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University of Arkansas Fayetteville. Office of University Relations. (2008). Research Frontiers, Spring 2008. *Research Frontiers*. Retrieved from <https://scholarworks.uark.edu/research-frontiers-magazine/12>

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UNIVERSITY OF ARKANSAS RESEARCH FRONTIERS SPRING 2008

**Conserving Water
Through Good Design**

**Creating Environmentally
Friendly Technology**

**Practicing Business
Sustainably**

Studying Biodiversity

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Fayetteville, Arkansas 72701

Office of the Chancellor
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Message from the Chancellor

In February of 2007, the University of Arkansas became the first institution of higher education in the state, and among the first 100 in the country, to sign the American College and University Presidents Climate Commitment.

This committed us to develop an action plan to make our campus climate neutral by 2009; to implement at least two specific programs for reducing greenhouse gases while this plan is created; and to make the action plan and all progress reports accessible to the public.

In this issue of *Research Frontiers*, you will learn more about the wide-ranging research projects being done on campus to make sustainability globally viable. It is equally imperative that we support sustainability on an institutional level. That said, signing the commitment was the easy part. Honoring it will be much more difficult, though we're off to a terrific start.

Achieving climate neutrality on campus will require all the students, faculty and staff do their share. Nevertheless, a disproportionate part of the heavy lifting will devolve to the facilities management team. Fortunately, the Presidents Commitment only accelerates, rather than initiates, a process that began in the early '90s with campus tree planting and recycling programs. Mike Johnson, associate vice chancellor for facilities management, is overseeing the implementation of dozens of new, ongoing or planned projects that include recycling at football games, move-in day recycling at residence halls and acquiring a fleet of campus vehicles that use alternative fuels or electricity.

To help implement the Presidents Commitment, we also have hired our first executive assistant for sustainability in the facilities management department, Nick Brown, who already has created a pollution prevention program for the university that currently is under review.

Someone who has been making the case that sustainability also is an economic imperative is Jon Johnson, executive director of the university's recently established Applied Sustainability Center, and a professor in the Sam M. Walton College of Business. With an initial \$1.5 million donation from Wal-Mart, the center's mandate is to unite academic experts and business leaders to develop sustainable business practices and implement them in the retail and consumer-goods industries.

On campus, the center will consult with the facilities management team to create green solutions, train and educate staff and students about sustainability, partner with student and non-governmental organizations and eventually coordinate with faculty to incorporate sustainability concepts into their curricula.

We're making great strides toward achieving climate neutrality by 2009. To learn more about the Presidents Commitment and ongoing campus initiatives in which you can become involved, please go to <http://sustainability.uark.edu> online. It's going to take all of us, doing our share, to turn commitment into accomplishment.

Happy reading,

John A. White
Chancellor



Patience: The Heart of Ethics

By Barbara Jaquish

While fidgety children may be told that "patience is a virtue," a philosopher has found patience to be much more profound than simple, passive waiting. Rather, Irene McMullin says, patience is "the living heart of ethics."

Her analysis of patience is part of a larger project aimed at showing everyday ways people acknowledge the "personhood" of those around us. Patience is a "neglected virtue," little examined by philosophy or society at large.

"I call patience a neglected virtue because we don't value it as much as courage or generosity because it involves a withholding of self," McMullin says. "In business, for example, we don't recognize good management as patient, such as when a manager steps back and lets others be part of the creative process."

The self-restraint particular to patience in one person is specifically oriented to another person's "agency" or ability to act. McMullin uses an example of letting her young nephew take his time tying his shoelaces. She holds herself back from doing the task for him. Her restraint is characterized by "a hovering attentiveness, a silent co-willing, an expressive encouragement and recognition of his struggle." While she wants the laces to be tied, her attitude is directed not to the goal of tied laces, but primarily toward her nephew's achievement of the goal. This type of attitude involves both a willingness to share one's time with the other person and an acknowledgement of the limits of human agency.

She contrasts patience with impatience, which can include an element of contempt for another person's abilities or a refusal to acknowledge the awkwardness and difficulties of so many human activities. McMullin calls impatience "a type of rage in the face of human finitude."

The impatient person — the one who taps a foot while someone else negotiates the ATM instructions — communicates a sense of being offended, even wronged, by the failures of others and the necessity of sharing time with them. In a sense, the very fact that the other person is in the world takes away from the impatient person.

McMullin distinguishes patience from tolerance.

"When I tolerate someone, I do not share the drama and meaning of his struggle," McMullin said. "Though tolerance is an important and necessary part of shared public life, patience involves a deeper form



Photo by Russell Cochran

of recognition and accommodation of the other's presence as an individual struggling to act in the world."

McMullin observes that in patience, a person subordinates his or her own wishes and goals to another's future, sometimes a future they will never share. An individual practicing tolerance simply waits for the completion of activity — for the other person to walk away from the ATM, for instance. In contrast, the patient individual encourages the other person to take the time necessary for *successful* completion.

"Though we may not be able to characterize patience as a 'heroic' virtue," McMullin says, "the ability to accommodate and forgive the limits of human agency in its struggle for self-expression is the bedrock of our public life."

Irene McMullin is an assistant professor of philosophy in the J. William Fulbright College of Arts and Sciences. ■

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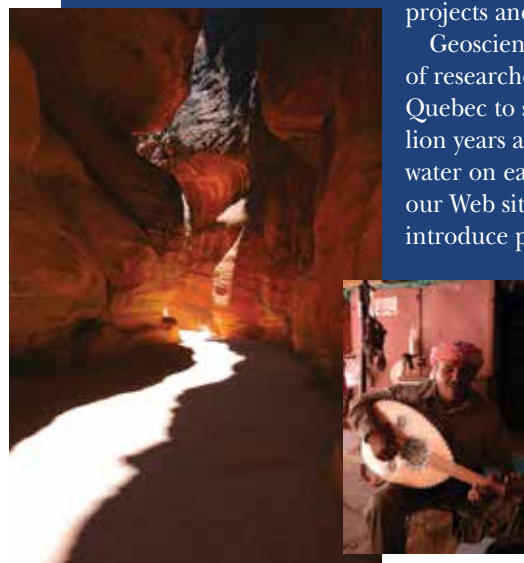
Clean water matters not only to those of us who drink it, but also to those creatures that live in it. An ecologist studies what happens to communities of macroinvertebrates when the water becomes overloaded with nutrients from runoff.



Research in Motion: From a pristine lake in northern Canada to a historic site carved from stone in the Jordanian desert, the world's wonders yield important information about the earth and the people on it. But these sites also are in danger of being destroyed. In two videos, two geosciences researchers discuss their research projects and the importance of preservation in both instances.

Geosciences professor Sonja Hausmann and an international team of researchers took ski-doo and sleds to Lake Pingualuit in northern Quebec to study core samples from its waters. The lake, formed 1.4 million years ago by a meteor crater, contains some of the most pristine water on earth — the water turns over about once every 300 years. Visit our Web site to find out how the researchers worked to be sure not to introduce pollution into the lake.

As tourists visit Petra, recently named one of the Seven Wonders of the World, they literally wear the sandstone away beneath their feet. Geosciences professor Tom Paradise and his colleagues are working with the Jordanian government to find ways for tourism and preservation to work together to keep this historically important site around for future generations. Visit the Web site to see the positive changes taking place at Petra.



Questions Answered: Watch translation professor John DuVal as he explains the difference between Italian and Romanesco and reads from examples of both. You can visit the site weekly to get the answers to all of your questions.

Creating Content: A group of ceramic artists from all over the country gathered on campus to discuss the culture of ceramics. Art professor Jeannie Hulen discusses the work of ceramicists and gives an overview of the exhibit that came to town during "Crafting Content: Ceramic Symposium 2008."

Photos submitted

Researchers Develop Adaptive Technology for Visually Impaired Engineers

By adding features to commonly used chemical-engineering software packages, researchers at the University of Arkansas, the University of Akron and Chemstations Inc. have developed adaptive technology that allows blind or visually impaired students and working professionals to perform the essential functions of chemical-engineering process design.

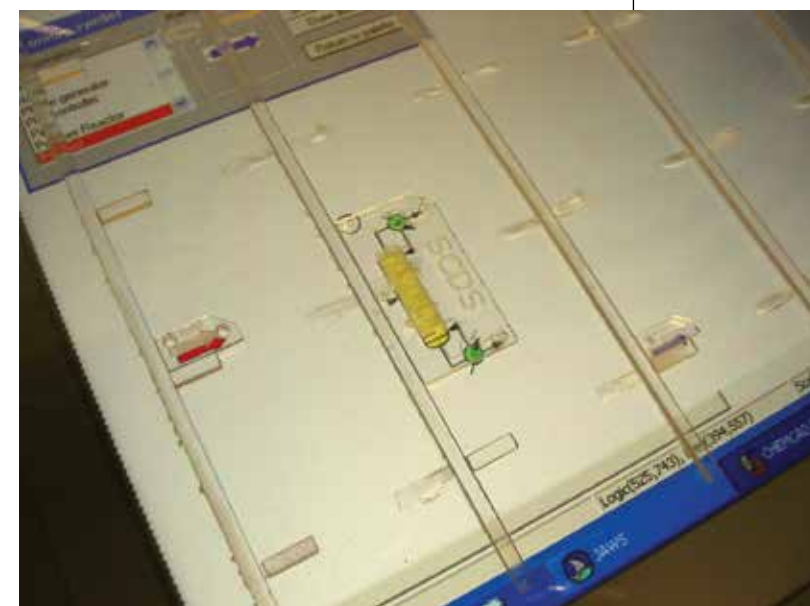
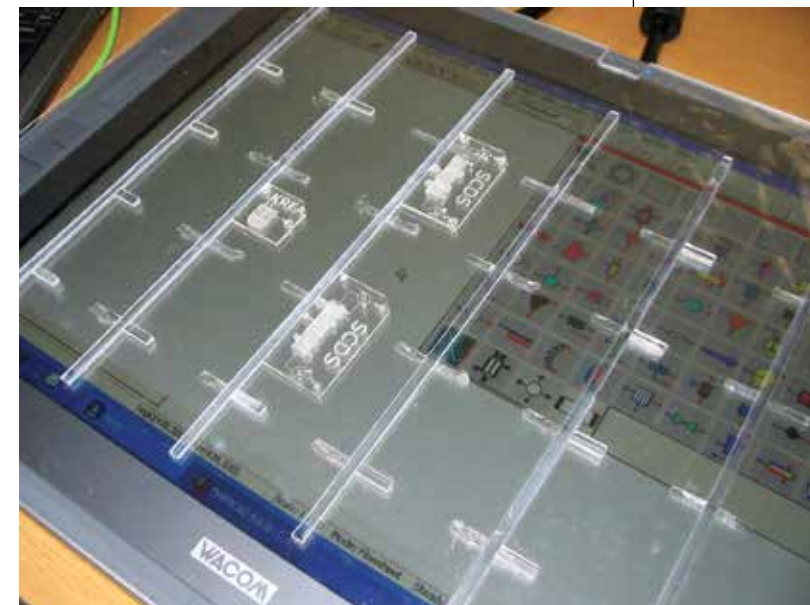
Led by Bob Beitle, professor of chemical engineering, the research team created a system that combines tactile, Braille-like representations that can be "read" by visually impaired chemical engineers. The system also includes an audio, screen-reading component and audible indicators of certain software functions. Researchers also have overcome a major obstacle associated with the user function of dragging and dropping or copying and pasting. A tablet computer with a customized overlay, a tablet pen functioning as a computer mouse, and alignment holes mapped to the tactile objects help facilitate the drag-and-drop function, which is the method that connects unit operations.

"We are far enough into this project for me to say that we have significantly minimized the differences between visually impaired and sighted engineers who do process design," Beitle said. "While we haven't eliminated all differences, we have reached a point where a blind chemical engineer can conduct himself as any engineer by manipulating process-engineering software to achieve improvements or investigate alternatives."

The system has been tested at a process-engineering firm by graduate student Noel Romey. Romey, who has been blind since birth, came to the university to study chemical engineering. Since May, he has tested the system by simulating and designing various chemical facilities. The extensive designs are used by clients of the design firm to improve manufacturing systems.

In addition to the computer modifications, the research project has a psychological component. Whether in the classroom or at an engineering firm, engineers must work as a team on design projects. This reality made Beitle think about the importance of language and the verbal exchange of information between blind and sighted professionals. How can design team members convey technical information when a visual diagram cannot be relied upon?

Beitle and his design students collaborated with Douglas Behrend, professor and chair of the psychology department, and Rachel Schwartz, a psychology graduate student. The researchers studied individuals with different communication styles and measured the reliance on vague language, visual cues and gestures.



Photos submitted

When working with Romey, sighted students seemed to modify patterns of communication in ways that suggested they were considering the dynamics of working with a visually impaired colleague. Behrend said this may be explained by group members using metacognition, defined as knowledge of and about their own and others' cognitive processes.

"This added dimension of this project will prepare sighted members of a design team to communicate effectively in a technical fashion with less reliance on visual cues," Beitle said. ■

The researchers' system for the visually impaired includes a screen overlay with tactiles, small objects embossed with patterns that represent various graphical-user-interface icons.

Lyrics Can Be a Scaffold for Literature

A former high school English teacher turned literacy researcher says that discussing song lyrics in the classroom can help students connect in multiple, complex levels with traditional literature. Christian Z. Goering now hosts a Web site for teachers to share links between literature and lyrics.

Goering emphasizes the ways song lyrics can open up literature and literary concepts to adolescents, but he is not suggesting replacing literature with popular culture in high school classrooms.

"What I am suggesting is that we pair pieces of classic literature with contemporary music, allowing some of the natural, thematic connections to come to the surface and allowing our students to see these connections and the relevance to their own lives," Goering said.

Music lyrics can be an especially effective hook, given the importance of music to adolescents. Goering cited a survey that asked which form of entertainment teenagers would take to a desert island. Students in seventh, ninth and 11th grades chose music over television, books, computers, video games, radios, newspapers and magazines.

Lyrics can serve as a bridge for students, Goering noted, from material that may be familiar or easily understood to classic literature that may be more difficult or challenging. For example, "California Sky" by the Bastard Sons of Johnny Cash takes listeners from "out in Oklahoma where the hard winds blow" on a cross-country journey that can open up a discussion of John Steinbeck's *Grapes of Wrath*.

"Tunes, I discovered, directed students toward an avenue where conversation about more serious, literary topics could take place," Goering said. "Pop music dismantled roadblocks between students and their peers, between students and literary texts, and between students and their teacher."

Goering's Web site, www.LitTunes.com, offers research into the use of music lyrics in teaching literature, examples of pairings of specific tunes and literature, and a place for teachers and students to contribute their own pairings. ■

Writing Was Performance Art on Archaic Greek Pottery

A "communication explosion" in the early days of the Greek alphabet brought both writing and figure scenes onto pottery in the eighth century B.C.E. Whatever the purpose of an inscription, when writing appeared on ancient Greek pottery, it became performance art.

Research by Alexandra Pappas of the University of Arkansas and Robin Osborne of Cambridge University revealed not only the great variety of writing on pottery from ancient Athens, Corinth and Boeotia but also its performative nature. They are co-authors of "Writing on Archaic Greek Pottery," a chapter in *Inscribing Images, Illustrating Texts: Art and Inscriptions in the Ancient World*, published by Cambridge University Press in 2007.

At times, writing provided an alternative form of geometric decoration to the lines and zigzags used on early Greek pottery. When figures were painted on a pot, inscriptions often played a complementary role in communicating a story.

For example, a Corinthian aryballos — a small, narrow-necked vase used as an oil bottle by athletes — shows horses with two figures, named "horse walker" and "horse turner." The shape of the names on the pot "reflects and reinforces their meaning." The name "horse walker" runs vertically behind the figure and leads to the ground, "planted there like the feet of the figure." In contrast, the name "horse turner" curves down from the head to waist of the rider, suggesting the forward motion of the horse.

"What is important about all the names is that they do not bring the viewer additional information from 'outside' the picture, but draw attention to features of the picture itself," Pappas and Osborne wrote.

Simply putting the words on a pot was more engaging than inscribing a stone tablet.

"Writing does things on a pot, it engages with the viewer as the viewer uses the pot," the scholars wrote. "The appearance of the writing was always important, and the effect of the writing on the user of the pot calculated." ■

Researcher Helps Banks Predict Losses in Lending

In response to federal banking regulators' concern about community banks' increased participation in commercial real-estate lending, a researcher has developed a system that allows banks to perform stress tests on their commercial real-estate portfolios.

Tim Yeager, an associate professor of finance, modeled how large losses within categories of commercial real-estate loans would affect a bank's overall losses, earnings and capital. His spreadsheet-based simulation tracked the effects of significant losses, or "shocks," in eight categories, including retail, industry and construction and land development.

"Nationwide, commercial real-estate loans at community banks have exploded from 23 percent of total loans in 1990 to 47 percent in 2005," said Yeager. "It is not surprising, therefore, that bank supervisors have expressed concern at the growing concentration."

Participant banks had an average of \$144.7 million in commercial real-estate loans, of which 45 percent was in construction and land development. A 20 percent shock — or rate of loss — to this category relative to

the other loan types produced the largest negative effect due to its dominant proportion of the banks' loan portfolios. This worst-case scenario reduced average capital ratios by 3 percentage points in the first year.

The capital ratio is a bank's equity divided by assets. High capital ratios protect a bank from insolvency because shareholder equity absorbs the first losses, Yeager said. Typical capital ratios for banks run between 7 and 9 percent. A capital ratio of 2 percent is the threshold that bank regulators use to close a bank.

As a tool for any community bank, Yeager's simulation method allows users to "shock" each loan category separately and provides a five-year forecast of balance-sheet and income-statement effects. Results of the simulation estimate the effects of a large loss to banks' commercial real-estate portfolios.

"To prepare banks and provide the most useful information, our results are skewed toward a reasonable, worst-case scenario," Yeager said. ■

Downloading Songs Part of Protected Speech

An Internet law expert argues that automatically punishing those who illegally download music violates the First Amendment.

"The First Amendment comes into play because downloading is a form of speech," said Ned Snow, assistant professor in the School of Law. "Downloading is the same as copying, and copying is a form of expression."

In his article, "Copytraps," Snow emphasizes that the First Amendment protects the act of downloading when the downloader has permission to make a copy. Snow argues that legal downloading, however, is chilled by the potential for "copytraps," Web sites that falsely represent downloading as legal. The automatic and severe punishment of innocent downloaders makes Internet users reluctant to download material that seems legal.

If a copyright holder has not authorized the downloading, regardless of a Web site's representations or appearance, the downloader is liable and can be fined a minimum of \$750 per downloaded song. This

automatic punishment, Snow argues, penalizes innocent Internet users who have no means to know that the material offered on a Web site infringes a copyright.

"Internet users who are aware of the law or who have fallen victim to a 'copytrap' are much more wary of sites purporting to offer legal downloads," Snow said.

This wariness is the essence of Snow's argument that "copytraps" may inhibit users from downloading legal material, and that inhibition represents a restraint on speech protected by the First Amendment. ■



Alexandra Pappas



Tim Yeager





What is International in Higher Education?

Graduate student surveys schools to find out

By Matthew S. Brizzi

When Karl Anderson set out to discover how globalism is affecting American higher education and what programs colleges and universities are implementing to internationalize their campuses, he was surprised to find an obvious gap in research on the subject.

Anderson, a Lincoln, Neb., native, is finishing up his final year as a master's student in the higher education leadership program and decided to use his thesis to fill in this gap after discussing the topic with his adviser, Michael T. Miller, department head and professor in the College of Education and Health Professions. As he read articles on international education and internationalization within the context of higher education, he was unable to find much information on what types of partnerships colleges and universities currently have in place to internationalize their campuses. Most of what he found dealt with study abroad programs.

"The purpose of my thesis is to get an idea of what kind of international partnerships exist, why they exist, who they benefit and to what extent they benefit from them," Anderson explained. "So it's not meant to analyze one type of partnership over another, identify a partnership that's better than another or identify the best partnership. It's just designed to see what kinds of partnerships exist among the 50 land grant institutions around the country.

"I chose to study land grant institutions because they were easy to identify. Most people have heard of at least the term land grant institution and can identify that they are public schools. Also, I chose them because of their original mission to reach out and assist the community, and I took the liberty of extending that in this day and age to globalized communities. So what role are these land grant institutions going to play in today's globalized world?"

Anderson developed a survey and sent it to all 50 land grant institutions. He wanted to make the survey as open-ended as possible so the institutions could report any and all international partnerships, however they chose to define them.

"When I decided I wanted to identify the types, value and impetus behind the programs, the survey kind of created itself," Anderson said. "The institutions know why they created these partnerships,

and so we wanted open-ended questions so they could articulate those reasons."

Anderson received 29 completed surveys, and 15 of the 29 institutions indicated that they had more than 101 international partnerships in place.

After analyzing the answers, he discovered some interesting trends. First on the list is an inconsistency in the data between what institutions say about internationalization and the reality on their campuses.

"I was surprised at how little the institutions seemed to know about the specific types of programs that are going on on their campuses," Anderson said. "They all expressed how important internationalization is to them, but they have no idea to what extent their campuses are truly internationalized. They can tell you maybe how many programs they have, but they don't know who runs them or why they were created. It seems to me something like this needs to be centralized as much as it can be."

Secondly, the survey respondents overwhelmingly indicated that the majority of partnerships benefit faculty and administrators more than students. Study abroad experiences provide direct benefits to students, but other types of international partnerships, like research collaborations, provide more direct benefits to faculty and administrators.

And these beneficiaries seem to want to create international partnerships for different reasons.

"Administrators see creating prestige and visibility as perhaps the most important outcomes of internationalizing their campuses," Anderson said. "They see it as the more international partnerships we have, the better we're going to look. I don't know if it's completely fair to say that, but from everything I've read and from the survey responses, a lot of administrators' comments deal with prestige and making a name for the institution and not benefits to students. So there seems to be a difference between faculty perceptions of these partnerships and administrative perceptions of these partnerships."

Faculty are the number one source of international partnership creation and, according to the survey, take the initiative to create them usually because they have a colleague at a foreign institution with whom they want to collaborate, usually on research.


"The extent to which faculty are involved in creating these partnerships surprised me," Anderson said. "I just didn't realize that faculty would be that interested or take the initiative to start them. I assumed when I started this study that the impetus would come from the administration down to the faculty."

Anderson considers his research as the first step in bridging the gap in research on the internationalization of American higher education.

"A future study could look at the best way to create an internationalization plan for a university," he said. "How do you run 101 plus programs from a central location so you have an idea of what's going on on your campus?"



Photo by Russell Cothren



Sustainability

By Matt McGowan

An essential principle of sustainability addresses the reality that the earth's resources, which provide basic necessities such as water, heat and shelter — not to mention luxuries such as electricity and fuel for automobiles — are not infinite and perpetually giving. They aren't even abundant, in an economically feasible sense. For example, most of the earth's remaining oil reserves will be difficult — and therefore extremely expensive — to physically access and exploit. Water is no different. As our insatiable thirst for it rapidly drains aquifers, millions of people in developing countries must walk half a mile or more to reach water fit to drink or bathe in, and tens of thousands of people die from water-borne illnesses every day.

So what can be done to slow down or reverse this trend? How can current generations ensure that future ones are left with enough water to drink, enough fuel to heat homes and enough materials to build those homes? One thing is certain: To conserve natural resources and preserve a similar quality of life for future generations, humans today must change their behavior. In

short, we must pollute less, waste less and consume less.

But more can be done. On the production end, the sustainability movement challenges researchers to design and build efficient, less wasteful and clean — or “green” — products and processes. As a fundamentally applied science, engineering has a huge responsibility in this endeavor. In fact, some professionals argue that good design is inherently sustainable.

“Sustainability, in the larger sense, is supposed to infuse everything we do as engineers — it's always been that way,” said Kevin Hall, professor and head of the department of civil engineering. “As the world's needs change, engineering practices change with it. It just makes a lot of sense that what we design and build now can be sustained — not to become obsolete and disposed of at some point. For engineers, it's about how we use technology to extend the life of products and restore, renew and reuse natural resources to meet society's needs over the long run.”

At the College of Engineering, sustainability has been a strategic goal and point of emphasis for many years, maybe a full decade before the university declared sustainability a priority. The issue pervades labs and classrooms. These researchers lead the way.

Photos by Russell Cochren, iStock



Chemical engineering researcher Jerry King, top, Julie Carrier, center, and Ed Clausen use clean and “green” processes to extract various products from fluids.

Improving Chemical Extraction With “Friendly” Natural Processes

Working with “green” fluids instead of chemicals, several researchers pursue projects that use an earth-friendly “critical fluid technology” to extract added-value products from foods before they are consumed or crops before they are converted to biofuels such as ethanol. Jerry King, holder of the Ansel and Virginia Condray Endowed Professorship in Biochemical and Chemical Separations, is one of the pioneers of critical fluid technology, a “green” process that uses water or carbon dioxide gas at high temperatures and high pressures to extract substances from biomass.

The process can remove caffeine from coffee, fat from meat and pesticides from fruits and vegetables. It also can replace the use of organic solvents, which result in expensive hazardous waste and often leave a chemical residue in the products.

“We’ve been working on this for a lot longer than ‘sustainability’ has been a catchword,” King said. “But it fits right in. We are going to use nature and give back to nature.”

With support from the U.S. Department of Agriculture, King and Luke Howard, professor of food science, extract antioxidant products from grapes. Human use of antioxidants is popular as a dietary supplement in fighting coronary artery disease, some cancers, Alzheimer’s disease and some forms of arthritis. Researchers in King’s lab have the capability to extract antioxidants and other products from a variety of other crops and convert the left-over residues into high-value, bio-renewable products.

Another aspect of King’s research involves coupling the green processing agents in consecutive extraction-reaction steps for the conversion of biomass and industrial waste products into fuels and higher-value chemicals. Collaborating with research teams in Japan, Germany and Great Britain, he is using compressed water and carbon dioxide with “natural” enzymes to produce feedstocks for the production of bioethanol and biodiesel as well as other chemicals. This sustainable-technology platform is applied to the recycling of waste plastics and the conversion of animal-based protein wastes into value-added chemicals.

The development of biofuels has been a hallmark of the sustainability movement. The great challenge is to make biofuel production a cost-feasible enterprise, since the cost of fossil fuels — even at their rising price — remains cheaper. In research similar to King’s, Julie Carrier, associate professor of biological and agricultural engineering, and Ed Clausen, the Ray C. Adam Endowed Chair in Chemical Engineering, combined their primary areas of study in a possible solution for

Sustainability is the recognition of the moral obligation that future generations’ prosperity should not be sacrificed for short-term gain today.

– Greg Thoma, professor of chemical engineering, College of Engineering



Students Joel Vincent and Brian Mattingly and chemical engineering professor Buddy Babcock convert feedstocks into biodiesel.

the biofuel economic equation. Carrier’s work concentrates on extraction of added-value products using critical fluid technology, and Clausen’s work concentrates on converting crops to biofuels.

They work with switchgrass, a plant that grows tall and in abundance, which makes it a good biofuel crop. Carrier and Clausen have successfully used water to extract antioxidants from switchgrass. Their studies have shown the extraction process leaves no measurable loss of energy potential when the crop is later converted to cellulose ethanol.

“Instead of just throwing away a product, which would not get used, we’re getting some additional value products,” Clausen said.

Converting Chicken Fat and Tall Oil Fatty Acid Into Biodiesel

Other chemical engineering researchers, supported by the Mack-Blackwell Rural Transportation Center, make biodiesel, a “green” fuel, out of low-cost feedstocks and other agricultural by-products. Buddy Babcock, professor of chemical engineering, Clausen, and Michael Popp, associate professor of agricultural economics, have supervised two graduate students, Brian Mattingly and Brent Schulte, who successfully converted chicken fat into biodiesel fuel. Schulte also converted tall-oil fatty acid, a major by-product of the

Sustainability, in the larger sense, is supposed to infuse everything we do as engineers — it's always been that way. As the world's needs change, engineering practices change with it. It just makes a lot of sense that what we design and build now can be sustained — not to become obsolete and disposed of at some point. For engineers, it's about how we use technology to extend the life of products and restore, renew and reuse natural resources to meet society's needs over the long run.

– Kevin Hall, professor and head of the department of civil engineering.



Equipment at the National Center for Reliable Electric Power Transmission will help researchers develop power-electronics interfaces for renewable energy sources.

wood-pulping process.

Both projects illustrated that in light of rising petroleum diesel costs, biodiesel can be economically competitive as long as feedstock prices are not prohibitive. Babcock said his students' work could lead oil companies and energy producers to seriously consider combining petroleum-based diesel with a biodiesel product made out of crude and inexpensive feedstocks.

"We're trying to expand the petroleum base," Mattingly said. "Even 5 to 20 percent blending of biodiesel into petroleum-based diesel significantly reduces our dependence on foreign oil, and, perhaps equally important, we're using a renewable resource. These are just a few of biodiesel's benefits."

For anyone concerned about air quality and global

warming, the thought of using fat from chicken parts to power automobiles that emit less pollution is exciting. Because biodiesel is derived from renewable feedstocks such as plant oils or animal fats, it is better for the environment than purely petroleum-based products. As Mattingly mentioned, it is renewable; it also is biodegradable and thus a carbon-neutral material, so it does not contribute to greenhouse gases. In fact, it decreases sulfur and particulate-matter emissions.

"In addition to being a renewable, biodegradable and carbon-neutral fuel source, biodiesel can be formed in a matter of months from feedstocks produced locally," Schulte said. "This process promotes a more sustainable energy infrastructure and creates new labor and market opportunities for domestic crops."

If it's not economically feasible, then it's not sustainable.

– Thomas Soerens, associate professor of civil engineering

In the first study, Mattingly worked with high-quality fat — chicken fat with a free fatty acid content less than 2 percent — and low-quality, feed-grade fat — fat with as much as 6 percent free fatty acid content. He subjected each grade of chicken fat to a one-step and multiple-step conversion process and discovered that free fatty acid content is the most important factor to consider for producing biodiesel using these two catalyzed processes. Both produced biodiesel fuel, but the single-step process could not convert free fatty acids into fuel.

Building on Mattingly's findings, Schulte jettisoned traditional, catalyzed conversion methods and instead subjected low-grade chicken fat and tall-oil fatty acid to supercritical methanol treatment, a chemical process similar to that used by Jerry King, who helped Schulte on the project. The treatment causes a reaction between methanol and feedstock components — in this case, chicken fat and tall oil — by subjecting the by-products to high temperature and pressure. In contrast to conventional methods of converting feedstocks into biodiesel, supercritical methanol treatment is a simple, one-step process that does not require a catalyst. Schulte produced biodiesel yields in excess of 89 percent from chicken fat and 94 percent from tall-oil fatty acid. The new method also avoided undesired production of soaps during processing.

Making Electric Energy More Efficient and Accessible

Energy is the lifeline of the industrialized world and the foundation of a high standard of living. Most energy comes from fossil fuels, a finite source that, when burned, also is harmful to the environment. Less than 10 percent of current energy resources are renewable. Meanwhile, the demand grows at an exponential rate. Researchers in the department of electrical engineering are working in several areas to address what is perceived to be, from a sustainability viewpoint, an amassing energy crisis.

At the university's National Center for Reliable Electric Power Transmission, Juan Carlos Balda, professor of electrical engineering, develops power-electronics interfaces for renewable energy sources and solutions. Referred to as "Combined Heat and Power," the project investigates power-electronics interfaces for systems like microturbines, which use wasted heat to generate electric power. For instance, heat from an industrial furnace can be channeled to a system of microturbines to generate new power. In Balda's project, this "recycling" of energy, along with the use of renewable energy sources such as a wind-powered generator or a photovoltaic array, make use of power electronics to



Projects led by electrical-engineering researchers Juan Balda, top, Roy McCann, center, and Hameed Naseem, bottom, focus on developing effective and alternative sources of electrical power.



Photos by Russell Cochran



Greg Thoma, professor of chemical engineering

interface with the power grid. Ideally, an industrial facility exploiting renewable energy sources and wasted heat could generate most, if not all, of its required electric power. In some cases excess power could be sold to the local electric utility.

Roy McCann, associate professor of electrical engineering, is developing a new type of generator that is more efficient in producing electric power. It uses a fundamentally new method of designing and operating electric motors and generators by embedding magnetic-field, micro-electromechanical sensors inside the motor. The system includes rotating components that directly monitor and adjust the operation to maintain a maximized level of electrical efficiency.

Existing generator technologies rely on taking a few external measurements such as voltage, speed and current. Recent advances in permanent magnet materials and electrical steels have improved energy efficiency. However, maximum efficiencies are possible only by knowing the instantaneous magnetic fields inside the generator. The inclusion of embedded sensors and control techniques developed from this research enables these energy-efficiency gains to be achieved by providing the required information from internal magnetic fields. This work also benefits electric motor efficiency, which is important for electric and hybrid-electric

vehicle propulsion, which also reduces dependency on fossil fuels.

Because conventional energy resources are limited and harmful to the environment, scientists and engineers are focusing on green alternatives, such as wind and solar power. The latter is beneficial because its source is practically infinite, and it can be generated at the point of use, so it does not depend on a power grid. Furthermore, with solar power, there is no loss of energy in transmission; it converts directly into electricity. Perhaps most importantly, it is harmless to the environment.

In his lab, Hameed Naseem, professor of electrical engineering, is trying to make solar energy practical and feasible. Naseem has spent much of his career developing solar cells. His current work focuses on the refinement and improvement of solar cells for a process called photovoltaic power generation, which uses semiconductors and solar cells constructed of silicon, the second-most abundant material in the earth's crust.

Latest improvements include the development of thinner, less expensive types of silicon wafers and films that absorb more light, Naseem said. His patented method uses a low-temperature process of metal-induced crystallization, which is superior to older, high-temperature process methods that cause a wafer "bowing" problem.

Minimizing the Environmental Impact of the Fayetteville Shale Play

For the past several years, there's been a lot of talk about the Fayetteville Shale Play, an unconventional natural gas formation across central Arkansas. Now, two large natural-gas production companies have begun exploration and production of the play, and many smaller companies will likely follow. Economists and business forecasters have predicted that extraction and recovery of natural gas from the play will contribute significantly to Arkansas' economy. But this project does not come without environmental costs. As with any subsurface resource extraction, significant development of surface infrastructure is required, which has the potential to cause localized environmental disturbances.

As more and more corporations embrace the financial and social benefits of sustainability, more grant money becomes available. It gives us a great deal of opportunity to provide new solutions. So it is a self-perpetuating arrangement, and a situation in which everyone wins.

– Ashok Saxena, dean of the College of Engineering

Being a sustainable university means that as we educate new generations of leaders, conduct the research that makes our lives better, and reach out to the communities of Arkansas and beyond, we do not compromise future generations.

– John A. White, University of Arkansas chancellor and Distinguished Professor of Industrial Engineering

Led by Greg Thoma, professor of chemical engineering, a diverse team of engineering and geospatial researchers is working to keep this impact to a minimum. With aid from the U.S. Department of Energy, Thoma is collaborating with researchers at the University of Arkansas Center for Advanced Spatial Technologies (CAST) and Argonne National Laboratory to develop a Web-based, decision-support tool that energy companies can use to plan for development that minimizes adverse effects on sensitive ecosystems. The researchers' work will serve as a model for the application of a proactive approach to reduce and manage risks associated with the exploration and production of unconventional natural gas resources in the United States.

Specifically, the researchers are developing Web-based application modules that identify areas sensitive to disturbance, so risks can be minimized in advance, or areas can be avoided altogether. Thoma's team is building three-dimensional maps of the geographical area of the play with underlying databases including important environmental and cultural features. For example, they are gathering information from state and federal regulatory agencies about sensitive watersheds and habitats

in the area. With this information and CAST's powerful mapping tools, the decision-support system will provide important information early in the development process so that, where possible, development can be located away from sensitive areas.

"Many times, this simply means building an access road or locating a well just a few hundred yards from the proposed site," Thoma said. "These shifts can make a significant difference in terms of limiting runoff into streams or threatening wildlife habitat, such as a nesting area."

When finished, the multipurpose system will serve as a type of clearinghouse of information and thus will educate the general public about the play and the process of extracting natural gas from it. The life cycle of a lease will be explained in detail, which will help the public understand stages of operation and industry's commitment to environmental stewardship. The online system also will facilitate communication among all stakeholders, including government, regulatory officials and industry representatives. Communication among the stakeholders will foster an atmosphere of cooperation that should result in early identification of potential problems that can be jointly resolved in a way that

protects the environment without unnecessary delays to development of the play.

"We've made significant progress, but we have a lot of work ahead of us," Thoma said. "With time, I think we'll have a tool that all stakeholders will be happy with, and one that will help to conserve and preserve these ecosystems." ■

There is no need to use treated water for watering trees, grass, bushes, etc.

– Thomas Soerens, associate professor of civil engineering

Other Sustainability Research in Engineering

Up and down the halls of Bell Engineering Center and the Engineering Building, out at the Arkansas Research and Technology Park, on the shores of Beaver Lake, at neighborhoods in Rogers and Fayetteville and even in remote villages of Central and South America, many other engineering research projects focus on sustainable processes and design. These investigations tackle stream restoration, "human ecosystems," low-impact development, water-filtration systems and decision-support tools to mitigate negative environmental impact. In addition to serving residents of Arkansas and the world, these projects, in some cases, may save lives. Go to the links below to read about these projects in previous issues of *Research Frontiers*.

Researchers Work to Solve Clean Water Problems
<http://researchfrontiers.uark.edu/8430.php>

Water Ways - Researchers Dream of Sculpting Streams
<http://researchfrontiers.uark.edu/8431.php>

The Business of Sustainability

by Matt McGowan

“Environmental sustainability is a business imperative at Wal-Mart.”

— Lee Scott
Wal-Mart Stores Inc. president and CEO

The above is a bold statement from the leader of a company that knows more than a little about how to conduct business and make money. Had Lee Scott uttered these words 10, maybe even five years ago, some shareholders probably would have scratched their heads. Of course, the irony is that Sam Walton, founder of the world's largest retailer, understood, perhaps better than any president or CEO of a Fortune 500 company, the “business imperative” of sustainability. He may not have used the word, but he understood.

So, without overanalyzing the message, what did Lee Scott mean by connecting these seemingly disparate concepts? More to the point, what does environmental sustainability have to do with selling tires, televisions

and laundry detergent? Quite a bit, says Terry Tremwel, research director of the Supply Chain Management Research Center in the Sam M. Walton College of Business.

In fact, laundry detergent is the perfect example. Over the past several years, chemists not only have reduced its toxicity — and therefore made it less harmful to the environment as water from washing machines is released into sewer systems that must treat it — but also smaller, as in more condensed or concentrated, which translates into smaller containers with less water.

“We don’t need to transport all that water,” Tremwel says. “It may seem insignificant — just one container. But think about a whole trailer full of them. That’s significantly less weight, which means lower fuel costs or the ability to deliver more product. This is just one small example of the marriage of sustainability and business.”

Tremwel studies companies that have become more sustainable organizations and explains why it is in their interest to do so. Many companies, especially those that either perform or rely heavily on logistics and transportation — Wal-Mart and FedEx, for example — focus on those aspects of business, but, Tremwel says, businesses



Photo by Russell Cochran

Terry Tremwel

and organizations can become more sustainable in virtually all facets of operation.

To explain this, Tremwel examines the many and diverse definitions of sustainability. Some definitions are specific, tailored to the physical environment or growth and development; others are more philosophical and add a moral or social component.

But even simple, yet classic definitions, such as the one developed by the United Nations’ Brundtland Commission — “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” — apply to sound business processes.

Savvy business people know that not “compromising the ability of future generations to meet their own needs” relates to concepts such as conservation, waste

reduction and efficiency, and these ideals, especially the latter, have direct and profound effects on every company’s balance sheet. Stated differently and in a purely business sense, sustainability is virtually synonymous with efficiency, which is all about cutting costs.

“The basic equation of business is that profits equal revenues minus costs,” Tremwel says. “So if you can reduce your costs, that has direct implications on your profit. That’s why sustainability works and why businesses are interested now — as a cost-limiting measure. Cost reduction increases efficiencies and profit. It’s that simple. And that’s what has motivated the current interest.

“The fact that sustainability happens to be a revenue-producing method is a bonus, and things like social justice, care for environment and just being a good corporate citizen are ancillary benefits. But what we’re seeing today is that more and more companies, including Wal-Mart, recognize these as priorities too, even though the companies openly admit that the initial motivation had to do with cost savings.”

While efficiency and cost savings are neither new nor foreign concepts to successful companies, sustainability



is — or, rather, was. Because of its association with environmentalism or green initiatives, both real and perceived, Tremwel found the concept of sustainability initially suffered in the global businesses community. Many business leaders assumed that it would only mean more environmental regulation or greater costs for products, services and the supply-chain network. But as information spread about the financial benefits of sustainability, the movement slowly gathered steam, especially among multinational corporations trying to expand into the huge consumer markets of Asia and India.

“The basic equation of business is that profits equal revenues minus costs,” Tremwel says. “So if you can reduce your costs, that has direct implications on your profit. That’s why sustainability works and why businesses are interested now

It is this phenomenon that Tremwel finds particularly interesting. Economists and business analysts predict that as these markets — and others in South America and Africa — continue to open, producers will prosper. But these companies cannot expect to succeed by continuing to make and deliver products as they always have, because consumers in these markets are very different than consumers in the United States and other developed nations.

The new markets include the roughly 4 billion people worldwide who have per capita annual incomes of about \$730. This huge population has great needs and demand for products and services. They also are highly motivated to improve their lives, but they cannot afford expensive products. To serve this population, Tremwel says, companies must adapt and develop innovative strategies to provide affordable and easy-to-use products that have low environmental impact. By wasting less, using more renewable resources and reducing costs wherever and whenever possible, companies create and develop new markets for their products. The process is not unlike Sam Walton’s philosophy of keeping costs of production to an absolute minimum so as to pass savings along to the customer.

“There is tremendous pent-up demand within this population,” Tremwel says, “but by using old methods, there are not enough materials in the world to create products to serve everyone. This demand will be captured by companies that create innovative and efficient products and services needed by poor people at prices within their reach. In other words, if you’re wasting resources, you’re not going to come up with products people can afford when they only make \$2 a day or less.”

Economists and business analysts call it “B24B,” which stands for “business to 4 billion.” B24B is a global business strategy that combines growth with sustainability. The strategy includes attention to product and package development, material sourcing, product formulation or reformulation, material reuse and efficient transportation networks and logistics. Many business leaders argue that these practices are simply good for business in general and should be applied in all contexts.

There are hundreds of examples. As mentioned above, a critical part of this effort has to do with product reformulation, which simply means changing or improving products to reduce costs, increase safety or limit any pernicious effect on the environment. In 2005, S.C. Johnson, manufacturer of popular household cleaning products such as Windex and Fantastik, reformulated Windex by removing more than 1.8 million pounds of volatile organic compounds from the glass-cleaning product. The change gave the product 30 percent more cleaning power, improved its safety and lowered its environmental impact. The company also cut material and handling costs because the formula was less toxic.

Tremwel and other theorists often refer to what is known as the “Triple Play,” yet another stab at defining sustainability. Developed within the Rio Declaration on Environment and Development at a United Nations conference in Rio de Janeiro, Brazil in 1992, the Triple Play definition refers to the financial and environmental components discussed above but also lays down the basic principles of a third leg — a social component. Depending on who you ask, some refer to it as cultural. Whatever the name, this component is subtle, sometimes difficult to understand, primarily because of language and cultural barriers, and often overlooked by companies trying to expand into new markets.

Part of the social component has to do with offering products that are too expensive, but there’s more to it than this. Many times, employees at companies from developed Western nations do not understand the

customs of people living in the developing nations of Asia, South America and Africa. Stuck within their own cultural conventions, many Westerners do not understand how people in developing nations wash clothes, for example, or commute between work and home. From a business point of view, Tremwel says, ignorance of these customs leads to failure. In fact, he found several cases in which technologically superior products were rejected by consumers because the products were not packaged in a manner that was culturally sensitive.

Continuing with the laundry-detergent and clothes-washing theme, consider the example of Hindustan Lever Ltd., the Indian subsidiary of Unilever, a multinational corporation. Rather than offering detergent in bulk via the customary large boxes used in U.S. homes, the company developed “Wheel,” an affordable detergent packaged in individual units, or sachets, which were easier to use based on how Indian villagers wash clothes. Villagers in India responded by buying a huge number of sachets, resulting in a dramatic increase in revenues and profits for a small investment. In five years, from 1995 to 2000, the subsidiary’s profits grew 25 percent per year, primarily due to Wheel.

“Villagers found value in the new packages and product, which improved their lives,” Tremwel said. “In response, they rewarded Hindustan Lever by buying the new product.”

Sustainability and Accounting

It’s good to be green — good for the environment and good for one’s image, especially when image determines one’s value on the stock market. Consider, for instance, that corporations that do not have environmental sanctions generally fare better on stock markets than those that do. It seems logical. The only problem with this dynamic, says Andrea Romi, is that many corporations do not report environmental sanctions, even when the U.S. Securities and Exchange Commission requires them to do so. And most people, save some accountants and attorneys, don’t know how or where to look for information to discover whether or not a corporation has been cited.

“That’s what I love about accounting,” says Romi, a certified public accountant and graduate student in the Sam M. Walton College of Business. “I know where to look, and I can find out if these companies are telling the truth or not.”

Romi has always been interested in corporate social responsibility, but recently, as sustainability has crept into and gathered momentum in the business world, she has focused on something called corporate sustainability reporting, an area of accounting in which accountants measure and analyze the voluntary reporting of information about an organization’s non-financial performance — environmental or social performance, for example — over a specified period. In general, these accountants — and there are very few of them nationwide — develop metrics for measuring environmental performance and examine financial reports to determine if companies meet their goals.

But, as Romi and other accountants emphasize, “voluntary” is the key word in the definition. Unless corporations are penalized severely, they do not have to disclose their environmental record. And most of the companies that do receive sanctions do not admit it because they know that reporting it will have a negative effect on their market value.

“These companies are violating SEC regulations,” Romi says, “but they don’t suffer any consequences because this is an area that the SEC historically has not focused on enforcement.”

Regardless of the regulating entity, SEC regulations require corporations to disclose environmental sanctions of \$100,000 or more. As part of her dissertation, Romi looked at all \$100,000-or-greater sanctions handed down by the U.S. Environmental Protection Agency over the past 10 years, and found that only 26 percent of all sanctions were disclosed. Nearly three out four sanctions at or greater than \$100,000 were not reported by the penalized corporations.

To a limited extent — because they only analyze financial disclosures and are not qualified to test emissions or toxicity levels — corporate sustainability accountants also can combat “greenwashing,” the term used to describe the act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or service. As the sustainability movement continues to grow in the business community, Romi says, there may be even more greenwashing, because executives and managers understand that consumers generally favor products that have low impact on the environment.

“Some companies have played up all the wonderful things they’re doing, which may be true,” she says, “but they fail to mention EPA sanctions or other things they’ve fallen short on.” ■

Consider the Source: Sustainable Means Keeping Water Close to Home

By Barbara Jaquish

Humans depend on water for life.

When it comes to considering a sustainable world, what we do with water has to be a central concern. Just one agency of the United States government spends hundreds of millions of dollars each year to predict when water will fall from the sky and how much will fall. We spend many more millions on flood insurance to deal with the consequences of that rain when it falls on human-built structures and infrastructure and suddenly becomes too much water in the wrong place. And none of those millions of dollars has any influence on when, where or how much rain falls.

To have sufficient water in the right places at the right times, we have to look at what we *can* influence. The rain water that runs off our roofs, that sweeps across parking lots and down storm drains, that overflows stream banks and washes out roads — all this rain water could nurture an apple tree or be a home for trout. To allow water to be a life-sustaining element rather than a rushing, roiling, destructive force, we have to look at what we do with the water we can control.

As landscape architect Mark Boyer says, “We haven’t been very successful in controlling when it rains, but we can be pretty successful in controlling what happens to the runoff when it does rain.”

Boyer is an associate professor of landscape architecture in the School of Architecture. He and his colleague, Carl Smith, a landscape architect from the United Kingdom who recently joined the faculty, are particularly interested in improving design and adoption of systems that are sustainable.

Some choices for handling rain water runoff don’t help and often have made the problem worse. When we shelter ourselves beneath a snug sloped roof, we stay dry while water funnels down a drainpipe to the street and eventually to a stream. When we pave our streets and parking lots with asphalt, we create a smooth, impervious surface that directs rain water into drains or ditches and eventually to a stream. These widely accepted ways of constructing our homes and infrastructure move water but also have some unintended consequences — polluting our streams, for one.

“The storm runoff in the first hour of rainfall has the same pollution index as raw sewage,” says Steve Luoni, director of the University of Arkansas Community Development Center.

Wasted water is another consequence. On days the water isn’t falling from the sky, we hook up a hose and water the grass and flowers.

“Less than one percent of the earth’s water is potable — it’s ridiculous that we spray potable water on our grass” says Boyer.

“When we use a rain barrel, for example, we’re using the water that falls from the sky, and we’re putting it on our plants. It’s a much better system.”

On top of increased pollution and wasted water, the ways we build and grow have increased the likelihood of flooding by ignoring the natural dynamics of streams. Luoni explains that flood plains serve “the natural metabolism of that river by absorbing excess water during heavy storms.” And flood plains, he adds, are usually the first thing that gets sacrificed when urbanism encroaches on streams.

“Most streams want a flood plain that’s 10 to 30 times the width of the stream,” Luoni says. “If a stream is 30 feet wide, it’s going to want a 900-foot flood plain. Where the Mississippi River is a mile wide, it needs a 30-mile flood plain. When we sacrifice flood plains, we get into trouble.”



Photo by Russell Colgren

Architecture student J.C. Choi and landscape professor Carl Smith discuss design. Holistic design can lead to water conservation and more environmentally sustainable landscapes.

Designing Holistically

Designing to accommodate and manage water is nothing new. Fran Beatty points to the work of Frederick Law Olmsted, who designed Boston’s Emerald Necklace parks in the late 1800s. A century later, Beatty directed the redevelopment and reconstruction of the Emerald Necklace for the city of Boston. The Emerald Necklace, she says, is emblematic of the way that Olmsted worked.

“He looked at it in a holistic manner,” Beatty says, “and that is



Photo by Russell Cochran

▲
 “Sustainability requires personal responsibility and advocacy,” says landscape architecture professor Fran Beatty. “It’s hard, because it means we will have to change how we think and we have to change some habits.”

part of his genius.”

Much of Boston sits on marshland, and designing the linked parks of the Emerald Necklace involved redirecting rivers and restoring marshlands that had been used as dumping grounds. Olmsted considered entire watersheds in his planning and worked closely with the city’s engineer, a partnership that was not typical of such projects. During the 20th century restoration project, the engineers were impressed by what Olmsted had been able to accomplish in terms of effective storm water management and enhanced ecology.

Olmsted designed pragmatic solutions to problems of flooding and sanitation that enriched the lives of Bostonians with restful landscapes and opportunities for recreation. That is, his design contributed to the sustainable handling of water as well as to what Beatty calls “sustainability as cultural relevancy.”

While Olmsted tackled problems in a way that contributed to both a healthy environment and a healthy civic life, the lessons of his work seemed to have been forgotten in the building booms of the second half of the 20th century. The renewed emphasis on sustainability suggests a kind of amnesia, Luoni observes, “our own cultural ignorance about what has gone on before us.”

Shifting Paradigms

Sustainability, Beatty points out, is not about pristine wilderness. The very presence of people changes a natural area, and human settlement means that some degree of management is necessary to ensure we continue to have such vital resources as water.

“Sustainability requires personal responsibility and advocacy,” Beatty says. “It’s hard, because it means we will have to change how we think and we have to change some habits.”

For example, to design, build and live in a sustainable manner, Boyer says we have to completely rethink how we look at storm water, and we have to use low-impact techniques that reduce storm water runoff, such as green roofs, bioswales or rain gardens, and pervious pavement.

“Instead of storm water being a problem or a liability that we deal with at the end of the development project, we have to deal with it at the beginning as an inspiration for design,” Boyer says.

He believes that if storm management systems were incorporated into the design, people would become more aware of the implications of development. Furthermore, if utilities charged based on the amount of storm water runoff generated, there would be more incentive to use sustainable methods to retain water at the source.

Storm water can be treated at the source — whether the source is a residential lot or parking lot. Low-impact technologies such as green roofs and rain gardens can retain water and slow its flow so that water has time to filter into the soil and recharge the aquifer. Or plants and trees can take up the water by their roots and release it slowly through their leaves.

“It’s really using the carrying capacity of the landscape to manage the water according to the landscape’s metabolism,” Luoni says, “which is what Olmsted did. He understood the metabolism and carrying capacity of the landscape and designed accordingly.”



Photo submitted

In fact, Boyer says, “It’s a whole lot easier to deal with storm water at the source than dealing with it at the site or at the city scale.”

One example of a way to deal with water at the source is a constructed wetland — an artificial wetland created to deal with water runoff in a place that was never a wetland before. Constructed wetlands offer some important benefits on site by allowing some of the water to soak in, some of it to evaporate off and some of it to transpire through the plants. These natural actions improve water quality and reduce the volume of storm water runoff. At the same time, a constructed wetland creates a living natural habitat. The alternative is to drain water away with a pipe.

“What the pipe does is just send the problem someplace else,” Boyer says. “A pipe doesn’t do anything for the water quality or water volume — pretty dramatic difference between the two systems.”

To handle water at the source, Smith noted the importance of “maintaining unsealed space at the source.” That is, rather than covering the earth with acres of asphalt, designers and builders can choose to use permeable paving that allows water to seep through to the land. Landscaping using bioswales, also known as rain gardens, and systems like green roofs all contribute to keeping water from tearing across the land as a destructive force.

Keeping it Open

Here’s how a bioswale or rain garden works. Vegetation is planted in what would be commonly called a ditch. When rain falls and water runs off buildings, streets or parking lots, the vegetation in the ditch does some of the same things that wetlands do. It improves water quality, slows the flow and reduces the volume, the key elements in handling water in a sustainable manner.

“The great thing about bioswales is that they’re often associated with impervious surfaces — parking lots and buildings — where we’re going to plant things anyhow,” Boyer explains. “We just have to reverse — instead of building up for the planting area, we actually go down so that the water has someplace to go.”

“Recombinant design addresses social, economic, aesthetic, as well as ecological criteria all at once” -- Steve Luoni, director of the University of Arkansas Community Design Center.

Once the water runs off the parking lot into the bioswale, the pollutants that are picked up from the parking lot are trapped, taken up by the plants or allowed to volatilize off. The water soaks into the ground to recharge aquifers. In a natural system it can take days or weeks for rainfall that hits the earth to make it into a stream.

“We’re killing our ecological systems with our development,” Boyer says.

With development that uses impervious surfaces, the water can get to the stream ten times faster. The rushing water carries all the pollutants and floods and erodes stream banks.

This is the problem the University of Arkansas Community Design Center faced with planning for campus improvements related to Mullins Branch, a stream running through the west side of campus and eventually draining into the White River. Much of the 40-acre site is covered by a parking lot. During storms, water runoff far exceeded the carrying capacity of the stream and produced major flooding that engulfed a campus foot bridge and threatened a highway overpass. The stream carried the highest sediment load in its entire watershed.

The Community Design Center, in collaboration with Audubon Arkansas, came up with three strategies to handle Mullins Branch. The design package for Mullins Branch received the 2008 Institute Honor Awards for Regional and Urban Design from the American Institute of Architects. The design was guided by an approach that Olmsted would have understood.

“Olmsted did something that is very difficult, that is to design what I call recombinant infrastructure,” Luoni says. “Recombinant design addresses social, economic, aesthetic, as well as ecological criteria all at once. So the infrastructure is not just fulfilling one function. It’s a multi-tasked infrastructure.”

In the case of Mullins Branch, recombinant design meant returning the stream to a healthy condition, returning sinuosity and a healthy bank to facilitate the return of a diverse aquatic wildlife natural to a stream of its size. At the same time, to



Photos by Russell Cochran



accommodate the parking lot, they had to devise ways to retain storm water. The designers suggested three strategies that are, Luoni says, “progressively aggressive.”

The designers called the most modest approach “hydrology pixilation.” It involves small bioswales and other water treatment facilities distributed equally across the site in much the way islands typically dot parking lots. In this case, the pixilated bioswales are vegetated dips, rather than mounds, that collect runoff. The entire site acts as a large sieve for groundwater recharge, diverting parking lot runoff away from the stream and holding floodwaters.

The second design, called “riparian bands,” alternates strips of bioswale with strips of parking, creating a green parking lot that handles storm water even more efficiently than the pixilated version.

The “total marsh” plan comes closest to what engineers originally advocated — that the entire site becomes a retention basin. With this plan, much of the site becomes a constructed wetland for a flood plain and storm water retention. Other uses — parking and visitors center — are moved to one edge of the wetlands in a parking garage that floats above the wetlands.

Planting Roofs

Another way to deal with water at the source is to use green roofs. While roof gardens are considered a form of green

Landscape architecture professor Mark Boyer has been studying the effects of green roofs, such as the one shown here in various stages of growth.

roof, an extensive green roof puts less load on the building, requires less maintenance and is commonly referred to simply as a green roof. Green roofs have been used in Germany and Scandinavian countries for generations.

A green roof replaces tiles or shingles with a minimal depth of growing medium and a hardy planting, often sedum. Green roofs reduce the amount of storm water that washes off the roof. In fact, Boyer says, with a green roof “it’s not uncommon for them not to have any water come off them in storms of one half-inch rain or less.”

Green roofs also insulate buildings, demanding less heating and air-conditioning and releasing less carbon dioxide into the atmosphere, thus reducing the urban heat island effect and cooling cities. Green roofs mitigate acid rain and other pollutants.

Boyer installed a green roof as a demonstration project on three storage buildings on the south side of campus. One purpose of the project was to test whether a green roof would survive. While the roofs have done well in the maritime climate of Europe, no one had looked at their viability in the continental climate of Arkansas, which can be hotter, colder and drier.

With the help of student volunteers, Boyer planted 32 species of plants. After installation, Boyer did nothing — no water, no cultivation, no weeding. Subtracting those that didn’t survive the first year, at least 20 species have thrived on neglect.

The cumulative effect of green roofs in a city can be dramatic, which is why Mayor Richard Daley of Chicago is promoting green roofs in his city. Daley visited Germany, saw green roofs, and, Boyer says, “got the bug.” Daley’s goal is to reduce the urban temperature in Chicago by one degree to save \$150 billion a year in utilities. The city is offering small grants as incentives to offset the cost of installation.

Boyer notes that nationally most green roofs are installed on industrial or institutional buildings. The most dramatic growth in impervious surfaces is in residential construction, where the use of green roofs has lagged.

In his work in the United Kingdom, Smith followed an inner-city rehabilitation project in Liverpool, England, in which green roofs were among the sustainable practices proposed by landscape architects. While public housing officials have “embraced environmentalism,” Smith observed that residents sometimes have other ideas. The Liverpool residents, who accepted solar panels, vetoed green roofs. In part, they didn’t want to live in a building “that was so radically different visually that they felt they were in some strange experiment.”

Smith also found that developers of higher-end homes objected that green roofs were “out of place” in their developments. At the same time, he points out, there are aspects of green housing that are appealing to developers. The green development accreditations — known as LEED in the United States and BREEAM in the United Kingdom — convey marketing benefits. In the abstract, people like the idea of green housing and are willing to pay more for some green elements, such as the use of less-polluting paints or sustainably sourced wood. Yet, Smith said, there’s still a question of how much this openness to green “will be mitigated by an unusual aesthetic.”

Although there are major problems with flooding in the United Kingdom due to intensive urbanization, Smith said that local

building regulations in the United Kingdom, as in the United States, often don’t allow for unsealed green space. “Low-rise” development of conventionally designed, one-to-two-story buildings contributes to the problem.

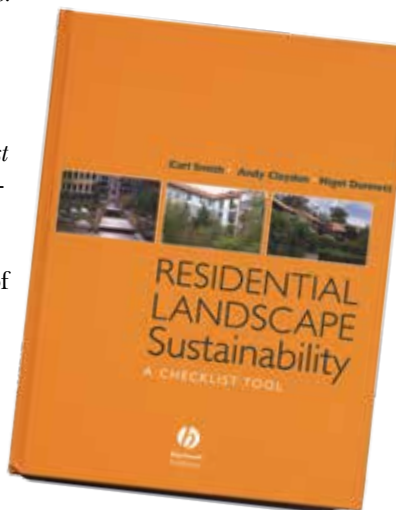
“Oddly enough,” he said, “high-density development that demands that we build upwards can potentially leave more room on the ground for permeable surfaces.”

Talking 21st Century

In his new book, *Residential Landscape Sustainability: A Checklist Tool*, Smith offers designers and developers a resource “to develop design solutions sympathetic to the environment and improve the sustainability of residential landscapes.” Smith shows landscape architects and urban designers how to conserve resources, minimize pollution and enhance ecological diversity, “without significant capital outlay.”

In recent articles in the magazines *Green Places* and *Sustain*, Smith and Boyer discuss examples of reluctance to use one element of sustainable design, green roofs, and the need to better understand public perceptions of a system that has proved effective in Europe.

They ask a question that applies to all the changes necessary for sustainable landscapes: “Should respecting local identity and vernacular be about preservation alone? What is a vernacular if not a physical manifestation of the technical, political and artistic climate of the day, and what better or more appropriate vernacular for the 21st century than one that is environmentally responsible and socially ethical?” ■



{SMALL-SCALE}

Sustainability

THE LIFE AND TIMES OF FRESHWATER MACROINVERTEBRATES

BY MELISSA LUTZ BLOUIN

Freshwater macroinvertebrates don't get a lot of credit; many people would have a hard time naming more than a few of these backboneless creatures, which include crayfish, snails, mollusks, aquatic worms and mayfly nymphs. Yet these animals act as the middlemen of the smorgasbord of life, serving as food for fish while also consuming algae, shredding leaves and eating other types of organic matter in the water. They perform critical functions in streams, rivers, small ponds and large lakes.

Many ways exist to measure water quality, and one of those ways involves looking at the health of populations within a stream. Biological sciences professor Michelle Evans-White, pictured right, and her colleagues, Debra Baker and Donald Huggins of the Central Plains Center for Bioassessment and Walter Dodds of Kansas State University, wanted to look at a possible way to assess stream health, and therefore water quality. The Environmental Protection Agency has created clean water criteria that all states must comply with — or the states can develop their own criteria, which must be scientifically defensible. Looking at macroinvertebrate biodiversity may be one way of developing such criteria.

To look at stream health, the researchers examined the biodiversity of macroinvertebrates in relation to the nutrients phosphorus and nitrogen found in the water. Many streams have accumulated excess levels of nitrogen and phosphorus due to runoff from fertilizers on lawns and fields. While it is known that these excessive phosphorus and nitrogen levels change stream communities, researchers are still examining the relative importance of various mechanisms and their relationship to biodiversity.

"Biodiversity can be important to ecosystem function," she said. "Losses in the biodiversity of these macroinvertebrates could mean losses in stream functionality." Without diverse communities of macroinvertebrate middlemen, functioning streams may founder.

Evans-White used data on the biodiversity of macroinvertebrates collected by state agencies over the past 20 years at different sites in Missouri, Kansas and Nebraska. The collectors used nets at timed intervals to scrape the bottom of the body of stream, overhanging vegetation, undercut banks, submerged tree roots and other dominant habitat types. All species collected were then identified and counted at each location.



The researchers took the biodiversity data and plotted it against a gradient of total nitrogen and phosphorous levels, which were taken from the same locations within 30 days of the biodiversity samples. They found that there is a “change point” at fairly low levels of nitrogen and phosphorous where the biodiversity plunges — and stays low. The point at which the biodiversity crashes lies at nitrogen and phosphorus levels near EPA clean water standards. But more than 70 percent of the streams surveyed had nutrient levels that were even higher — too high to sustain biodiversity among the macroinvertebrate populations.

“Communities are constrained to low levels of diversity when there is a high nutrient load,” she said. “We wondered whether changes in food nutritional quality might drive the relationship.”

The researchers decided to examine the nutrient content of the animals, which is an indicator of dietary nutrient demand, and its effects on the community.

“It’s a little like ‘you aren’t necessarily what you eat,’” Evans-White said. “An organism’s food choice doesn’t always match exactly what its body needs to grow. This is true for humans too. Some macroinvertebrates need more nitrogen and phosphorus in their diets to grow than others.”

In other words, they looked at the organisms in terms of their ability to consume and excrete, or cycle, nitrogen and phosphorus. The thought was that as nutrient levels increased, organisms that needed lots of nitrogen and phosphorous would out-compete those that used less.

“We are seeing evidence for that on a large scale in certain macroinvertebrates,” she said. Many organisms living in the water rely on low quality foods, so organisms with high phosphorus or nitrogen demands and high growth rates are kept in check under normal circumstances. As nitrogen and phosphorus levels increase and communities that thrive on these nutrients grow, they could crowd out the lower-demand organisms, resulting in lower levels of biodiversity.

However, the picture is not entirely clear; the researchers in this study did not find evidence that this high consumption scenario to be the case for all macroinvertebrate feeding groups — including those that scrape and feed upon algae.

“Their diversity is decreasing, but in this case there is no evidence

in our study that this mechanism is causing the decrease. It could be multiple things,” she said.

To look at other possible mechanisms causing biodiversity to crash, Evans-White plans to study “dropouts” and successful species to see what might be causing certain species to disappear. In the meantime, streams continue to decrease in biodiversity as nutrient levels rise.

“By enriching these streams we are lowering biodiversity and potentially altering the stream state,” Evans-White said. The question of whether or not these streams can recover if the nutrient content is returned to normal has not yet been answered.

“Macroinvertebrate biodiversity is just one variable people are looking at,” she said. “It’s one part of the whole story.” ■

Who's Who in the Macroinvertebrate World:

Here are a few of the creatures that live in streams — some thrive in healthy streams, and some exist in less than ideal circumstances. Their presence — or absence — in a stream can serve as an indicator of stream health for researchers seeking to know the water quality of a particular body of water.



istock photo

{CRAYFISH}

Crayfish resemble miniature “lobsters;” they possess four pairs of walking legs and a pair of strong pinchers. Their color can be brown, green, reddish, or black, and they grow to lengths of up to six inches. They are omnivores, eating both plants and animals. They are seldom seen in polluted water.



istock photo

{MUSSELS}

Mussels can grow up to nine inches in diameter. They are known as filter feeders; they filter organic debris and plankton out of the water; preyed upon by numerous fish and mammals. They are sensitive to stream pollution.



photo by Declan McCabe, www.benthos.org, NABS image library

{WATERPENNY}

Water penny beetle larvae resemble circular, sucker-like creatures found on rocks in the water. They can be green, brown or black in color. The adults have a typical beetle body and are not fully aquatic. The larvae and adults feed on plant debris, algae and diatoms. They are found in fast-running, clean streams.



photo by Jeremy Moore, Freshwaters Illustrated

{MAYFLY}

Mayfly nymphs can grow up to an inch in length. The adults sport a pair of long, lacy wings. They eat small plant and animal debris, such as algae, diatoms and plankton, and they are preyed upon by fish. They are considered to be an important part of the food chain. They are an indicator of clean water.



photo by Larry Serpa, www.benthos.org, NABS image library

{POUCH SNAILS}

Pouch snails grow up to half an inch in length and have brown, black or gray shells, which are sometimes covered in algae. The snails eat algae, other aquatic plants, and sometimes dead animals; they are preyed upon by fish, birds and some turtles. These creatures are often found in nutrient enriched environments where there is poor water quality.



Adventures in the Wild: Tales from Biologists of the Natural State

Edited by Joy Trauth
and Aldemaro Romero

University of Arkansas Press

The true tales in this collection will take readers from the chicken houses of Arkansas to the caves of Venezuela and Mexico to the coast of Alaska. These 15 adventures range from amusing to life-threatening. Some are filled with suspense and danger in exotic places, while others document more routine but important biological field and laboratory work.

Meet the roommate with the rash that wouldn't go away, a friendly bull, some blind cave fish, killer whales, drug smugglers and hairy roots that are used to produce new medicines. Read about researchers crawling through rotten-egg-smelling muck in search of an elusive mosquitofish, diving into the cold black water of the White River in search of mussels, flying with bush pilots in Alaska and working with David Attenborough in Arkansas. Here are teachers and researchers, biologists all, all from one university, real people who get their feet wet and their hands dirty in the pursuit of knowledge.

The editors are in the department of biological sciences at Arkansas State University. The book includes a foreword by Cristián Samper, acting secretary of the Smithsonian Institution. ■



**Beyond Redemption:
Texas Democrats after Reconstruction**

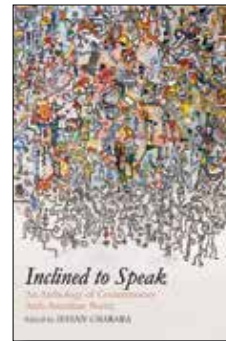
Patrick G. Williams

Texas A&M University Press

Between 1874 and 1890, Texas Democrats known as Redeemers dismantled Reconstruction reforms, adopted a fundamentally revised state constitution and steered Texas in a new direction. This book by historian Patrick G. Williams establishes that their constitution and policies affected the development of the state all the way to present times.

In his book, Williams offers a detailed study of how Democrats destroyed Reconstruction and established power in Texas. Williams also considers how the Redeemers' policies in the areas of economic development, public services and citizenship rights created long-lasting patterns that guided the state's development and governance. Their influence has proved pervasive and persistent.

As a Southern state, Texas had to address the consequences of emancipation, black enfranchisement and the spread of cotton cultivation. What set Texas apart from much of the South was ethnic diversity, a post-Civil War population boom, undeveloped land lacking infrastructure and public lands under the state's control. ■



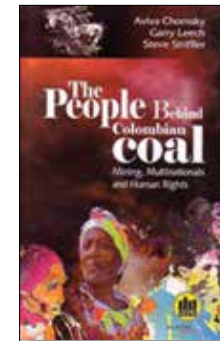
Inclined to Speak: An Anthology of Contemporary Arab American Poetry

Edited by Hayan Charara

University of Arkansas Press

This anthology gathers together poems from the most important Arab American poets — poems that shape and alter people's understanding of this experience. The poems also challenge readers to reconsider what it means to be an American. The book provides readers with an astonishing array of poetic sensibilities, touching on every aspect of the human condition. Whether about culture, politics, loss, art or language itself, the poems here engage these themes with originality, dignity and an unyielding need not only to speak, but also to be heard.

The book includes 39 poets offering up 160 poems. Included in the anthology are Naomi Shihab Nye, Samuel Hazo, D.H. Melhem, Lawrence Joseph, Khaled Mattawa, University of Arkansas creative writing professor Mohja Khaf, Matthew Shenoda, Kazim Ali, Nuar Alsadir, Fady Joudah and Lisa Suhair Majaj. Editor Hayan Charara has written a lengthy introduction about the state of Arab American poetry in the country today as well as short biographies of the poets. He also has provided an extensive list of further readings. ■



**The People Behind Colombian Coal:
Mining, Multinationals & Human Rights**

Steve Striffler, Aviva Chomsky
and Garry Leech

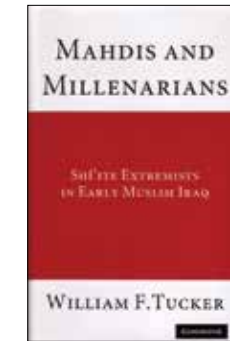
*Casa Editorial Pisando Callos,
Colombia.*

A case study of the world's largest open-pit coal mine reveals the hidden costs of coal from Colombia — the effects on indigenous and Afro-Colombian villages.

In *The People Behind Colombian Coal: Mining, Multinationals and Human Rights*, anthropologist Steve Striffler and his colleagues have assembled reports on the impact of the Cerrejon mine, located in northern Colombia. The expansion of the Cerrejon mine has led to the forced displacement of indigenous Wayuu and Afro-Colombian communities.

The Wayuu, indigenous inhabitants for hundreds of years, had retained autonomy while their region remained undeveloped. Although it is a large and complex tribal group, the Wayuu have no centralized political power, which has made it difficult for them to confront external pressures.

The book includes socio-cultural and environmental studies, human rights and health reports, and accounts of international support by nonprofit, environmental and religious organizations. English- and Spanish-language editions of the book are available. ■



Mahdis and Millenarians

William F. Tucker

Cambridge University Press

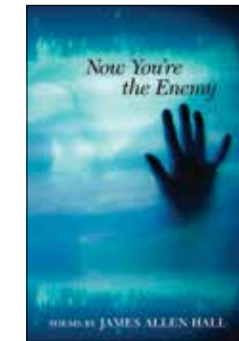
The world view of four Arab sects in 8th and 9th century Iraq and Iran is powerful centuries later, influencing revolutionary Shiites and their religious leaders in today's volatile Middle East.

Sect members formed the first millenarian groups to emerge in Muslim history, their beliefs often intersecting with those found in other religious traditions. They expected imminent, total salvation in this world, led by the Mahdi, or savior, who would establish a reign of righteousness and justice on earth. Their impact on Islamic thought would, over time, outweigh their numbers.

Historian William Tucker traces their genesis in his book *Mahdis and Millenarians*. He examines their theology and their political and cultural beliefs. He is one of the first scholars to examine millenarianism in Islamic society.

In present-day Iraq and Iran, scholars find a similar emphasis on the Mahdi and on political and economic justice among the Shiites.

Early Shiite groups often comprised the downtrodden or persecuted, who saw themselves as true believers who were the real community of worth. Because they recognized the leadership of the Imam, they also felt they didn't have to obey societal rules or laws. ■



**Now You're the Enemy:
Poems by James Allen Hall**

Enid Shomer, Series Editor

University of Arkansas Press

Now You're the Enemy: Poems by James Allen Hall, is a debut collection of poems that focuses on the structure of feeling and family figures. The featured poems center on a family in the aftermath of violence.

Hall focuses his words on the complicated dynamics and relationships contained within a family. "I was mothered into art," he writes.

The collection was a finalist for the Walt Whitman Book Award and a semifinalist for the Crab Orchard/Open Competition Book Award.

"Hall's poems are physically charged, nervy, both measured and fevered, compassionate and outrageous, and alive to the very core," writes poet and author Mark Doty.

An assistant professor of English at Bethany College in West Virginia, Hall is also the recipient of an Academy of American Poets Prize.

The collection has been published as part of the University of Arkansas Press Poetry Series, which is edited by poet Enid Shomer. The poetry series publishes works by emerging and mid-career poets. ■





why is it that children learn a second language more readily than adults?

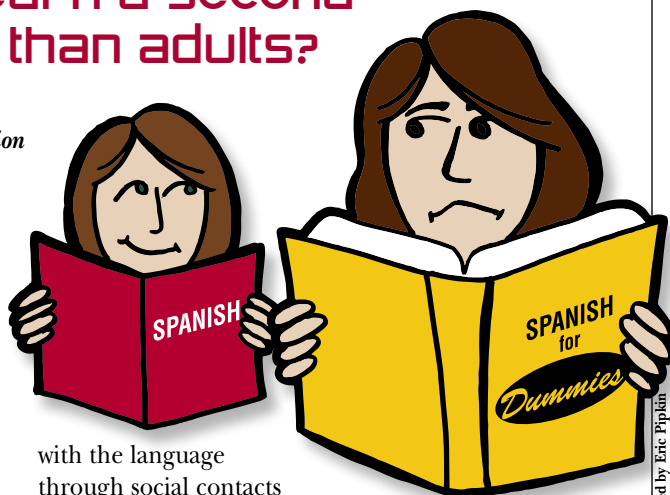
Freddie Bowles, assistant professor of foreign language education in the department of curriculum and instruction in the College of Education and Health Professions, replies:

People who have bilingual children marvel at their ability to pick up a second language so readily and seemingly without effort. This observation perpetuates the general supposition that children learn another language more easily than adults, but linguists caution us to take this bit of folk wisdom with at least one grain of salt.

In 1967, Eric Lenneberg proposed the Critical Period Hypothesis, a suggestion that the brain's plasticity lends itself to language learning until puberty. The popularity of this hypothesis has some limited validity. Most researchers agree that there is a 'sensitive' period for language learning before puberty, but the successful acquisition depends on the linguistic function.

Then why do children learn a second language so readily? First of all, they are unafraid to use the language. They enjoy mimicking the sounds, patterns and rhythms of a new language. They are naturally attuned to the phonological system of a language.

Another reason is contextual. Children interact



Illustrated by Eric Pipkin

with the language through social contacts in school, on the playground and after school. They are immersed in a language-rich environment. This informal use of the language is readily acquired within one to two years of exposure, so adults perceive children to be fluent speakers of the new language. However, we should be cautioned that the language of school, academic language, is not so readily acquired. It takes between five to seven years to acquire this special form of language, so although a child may be a fluent speaker and listener of everyday social language, they aren't so readily prepared to tackle the more demanding language of the classroom. ■

what is the subprime market?

Ventsi Stamenov, portfolio manager and investment analyst at the Garrison Financial Institute in the Sam M. Walton College of Business, replies:

Subprime lending is the practice of making loans to borrowers with questionable or deficient credit history. To compensate the lender for the default risk associated with lending to borrowers with poor credit, subprime borrowers are charged a higher interest rate than borrowers with good credit ratings. Subprime lending is risky for lenders and borrowers due to the combination of high interest rates, poor credit history and adverse financial situations usually associated with subprime applicants.

The subprime mortgage financial crisis of 2007 was characterized by a rise in home foreclosures, which started in the United States during the fall of 2006. The value of U.S. subprime mortgages was estimated at \$1.3 trillion as of March 2007. The share of subprime mortgages to total originations increased from 9 percent in 1996 to 20 percent in 2006. While U.S. housing prices

continued to increase from 1996-2006, refinancing was available. However, once housing prices started to drop in 2006-2007 in many parts of the U.S., refinancing became more difficult. Mortgage lenders that retained credit or default risk were the first impacted, as borrowers became unable to make their mortgage payments.

Due to a form of financial engineering called securitization, many mortgage lenders had passed the rights to the mortgage payments and related credit risk to third-party investors via mortgage-backed securities. Investors holding these securities faced significant losses, as the value of the underlying mortgage assets declined and payment streams became unpredictable. In addition, legal entities designed to isolate this risk from the originating lenders, called collateralized debt obligations and structured investment vehicles, held substantial amounts of mortgage-backed securities. As the value of payments into these entities declined, their value also declined, forcing the sale of these securities, sometimes at fire-sale prices. ■