davis and Greg Thoma observe.

Photos submitted

"The Arkansas River no longer flows in the stretch from Garden City to east of Dodge City, a distance of over 100 miles, because the ground water is just too low. In much of the Great Plains, no new development is possible," Davis said. "The Ogallala Aquifer is a poster child for non-sustainable use."

He draws similarities between the situation with the Ogallala Aquifer and conditions in areas as far-ranging as Saudi Arabia and eastern Arkansas. In all of these areas, we are drawing geologic water that is 10,000 or more years old, water associated with the last glaciation. And Davis is blunt: "These aquifers can't be replaced."

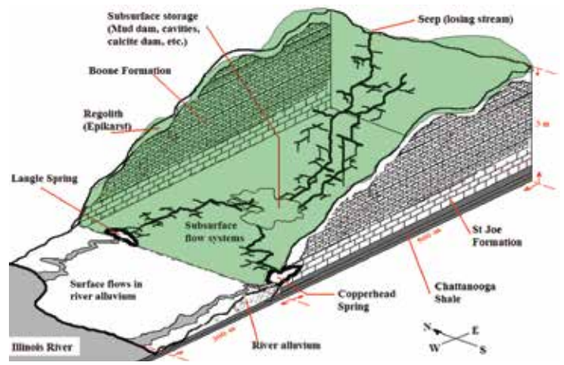
Over-use of aquifers can cause irreversible damage. With over-pumping, the water table drops, and eventually there's a collapse of the pore space – the space between the components of soil that had been occupied by the water. The effects of over-pumping can be seen in places like Mexico City or Houston, where the sediment has compacted to the point that people have to walk down steps to get to the front doors of buildings. Once this damage occurs, the aquifer can no longer recharge as effectively – even should more water be introduced.

Tracing Water Through Karst

Geosciences professor Van Brahana is proud of the development of the Savoy Experimental Watershed, "a premier water quality research collaborative," originally involving the university's department of animal science, the U.S. Geological Service and other UA departments. Located about 15 miles west of the main campus, Savoy is, in Hays' estimation, "an exceptional field station and a unique research setting."

Brahana predicts Savoy will be particularly beneficial as a long-term site to help researchers understand the multiple questions related to ground water in a karst environment, including how water enters the system, where it goes and how it is processed. The karst terrain is produced by the dissolution of rocks, mainly limestone and dolomite. On the surface, the landscape is characterized by dips and depressions known as sinkholes, produced by the collapse of the supporting rock after it has been eaten away by water. Water seeps, where water oozes out of a hillside, are also common. Beneath the ground are cracks and fissures – and sometimes caves – produced as the rock dissolves.

Savoy's 3,000 acres of forest, meadows and river offer researchers an outdoor laboratory with a typical karst landscape underlain



Graduate student Tiong Ee Ting developed this conceptual model to show the relation between the karst components in one section of the Savoy Experimental Watershed. A contaminant entering the system on the hillside may not show up in springs or wells in the same watershed. It may travel along unseen underground flow routes to discharge at another point. For an animated version of the model, which also shows the relationship between ground water and surface water, see the Research Frontiers Web site, http:researchfrontiers.uark.edu/.

This Savoy field is dotted with water sampling devices such as lysimeters, wells and surface weirs. Back in the lab, Sue Ziegler and graduate student Byron Winston test water samples for nitrate contamination.

Photo submitted

Photo by Russell Cothren

with porous limestone and involving a mix of interflow zones and focused-flow conduits. In the interflow zone, water moves laterally, and it slows down. In contrast, water in the focused-flow conduits moves quickly, at rates of miles per day, rather than feet per year.

Savoy has been important to Sue Ziegler, associate professor in biological sciences, who is interested in learning more about a poorly understood area: how nutrients are processed in the ground water system, particularly nitrate.

Nitrate is a common, naturally occurring form of nitrogen that can be introduced into the soil by the application of fertilizers and animal wastes and move from there into surface and ground waters. While more research is needed into the health effects of nitrate on humans, it is known to reduce oxygen transport in the blood and to affect thyroid function, with particular concern for infants and pregnant women. According to the World Health Organization, nitrate-related toxicity problems are only beginning. Their 1998 report on nitrate in drinking water found, "Because of the delay in the response of ground water to changes in soil, some endangered aquifers have not yet shown the increase expected from the increased use of nitrogen fertilizer or manure." Many factors affect whether nitrate in the aquifer is converted to nitrogen gas, such as the height of the water table, the amount of rainwater and the presence of other organic material.

For Ziegler's work, "the infrastructure at Savoy is fantastic." In addition to the naturally occurring seeps, Savoy features a trench cut into the ground to enable researchers to observe and collect from the water flow through the interflow zone and the soil above. Researchers also have sunk a series of lysimeters, small, tubular wells, to pull water from the surrounding soil zone for analysis.

One goal for Ziegler is to determine how much of the reduction in nitrate levels at a series of sample points is due to biological processing and how much is due to simple dilution. Understanding how important processing of nitrate is and where it takes place is critical to managing land-use practices on the surface to reduce ground water nitrate contamination. Additionally, Ziegler notes, it is important to understand what controls the actions of the microorganisms, known as denitrifiers, which use nitrate to gain energy, like humans use oxygen. These denitrifiers are ultimately responsible for removing nitrate from the aquatic environment.

"These are the guys that everyone's really interested in when we think about dealing with nitrate contamination," Ziegler said. "It's the main way nitrate can be lost from an ecosystem. It's the natural way. The interflow zone is likely to be the place where denitrification is occurring in karst ground waters, and we want to understand what surface processes do to that zone. We want to go from just a single plot to using multiple plots within the Savoy watershed. Then we can test different agricultural practices to see how they impact the surface and how that impacts the flow through the interflow zone, and ultimately, how this all impacts denitrification and nitrate processing within these vulnerable watersheds."

Other UA researchers seek to understand the processes of water moving through karst in relation to common bacteria. Davis, Brahana and Greg Thoma, the Bates Teaching Professor in chemical engineering, have worked with other researchers and graduate students to learn more about the life of bacteria, in particular *Escherichia coli (E. coli),* in a karst aquifer. They had noticed that when a heavy rain hit at Savoy, bacteria levels would shoot up in the water that was flushed out in springs. This was odd on two counts: Normally, with more water, common sense would suggest that any bacteria present would be diluted. Also, since the optimal environment for *E. coli* is the warm gut of a mammal, it seemed that the bacteria should die out in the 57 to 58-degree temperatures of the aquifer.

One of Thoma's doctoral students, Tiong Ee Ting, collected *E. coli* and tagged it with a metal trace element that allowed them to quantify when the bacteria went into storage and when it was flushed out. What they discovered was that *E. coli* goes into a kind of stasis in colder temperatures, remaining viable for extended periods in the aquifer until flushed out.

This finding is important for two reasons. First, karst aquifers lay under as much as 20 percent of the United States, supplying water to rural residents, and much of this water is untreated. Also, the researchers used *E. coli* because it is easy to detect and easy to grow in the lab. It is what they call an indicator organism. That is, when *E. coli* is present, there is also the potential for other serious viruses and bacteria to be part of the mix.

Arkansas and the World

"By understanding what we can learn at Savoy, we can extrapolate to put the best science and social considerations into account when making decisions on development questions," Brahana said. "The excitement about Savoy is seeing the complexity."

Hays uses his experiences in El Dorado, Ark., as an example when he speaks nationally and internationally about effective strategies to improve sustainability. El Dorado was the first region in Arkansas to be designated a critical area under a federal program that makes resources available to improve such sites. After a century of pumping, the Sparta Aquifer had dropped by 200 feet. With assistance from state, federal and university experts, the local conservation district was able to make changes that allowed the aquifer to see some recovery for the first time in 100 years.

Brahana has also worked with a graduate student on a project aimed at reducing the demands on the aquifer by using water from flooded coal mines in Greenwood, Ark., to supplement city water. Although the project is still in the beginning stages, initial studies have indicated that up to 500 million gallons of usable water may be available.

For the people of Bangladesh, India and Cambodia, it is vital today to unravel ground water processes that produce arsenic-tainted wells. As countries around the world put more demands on the finite resource that is ground water, it will become increasingly important to us all to understand how our aquifers work. ■

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Arsenic in Alluvial Aquifers

Geosciences professor Kenneth Steele has looked at a different type of aquifer contamination in a different type of aquifer. He has begun a project to look at arsenic in the sediment of the alluvial aquifer in the Bayou Bartholomew of southeast Arkansas.

Alluvial aquifers, the thick blankets of sandy soil associated with major river systems, commonly carry arsenic. According to Steele, some of the arsenic is the result of industrial activities, but most is naturally occurring. While the presence of arsenic in ground water is a world wide problem, the case of Bangladesh has been particularly dramatic and inspired continuing studies over the past decade that have raised more questions.

The government of Bangladesh switched their source of drinking water from surface water that carried diseases such as cholera and dysentery to a system of shallow wells. Then the wells were found to contain high levels of arsenic, five to 100 times the safe level allowed by World Health Organization guidelines.

In Bayou Bartholomew, about 20 percent of the wells test for arsenic at above safe levels for drinking water. Steele will focus on sediments and water to understand what forms of arsenic are present and what effect rising and falling water tables have on arsenic levels in the water.

Here's what is known: Arsenic and other metals attach to iron oxide. Water in eastern Arkansas is high in iron, which could work to decrease levels of arsenic in the water. But, as Steele puts it, "Arkansawyers drill their wells though cypress trees 100 feet below the surface." As those cypress trees and other organic matter in sediment decay, they use up oxygen. In the resulting oxygen-reduced environment, combined with a falling water table, arsenic and other metals can be reintroduced into the ground water supply. Tests also have shown that the levels of arsenic across an aquifer are not consistent from well to well, and the concentrations are clustered. ■

Photo by Tim McCabe, USDA Natural Resources Conservation Service

Who Owns the Water?

By Melissa Lutz Blouin

A boat bobs up and down on the water, its occupant still except for an occasional inquiring tug on the fishing line. On the lakeshore, a deer looks cautiously from side to side before bending its head to the water to drink. In the distance, a house sits atop a hill overlooking a lake, while cows graze on a fertile green field between the building and the water. The sounds of a city hum in the distance.

Everything in this scene is tied to water. Water is essential to our lives, but in addition to drinking water we use it for many other purposes – to grow crops, keep bodies, clothes and dishes clean and run industries. We play in the water, swimming, fishing, canoeing, boating, jet skiing, scuba diving. And of course we share the water with all the teeming life on earth that needs it as well – birds, mammals, fish, insects and plants.

Water slips through our fingers, yet over the course of time it carves canyons. We cannot survive long without water, yet too much of it can devastate cities and destroy coastlines, as we have seen in recent years in Southeast Asia and New Orleans.

And as human beings living in the United States, we tend to take water that flows from our taps for granted – until there isn't enough to go around. Then, finally, the question of who owns the water arises.

Water Rights, Underground

Historically, the law has ignored the geology of ground water and focused instead on personal property rights – the right of a person to do what he or she wishes with the water on the land, regardless of the harm to neighboring tracts. However, in the case of ground water, American courts have modified this finding to one of reasonable use, said Phillip Norvell, professor of law.

Under the reasonable use clause, a person can draw all the water needed for use on the particular tract of land in question – be it for municipal use, crop land irrigation or to provide water for a subdivision. But often the question of what constitutes reasonable use comes under dispute, and in Arkansas, there have been different interpretations of reasonable use, with some courts applying the same criteria to ground water and surface water, and other courts arguing for each land owner to have a proportional right to the water underlying the land.

Into this confusion drop problems that current ground water law does little to address. Agriculture in eastern Arkansas illustrates the issues at the forefront of water use nationwide. The Grand Prairie Alluvial Aquifer in eastern Arkansas has been a main source of irrigation for crops since 1904, making that region one of the largest producers of rice in the United States today. In the 100-plus years since then, the signs of trouble with the aquifer have started to appear. Compaction of the soil has made re-charging of the aquifer increasingly difficult. Salt water has begun to intrude where none appeared before.

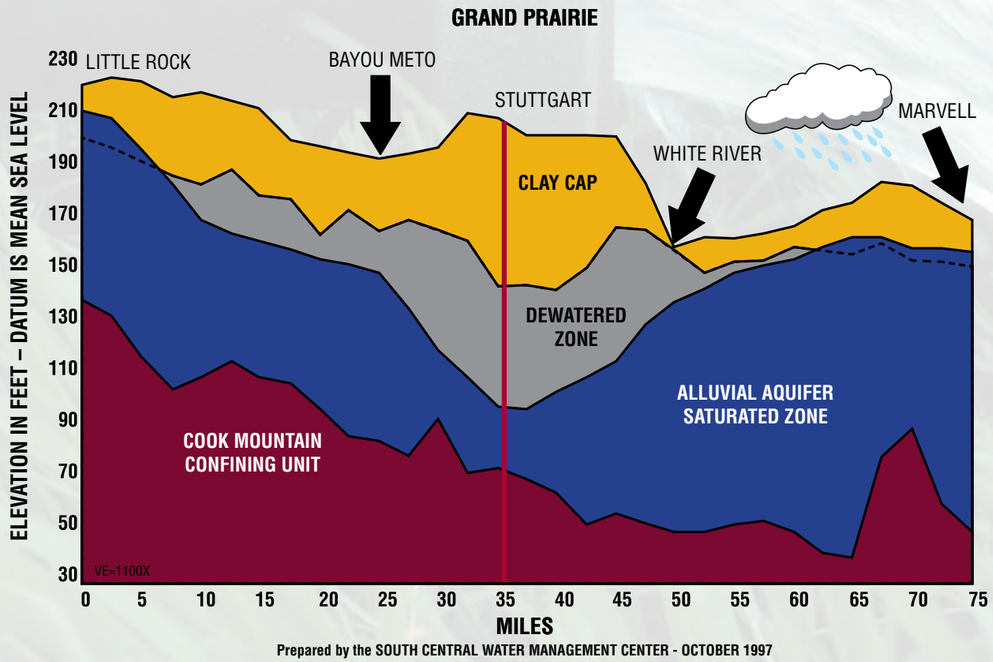
Every day, it costs the farmers in the region more to pump fresh water onto their land. And as the water becomes scarce, the farmers begin to seek other means for irrigating their fields.

The U.S. Army Corps of Engineers estimates that the aquifer will be too small for commercial use by 2015.

"The old common law has nothing to say about this," Norvell said.

In 1991, the Arkansas legislature passed the Arkansas Ground Water Protection and Management Act, which allows the Arkansas Soil and Water Conservation Commission to designate "critical groundwater areas." However, the act is complicated, requiring a permit system that applies only to high capacity wells. Wells in existence are entitled to "grandfather rights," which may enable them to continue to draw an equivalent amount of water to that which was withdrawn on average in the past three years. The act has done little to stem the flow of water out of aquifers.

Missippi River Alluvial Aquifer
Geohydrologic Cross Section



Prepared by the SOUTH CENTRAL WATER MANAGEMENT CENTER - OCTOBER 1997


Photo by Tim McCabe, USDA Natural Resources Conservation Service

USDA Photo by: Dorothea Lange

This Mexican irrigator, photographed in 1940, is working to prepare a field for flax seed in Eloy District, Pinal County, Ark. Historic water practices have lowered water levels in aquifers and created a landscape vulnerable to drought, causing pressure among different groups who want to have rights to the water.

On the Surface

Like ground water, surface water rights have their own complicated history in Arkansas. The Arkansas state legislature passed Act 1051 in 1985, which gave the Arkansas Soil and Water Conservation Commission a mandate to inventory surface water resources and to determine water needs for fish and wildlife, navigation, city use, industrial use and agricultural use. The commission also has the authority to allocate surface water as necessary during times of drought and shortage. And the commission can authorize "reasonable" transfers of "excess surface water" to entities that do not have the water on their land.

Such is the case with the Grand Prairie Area Demonstration Project, funded mainly by the federal government and implemented by the Corps of Engineers, which would take water from the White River and pump it into holding tanks on farms in the Grand Prairie region to allow the aquifer to re-charge while farmers continue to grow rice. Pump stations are expected to be online in 2007.

However, controversy surrounds the project, which some people believe will deplete the White River of necessary water – especially in times of drought, which has been the case in Arkansas for the last three years.

"The problem is, drought exacerbates the lack of surface water resources," Norvell said. This could mean difficulties if there is a lack of water for both the river and the aquifer.

The right to use surface water under what is known as the riparian rights doctrine requires that the users own the tracts of land they use the water from. This presents many problems today, Norvell said.

"Limiting use of surface water to certain tracts isn't conducive to efficiency," he said. Plus riparian rights fail to take natural factors, like drought, into account.

Norvell sees the issue with the Grand Prairie Aquifer, as well as issues like it, as an indication of a larger problem in want of a solution.

"We need a water code – a unified system to deal with ground water and surface water," he said. Norvell was involved in writing a draft of a unified code in the 1980s, but the draft did not go far.

"No one wants their rights restricted," Norvell said. However, prolonged drought may eventually force the issue, creating the need for a permit system that can help people deal with water shortages and prevent environmental harm.

"Water is peculiar. It involves private property rights, but is something the public has a great interest in," Norvell said. In Western states, water rights appear to be evolving from a private to a public issue – something that may well be headed in this direction. ■

researchers dream of sculpting streams

water ways

By Matt McGowan

UACDC

Steve Luoni points to side-by-side photographs, a juxtaposition of images that illustrates – better than 1,000 words can explain – how engineers, developers and urban planners have failed with water. The pictures document the same scene, but the images are very different. On the left is a small creek dominated by a wide, concrete sidewalk. On the right, the sidewalk has disappeared and the creek dominates everything.

Ripples on the surface illustrate the stream's violent surge. The bank is gone, and the water is poised to invade a large, flat lawn where children normally play safely. It's no surprise that people are conspicuously absent.

The volume of water in such a confined space is hard to fathom. It looks like someone's trying to pour a gallon of chocolate milk into a shot glass. The image is disturbing because the bloated creek is completely out of control. There's a kind of anarchy to it. You sense the water could do anything, go anywhere, in the blink of an eye.

"My guys have taken pictures in dangerous places," said Luoni,. "They aren't easily scared, but they said they were pretty anxious when they took those shots. And that was just ten minutes into a typical storm."

The photograph captures the awesome power of hydrology and the dangerous consequence of burying creeks underground, turning them into concrete ditches or otherwise destroying their natural structure. In this case, the creek is College Branch, a first-order stream – which means it has no tributaries – buried under Donald W. Reynolds Razorback Stadium, Bud Walton

Arena, a large parking lot and other structures on the western edge of the University of Arkansas campus.

The stream is the focus of an innovative community design project inspired by collaboration between Luoni's center, which includes students from the School of Architecture as well as permanent project designers from the center, and a group of ecological engineers led by Marty Matlock, associate professor of biological and agricultural engineering. Matlock's group consists of College of Engineering faculty, students and research engineers who also work closely with faculty in other UA schools and colleges.

In addition to the College Branch project, officially called Campus Hydroscapes, Luoni and Matlock have reached beyond the UA campus and Fayetteville to help an Arkansas town begin the arduous process of turning a polluted, flood-prone creek into an ecologically healthy stream that will serve as the core of an urban greenway and park. Another project, an innovative Habitat for Humanity housing development in Rogers, will be the first totally "green" neighborhood in Arkansas and possibly the Midwest. With hydrological analysis by the ecological engineering group, landscape design by Mark Boyer, associate professor of landscape architecture, and community and building design by staff and students at the design center, the Habitat development will reduce stress on municipal services by absorbing and treating stormwater runoff on site. Design of the Habitat development will also promote environmental responsibility and a deeper sense of community among residents.

UACDC

One design concept for the remediation of College Branch on the UA campus includes converting current parking lots along Sixth Street into a marsh to absorb rain and runoff and limit creek erosion. To recover parking spaces, this plan also suggests construction of a parking garage.

buried pipes and concrete ditches: the legacy of 'command and control'

Sadly, College Branch is the rule rather than the exception. Urban streams in virtually every American city suffer from the effects of conventional civil engineering – what a new breed of urban planners call "command-and-control" design. Chronic and flash flooding due to the elimination of flood plains and wetlands, stream-bank erosion that encroaches on and threatens property, sediment migration, loss of wildlife habitat and inferior water quality are all consequences of relegating streams to underground pipes or paved culverts.

Luoni and Matlock say these and other problems exist because planners, developers and engineers do not understand the relationship between hydrology and the value of essential ecological services provided by streams. Command-and-control strategies are ineffective in some contexts because they do not respond to environmental change. They're inflexible; they lack the ability to adapt or self-correct. This static nature complicates environmental problems and makes them more expensive to correct. The result is that cities and counties have been forced to spend taxpayers' dollars on more infrastructure and services to correct problems that could have been better addressed in the beginning.

"If we keep shoving water down a concrete ditch, somebody, somewhere has to treat it," Matlock says. "If we can increase the ecological services upstream and preserve them, it will ultimately reduce costs of treatment and increase public confidence in water quality."

Photo by Russell Cothren

Steve Luoni

Like the human body, the earth is a dynamic system with awesome power to regenerate and heal. Of course, humans have exerted their influence on the environment and severely limited the earth's propensity to self-correct. Almost daily, we see how man-made inventions threaten the earth's ability to achieve what Matlock calls dynamic equilibrium. Water is an integral part of the regenerative and healing process. If streams can exist in something close to a natural state, they will help the earth absorb, disinfect and treat nutrients, such as nitrogen and phosphorous, and toxic compounds, such as pesticides and cleaning products. This is what Matlock means by "services."

"Ecological services are the key," he says. "It's not ecosystem function or ecosystem process. It's service. It's the things we get from the ecosystem that we value."

These services include food, fiber and other raw materials, aesthetics and recreation. However, the mundane but probably more valuable services are waste treatment, disinfection, nutrient cycling and carbon sequestration in trees.

Allowing water and streams to perform these natural functions will decrease the extent to which cities and other local governments will have to treat water artificially, which is an expensive process. Matlock and Luoni argue that developers, planners and engineers have either ignored or failed to consider these important ecological services and their long-term benefits.

"These services are hugely valuable on a per-unit-area and per-unit-volume of soil," says Matlock. "We don't think about these things at all when we pave over rich, loamy earth to put in a Wal-Mart or housing addition. When this happens, we don't consider the fact that we've just encapsulated so many thousand cubic meters of living soil forever."

UACDC

Riparian Meadows, Mounds and Rooms: Urban Greenway for Warren, Ark., is UACDC's plan for a half-mile public greenway along a flood-prone creek in downtown Warren. The plan includes a series of outdoor "rooms" that can be used for recreation but also serve the critical ecological function of storing water during floods.

stream restoration, urban greenways and low-impact development

Matlock and his team put streams back together, make them into something that closely resembles what they were before humans mangled them. Property owners, developers, government officials and environmentalists ask Matlock to share best practices for developing property around a stream.

It sounds weird that someone would design a stream, but that's exactly what members of the ecological engineering group do. They use the science of ecology to design and build natural streams that not only process pollutants and control flooding but also interact with people by providing recreational space or something pleasing to look at. In essence, Matlock's group converts lifeless, artificial conveyances into dynamic, robust and diverse ecosystems that respond and adapt to environmental change.

How do they do this? The process begins with a fundamental understanding of hydrology, stream geomorphology and wildlife habitat. After assessments of the aquatic and terrestrial environment, the researchers develop a plan that may include some or all of these strategies: decreasing the topographical slope of the stream; restoring the stream's basic structure by creating a series of pools, runs and riffles, or shoals; converting a straight channel into sinuous stream; reconnecting the winding channel to the flood plain; and stabilizing stream banks by planting trees and other native plants.

As Matlock says, the priority of every engineering project is to ensure the safety of people and property. Design to maximize risk reduction. Because water has such a powerful effect on the environment and can threaten the safety of people and property if the natural systems that convey it are abused, sound hydrological design is the foundation of the collaboration between Matlock's engineers and Luoni's designers. They agree that hydrology is the base of everything else.

"First, we take care of the stream," Luoni says, "and then we take care of the urban systems around it. Improvement of ecological services in the stream serves as a platform for community development."

Beyond hydrological design, the line separating engineering and community design often blurs. While Matlock's engineers create a plan to return a stream to its floodplain, Luoni's planners visualize and design human spaces within the floodplain. Discussion between the two groups ensures that designers consider ecological services as part of a community development plan. Although areas of expertise overlap, Luoni's shop generally takes over at that fuzzy place where people can begin to occupy outdoor space without damaging the stream.

The result of this discussion is Campus Hydroscapes, which includes three design concepts for the remediation of College Branch as well as campus improvements on both sides of the stream, and Riparian Meadows, Mounds, and Rooms: Urban Greenway for Warren,

Arkansas, a study and design model for an approximately half-mile-long public greenway along a polluted and flood-prone creek that runs through heart of Warren, Ark. In addition to the plan for stream restoration, Riparian includes a series of outdoor rooms, a landscaped walking loop and raised mounds for performances, picnics and plays. As part of a broader plan for development, the study suggests refurbishing existing buildings and converting them into valuable space for public events.

The Warren project generated notoriety for the design center in 2005. In January, the center won an American Institute of Architects Honor Award for Outstanding Regional and Urban Design. The AIA honor awards constitute the highest recognition in the nation for design accomplishment in architecture, interior design and urban planning. The award is the first national AIA recognition for an Arkansas project since the late architect Fay Jones was designing homes and chapels in his native state. The design also won an Honor Award from the Arkansas Chapter of the AIA.

UACDC

UACDC's design concept for Habitat Trails, an ecologically sustainable neighborhood that will absorb and treat all storm-water runoff onsite.

In September, the Holcim Foundation for Sustainable Development, an organization that has developed a worldwide forum on design and sustainability, awarded $10,000 to the center for its work on the Warren Project. Luoni is particularly proud of the Holcim award in light of the center's emphasis on sustainable design and its collaboration with Matlock's group.

"In the architecture profession, sustainability and good design have been seen as antithetical for last 50 years," he says.

Although it is located in an upland area and not focused on a specific stream, the current collaborative project will benefit water quality downstream by processing nutrients and pollutants onsite. This summer, the Benton County, Ark., chapter of Habitat for Humanity will begin construction on Habitat Trails, a radically different kind of residential development.. Staff members and students at the design center created a neighborhood model with architectural and landscape-design features that promote community and encourage social exchange among residents. The homes – 17 units in 14 structures – will face each other and a large, open green space. As part of a Habitat project, the homes will be affordable and not too big; each unit will be approximately 1,100 square feet. Without compromising architectural aesthetics, the structures will be simple and flexible in terms of multiple uses for indoor and outdoor spaces. Carports, which may be used to park a car in or create an outdoor or indoor room, will be at the back or recessed on the side of the homes. Welcoming neighbors, open porches will face the street and common area.

When talking about the development, Luoni uses the word "neighborhood" or "community," not subdivision. "Subdivision is a real-estate phenomenon," he says. "A neighborhood is a social, civic and cultural phenomenon."

If things go according to plan, the development will also be a mini water-treatment plant. The streets will not have expensive catchment infrastructure to convey storm water off the property. There will be no buried pipes or culverts, no curbs and no storm-water drains or inlets. Rainwater and its accompanying pollutants will be retained onsite and percolate into the soil via a series of infiltration systems called bioswales. The runoff will be treated by natural bacteria in the soil via a wet meadow at one end of the development.

Photo by Russell Cothren

Marty Matlock

Matlock said the site will handle 100-year-flood volumes of water and will also meet the pre-construction, even pre-development conditions. In other words, hydrological design of the development and the plants used in the bioswales and wet meadow will ensure that the five-acre site will hold more water than it did before humans came anywhere near Northwest Arkansas.

"That means remediation is happening," he says. "We're not just treating the problem we created, we're remediating other people's problems. It shows the power of these ecology-based systems."

ecology, oikos and the re-convergence of divergent disciplines

Matlock, Luoni and Boyer, the landscape architecture professor, agree that planners' and engineers' poor understanding of the connection between hydrology and the ecological services streams provide is indicative of a deeper problem: Humans don't understand their relationship with the environment in which they live. Nowhere is this more evident than in the things we build. Roads are under water, buildings are crumbling, homes are on fire or falling off mountains and entire cities are sinking into the earth because man builds anywhere and everywhere without respect for or even fundamental understanding of ecology.

Luoni reminds us that ecology is more than a word tossed around by biology professors and environmentalists. He points to Frederic Migayrou, an influential French architect and philosopher, for a deeper understanding. Migayrou traces the etymology of ecology to the Greek "oikos," which means habitat. In Migayrou's view, ecology is a dynamic system, a dialogue between man and nature. It is the place we live, our home. Luoni says this deeper understanding of ecology explains and strengthens the convergence of his and Matlock's disciplines.

UACDC

Habitat Trails includes architectural and landscape-design features that promote community and encourage social exchange. This image shows a bioswale in front of the home. Bioswales are infiltration systems that allow rainwater to percolate into the underlying soil.

"I think the thing that binds us is the notion of ecology. … If the examination of all habitat, including human habitat, suggests that you look at everything as a resource, then there is no boundary between nature and what we construct as habitat. For me, that's always been a very important definition that binds our disciplines."

Luoni says this meaning of habitat and ecology challenges engineers and urban planners to figure out what is fundamentally ecological about environments dominated by humans. A basic principle of ecology, says Matlock, is that pristine or static ecosystems do not exist. Movement and change are constant.

"In ecology, nothing is natural," he says. "There is no such thing a pristine state, an ideal or undisturbed system. Everything is in the process of changing. There's one fundamental concept in ecology and ecosystems, and that's change. So we have to understand that and live within those constraints."

So far, planners, engineers and developers haven't done a very good job of designing and building within these constraints. Too many public spaces are planned and built as if rain were not supposed to fall and trees were not supposed to grow. Even more absurd, design of many structures seems to assume that people will not inhabit the structures. Once designers and engineers understand the fundamental concept that everything is in the process of changing, then they can begin to design systems that are robust enough to adapt to changes of the landscape.

Luoni and Matlock agree that one of the big challenges for their disciplines is how to design in human-dominated ecosystems. For this to happen, it is essential that designers and engineers examine ecology. It's not living in harmony with nature; it's living in dynamic equilibrium.

"We need to study human-dominated ecosystems as they are, not as we wish they were," Matlock says. "It's about adaptation, interaction and dynamic systems. We are part of that system, but not the sole part. We have to make where we are livable."

For Matlock, the beauty of his group's collaboration with the design center lies somewhere in his effort to rediscover the art of engineering and re-converge divergent disciplines.

"Two hundred years ago, the planners of Washington, D.C., New York and Boston got all this," he says. "Our disciplines diverged, so we're rediscovering what we already knew. Our collaboration has been incredibly robust and successful because we see the same opportunities before us with the landscape and we have different tools in which to approach those opportunities. The skills are so complementary that after working with them, I don't see how I could do my job without working with them. Sometimes there are collaborations of convenience; this is now one of necessity." ■

Steve Luoni (sluoni@uark.edu) is director of the University of Arkansas Community Design Center. Marty Matlock (mmatlock@uark.edu) is an associate professor of biological and agricultural engineering in the College of Engineering. Mark Boyer (mboyer@uark.edu) is an associate professor of landscape architecture in the School of Architecture.

To read the latest news about awards received by the University of Arkansas Community Design Center, visit the Research Frontiers Web site at http://researchfrontiers.uark.edu/ .

Researchers work to solve clean water problems

design by Amanda Ryan

story by Matt McGowan

Mother Earth has no shortage of environmental problems, but the fight for clean water may dominate environmental issues of the 21st century. Consider this fact: The World Health Organization (WHO) estimates that approximately one-sixth of humanity lacks access to any form of safe and improved water supply within 1 kilometer of their homes. That's more than a billion people, roughly three times the population of the United States, who must walk more than half a mile to find water that is clean enough to drink or bathe in.

This barrier is killing people, mostly children, because they are forced to consume and use unsafe water. According to the WHO, waterborne diseases, primarily diarrhea and malaria, account for more than two million deaths worldwide every year.

Although most deaths occur to children under five who live in rural and semi-urban areas of developing countries, disease caused by consumption of or contact with unsanitary water is not limited to the underdeveloped nations of Asia, Africa and South America. Unsafe water supply causes endemic and epidemic disease in all countries. The problem leads not only to disease and death but also economic hardship for individuals and entire communities.

In recent years, several international organizations have responded to this problem. WHO and the International Water Association have developed an international framework for the provision of safe drinking water. Described in *WHO Guidelines for Drinking-water Quality* and the *Bonn Charter for Safe Drinking Water,* the framework led to a United Nations Millennium Development Goal to reduce by half the proportion of the world's population who is unable to reach or afford safe drinking water by 2015.

Researchers and students at the University of Arkansas are contributing to the United Nations' goal. Three distinct, yet not entirely disparate, research projects led by investigators in the College of Engineering will improve water quality and ensure that more people have access to safe water. The projects vary in scale and impact, but all three will improve and perhaps save lives.

The Zaragoza Project: "I Realized I Didn't Have Any Specific Skills"

Thomas Soerens never let go of youthful idealism. Years ago, more than a decade before he earned a doctorate in civil engineering, Soerens joined Shelter Now International, a relief organization that sent him to Mexico and Pakistan. While working at an Afghan refugee camp in Peshawar, Pakistan, he had a moment of clarity about his future.

"I realized I didn't have any specific skills," said Soerens, now an associate professor of civil engineering. "So I decided to go be an engineer."

He returned to the United States, picked up a bachelor's degree in civil engineering, and went back overseas, this time to the Republic of Maldives, an island nation in the Indian Ocean. Soerens worked there for two years as a water and sanitation engineer before returning to school and eventually becoming an engineering professor.

Two years ago, a friend who works with missionaries in South America told Soerens that children in rural villages near Leticia, Colombia, were dying from waterborne diseases. The friend asked Soerens to see what he could do to help the villagers. In December 2004, Soerens visited several tiny villages on the Amazon River where Colombia, Peru and Brazil intersect.

During dry months, villagers used this pond for bathing, cooking and drinking.

He discovered the indigenous people in the villages did not have access to clean water.

There were a few wells, but they had dried up or were contaminated. For most of the year, villagers relied on rainwater for drinking and bathing. A few industrious residents had constructed crude catchment systems to exploit what nature provided. During the short dry season, people used untreated water from ponds and the Amazon.

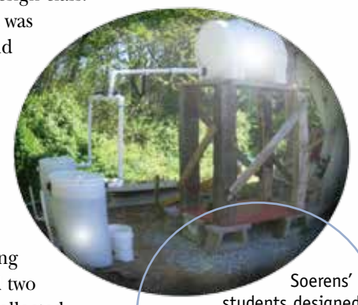
Soerens also confirmed that parasites and bacteria in the water had caused illness and death. Sadly, most villagers did not understand the connection between use of bacteria-laden water and illness or death.

Without access to a source of clean water, villagers built crude catchment systems. In this system, a cloth functioned as a filter.

Soerens returned to Fayetteville with a plan. He challenged students in his senior-level design class.

"I told my students what it was like there," Soerens said, "and asked them to come up with a system that people could use and maintain."

The students gathered scrap materials from the Engineering Research Center and devised a system that included plastic plumbing pipes, large plastic tanks and two kinds of filters. The system collected rainwater from the roof of the research center and funneled it into one tank on top of a wooden platform. Water from that tank flowed through plastic pipes to filters inside the two other tanks. The students built and tested a slow-sand filter and a biosand filter.



Soerens' students designed and built this water filtration system at the UA Engineering Research Center.

Both systems removed bacteria from the water, but the biosand system, a filter that keeps sand wet and forms a biologically active layer to help treat bacteria, worked better and produced water clean enough to drink. After construction, Soerens observed the system further and noticed that it filtered water slowly, so he modified it and added an extra tank for storing the water after it had been processed by the filter tank.

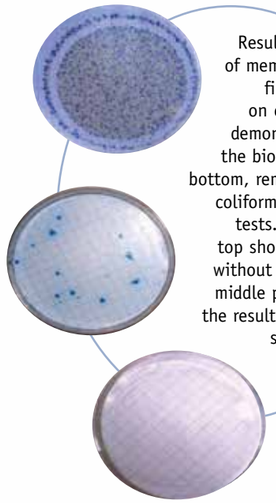
In June, Soerens returned to South America and, with help from several locals, built the filtration system at a church in Zaragoza, a small village in Colombia. Since then, villagers have used the system to obtain clean water. Soerens communicates with local officials and residents and recently confirmed that the system is working well. He said the villagers like it and requested more storage capacity to get them through dry months.

The Zaragoza system consists of gutters, a collection tank, a filter tank and a storage tank.

Through a foundation in Arkansas, Soerens is trying to raise money to build additional filtration systems in and around Zaragoza. The mayor of Leticia and governor of Amazonas, a Colombian state, have offered to help build systems at schools in other villages if the Zaragoza system continues to work well.

Without offending the indigenous population's cultural sensibilities, Soerens also wants to provide education about the importance of clean water, sanitation and hygiene.

"The priority is prevention of illness and death," he said. "For this to happen, the local people must take ownership of the system culturally and develop a reputation of being responsible for it."



Results of membrane filter tests on creek water demonstrated that the biosand filter, at bottom, removed all fecal coliform bacteria in all tests. The picture at top shows creek water without filtration. The middle picture shows the results of a slow-sand filter.

Developed Nations: Poor Land Management and the Effects of Urbanization

Poor understanding of the connection between unsafe water and disease may seem like a problem affecting only developing nations. But, when it comes to laws, policies and behavior that affect water quality, developed nations aren't much better.

In the United States and much of the developed world, population growth and urbanization have degraded water quality. To most people, this cause-and-effect relationship is not apparent, especially for those who don't consider the source of their treated water. In short, urbanization equals profound land-use change, which damages streams, rivers and lakes.

Development is particularly traumatic because removal of trees and vegetation to construct roads and buildings increases runoff, which leads to flooding, erosion and sediment washed into streams, rivers and lakes. As areas continue to develop, impervious surface – roads, buildings and parking lots – replaces pervious surface – pastures and woodlands. This means rainwater that used to soak into the soil – which processes nutrients such as nitrogen and phosphorous – now flows through a series of artificial conveyances until it reaches a stream.

Too often, agricultural operations and poor land-management practices compound the problem. Farmers use more nitrogen and phosphorous – organic elements that are essential constituents for plant life but, in excess, can accelerate eutrophication, which leads to a reduction in dissolved oxygen in water. Runoff carries these nutrients into streams and rivers. Furthermore, agricultural and domestic use of herbicides and pesticides contributes to poor water quality in streams, rivers and lakes. Not surprisingly, the influx of nutrients and chemicals makes water-treatment processes much more difficult and expensive.

Even in upland areas, urbanization and land-use change damage streams, rivers and lakes and degrade water quality.

Beaver Lake Watershed Decision Support System

Northwest Arkansas, one of the fastest growing urban areas in the United States, is not immune to the above problems. In fact, the area might be viewed as a classic example of the effect of population growth and urbanization on water quality.

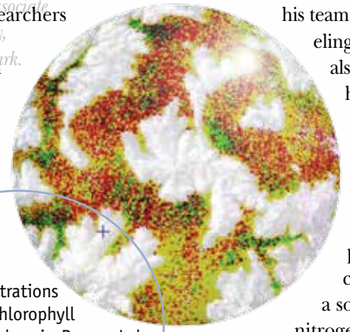
In the 1960s, the Army Corps of Engineers dammed the White River near Eureka Springs, and Beaver Lake was born. Today, Beaver Lake is the primary source of drinking water for approximately 300,000 people in a four-county area and generates millions of dollars annually in tourism revenue for the state of Arkansas. It also produces electricity for the nation's power grid.

The lake is clean, but the environmental consequences of rapid growth are threatening its water quality. Widespread development and agricultural operations within the lake's watershed have caused erosion in streams and rivers and increased transport of sediment and nutrients. The situation has caught the attention of many stakeholders because the lake is so vital to the health of the local economy.

Five years ago, Indrajeet Chaubey and his colleagues in the department of biological and agricultural engineering received funding from the Arkansas Natural Resources Commission (formerly the Arkansas Soil and Water Conservation Commission) to develop a comprehensive, geographic-information-systems-based program for the management of Beaver Lake's watershed. The first step toward creating the program involved conquering a mountain of historical data from many water-quality reports and projects sponsored by various governmental agencies and environmental organizations. Chaubey said some of these reports were in paper format only or otherwise unavailable to the general public.

After many months of work, the researchers synthesized the

historical information, which helped them accurately assess water quality and identify knowledge gaps, and created a general database of all watershed and water-quality information. They then linked the database to GIS-based information about the watershed. The researchers combined this information with their own water-quality samples taken from virtually every nook and cranny on the lake. The combination of all data comprises their final product, the Beaver Lake Watershed Decision Support System.



This satellite photograph shows concentrations of sediment, chlorophyll and organic carbon in Beaver Lake. Researchers can use satellite images to indirectly predict nutrient content in the lake water.

The system allows researchers to develop mathematical models that explain environmental processes in upland areas, streams and rivers, and the lake itself. The models show how the land is changing and how that change contributes sediment, nutrients, pesticides and other water-quality constituents to Beaver Lake. For example, the models indicate that the urban area around Fayetteville and Springdale contributes pollution to the streams and rivers that feed Beaver Lake, but agricultural areas along the west, middle and main forks of the White River also are high impact areas.

In addition to identifying low- and high-impact areas, the models can predict the environmental consequences of developing a particular piece of property and land-management changes.

"You can provide different scenarios," says Chaubey. "If I change the land here, how will it affect the lake? If you take the amount of animal manure that farmers apply and cut that in half, how much will that potentially reduce the amount of phosphorous getting into the lake?"

Chaubey says publication of the database via the Internet will ensure that watershed water-quality information is accessible and free to the public.

Recently, Chaubey has relied on satellite photographs of Northwest Arkansas to predict sediment loads and nutrient content in the lake. The new technology reduces expense because his team can gather water-quality information without traveling to many locations on the lake. The photographs also provide near real-time results, rather than having to wait a week for lab analyses of pollutant concentrations in actual water samples.

Although reading the photos is tricky, the process works because certain constituents – sediment, chlorophyll and organic carbon – in the water interact with light, and nitrogen and phosphorous attach to sediment. Also, high concentrations of chlorophyll mean there must be a source of energy, which indicates the presence of nitrogen and phosphorous.

"If you see high concentrations of chlorophyll," Chaubey says, "chances are there are high amounts of nitrogen and phosphorous present. If they weren't, algae would not be growing."

He knows algae are present because his researchers continue to draw water samples at the exact locations captured in the photographs. They compare lab results from the samples to predictions based on the photographs. So far, their predictions of the concentration of nutrient levels at various locations on Beaver Lake, based on images provided by satellite photography, have been 98 percent accurate.

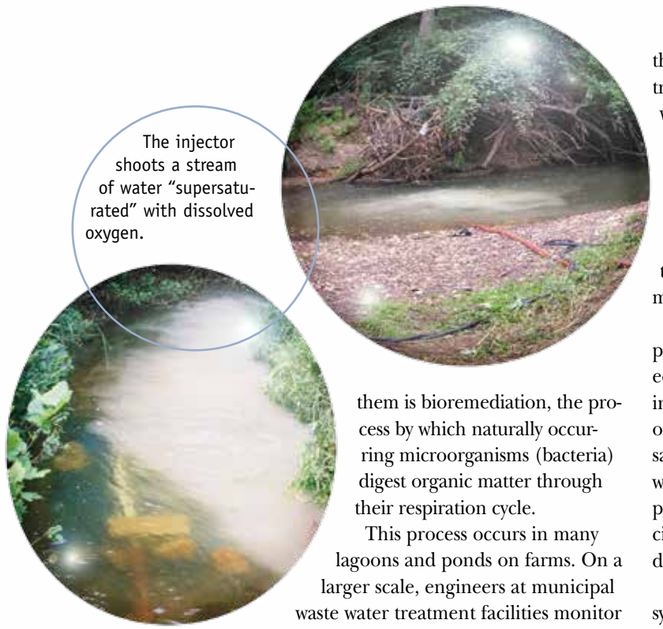
"Satellite photography provides several advantages," Chaubey says. "We can monitor the entire lake, not just one area where you take a water sample. We can do this with much less expense than having to process hundreds of thousands of water samples through the traditional lab process. Until now, we've had very limited capability to monitor what is happening on a real-time or near real-time basis."

Chaubey says Beaver Water District, the public entity charged with treating water from the lake and providing it to most Northwest Arkansans, will be able to use this technology to overlay snapshots that will help them identify water-quality trends in the lake over time.

Sumit Sen, former graduate student in the department of agricultural and biological engineering, collects a water sample from Beaver Lake on the same day that a satellite takes a photograph of the lake. Researchers compare actual water quality samples with predictions based on satellite images.

Supersaturated Dissolved Oxygen Injector

Ecologists and ecological engineers like Chaubey understand that many times the best environmental policy, other than mitigating damage at the source, is to step back and let Mother Nature do her thing. For example, when excess nutrients and other organic waste reach a body of water, the cheapest, most effective and efficient method of treating them is bioremediation, the process by which naturally occurring microorganisms (bacteria) digest organic matter through their respiration cycle.



The injector shoots a stream of water "supersaturated" with dissolved oxygen.

This process occurs in many lagoons and ponds on farms. On a larger scale, engineers at municipal waste water treatment facilities monitor the health of water bodies to facilitate the proper environment for this natural process to occur. One of the problems they encounter is insufficient oxygen in water, which reduces the rate at which bacteria can eat waste. When this happens – when waste-water becomes anaerobic – bioremediation slows down and the public complains because odor is an undesirable byproduct of insufficient oxygen.

"One of the things we're facing in Northwest Arkansas and all around the country is that when population becomes more urbanized and cities grow out to what traditionally had been rural areas, people find themselves living close to these huge waste lagoons that used to be out in the middle of nowhere," says Scott Osborn. "So now people live next to the lagoons, the wind blows, it stinks, they complain, they've got political power, and you've got to do something about it."

Traditionally, landowners and waste water treatment engineers have introduced oxygen, which is a gas, into the water to make it aerobic, speed up the biological process and eliminate the odor. Various technologies accomplish this, but none are terribly efficient because they apply oxygen directly to water. With these systems, oxygen bubbles quickly rise to the surface, and much of the gas escapes before it absorbs into the water.

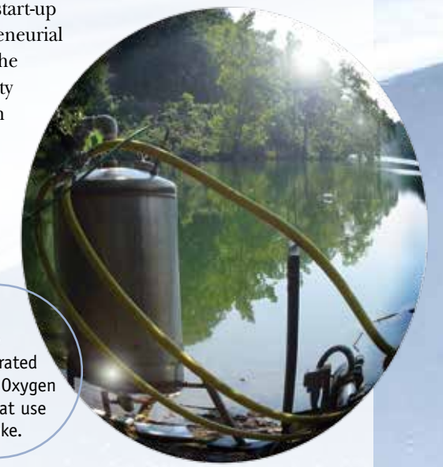
Osborn and Marty Matlock (see story about Matlock's collaboration with the UA Community Design Center, page 18) pondered this problem and created a system that more efficiently applies oxygen to water. Their patent-pending invention, the Supersaturated Dissolved Oxygen Injector, shoots a stream of water saturated with dissolved oxygen directly into a body of water that needs treatment. Because gas cannot escape from the carrier stream, the system reduces energy expenses. Water-treatment operators do not have to churn larger bodies of water to mix gas and prevent it from escaping.

"It's like mixing your coffee with liquid creamer instead of powder," Osborn says. "With liquid, you stir it once and it's mixed. With powder, you have stir and stir to get it mixed in. A lot of energy, particularly at waste water treatment plants, is spent on getting that mixing done. With our system, the energy savings is that this is simply a stream of water mixed in with other water."

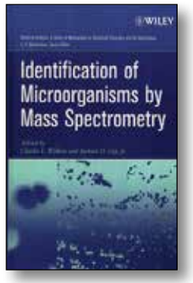
The simple device collects a water sample from a creek, pond or lake that needs dissolved oxygen. The water is directed through pumps and then into a chamber where the gas is introduced. Liquid water containing dissolved gas then comes out of the chamber. The system can strategically inject supersaturated water at any depth without significantly disturbing a water column. In other words, with long hoses, the device can pump oxygen into the bottom of lakes where there is insufficient oxygen during the summer without affecting areas that do not need additional oxygen.

The device is completely scalable. Osborn says they can build systems to fit in cupboards for in-home use, large, portable units that could deliver 200 gallons of water per minute or even gigantic, permanently installed units for waste water treatment facilities. The smaller systems are portable and, along with a generator, may be taken to remote locations that may not have a source of electricity.

Osborn is chief technology officer for BlueInGreen, LLC, a start-up company and entrepreneurial partnership between the inventors, the university and Virtual Incubation Company, a local, private company. BlueInGreen will build, sell, assemble and install the Supersaturated Dissolved Oxygen Injector and other similar systems. Osborn says they hope to sell the first oxygenator this year. ■



The portable Supersaturated Dissolved Oxygen Injector at use in a lake.



Identification of Micoorganisms by Mass Spectrometry

Edited by Charles L. Wilkins and Jackson O. Lay, Jr.

John Wiley & Sons, Inc.

Two researchers have edited a book describing ways to identify bacteria using mass spectrometry, a technique that may one day lead to early detection of biological terrorism threats.

Charles L. Wilkins, Distinguished Professor of chemistry and biochemistry, and Jackson O. Lay Jr., director of the UA Mass Spectrometry Facility, wrote chapters for and edited the book, which provides an overview of the field and the current research in specific areas.

The book will help experts from two diverse fields learn more about the other field, enhancing both.

Advances in mass spectrometry have allowed researchers to examine samples with higher masses, and advances in computational science have created larger databases, which can contain information on the myriad of proteins found in different bacteria.

Lay and Rohana Liyanage wrote two chapters on a technique known by its acronym, MALDI-MS. Lay published the first paper on MALDI mass spectrometry and bacteria in 1996 and has researched this area extensively since then.

Wilkins wrote about a technique that he pioneered using a form of MALDI-MS called Fourier transform mass spectrometry. ■

The ADD/ADHD Revolution: Treatments That Work

LaVonne Kirkpatrick and Rick Kirkpatrick

iUniverse Inc.

Parents of children diagnosed with attention deficit/hyperactivity disorder can turn to a new guidebook to help them explore additional and alternative treatments as well as traditional medication and behavioral therapy. The treatments examined range from EEG neurofeedback to aromatherapy.

LaVonne Kirkpatrick, an assistant professor of education, and her husband, Rick Kirkpatrick, a licensed clinical social worker, spent several years researching alternative treatments for ADHD. They present the information in an easy-to-read format that explains each treatment, the research behind it, the time in which results could be seen, the cost, the pros and cons and contact information.

An educator for over 30 years including several as an elementary school teacher, Kirkpatrick witnessed the anguish parents feel when faced with the ADHD diagnosis as well as their search to find the best way to help their child.

"No one treatment works equally well for everyone. Our intent is to help you (the parent) wade through the confusion so you can form your own opinions and make your own treatment choices for your child," the Kirkpatricks write. ■

Divided Power: The Presidency, Congress and the Formation of American Foreign Policy

Edited by Donald R. Kelley

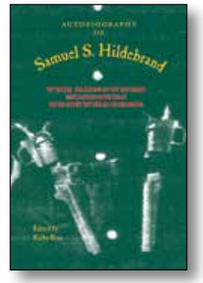
University of Arkansas Press

Divided Power, the third volume in the Fulbright Institute Series on International Affairs, focuses on the relationship between the executive and legislative branches of government in the formation of U.S. foreign policy.

The book is a collection of eight essays written by political science scholars and edited by Donald R. Kelley, professor of political science and director of the Fulbright Institute of International Relations. The essays attempt to capture the struggle between the division of powers mandated by the Constitution and the political realities of the day. The authors also examine the culture and society in which those realities exist.

Subjects touched on include foreign trade policy, authorizing war, factionalism and rivalries between the executive branch and Congress. Another essay focuses on long-term trends in congressional foreign policy behavior.

The book addresses foreign policy issues from the dawning of the 20th century to the post-September 11, 2001, era. The essays offer the reader a chance to explore the interaction of the executive and legislative branches in shaping foreign policy in modern times. ■



Autobiography of Samuel S. Hildebrand: The Renowned Missouri Buschwhacker

Edited by Kirby Ross

University of Arkansas Press

Missouri native Sam Hildebrand, one of the state's most notorious guerrillas during the Civil War, survived the conflict and, although illiterate, had his story taken down and published. The UA Press has brought that story back to modern-day audiences with a new edition featuring notes by Kirby Ross, a journalist, author and historian.

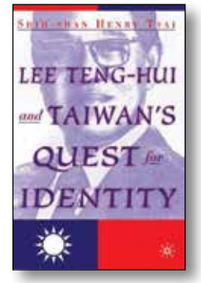
Hildebrand's reign of terror lasted for more than seven years, giving the Union army fits and keeping much of the Trans-Mississippi, especially Missouri, in turmoil. He and his men killed dozens of soldiers and civilians, and he was accused of many heinous acts. At times whole battalions of Federal troops were dispatched to hunt him down.

The bushwhacker's history has historical significance, but his story is also readable and stands on its own as a cold-blooded portrait of a violent time in American history.

The original autobiography was published in 1870 but it has long been out of print until Ross and the University of Arkansas Press created this new edition.

The book includes a bibliography of sources Ross used to examine the facts behind Hildebrand's words.

The book will be a delight for both Civil War historians and enthusiasts. ■



Lee Teng-hui and Taiwan's Quest for Identity

Shih-shan Henry Tsai

Palgrave Macmillan

Shih-shan Henry Tsai's seventh book provides a chronicle of a leader's life, and a description of the evolution of a country of key interest to the global economy.

Today, Taiwan is an economic powerhouse, a small island with 23 million people, nearly 3.7 percent of the world's gross domestic product and over $375 billion in foreign reserves. The country's history is entwined with that of Lee Teng-hui, who served as mayor of Taipei, governor and vice president of Taiwan, and finally president of Taiwan for 12 years.

As an island nation, Taiwan is vital to controlling the sea lanes. Despite Taiwan's current democracy, China still claims sovereignty over Taiwan. Because Taiwan generally shares American values and also occupies an important strategic position in the West Pacific, the United States wants to keep communist China from swallowing Taiwan. Against this backdrop, Tsai's book presents the current challenges of U.S.-China-Taiwan relationships.

Tsai tries to answer questions about his protagonist, who has been called an opportunist by some and a hero by others. He concluded that as the leader of Taiwan, Lee finally could speak from his heart of hearts. ■

Dying Light and Other Stories

Donald Hays

MacAdam/Cage Publishing

The collection of short stories by creative writing professor Donald Hays begins with a character in "The Rites of Love" observing that "Wasn't for dying, wouldn't be no living at all." Throughout, the people he creates contend with lives gone awry and live with "the sweetness of regret."

Novelist Ellen Gilchrist says that "Donald Hays takes us to meet people we want to know more about." Dying Light, she says, is "a generous and compelling read, fresh and real and true."

In the end, in the title story, a dying man tells his son that death is easy: "Nothing you can do about it. But you know, you got choices to make, one way or the other." The consequences of choices made or accepted mark the lives of these people. The stories are suffused with regret, sometimes bitter and vengeful. They are also relieved with moments of humor and lines like "Phoenix is what happens when there is no poetry."

Several of the stories previously appeared in literary magazines such as The Southern Review and The Missouri Review. The title story, "Dying Light," was selected for inclusion in New Stories from the South: The Year's Best 2003. ■

How is coffee decaffeinated?

Jerry King, the Ansel and Virginia Condray Distinguished Professor of Chemical Engineering, replies:

Coffee can be decaffeinated by various means. Existing processes employ organic solvents, or alternatively compressed carbon dioxide or hot water. In many of these processes, water is used to swell the coffee bean – which contains approximately one percent caffeine, 25 percent soluble flavor components, and 74 percent insoluble components – to better prepare it for the selective removal of caffeine. One of the more popular methods of coffee decaffeination is called the "Swiss water" process in which hot pressured water is used to extract the caffeine and some of the soluble components – the caffeine being removed from the water process stream via adsorption onto activated carbon, while the flavor components remain in the water stream to treat the next batch of coffee beans.

Another popular process uses "supercritical carbon dioxide," which is compressed carbon dioxide held at a high temperature and pressure, to extract the caffeine. The extraction for caffeine is made specific by adding moisture to the beans. Methods which employ carbon dioxide and/or water are frequently termed "natural decaffeination" methods and offer an alternative to using toxic chemicals such as methylene chloride for caffeine extraction. Methylene chloride-decaffeinated coffees typically have less than 0.1 parts per million of residual methylene chloride, 100 times less than the maximum level allowed by the Food and Drug Administration. Hence, even with this organic solvent extraction process, decaffeination processors endeavor to keep residual organic solvents at very low levels. There are many variations for coffee decaffeination, but all yield a coffee that is 97 to 99.9 percent caffeine-free. The largest supercritical carbon dioxide decaffeination plant in the world is operated in Houston, Texas. These pressurized extraction methods are used by several research groups here on campus in their research efforts. ■

What is game theory and what are some of its applications?

Mark Arnold, associate professor of mathematics, replies:

Photos by Russell Cothren

Under what conditions should a newly hatched caterpillar eat other butterfly eggs sharing its leaf? Should one ignore an insult, or is it better to reply in same, or with harsher retribution? Can a government selling radio frequencies detect whether companies are bidding fairly, or are in collusion? All of these questions have been illuminated by a branch of mathematics called game theory.

Today game theory is a fundamental tool in corporate, military and political decision making, and is a powerful explanatory tool in biology, economics, management and political science, to name a few. Modern game theory began with an ancient game: a 1913 theorem postulated by E. Zermelo about chess.

But John von Neumann was the major figure in the field from 1928 through World War II. By the 1950s, game theory had become a major branch of applied mathematics. Stephen Nash's Nobel Prize in Economics was awarded for his work on game theory in the early 1950s.

Game theory is the study of mathematical models describing the interactions of player strategies as they relate to achieving some goal. For example, suppose you and a number of coworkers who currently make $18/hour have failed to negotiate a new contract for $20/hour, and have decided to strike. The company is offering $19/hour to anyone willing to work. A $1 raise is therefore possible for someone willing to cross the picket line, while sticking together could yield everyone a $2 raise. Management might arrive at $19 as an optimal value which inhibits cooperation among workers while minimizing labor cost. ■