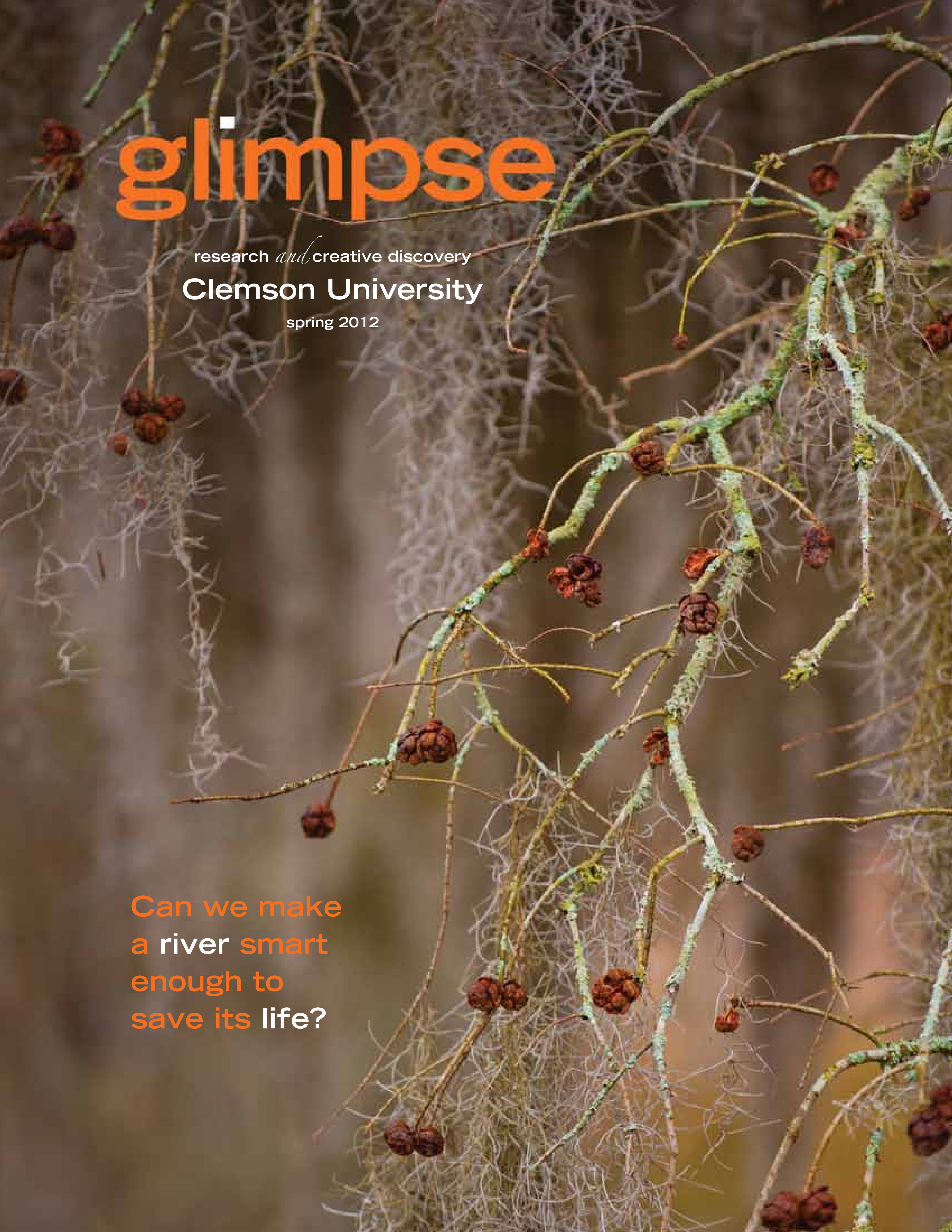


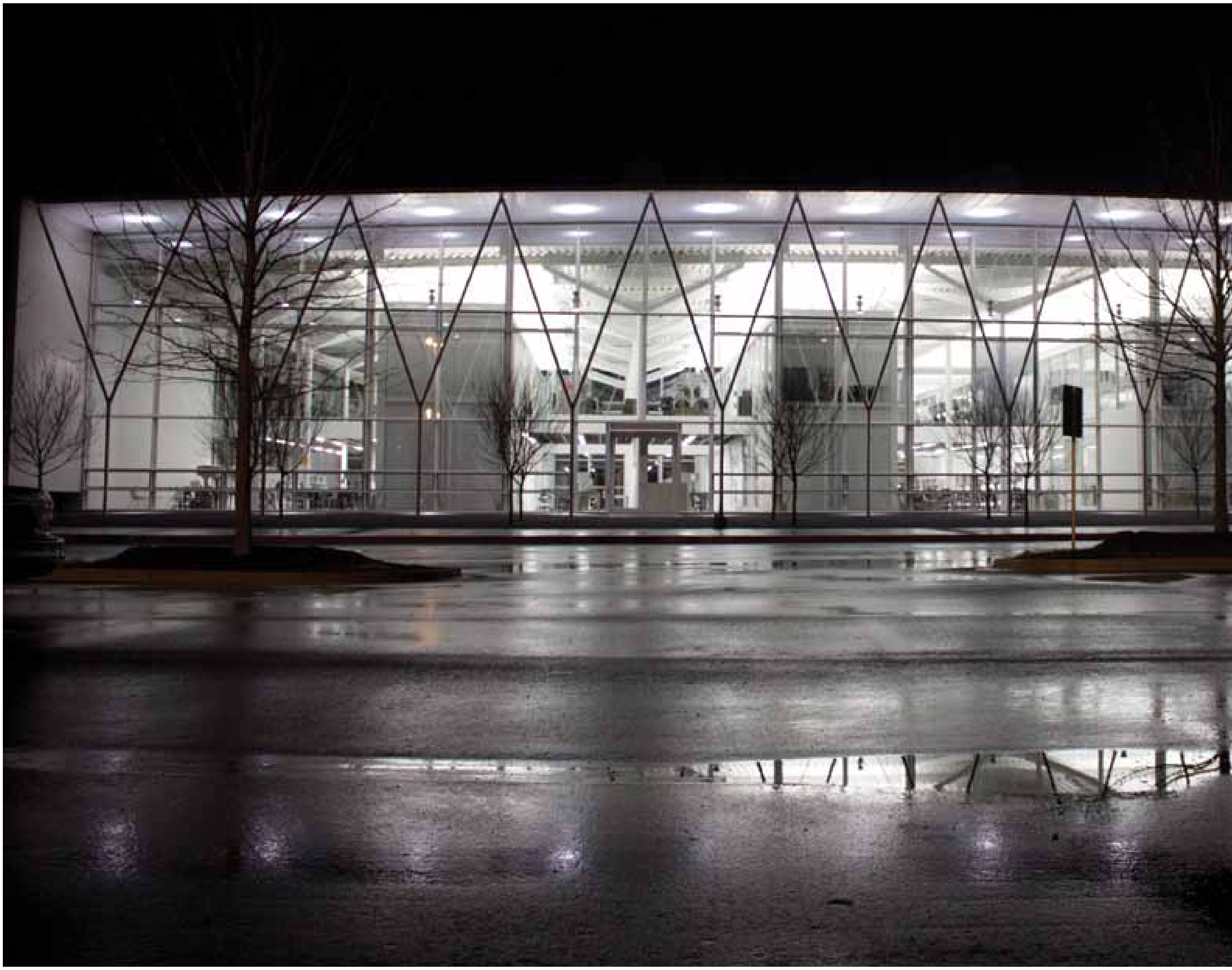
glimpse

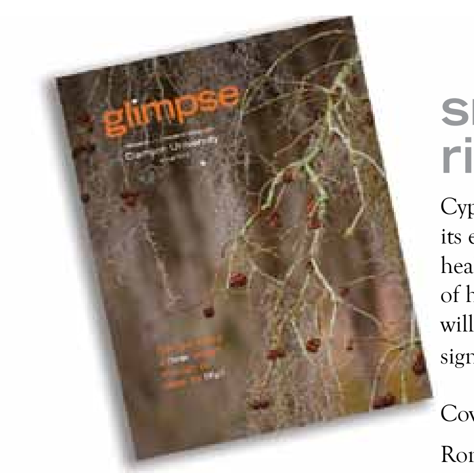
research *and* creative discovery

Clemson University

spring 2012

Can we make a river smart enough to save its life?





smart rivers

Cypress seeds, like a region and its economy, depend on the health of a river. With hundreds of high-tech sensors, scientists will watch a vital river's vital signs. Page 8.

Cover photo by Craig Mahaffey.

Ron Grant, public information director in the College of Engineering and Science, first proposed *glimpse* as the magazine's name.

glimpse

Volume 1, number 1, Spring 2012

glimpse is published by Clemson University's Office of the Vice President for Research. Editorial offices are in Public Affairs, Trustee House, Fort Hill Street, Clemson, SC 29634-5611.

Find us online: clemson.edu/glimpse

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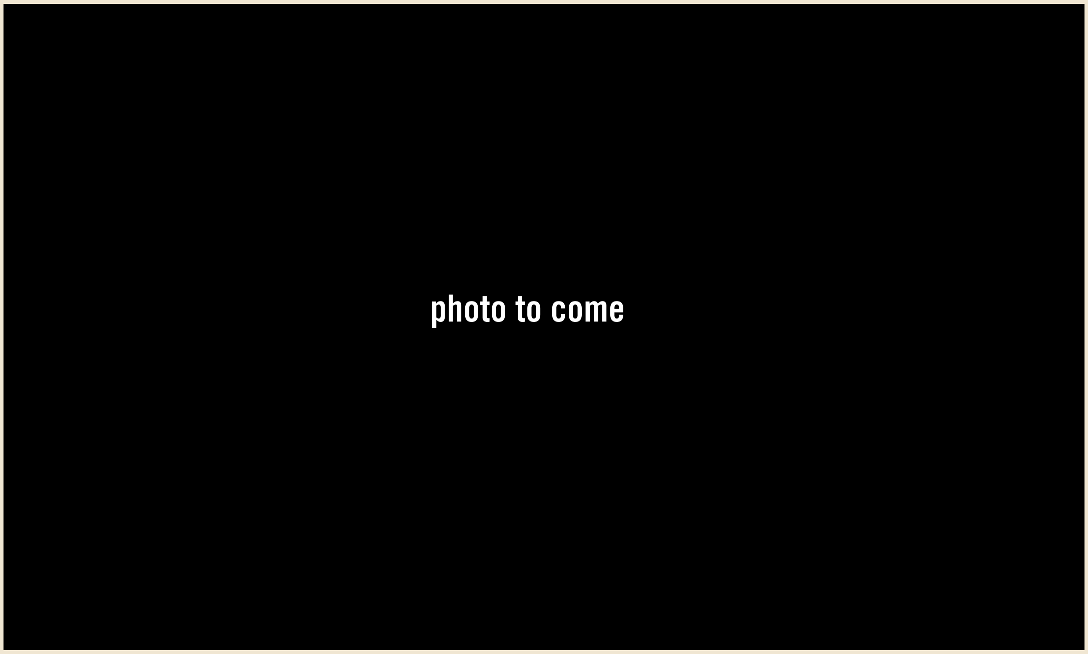
Above: Lit for early risers, Lee 3, a sparkling new addition to Lee Hall, radiates optimism on a rainy morning in January. Designed by Tom Phifer, a Clemson graduate, the building uses state-of-the-art tecnhologies to save energy and fill its spaces with fresh air and natural light. For students and faculty members, the building sets a high bar: design for the future but learn from the past. For more, see page 42.

in this issue

Craig Mahaffey



James Barker (left) and Gerald Sonnenfeld (right) visit with students and faculty members in the Jordan Hall Imaging Facility.

Research is a way of learning.

This year, as we celebrate the 150th anniversary of the Morrill Act, which established the land-grant college system, it seems fitting to launch a new magazine devoted to research and creative discovery at Clemson University. As a land-grant institution, we know how to put new knowledge to work in the service of society. We do this every day, in our teaching, extension, scholarly publishing, and partnerships with industry and government. And we do it by sharing with the public what we learn from research.

Today, when the tap of a key can access more information than a person can possibly fathom, what can a magazine add to the mix? It can help us make sense of the science, the scholarship, and the artistic achievements that are changing our world. And it can give us a glimpse of the struggle behind the scenes. What does it take, for example, to engineer a new technology, design a better building, or produce a better food? These are stories of technical advances, yes, but they are also stories of human ingenuity, perseverance, and the passion to *learn*. At Clemson, research is first and foremost a way of learning, for students and faculty members alike.

Knowledge today expands so rapidly that the only way to stay current is to work at the frontier, conducting research, pushing the limits of what we know. When we expose our students to research, we equip them to change with the times. We also instill in them an appetite for discovery, the habit of precision, and the discipline of rigorous, original thought.

For all of these reasons, we want you to have a glimpse of what we are learning. We want to include you in the intellectual life of Clemson University as we wrestle with the crucial topics of our time. I hope you will join us, and I hope you enjoy what you find in the pages of *glimpse*.

James F. Barker
President

Have a glimpse of what we do.

When I arrived at Clemson in 2010, I found an impressive array of research especially relevant to the urgent issues of our time. Business and employment, engineering and advanced materials, health and nutrition, food and agriculture, the environment—all of these were front and center in Clemson research. The faculty here, I learned, included exceptional problem-solvers with a knack for working with partners in the outside world. We have specialists, yes, but they do not isolate themselves in specialization. They work across departmental lines to increase knowledge, create opportunities, and improve the quality of life.

This commitment extends beyond the bounds of science. In my first months at Clemson, I met historians, architects, artists, English professors, and many others who clearly shared a passion for discovery. Discovery is the heart of academic achievement, at every level and in every field.

We inspire that passion for discovery in our students. Everywhere I look, I find teams of undergraduate students working with faculty members to solve problems and push the limits of knowledge, learning the tools and techniques that will help them thrive in a rapidly changing, high-tech world.

We wanted to share this culture of discovery with people everywhere, to give them a glimpse of what goes on here. That's why we chose to create a magazine, the first-ever campus-wide research magazine here at Clemson. Yes, we will continue to use the new tools of modern communication, including websites, digital publishing, and social media. But there is nothing like a magazine to capture, in tangible and enduring form, the spirit of a community. We believe that over time our magazine will help us enlarge our community, drawing new readers into the intellectual life of Clemson University. We will do this with good, true stories, not with bragging points and spin. And we will do it with our readers foremost in mind.

We would be honored to count you among our readers. Please join us. Have a glimpse of what we do.

Gerald Sonnenfeld
Vice President for Research

zoom in

"Art is not what you see,
but what you make others see."
Edgar Degas

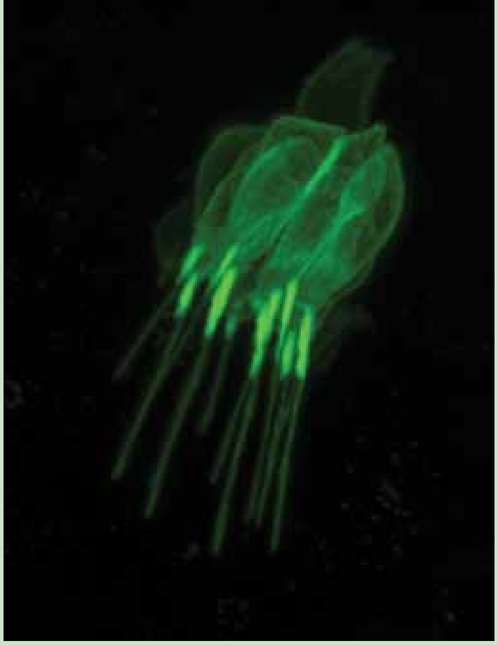
transformations

A new generation of tools is allowing scientists to reveal, in breathtaking detail, once-hidden patterns of life. "From the scientific point of view, images like these are a treasure trove of information," says Terri Bruce, manager of the Jordan Hall Imaging Facility. "There is a vast amount of detailed data within a single micrographic image."

Researchers skilled in reading the images can observe, for instance, how an organism develops, the movement of living cells, the arrangements of proteins, or the surface properties of materials. Today, a picture is worth more than a thousand words. It is worth reams of data.

But the value of images goes deeper than data, Bruce says. She points for example to the work of Poulomi Ray, a Ph.D. student in Susan Chapman's lab in the Department of Biological Sciences. "One look at the remarkable intricacies of her tissue sections transforms the perceptions of the viewer," Bruce says. "She makes us see how lovely our world truly is."

Terri Bruce is a research assistant professor in biological sciences.



Hair cells in the developing ear of a zebrafish. The specimen is genetically engineered to express a green fluorescence protein. Terri Bruce made this image on the Nikon Ti Eclipse C1si confocal microscope.

Chick embryo intestine, 200X magnification. To prepare this image, Poulomi Ray used 40-micron frozen sections taken from the trunks of chick embryos. She treated them with stains, labeling agents, and antibodies to reveal hidden structures, and took confocal images.

life most vulnerable

Susan Chapman's lab studies how complex organs develop in embryos, a step toward learning how to prevent birth defects. With images like the one at left, a confocal micrograph of a section of a chick intestine, Chapman and Poulomi Ray can study cells and tissues as they develop.

A similar approach helps Chapman investigate the possibility of regenerating damaged hair cells in the inner ear. In this research she uses zebrafish, which, unlike people, can naturally regenerate the damaged cells. The image above shows zebrafish stereocilia, which transform the energy of sound waves into electrical signals. Mutations, noise, and chemical exposure can break the links between stereocilia and hair cells. Chapman's research studies ways to regenerate these links and restore hearing. The research could lead to therapies for reversing hearing loss in people.

Susan C. Chapman is an assistant professor in the Department of Biological Sciences, College of Agriculture, Forestry, and Life Sciences. Her research is funded by the National Institutes of Health, National Institute on Deafness and other Communication Disorders.

learning from the butterfly

With powerful new imaging systems, scientists can look to nature for ideas about how to design better instruments and machines. Matt Lehnert, a postdoctoral fellow in entomology, works with a team of engineers and biologists to develop a new device for use in microfluidics, the precise management of small amounts of liquid. Uses for microfluidic devices range from inkjet printers to lab-on-a-chip technologies in medicine. As it turns out, the feeding tube of a butterfly, called the proboscis, is a marvel of microfluidic design.

"The butterfly proboscis previously has been assumed to function only as a drinking straw," Lehnert says, "but the butterfly proboscis is much more complex than that."

The research team's experiments have shown that the proboscis has hydrophilic (water-loving) and hydrophobic (water-fearing) properties that combine sponge-like capillary action with straw-like sucking. Working together, these structures enable butterflies to take up minute amounts of liquid.

The image below (and on page 5) shows the proboscis of a red-spotted purple butterfly, *Limenitis arthemis astyanax,* which feeds on juice from rotting fruit, sap, and sometimes nectar. The red structures are hydrophobic; the green are hydrophilic. By studying this system, the research team can learn how very tiny structures can take up minute amounts of fluid. This will yield new knowledge about the evolutionary biology of butterflies and other fluid-feeders; it may also lead to microfluidic devices with wide applications, Lehnert says.

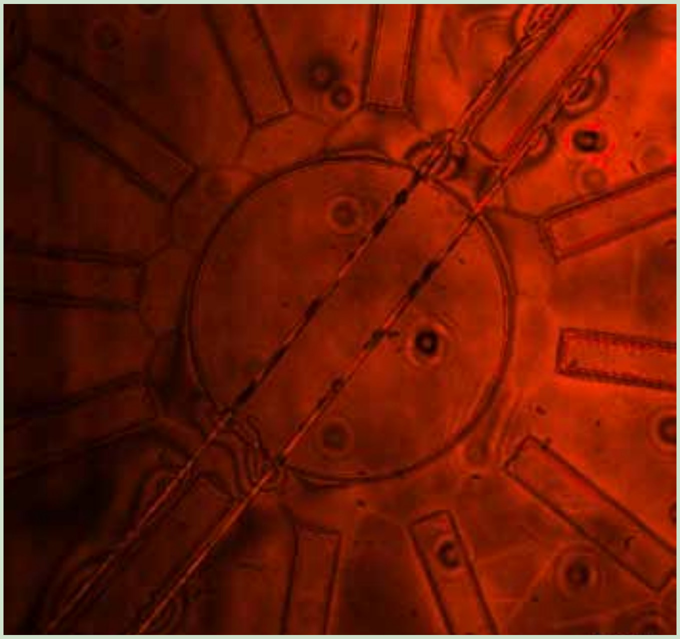
Matthew S. Lehnert is a member of a research team led by Konstantin G. Kornev, associate professor of materials science in the College of Engineering and Science, and Peter H. Adler, professor of entomology in the School of Agriculture, Forestry, and Life Sciences. The National Science Foundation funds this research.

Proboscis (feeding tube) of a red-spotted purple butterfly. This image, a portion of which appears on page 5, was prepared by Matthew S. Lehnert, Charles E. Beard, and Terri Bruce. It was taken near the tip of the proboscis with a Nikon Ti Eclipse C1si confocal scope at 100X magnification. The proboscis had been stained with a fluorescent dye, Nile red, which binds to hydrophobic parts and appears red when excited with particular wavelengths of light.

breaking the wave

Flexible electronics (think bendable TV screens) are exciting new devices. One challenge: the bond between the metal circuitry and the polymer backing must be durable. As part of a collaboration with Neville Moody of Sandia National Laboratory, students in Molly Kennedy's group studied tungsten films applied to substrates made of PMMA, a polymer. In the upper right hand corner of the image at right, "river marks," formed as the film initially buckled, led to the kind of separation shown in the lower left. Ashley Sachs, an undergraduate student in Kennedy's group, prepared the sample for imaging.

Molly Kennedy is an assistant professor in the School of Materials Science and Engineering, College of Engineering and Science. Funding for this work is from Sandia National Laboratory.



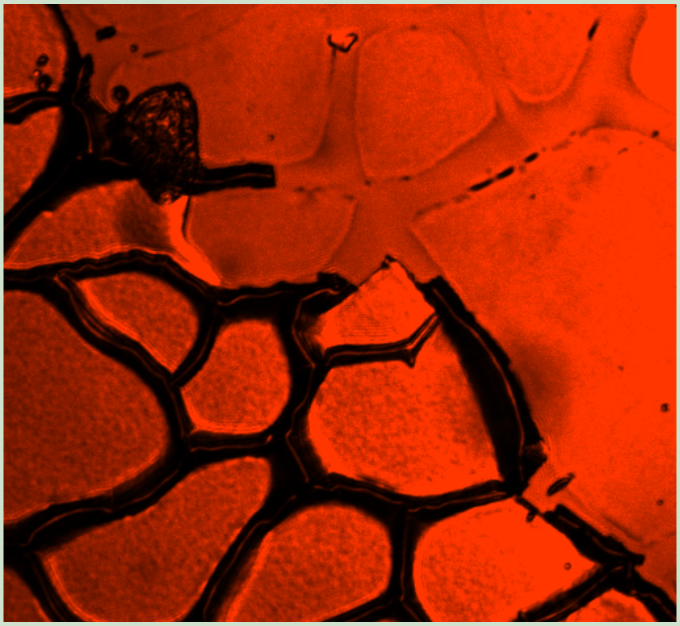
A tiny sensor imaged by Terri Bruce on the Ti Eclipse C1si confocal microscope.

lab on a chip

A laboratory the size of a computer chip? Yes. Scientists are learning how to create miniature labs that can help analyze tiny amounts of material, even single cells.

Yang Yang, a visiting Ph.D. student from China, designed and fabricated the radio-frequency (RF) sensor above at Oak Ridge National Lab. This ultrasensitive sensor allows scientists to detect and analyze the cell intact, without cutting or labeling. A tube-like structure on the device will enable detection with radio-frequency waves, and the spoke-like AC electrodes are designed to rotate the cell.The RF techniques are expected to be portable, low-cost, and easy to use.

Pingshan Wang, associate professor of electrical and computer engineering, leads the group. Primary funding is from the National Science Foundation.



Tungsten film imaged by Terri Bruce on the Ti Eclipse C1si confocal microscope.

star power

When you're on the beamline, the sky's the limit.

With a rare tool called an ion beamline, Chad Sosolik will make star stuff in his lab. He and other scientists will strip atoms of their electrons, producing highly charged ions that in nature are made only in the bellies of stars.

"It's really a puddle of stellar matter," Sosolik says. "In an iron atom, for instance, this produces a highly charged ion at an extremely high temperature—on the order of ten million Kelvin—hot as the inside of a star. Such highly charged ions don't exist on Earth outside of a lab environment. They fly through space, hit the atmosphere, and immediately pick up electrons. So this is a rare opportunity for us to observe them and actually use them in ways that weren't possible before."

A single highly charged ion can deliver more energy with precision than the biggest lasers, Sosolik says, and is easier to use. "What can you do with it? We don't know. Pretty much anything we try is going to be new."

The beamline, which will be fully operational this summer, will be the third Electron Beam Ion Trap (EBIT) beamline of its kind in the U.S. and one of only seventeen in the world. Thirteen universities and research labs are working with Sosolik to establish collaborative arrangements that will attract new research to Clemson.

Sosolik sees an immediate impact in research on new industrial materials, such as radiation-hardened electronics destined for the space. "We can simulate solar wind on the ground and see if the material is impervious to radiation," he says. "In space-bound equipment, with your electronics packed into a very small area, you could lose it all with one ion impact."

Biomedical researchers, for example, could use the tool to send charged ions down a fiber-optic cable to treat tumors. Physicists could use the EBIT to measure what happens to materials inside a fusion reactor, something that cannot be done in existing fusion facilities.

The first EBITs for creating highly charged ions emerged more than twenty years ago, but their superconducting magnets expended liquid helium for cooling and cost thousands of dollars a day to operate. A breakthrough in cooling technology recirculated the helium and cut costs.

Established scientists won't be the only users. Sosolik will also make "beam time" available to undergraduates studying atomic and nuclear physics, electronic materials, and fusion energy.

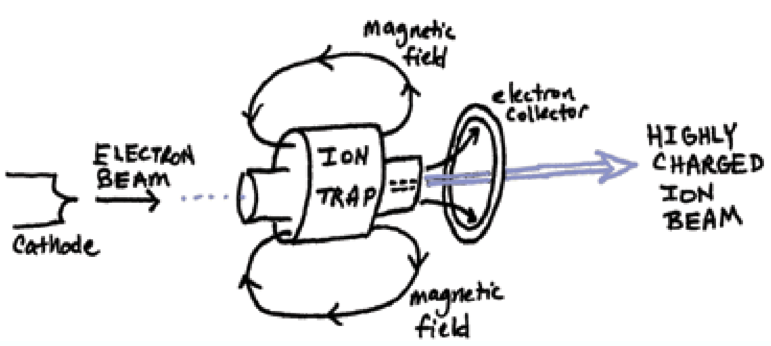
Sosolik will use the EBIT to simulate the evolution of dust and ice in the cosmos. He plans to reproduce X-ray emissions from comets by making ice targets in the lab and dropping them in front of the ion beam.

"You can't exactly make a comet in the lab," he says, "but that's essentially what's going on."

Chad Sosolik is associate professor of physics. His collaborators include Sean Brittain, Rod Harrell, Jian Luo, and Pete McNulty. The National Science Foundation provided the funding.

– Tom Hallman

Whiteboard



An Electron Beam Ion Trap, or EBIT, allows scientists to trap the highly charged ions in an electromagnetic field and then release them down a vacuum tube—the beamline—where they are focused on tiny targets. Potential research projects range from new semiconductor materials and cancer-fighting particle beams to basic science in astrophysics and the properties that govern the quantum mechanical tunneling of electrons.

Sketch by Chad Sosolik

firing up a cool hot car

Previous Deep Orange teams reingineered the insides of existing car bodies like the one shown below. For Deep Orange 3 the student team began with a blank sheet of paper. The schematic at right shows the position of drive-train elements for the team's all-wheel-drive hybrid, scheduled to be unveiled in August.

Most graduate programs end with a tome for the shelf. This one produces a car. Do it right, and you can crank up your thesis and drive it around the block.

Deep Orange 3, the third generation of Clemson's build-it-yourself master's program in automotive engineering, is coming together on computer screens and hardware-assembly stations in a soaring, sun-filled lab at CU-ICAR, the Clemson University International Center for Automotive Research. In the past, Deep Orange teams began with existing car bodies and reengineered the insides. This time the stakes are higher.

"The students began with a blank sheet of paper," says Paul Venhovens, the faculty member who leads Deep Orange. "They are designing and building a car from start to finish."

One car, two coasts

The Clemson team, now thirteen master's students who plan to graduate in August, collaborates with the Art Center College of Design in Pasadena, Calif., where students style the vehicle's exterior. It's a two-year project with one car, two coasts, and two cultures.

"Working with the team in California, our students gain insight into the stylistic and emotional elements of the vehicle," Venhovens says. "They also bring the Art Center students down to earth. It's one thing to draw a pretty picture, another thing to turn that picture into a real, working car."

In this case the real working car will be a sleek hybrid with all-wheel drive and room for six. The goal? A halo car—something bold enough to claim attention for the brand.

Christopher Damico, a student engineer on the project, says the team began with a study of the market, researching the preferences of Generation Y consumers aged seventeen to thirty-three. Gen Y buyers are asking for an environmentally friendly car with unique styling, excellent fuel economy, and plenty of room for friends. The buyers also want the extra traction of all-wheel drive, especially for winter driving in the Northeast.

"From the market research, we came up with hundreds of targets," Damico says, "and we had to engineer systems to hit those targets." One target, for example, was quick acceleration; another was fuel economy. Such targets conflict, so students learn to set aside their personal preferences and work in teams to balance the trade-offs and integrate hundreds of systems into a coherent whole.

Along the way they use a few off-the-shelf parts supplied by their sponsor—in this case, Mazda. "Why design a new radiator if you don't need to?" Damico asks.

A new kind of hybrid

The biggest innovation in Deep Orange 3, the students say, is its hybrid powertrain. Nothing like it exists on the road today.

At the moment, there are two kinds of hybrid vehicles in production—series hybrids and parallel hybrids. The Chevy Volt is a series hybrid, which means that its combustion engine serves as a generator, recharging a battery that always powers the car. The Toyota Prius is a parallel hybrid; it can send power to its drive wheels from either an electric motor or an internal-combustion engine.

Deep Orange 3 will be a new kind of parallel hybrid. Unlike the Prius, which requires an elaborate transmission system to distribute power from one engine or the other, Deep Orange 3 will drive the front wheels with a combustion engine and the rear wheels with an electric motor. An onboard computer will keep the two in sync. The team also engineered the car's computerized battery-management system, which monitors and regulates the flow of electrical power.

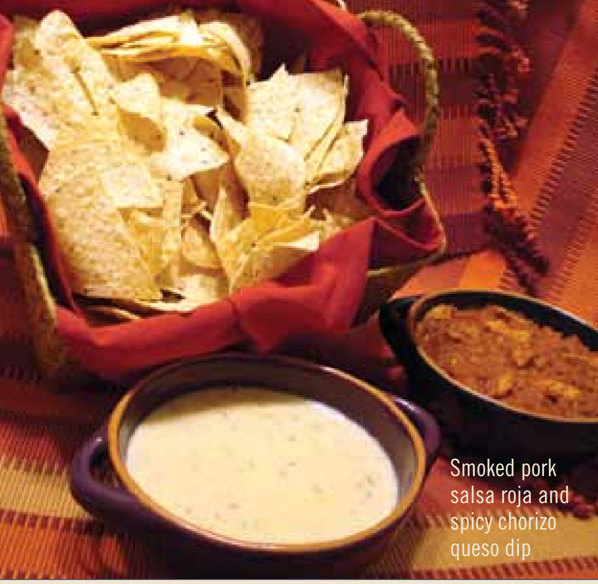
"The main idea is to make a hybrid more fun, more spirited," says Patrik Frommann, a student on the team. "We want the electric drive to support accelerating the vehicle and provide an exhilarating driving experience."

The students say the car will be ready to roll in August, in time for graduation. Meanwhile, they refuse to divulge certain proprietary details, including the sleek wrapper being designed in Pasadena. After all, no serious carmaker gives away its secrets, and for students in Deep Orange, this is serious business.

"They begin with the marketing data and are building a new, working car from scratch," Venhovens says. "Where else can you find an experience like that?"

Paul Venhovens is the BMW Endowed Chair in Automotive Systems Integration and SmartState Endowed Chair in Automotive Systems Integration. Mazda North American Operations is a primary corporate sponsor for Deep Orange 3. For a complete list of sponsors, see www.cuicardeeporange.com/do3partners/.

– Neil Caudle



Smoked pork salsa roja and spicy chorizo queso dip

food fight

Two creations by two teams of students. Both have a shot at the prize. Their edge? Science.

Texas triangles with poblano cheese sauce

JoAnna Gorcesky admits she's a little bit nervous about the big shootout in San Antonio. "I have dreams about it," she says. "Not the good kind."

But Gorcesky, a senior in food science and human nutrition, says she'll be ready, come March. She and teammates Mollye MacNaughton and Chad Carter already show a bit of Texas swagger as they prep their savory pastries in the research kitchen of Poole Hall. In San Antonio, the team will cook against student teams from across the nation in a contest sponsored by the Research Chefs Association.

The stiffest competition may well come from another Clemson team, the Three Senioritas, whose dip duo aims at the same market: party food for people with a taste for Tex-Mex. At stake: $5,000 for the winning team.

"We have finalized our commercial product, and now we're working on our speed and efficiency," MacNaughton says. "We have to prep and cook the whole dish in an hour and a half."

Both teams began with the same set of ground rules: each dish would be Tex-Mex, would include pork, would qualify for sale in the frozen-food aisle of a club store, and would retail for $7.99. The cost of the ingredients, including the package, could not exceed 25 percent of retail price.

And (this is the hard part) the frozen product, heated and served to the judges, would have to match the "gold standard," the dish as the team would prepare it from scratch during the contest using fresh ingredients.

One food, two versions

Consider the label of any frozen, prepared food. Most of the mystifying ingredients listed there are present because freezing, shipping, storing, and reheating will, without help from modern chemistry, yield a flavorless, soggy mush. So a commercial product, with its stabilizers, emulsifiers, and flavor enhancers, is radically different from the version made at home.

Cheese sauce, a must for both teams, has trouble keeping itself together in a freezer. And the small amount of lard in the pastry shell for Texas triangles? That's a no-no in the commercial version. So the food scientist adds, with precision, a touch of artificial lard flavoring, to give the crust a hint of richness. Smoked meat, grilled meat, lime juice, or almost any other flavor you can imagine has a chemical correlate, but you have to know the science to use it.

"You run experiments," Chad Carter says. "You try each ingredient, measure it exactly, keep careful records, and analyze the results. It's a long process of trial-and-error. This is real research."

Beyond the kitchen

After some brainstorming, both teams settled on ideas for products, refined their recipes, and delved into an industrial-strength database of product information, food-consumption patterns, and sales trends for the food industry. Drawing on the research, each team developed a business model, defined a market niche, and developed marketing materials. They also calculated nutritional information and used a focus group of students, faculty, and staff to test various recipes. A student in packaging, Natalie Quin, designed packages for both teams' products.

Carter, a chef who returned to college to retool for a new career in the food industry, says this kind of hands-on research is an ideal way to learn. "You take more ownership, on a project like this," he says. "People are passionate about what they're doing."

Aubrey Coffee, faculty advisor for both teams as part of Clemson's Creative Inquiry program, says that today's students are tuned in to the science of food. "When I started here in two thousand and five, I had twenty-five advisees," Coffee says. "Now I have seventy-six. We tell people that we study food from the farm to the table. That's what it's all about."

Aubrey Coffee is a senior lecturer and sensory coordinator in food science and nutrition in the College of Agriculture, Forestry, and Life Sciences. Creative Inquiry students earn course credit for conducting research.

– Neil Caudle

Learn how the teams fared in Texas: **clemson.edu/ glimpse**

Left: the Three Senioritas team: Audrey Boushell, Keri Lipscomb, Aubrey Coffee (faculty advisor), and Kathryn Davis. **Above left:** "functional" ingredients await alchemy. **Above right:** chef Chad Carter minds the timer. **Right:** Mollye MacNaughton and JoAnna Gorcesky roll dough for Texas triangles.

water for Cange

Clemson Engineers for Developing Countries help bring clean water to thousands of Haitians.

by Thomas Larrew

Jeff Plumblee, CEDC program director, measures a dam.

CEDC students and Haitians route pipe.

A few years ago the people of Cange, Haiti needed water. Some of them had to walk a thousand feet down the mountain and climb back up lugging forty-pound buckets. Today, a new system pipes clean water up the mountain and into Cange. A team of Clemson students, working with Haitian partners, helped make it happen.

Clemson Engineers for Developing Countries (CEDC) began in the fall of 2009, when seven students in civil engineering noticed that something was missing from their curriculum.

"We wanted to take our technical skills outside of the classroom to gain real-world experience," says Jeff Plumblee, a Ph.D. candidate who is one of the founding members and program director of CEDC. "This helped develop our students into better team members, leaders, and more compassionate community members."

When the team heard that the Episcopal Diocese of Upper South Carolina had a new project to replace the water system of Cange, the students knew it was a perfect fit. This was a project that could teach both collaboration and leadership, and it would test their engineering knowledge and communication skills.

In January 2010, a few months after the project began, an earthquake killed 300,000 Haitians and devastated the lives of more than three million people. In an instant, the water-system project became urgent. Even though Cange did not take a direct hit, most of the hospitals in nearby Port-au-Prince did, and they sent many sick or injured patients to Cange. With the lives of thousands of fellow Haitians in their hands, the people of Cange needed clean water.

A first for Haiti

CEDC designed a system that would filter out large contaminants, kill microbes with ultraviolet radiation and chlorine, and then transport the water through the village in new pipes buried underneath recently paved roads. It would be the first chlorinated municipal water system in Haiti.

The water system now serves 20,000 people. CEDC is installing a second pump to meet the needs of Cange's growing population and to ensure a supply of water when one of the pumps is down for repair. The system has been so popular that people from the surrounding mountains walk great distances to access Cange's water.

Meanwhile, CEDC has been growing, moving beyond Cange into Haiti's Central Plateau. By 2012, CEDC included fifty-two students from multiple disciplines. English students document the work and handle communications with partners and communities. Engineers develop pumping systems, some of them solar-powered, for villages situated uphill from their water supplies. Students in computer science manage the website and document-storage system.

Kaleen Greenwade, an undergraduate engineering student, spent last summer in Haiti pouring concrete, setting rebar, building masonry walls for cisterns, and running a pipe-laying crew. He learned from his Haitian partners how to improvise. "You're building easy structures, but you're doing it in a new culture, without the right tools," he says. "You learn to rely on your partners and work with what you have."

Wherever they went, the team encountered rugged terrain. "The land in Haiti was mountainous, and the water sources were usually quite a distance from the villages," recalls Mette Kolind, an undergraduate member of the team. "We had to work up hills, around trees, and through farmland."

The next step? Make sure the new facilities keep working. The team plans to construct a project-management office in June of 2012 and teach Haitians how to maintain the new water systems. CEDC's partners have flown several Haitians to the U.S. for training.

A immense impact

But the students are learning as much as their hosts. Katie Wunder, a senior English major who went to Haiti last fall, says Haiti "had an immense impact" on her life.

"Perhaps most moving is realizing and accepting how a life without safe water is standard for them," she says.

In May 2011 CEDC, which is a part of Creative Inquiry, received a commendation of excellence for service learning from the South Carolina Commission on Higher Education. Primary faculty advisor is Jennifer Ogle, associate professor of civil engineering; numerous faculty members have contributed. Funding has been provided by Creative Inquiry, Clemson University student government, and the Episcopal Diocese of Upper South Carolina. For more information, visit: people.clemson.edu/~cedc/

Thomas Larrew is a senior majoring in biochemistry.

after Fukushima

It's not enough to engineer a safer facility. You also have to understand what happens in the environment, if things go wrong.

The earthquake and tsunami that disabled the Fukushima Daiichi Nuclear Power Station in March 2011 rocked the industry like a tidal wave.

"Once again, people were debating the risks and benefits of nuclear power," says Timothy DeVol, a professor in Clemson's nuclear environmental engineering and science (NEES) graduate program. "Right now countless industry professionals are trying to determine exactly what happened and how we can apply those lessons learned."

At home in the environmental sciences, NEES researchers study nuclear power in an environmental context. What are the factors that affect the movement of plutonium and other radionuclides, the atoms involved in radiation? How can we develop better systems to detect and measure radiation? And how can we prepare the next generation of skilled engineers to guide a changing nuclear industry?

Today, South Carolina finds itself in the midst of a nuclear renaissance. The Department of Energy is building a $4 billion facility at the Savannah River Site (SRS) to dispose of surplus weapons-grade plutonium by converting it into fuel for nuclear power reactors. On the commercial side, Duke Energy and South Carolina Electric and Gas are both constructing nuclear plants, and companies are applying for twenty-year extensions on licenses for reactors that began operating in the late 1970s and 1980s. In Burke County, Ga., just across the river from SRS, the Southern Company has begun site preparation for two new units at its Vogtle facility.

Detective work

"All of these locations present different challenges in terms of spent-fuel storage, high-level waste, and legacy materials," says the newest NEES faculty member, Lindsay Shuller-Nickles. "If you are a nuclear researcher and educator, Clemson is the place to be."

Shuller-Nickles and her students are evaluating the release of radionuclides into the environment and their subsequent mobility. If radionuclides escape containment, how will they react with local groundwater and minerals? And how will different forms of waste change over time?

Three years after completing his Ph.D., Brian Powell returned to Clemson to lead a program in environmental radiochemistry. He studies the behavior of radionuclides to learn how to clean up sites contaminated during nuclear-weapons production and how to evaluate nuclear-waste disposal sites. Powell's data could show, for instance, when nuclear waste would find a safer resting place outside of South Carolina.

In other cases, researchers work to improve the storage of waste already here. As part of its cleanup effort, SRS asked for data on the performance of engineered barriers used in radionuclide disposal. NEES researchers are providing it. (On-site disposal of waste costs approximately ten percent of what would be charged for off-site disposal.)

With two grants from Department of Homeland Security, NEES is building up its training program in radioanalytical chemistry and establishing a nuclear forensics program in collaboration with national laboratories. The research will focus on water-system monitoring and changes in nuclear fuel particles after release into the environment. Another project will deploy fifty lysimeters—instruments for tracking precipitation and the movement of water—to follow plutonium and other key radionuclides under natural conditions for ten years.

Such studies are especially timely, DeVol says, because many of the issues facing the industry today have to do with radioactive contaminants in the environment.

"While a Fukushima-type event correctly gives us pause," says DeVol, "it is our responsibility as nuclear educators and researchers to apply lessons learned and continue a tradition of service, safety, and reliability."

NEES is a part of the Department of Environmental Engineering and Earth Sciences in the College of Engineering and Science. Timothy DeVol was recently named the Toshiba Endowed Professor in Nuclear Engineering.

– Ron Grant

on the job

During the Fukushima crisis, Clemson alumni applied their expertise. A few examples:

David Brown (M.S., 1993) is a senior health physicist with the U.S. Nuclear Regulatory Commission (NRC), where he applies lessons learned in Japan to the development of new requirements for U.S. reactors.

Andrew Scott (MS/Ph.D., 2010) is a nuclear weapons effects analyst with the U.S. Army. After the tsunami, he developed recommendations and policies designed to protect service members working in Japan.

Aurelie Soreefan (Ph.D., 2009) is the radioanalytical technical director with the U.S. Air Force Radiations Analysis Laboratory, at Wright-Patterson Air Force Base in Ohio. Soreefan reorganized work in the lab to make Fukushima sampling a priority.

Andrew Sowder (Ph.D., 1998), a senior project manager with the Electric Power Research Institute in Charlotte, N.C., is part of a team of industry and government experts who tried to understand what was occurring at the Fukushima plant and what mitigating measures might be prudent.

killer raspberries

In the lab, they snuff out cancer cells. Will it work in people, too?

Sister Mary Eris

Can raspberries help protect us from cancer? Lyn Larcom and Patilee Tate are studying that possibility, and the initial results look promising.

Most of us have heard about antioxidants, which scientists think neutralize free radicals, the natural byproducts of mitochondria burning energy for the cell. Free radicals may damage DNA and initiate tumors. "Ellagic acid is one of the most potent antioxidants," Larcom says. "Raspberries have the highest concentration of anything except walnuts. So that's how we chose raspberries."

"I tried to talk him into doing chocolate," Tate says, laughing. "It's a food. It's an antioxidant."

She spends most of her days in a small ten-by-twelve lab, working under a tissue-culture hood that resembles an oversize stainless-steel stove hood. It's a tight fit. But today she's come up to the office, another tight fit, which she shares with a bulky confocal microscope, shrouded now in a green dustcover. She uses the microscope to create three-dimensional images of cells.

Lyn Larcom, who began his career in biophysics, retired, and came back to work in Clemson's healthcare genetics doctoral program. In his narrow, Spartan office, he speaks quietly but intensely. "We showed, for example, that raspberries will kill cancer cells in culture," he says.

One of Larcom's graduate students, Jason God, compared the effectiveness of vitamin C to raspberry juice when it came to killing cancer cells. He used pH to adjust for level concentrations and treated various cancer cells with both of them. It turned out that the raspberry extract was considerably more effective than the standard antioxidant, vitamin C. The key factor may be how raspberry extract interacts with a specific compound.

"We don't know why the extract inactivates the matrix metalloproteinases," Larcom says.

Tumors secrete matrix metalloproteinases, which "chew up the proteins" around the tumor so that it has room to expand, Larcom explains. The study indicated that the raspberry extract may inactivate the matrix metalloproteinases and prevent the migration of the tumor into the blood and lymph system. Larcom wants to know how this mechanism works. "It's kind of a hard job because cells are so complicated," he says. "There's so much going on in there, to dissect it, to figure out what enzyme is involved. That takes a while." It's also tricky to keep the cells alive, he adds. "They're very delicate. It's not like growing bacteria."

One cell at a time

Back in her office, Tate spins in her chair to face her computer, grabs her mouse, and pulls up images of cells from the website where she orders them—cancer cells with particular receptors that can be labeled for the flow cytometer and the confocal microscope. The photographs range from intensely colored cancer specimens with bright blue nuclei to lacy, fluorescent green, cancerous neural cells.

Tate maintains the cells in a medium of water, minerals, and vitamins, adding serum to her cultures—fetal bovine serum, calf serum, or horse serum. The serum has growth factors and sometimes hormones, to mimic the environment in an animal. For analysis, she suspends the cells in a simple solution and places them in a flow cytometer, where they pass through a small capillary one cell at a time. The flow cytometer's lasers activate labels on the cell and the cell fluoresces. That shows the cell type and what it does. Tate holds up a printout of results from the flow cytometer. They resemble scatterplots.

"You can measure, for example, whether or not they're doing DNA repair," Larcom says. "You can do things in cell culture with tumor cells growing in a flask, but that environment is entirely different from the environment you have inside your body. What's really important is what's going on in your body, not what's going on in that flask."

Kathy Romero, another grad student, conducted the preliminary human study, which involved sixteen individuals. The study compared the blood samples—one sample taken after volunteers had abstained from fruits and vegetables for four days, the other blood sample taken after people had eaten two cups of raspberries for four days. There were dramatic results for three or four people, a promising but not definitive result.

"I'm convinced there's something going on in the blood in terms of the cell types," Larcom adds. "But we just don't have the data at this stage to go any further with that, to publish it. Because when you see a dramatic response in three or four people out of fifteen, you know something's happening in those people, but it's not enough to publish. What really needs to be done is a large-scale study on that."

Larcom says people want him to find the main active ingredient so that it can be produced in concentrated form as a pill. But of the thousands of molecules in a raspberry, Lyn estimates that perhaps three hundred could be anti-cancer agents.

"It's synergistic," Larcom explains, "with all the compounds in the berry working together." Isolating and understanding the most important of these, rather than one single element, is important too. Larcom thinks factors such as diet, stress levels, and mental attitude can be almost as influential as drugs in fighting cancer or preventing it.

"People need to realize that it's not like taking a pill, an antibiotic and getting over an infection," Larcom says. "Cancer is your body working against itself. It's your own cells. That's why no one's ever found a cure for it. You can kill bacteria, because you can find drugs that specifically kill bacteria but don't affect your body, but you can't do that with cancer, because the cancer cells are actually part of your body."

Can we protect ourselves from cancer with a healthful diet, rich in fruits, nuts, and berries? Maybe. With more data, the raspberry research might help scientists formulate a preventative for people who have a high genetic susceptibility to cancer. It might also be useful for preventing metastasis in cancer patients, particularly when the cancer is inoperable.

"If you could give them something that would inhibit that metastasis," Larcom says, "then it would be a real step forward."

Lyndon Larcom is research professor of healthcare genetics in the School of Nursing, College of Health, Education, and Human Development; he is also professor emeritus of physics and microbiology. Patricia "Patilee" Tate is a research associate in the School of Nursing. Primary funding for the raspberry research is from the Washington State and Oregon State Berry Commissions and from the Cancer Research Fund provided by Mr. and Mrs. Jim Creel.

– Jemma Everyhope-Roser

# of seeds and the river

In chilled white hands and fingertips reddened by a raw December rain, Gene Eidson holds the future: scruffy, pea-size packets of potential life. Winter is when the cypress trees drop their seed onto the ground and into tea-colored swamp water.

"Seed rain," Eidson calls it.

If there's enough water to carry the seeds to the floodplain, they will take root and grow. "It's not a sure thing," says Eidson, who directs the Institute of Applied Ecology. "The way we manage rivers today with flow control, often there's not enough water to carry the seeds. You can see the results. Floodplains have become populated by poplars and pines where cypress used to be."

So for Eidson, the story begins in the swamp, with the seeds. "I grew up not far from here," he says. "An uncle would take me along whenever he came to hunt."

The swamp was a haven, a living classroom. Eidson learned to how to see the place from Mrs. Forrest, an elderly woman of Native American heritage who befriended him and taught him to look and listen to nature.

story by Peter Kent
photos by Craig Mahaffey

Gene Eidson grew up learning to imagine the conditions for maintaining life in a river, a forest, or a swamp: "It's all connected," he says.

"She taught me to 'think' like a tree, to think about what that tree needs," Eidson says, spilling his handful of seeds into the water. "That tree spent a lot of effort producing those seeds, and it evolved with the river over millions of years, so it knows when to drop the seeds at the right time. She taught me to think like a fish, an insect, a bird. It made me imagine what the conditions are to carry on life. It's all connected. Do something here and it causes something else to happen."

Into the swamp

Eidson has brought us to Phinizy Swamp, the 1,100-acre nature park and wildlife refuge that he and a team of Augusta residents restored and made the headquarters of the Southeastern Natural Sciences Academy. Eidson founded and ran the academy, which raised more than $6.5 million to fund watershed research and public education programs. The academy research team pioneered methods to assess water quality in the Savannah River and track the impact of wastewater discharges from industries, cities, and other sources.

"We took Augusta from being the most polluted city in Georgia to being an outstanding example of environmental initiatives," Eidson says.

A decade in Augusta also taught Eidson that environmental science would have to expand at least as rapidly as environmental problems, which were already enormous in scale. To keep track of a changing environment, scientists needed better sensors, a reliable and robust computer system to manage vast amounts of data in real time, and a way to present the results, not just for scientists but for policymakers and the public.

That kind of monitoring did not exist, so Eidson went looking for the right mix of scientists to develop his project. He found them at Clemson, where he had done graduate work in the 1980s.

For Clemson's administration, Eidson's approach promised to plant some seeds of change within the university itself. Federal grant-making agencies increasingly favored big teams of scientists from multiple disciplines over solo investigators. The agencies were also looking for research results with commercial potential. Money mattered, and the project Eidson had in mind would jump-start a new industry in environmental monitoring.

Eidson debuted his ideas on campus in April 2007, when he held a faculty forum on water resources. At the time, South Carolina was dealing with a drought, and water issues were looming for the public and policymakers. After some talks by water resource experts, faculty members sorted themselves into groups and began to talk. That day, the project got rolling, but not everyone climbed on board. In the end twenty-five faculty members decided to form what Eidson describes as "a dedicated team."

Getting people on the bus involved more than signing up individual researchers. Eidson needed whole groups of environmental scientists, especially those dealing with land use and coastal ecology. Carrying his notebook, Eidson went to dozens of meetings. He listened. He took notes. He talked about his vision. Gradually, Eidson's project became *their* project too. It would change the way we monitor and manage rivers. It would involve developing and deploying remote monitoring sensors connected to each other and to Clemson through a data-transfer system. The information would be displayed not as a snapshot of what had already occurred but in real time. A pollution spill, a fish kill, flood stages—all could be reported within minutes of the incident. And scientists, water managers, government regulators, public safety responders—anyone with a connection to the Intelligent River® data network—could view the conditions online.

The team would build Clemson's first macroscope.

The word *macroscope* was coined in 1975 by French molecular biologist Joël de Rosnay. In the 1979 English edition of *The Macroscope:A New*

World Scientific System, de Rosnay wrote:

> We need, then, a new instrument. The microscope and the telescope have been valuable in gathering the scientific knowledge of the universe. Now a new tool is needed by all those who would try to understand and direct effectively their action in this world, whether they are responsible for major decisions in politics, in science, and in industry or are ordinary people as we are.
>
> I shall call this instrument the *macroscope* (from *macro*, great, and *skopein*, to observe).

Eidson named Clemson's macroscope the Intelligent River®, and he would turn it first on the Savannah, the same river whose banks he had roamed as a boy, and the same river he had helped to purge of pollution during his years in Augusta.

Stretching from mountains to the sea, the 312-mile Savannah River slakes the thirst of a burgeoning population, dilutes wastewater from industry and sewage treatment plants, irrigates farms and, oh yes, is home for the biota of the watershed.

Buidling a macroscope

The macroscope would include a network of remote sensors able to collect, store, and send data on river conditions ranging from water quality and flow to storm-water runoff and pollution discharges. Wireless transmitters would send data on temperature, water clarity, dissolved oxygen, and other environmental indicators to Clemson, where the information would be processed and put up on the Internet. Anyone anywhere in the world could view on a computer—even on a smart phone—the well-being of the river.

"Our goal is to optimize every drop of water—protecting the environment, nourishing the economy," Eidson says. "We believe we can do it all, but you need data to do that. You need a system."

The system is being built from scratch, created by an interdisciplinary team of scientists, including hardware developers, software engineers, river ecologists, information technologists, visual-effects designers, forestry and natural resource experts, and economists.

The research challenges are daunting: The goal is to deploy as many as a thousand sensor platforms in the river. The results will create a flood of information that will have to be made meaningful.

Computer scientist Jason Hallstrom works on the macroscope's brain, the MoteStack, which is a very small, battery-powered computer.

Old English for *speck* or *particle,* the word *mote* was used by military researchers to describe smart dust—tiny, low-power, cheap sensors that could be released like a cloud to gather and relay data on battlefield conditions.

Hallstrom called his device a MoteStack because it consists of layers of sensor platforms. The design will let researchers deploy a very large number of sensors and configure them in a network.

The MoteStack itself is not a sensor. It's a battery-run computer about the size of a Rubik's Cube and is comprised of stacked circuit boards to power and operate sensors and other electronic components.

While the Intelligent River® isn't the only large-scale sensor network, it will be the largest basin-scale network in the U.S., Hallstrom says. "Anytime you start talking networking more than five sensors, it's a challenge; ten is a big problem and we're talking about deploying a thousand."

Before you begin to think about the ins and outs of moving and massaging vast amounts of real-time data, there are more practical problems. The patent-pending MoteStack needs a very special home.

Environmental Information scientist Chris Post leads the work on housing and deploying the MoteStack and linking the web of sensor platforms. The red buoys are designed to deal with all sorts of misfortunes, natural and manmade. When heavy rains raise the water level, the buoy submerges to avoid debris. Post also has to contend with vandalism, figuring out how to make the buoys bulletproof and theft resistant.

The team had to puzzle out how to deal with the Achilles Heel of all field sensors: power. Batteries were the traditional energy source, but they were costly not only to replace but also in technician time—trips to sensor sites were draining time and money. Plus, the power problem had to be solved not only for the MoteStack but also for the receiving site onshore. Solar panels are a popular choice, but they can be stolen—as batteries can be—in isolated locations.

The researchers found a way to minimize the power needs by efficiently running each task in the data collection and transmitting sequence. Nothing would use power until needed. They maximized the efficiency of the staggered process and miniaturized the communications hardware, tucking it all inside the buoy. This was a breakthrough.

"When we started the macroscope we had no idea what we were doing in terms of building the hardware," Hallstrom says. "When you look at early designs, they were total disasters. I still have them on my desk. They're a mess."

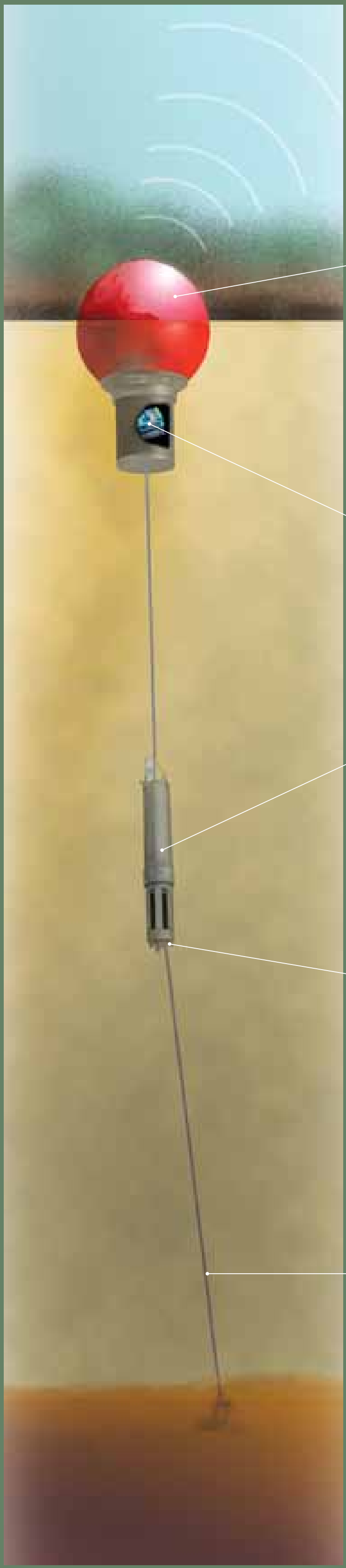
The newest version of the MoteStack opens the information floodgates, sending a torrent of raw sensor data that must be sent somewhere and configured so that it can be used. Computer engineer Sebastien Goasguen specializes in storing and accessing data.

"The first thing we are going to do is put the Savannah River in the cloud," Goasguen says. "That means that all the data collected by the sensors we are going to move on to the computer network, so that everybody can access it…. We are going to be able to go to the cloud and access data from the Savannah River."

Access to data is one thing, using it another, Goasguen says. "We are going to be able to use the Palmetto Super Computer to analyze this data and extract knowledge from it. So I think it will be a terrific resource for

Eidson follows a winding walkway into the 1,100-acre Phinizy Swamp Nature Park,which he and a group of Augusta, Ga. residents restored.

From the flow of water, a stream of data.



Each buoy beams data to cell phone towers, which relay the data to computers at Clemson, making real-time information available to researchers and resource managers.

A buoy protects the equipment from damage and houses instruments for communicating data.

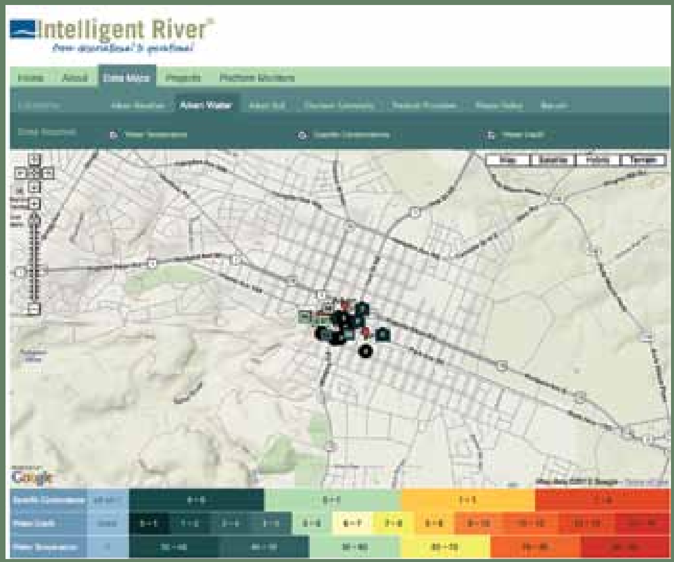
The MoteStack computer processes data collected from multiple sensors.

The data sonde, tethered to the buoy, houses various sensors and sends their information to the MoteStack.

Sensors mounted on the sonde can detect water depth, temperature, dissolved oxygen, conductivity, and physical parameters.

The assembly is anchored to the river or lake bottom.

Neil Caudle



The team's website allows scientists and resource managers to monitor rivers and other environments by selecting location and type of data.

MoteStacks can work almost anywhere—in a farm field, a forest, or a city, for instance. Here, a small, green box mounted on a stake contains the MoteStack, whose data stream can reach the central computer and then a cellular telephone.

Rebecca Dalhouse

Sam Esswein, a doctoral student in computational ecology working with Chris Post, deploys a sonde near the Issaqueena Dam.

the student and the researcher, and we hope it will be a boost for the knowledge economy."

Data, however, are only valuable when they reliably and accurately represent conditions. Environmental informatics specialist David White oversees the quality-control process. "Data from the sensors will be continuously monitored," White says. "If results fall outside expected limits, we will examine and diagnose the problem and fix it. Some procedures can be done remotely, but if we need to, someone will go out and check at the river."

Making sense of the data flood

To the end-user, Jerry Tessendorf's role will have big impact on whether or not the Intelligent River® makes a splash. Tessendorf is a visual-effects engineer with the exotic credentials of a Ph.D. in physics and experience designing computer-generated imagery in Hollywood.

"So the Intelligent River® will produce a flood of data about the ecosystem of the river," Tessendorf says. "In order to make sense of all that data, we are building a new computer system that uses the latest technology and graphics processing units to simulate the river system as it might actually be occurring. The level of detail and realism will include moving waves going down the river, bushes and trees blowing in the breeze, animals, plants, and the atmosphere and weather conditions that are appropriate for that moment. And we hope that this will help to better understand how the river ecosystems components work together."

Tessendorf leads the design of the Intelligent River® Viewing Room (IRVR) in the building which houses the Strom Thurmond Institute for Government and Public Policy and the Institute for Applied Ecology. The room will have two banks of high-definition projectors beaming realistic images of the river on curved screens synchronized with a long table depicting the river. Point to the location of a fish kill, for example, and the projectors will use the sensor information at the location to present an image of the situation. At the end of the room will be a large-screen monitor displaying numerical data to analyze in relation to the imagery.

The IRVR will be a dramatic tool to help viewers grasp the power of the macroscope to present a detailed landscape view of the river. The room will also help recruit clients for the technology and data.

The team tested parts of the macroscope and tried a prototype at a handful sites around the state. Bannockburn Plantation in Georgetown offered the opportunity to try out the system as way to collect data on the environmental impacts of development. A raft of equipment anchored in Lake Issaqueena in the Clemson Experimental Forest tests the configuring sensors on a MoteStack.

The project in Aiken to control storm-water runoff downtown and use sensors to measure water flow and quality has provided encouraging results. It also offered Hallstrom some insights into how his work fit into the big picture.

"Computer science is not known for its social side," Hallstrom says. "We spend most of our lives sitting in an office, staring at a screen. Building sensor devices in isolation, I had ill-conceived notions of what they could be used for. When you talk to people who might benefit from this technology, it gives you a much better idea of what you ought to be working on."

Hallstrom is not a person you would kayak the Savannah River with and expect a running account of the flora and fauna. "What I know about river ecology I learned from working with the domain scientists—the ecologists," he says.

In Aiken, the team set up a network of sensors to collect data on weather, storm water, and soil moisture conditions. The data would be sent wirelessly to Clemson, organized in a database, and viewed via the internet.

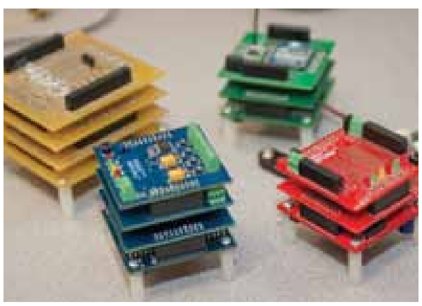
"When we walked into the woods it brought the problem into focus when I saw this huge canyon that was carving the woods apart," Hallstrom says.

Hitchcock Woods is a landmark in Aiken, an equestrian center where the city streetlamps are embossed with horsehead medallions. The woods are known for bridle paths and a unique geographical feature called the Sand River. It is an ephemeral river of sand after rainfalls, a

Peter Kent

The sand river in Aiken's Hitchcock Woods has cut a canyon, "carving the woods apart," Hallstrom says.

Jason Hallstrom solders circuitry on a MoteStack, a small computer that manages streams of data from environmental sensors. "Anytime you start talking about networking more than five sensors, it's a challenge," he says. "Ten is a big problem, and we're talking about deploying a thousand."



From generation to generation, Hallstrom fine-turned the Motestacks to use less energy and do more tasks. The blue version is the brightest brainchild in the MoteStack family.

stark example of erosion that leaves a bed of beach-like sand between banks of broken limbs and tree trunks draped with debris disgorged from storm sewers.

"I was stunned," Hallstrom says. "I saw it was having a fundamental impact on the landscape, and it matters to the people who live there. We had been talking about flow-prescription issues and water flow downstream. And it was amazing to imagine how a little less water downstream could make a tremendous difference."

It was a critical time in learning how to work as a team, and Gene Eidson was the coach. There were lots of heart-to-heart talks with researchers who had a hard time learning to be one of many or "sticking to the knitting," as Eidson calls staying on task.

Eidson had his own knitting to do. He applied for and earned the designation of Clemson as an EPA Center for Watershed Excellence, the first in the nation to focus on digital monitoring of water systems, which would be the seed for the Institute for Applied Ecology. He helped the university apply for an endowed chair in sustainable development through the S.C. Centers for Economic Excellence program, which uses lottery revenues to fund research that can help build the state economy. He met with the Clemson University Research Foundation to register the Intelligent River® trademark and plan how to patent the results and spinoffs that could come from the research.

"We are creating a technology that will transform the way we monitor both the natural and built environments," Eidson says. "This is the green economy, and this is the knowledge-based economy. The tools and systems we are developing and using will not only bring a new cost-effective way to monitor resources within our state, they will also bring jobs."

Hallstrom sees the river technology creating spinoffs. "The same type of technology used to monitor rivers can be used to monitor virtually anything in South Carolina or throughout the world," he says. "In the future, we are considering MoteStack applications for intelligent farming, traffic monitoring, forestry, buildings—the list is virtually endless. We are just starting to understand all the application opportunities that are available."

Gene Eidson is director of the Institute of Applied Ecology and is a professor in the Department of Biological Sciences, College of Agriculture, Forestry, and Life Sciences. Jason Hallstrom is an associate professor in the Computer Science Division of the School of Computing in the College of Engineering and Science. Other team members include: Chris Post, GIS scientist; David White, environmental informatics; K.C. Wang, wireless computing; Sam Esswein, computational ecology; Jerry Tessendorf, visual effects; Robert Geist, visual effects; Sebastien Goasguen, computer engineer; Jill Gemmill, cyberinfrastructure; Calvin Sawyer, biosystems engineer; Dan Hitchcock, biosystems engineer; Brad Putman, civil engineer; Anand Jayakaran, hydrologist; Ahmad Khalilian, precision agriculture; Oscar Flite, ecologist; Dan Harding, architectural designer; David Pearson, landscape architect; Julia Sharp, statistician; Tom Williams, forestry; William Conner, forestry; and Victoria Chanse, landscape architect.

Primary funding is from the National Science Foundation, Clemson Public Service Activities, and the Clemson Experiment Station. Other partners include the Belle W. Baruch Institute of Coastal Ecology and Forest Science; Clemson University Restoration Institute; Southeastern Natural Sciences Academy; EPA Region 4 (Southeast) Centers of Excellence for Watershed Management; S.C. Centers of Economic Excellence Program; U.S. Army Corps of Engineers, Savannah District; National Park Service, Atlanta District; city of Aiken; Lucille Pate, Arcadia Plantation; Pate Foundation; and the Belle W. Baruch Foundation.

How the project survived two unhappy calls.

On October 20, 2011, Gene Eidson and Jason Hallstrom stood before members of their research team, the media, and Clemson's board of trustees to announce an award: $3 million from the National Science Foundation for the Intelligent River® project. The presentation was seamless and professional, a well-honed talk with vivid color slides.

What it didn't show was the three-year ordeal that it took to land the cash, and how it very nearly failed to happen.

We won't usually write very much in these pages about funding. But these days science, especially big science, cannot happen without it. And it just so happens that the funding for the project Eidson and Hallstrom unveiled that afternoon in October has had more ups and downs than a rollercoaster ride.

About six months into the Intelligent River® project, Eidson asked Hallstrom what he wanted to get out of the deal. "I told him I wanted an opportunity to lead large-scale programs," Hallstrom says. He got his chance in 2009. It was one helluva learning experience, he says.

The National Science Foundation awards Major Research Instrumentation (MRI) grants. MRIs usually are big things, like deep space observatories and super colliders. The team decided to write a proposal titled "Development of the Intelligent River®, a Basin-Scale Monitoring Instrument." The $3 million grant application went to the NSF Division of Computer and Network Systems. The funding would pay for the team to design, develop, and deploy the macroscope along the entire Savannah River from headwaters in North Carolina to the estuary at the Atlantic Ocean.

Before the proposal could go to NSF, it had to be vetted internally by the associate vice presidents and deans for research. Proposals are ranked for likelihood of being funded. It's not only a matter of improving your odds of success; it's choosing which projects the university deems worthy of cost sharing. Many grants require the institution to pay thousands, even millions, of dollars as earnest money, a show of good faith that they are serious about supporting the research.

The macroscope made the cut; the proposal went to Washington, D.C.

More confident than prepared

"The first time we submitted we were lucky in a couple of ways," recalls Hallstrom. "The first year we applied, the MRI program was supported through ARRA funds. This was important for the proposal because it meant there would be no cost-sharing—a $1.3 million roadblock in trying economic times. In retrospect, I think we were also lucky that we weren't funded. We hadn't had enough field experience with the technology to understand all of the obstacles we were going to encounter. I question whether we would have been able to deliver."

Hallstrom says they were more confident than prepared. "We would have been in big, big trouble if we had gotten it on the first submission."

When the NSF sends a project back, it comes with a critique. Hallstrom went to Washington and met the NSF program manager, who is the make-or-break gatekeeper for funding approval. It was show-and-tell time for an audience of one: Rita Rodriguez. "When I met Rita, I came with our slides and MoteStacks and laid them out on her desk and explained the proposal and our vision," Hallstrom says. "She was very gracious, and fortunately, she saw where we wanted to go."

It was a teachable moment for Hallstrom. "When you talk to smart people, they find the flaws in your ideas. At the NSF it's their job. Your job is to help them understand the proposal and that your university supports it."

The team felt confident. Now it had to convince the internal review committee to green light the application again. This time there was a catch. The economy had tanked and the NSF reinstated the cost-sharing requirement. Clemson was going to have to contribute $1.3 million.

Eidson and Hallstrom were door-to-door salesmen, making the rounds to convince administrators to commit the money. Departments across the university were feeling the economic downturn. The cost-share deal had a third coming from the colleges, a third from the vice president for research, and a third from the participating departments. All three said yes; the proposal headed back to NSF.

"'Oh, Jason, this is not a happy call,' Rita said," Hallstrom remembers. Rodriguez told him the proposal had ranked No. 2 in 2010, a budget year when only one large MRI was funded in CNS.

In 2011 Hallstrom and Eidson wondered if they would get another chance. There were other Clemson proposals that deserved a shot at funding. If the macroscope was going to go back to the NSF, it meant someone else's proposal would not.

John Ballato directs COMSET, the Center for Optical Materials Science and Engineering Technologies. It is a hothouse of engineering innovation in optical materials—glass and fibers that carry energy and information in a world where speed and accuracy are deified. COMSET had a proposal at the front of line in 2011, when Hallstrom and Eidson were requesting a third chance.

Ballato thought it over. "I knew the researchers here and I knew where they were on their work," he says. "I decided that our team wasn't at the point where they were ready."

The macroscope was back in the game.

Recommended. No, wait...

Major Research Instrumentation grants are a large category. In 2011, there were some 40 proposals for the review panels to critique. The ranked proposals would have to go through a runoff. The final review is the TOC, which had the ominous sound of a countdown clock's *tick tock*. TOC stands for Technical Officers Competition, and it is said to be so aggressive that proposal advocates have been known to leave the room in tears.

The TOC convened. Hallstrom waited.

Two hours later, Rodriguez called. The macroscope would be funded.

"I called Eidson but didn't tell anyone else," Hallstrom says. "We wanted to wait until the NSF web page changed, identifying the projects recommended, before we sent out a note to everybody," says Hallstrom. The page changed. It said "recommended." The team would get the money.

Congratulations overwhelmed email inboxes. A celebration was set.

Two days before the party Rita Rodriguez called Hallstrom. "She said, 'Jason, this is a very difficult call. The proposal has been returned from the Office of Integrative Activities (OIA) without funding.'"

The NSF website withdrew "recommended."

Rodriguez thought there was a chance that the macroscope could recover if they acted quickly. Over the next several days, Hallstrom and the team wrote clarifications explaining a wide range of questions that arose in the final hour and participated in several long discussions with some of the top staff in CNS. The final issue concerned an ill-described expense in the budget. With this final clarification approved, Rodriguez said funding had been reinstated. But the website remained unchanged.

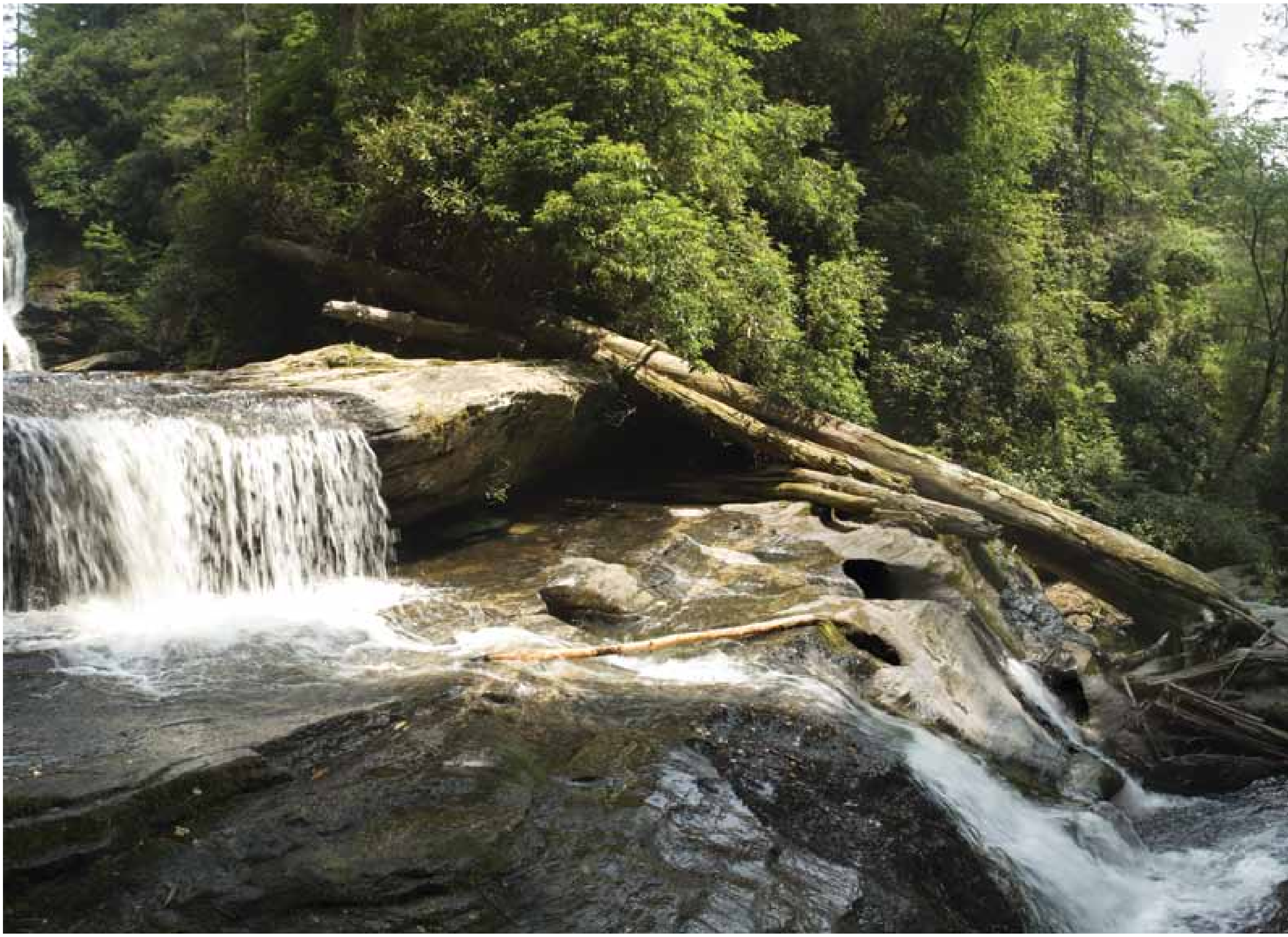
At the celebration Eidson was miserable. "Everybody was congratulating me. I was sitting there thinking, 'Oh my God, how am I going to explain this? What do I do?'"

Hallstrom went to the NSF website over and over and over again.

Finally, "recommended" returned. They had a project after all.

The NSF's award abstract for the project included the following statement: "It is evident that the growing mismatch between water supply and demand impacts us all: USA watersheds are in peril! This project does something about it...."

– Peter Kent



The Sultan of Zanzibar on the Thompson River as it meets Lake Jocassee, 2011.

Silver Run Falls on Silver Run Creek, Jackson County, North Carolina, 2009.

Lower Secret Falls on Big Creek, North Carolina, 2006.

Sunset on Lake Hartwell near Clemson, 2010.

pictures from an expedition

photography by Anderson Wrangle

For two years, photographer Anderson Wrangle has explored the watershed of the Savannah River, beginning in the mountains, where trickles wander into creeks, and working his way downstream. He goes in every season, in all kinds of weather, and mostly he goes alone.

"I lug a huge Deardorff four-by-five, five-by-seven view camera, a giant tripod, and a lot of other gear," he says. "It's a lot to ask of people to put up with a photographer and his equipment, and waiting forever while I set up a shot."

Wrangle calls his project an expedition. He explores a territory and records what he finds on large-format color-negative film. Scenic rivers. Eroded banks. Derelict old dams. Trout fishermen and bathers in sun-dappled streams. He takes us there and makes us stop and consider what it means.

So far, the exploration has progressed to Lake Hartwell, a spectacular caesura on the way to the sea. And Wrangle hopes to finish the journey. The river, Wrangle says, runs through the geography of his life. His father lives in Cashiers, North Carolina, at the headwaters of the Savannah; his mother is from Savannah, Georgia; and her ancestors lived along the river beginning in the late 1730s. Wrangle and his brother spent much of their childhood at their grandmother's house near the river.

"I had all of these personal connections to the river," Wrangle says, "and I had taken photographs on it for a dozen years. So setting out to explore this watershed was the most natural thing in the world."

When he began the project, Wrangle knew very little about the river and the landscape that sustains it, he says. But pursuing his art drew him into science.

"My level of hard knowledge about the natural world is relatively low," he says, "but I keep running into people who can teach me, and that's the part that excites me."

One of those people is Karen Hall, a faculty member in the Department of Forestry and Natural Resources and state coordinator of the S.C. Master Naturalist Program. Hall can look at Wrangle's photographs and tell him in detail about the landscape they reveal. For him, he says, this makes the experience richer. He plans to create an archive of his photographs and make them available to anyone who studies the watershed. Yes, he works alone. But he sees himself as one of many—artists, scientists, and scholars—who document the natural world.

"In the history of art, landscape more than other forms is a massive group project," Wrangle says. "You're contributing to something much larger than your own body of work."

What interests him most is how water moves through a complex landscape and defines it. When we visit a point in the mountains where the Chattooga River begins, we may not understand how that point connects to the river system as a whole, through a series of streams, rivers, and lakes, all the way to the sea.

"It is one thing to look at a map and to read about a place," Wrangle says, "but the actual experience of the place typically defies an easy understanding. I am attempting to make a composite picture, a document, of that more complex relationship."

Anderson Wrangle is assistant professor of art in the College of Architecture, Arts, and Humanities. Funding for his watershed project has been provided by a research grant from the college.

– Neil Caudle

Woodside II Dam, Twelve Mile River, Pickens County, S.C. The dam was demolished in 2011 to remediate PCB pollution.

Along the journey, every dam was a pause to reflect.

photography by
Anderson Wrangle

Hartwell Dam and Lake Russell, Highway 29, below the confluence of the Seneca and Tugaloo Rivers, in the Savannah River proper, 2011.

"Dams are incredible," Anderson Wrangle says, "when you think about what they've meant to the history of the watershed and the economy of the region. Some of them are being torn down because they are no longer useful and because restoring the natural flow of the river improves the habitat for fish and wildlife. But each dam is different, and each one has a story to tell."

Hartwell Dam, 2011.

the sweet spot

If South Carolina has a sweet spot, this is it. The peach.

Its gush of luscious flavor has made the state a national power in peach production, second only to California. In fact, a single farm in South Carolina, Titan, ships more peaches than the entire state of Georgia.

Why? South Carolina has favorable land and climate, yes, but mostly it has know-how. South Carolina has been in the peach business for 150 years, with farms enduring several generations. And Clemson is the only university in the Southeast with a team of experts to help keep peach growers ahead of the curve. Some 17,000 acres of peach orchards yield an annual harvest of 60,000 tons, valued at $60 million.

But like most things sweet, the peach is appealing to pests and diseases, its survival so precarious that scientists and producers constantly struggle to keep it alive. Beginning in the 1970s, a scourge swept through the peach orchards, killing trees and putting farms out of business. The villain: peach tree short-life syndrome, the sudden death of young trees in spring, usually caused when ring nematodes invade the roots and bacterial cankers develop on cold-damaged wood.

With funding from the state and federal governments, Clemson went to work studying the syndrome and ways to combat it. By the early 1990s, growers were hearing about a new rootstock, developed by Clemson's Greg Reighard and U.S. Department of Agriculture (USDA) colleagues, that resisted the syndrome, and the industry was demanding it even before testing was complete. In 1994 Clemson released the rootstock, called Guardian™. Within a few years, most new peach trees in the Southeast were growing on the new rootstock, and orchards were thriving again.

Case closed? No. Another threat was afoot in the orchard, biding its time. *For more, please see page 28.*

Desmond Layne

Late 1990s

The peach industry rebounds as Guardian™ takes root in Southeastern orchards.

1100 BC

People are already writing about peaches in China, where they probably originated. Today, Clemon's peach experts spend time with Chinese scientists, sharing what they've learned about this ancient treasure. **Right**, pigeon on a peach branch, by Emperor Huizong of Song, Northern Song Dynasty, 1108 or 1109.

Courtesy of A.P. Nyczepir, USDA-ARS

1970s and 1980s

Peach tree short-life syndrome kills thousands of trees each year, costing producers millions. Some experts predict the end of South Carolina's peach industry.

1890s

Peaches boom and packing houses spring up near rail lines in the Southeast. **Right,** pickers in Hale County, Ga., 1895.

Courtesy of M.E. Ferree, UGA

2011
Clemson sells more than 1.4 million seeds for the Guardian™ rootstock, which supports the vast majority of peach trees in the Southeast.

1994
After two decades of research, Clemson releases Guardian™ rootstock, working with the USDA to introduce it to growers.

Stigmas, the long, yellow, female receptacles for pollen, will be carefully dusted with pollen from the “male” tree.

Anthers, the source of pollen, are removed from the “female” tree.

Do we dare breed a peach?

This won’t be a one-night stand. Peach breeders have to be patient, in it for the long haul. Here are the basics, simplified:

1. Select parent trees with the traits you want. Collect and dry the anthers from flowers of the male parent to release the pollen.
2. Pull off the male parts of the blossoms on the female parent tree, which will bear the fruit. (This is called emasculation.)
3. Pollinate the female blossoms, hundreds of them, and hope that genetic recombination will yield something better than either parent, with the best characteristics of both. The odds are against this. That’s is why hybridization is slow, painstaking work.
4. If pollination succeeds, a peach will develop some months later. Harvest the ripe fruit, extract the seed from inside the pit, and keep it cold. Sow the seeds in pots and set them in a greenhouse. In the spring, transplant the seedlings into a breeding nursery.
5. When the seedling trees begin to flower in the field, evaluate their characteristics. This is both an art and a science, a test of experience and skill.
6. After two or three years, select the most promising, collect some budwood and produce grafted trees. Test the trees at multiple locations for several years. After five or so good years, you may be ready for a commercial release. Two of Layne’s joint releases with breeder Dick Okie (USDA, retired) Early Augustprince and Augustprince, both released in 2008, were first hybridized in 1995.

Why go to so much trouble?

Don’t we have lots of good peach cultivars already? Yes, but we’ll always need more, says Ksenija Gasic, a peach breeder and the newest member of the peach team. New types can resist pests or diseases, ripen late or early in the season, or appeal to new markets. While native Southerners tend to prefer an old-fashioned balance of acidity and sugar, newcomers may want eye-popping sweetness, hold the acid. So a new peach can help producers compete for new markets.

Desmond Layne

2000s
A common sight in orchards: peach trees killed by *Armillaria,* the cause of oak root rot, are piled for burning.

This new adversary is as old as the hills: oak root rot.

Native to woodlands that once covered the Southeast, the *Armillaria* fungus is everywhere peaches grow. It persists in the soil and creeps across an orchard underground, as roots from one tree connect with another. Over time, the fungus builds up in a peach orchard, killing tree roots and moving up to the lower trunk where it girdles the tree with a deadly, mushroom-like growth.

"Before we began using the Guardian™ rootstock, trees wouldn't live long enough to die of oak-root-rot disease," says Desmond Layne, a tree-fruit specialist and state program team leader for horticulture. "But now that the trees are living longer, we're seeing more and more *Armillaria.*"

So far the fungus has defied all attempts to control it. The best solution? Move. Don't grow peaches in soil with a buildup of *Armillaria*. Trouble is, the best land for peaches is already growing peaches, which require well-drained soil, sunny slopes, and good air circulation, with no pockets to accumulate cold. Most of the sites that meet those criteria have been growing peaches for generations.

Guido Schnabel, a plant pathologist, may have discovered one solution. In his experimental plots, he found that planting young trees into soil mounded into berms suppressed the fungus by discouraging its movement in above-ground roots and up the trunk. If tests in commercial orchards succeed as well, producers may have a low-cost way to keep the peaches growing on their most productive land.

Desmond Layne

2003
Armillaria girdles the base of the tree and produces edible mushrooms called honey fungus.

Big, bad brown rot

Even if we gain ground against root rot, a host of other afflictions can spring nasty surprises. One of these is brown rot, also a fungus, which can rapidly spoil a whole truckload of peaches, especially in damp, humid weather. The threat is so severe that producers typically treat their crops with fungicides just before harvest. But over the last few years, Clemson scientists have detected strains of brown rot that resist fungicides—a nightmare scenario for peach producers.

Schnabel attacks the problem from several directions. First, he developed a test kit that can help extension agents determine whether a strain of brown-rot fungus is present in an orchard and, if it is present, which type of fungicide will kill it. This eliminates unnecessary spraying, saves the producer money, and reduces the chemical load. Meanwhile, Schnabel uses advanced techniques in genetics and molecular biology to find the exact segment of DNA responsible for the pathogen's fungicide resistance—a step toward finding a way to combat it.

Where will the next threat to peaches appear? Perhaps from a bacterium or a virus. Either would be dire. So in their labs and test plots, the peach team feels the heat. Science, they say, is an ally peaches can't live without.

– Neil Caudle

Desmond Layne

2009

A field test kit developed by Guido Schnabel helps save peach producers $4 to $5 million in a year conducive for disease development by detecting the presence and type of fungus in an orchard, preventing crop loss and unnecessary fungicide spraying.

2011

Genetic studies in Schnabel's lab pinpoint locations on DNA segments responsible for fungi resistance to certain fungicides.

2011

Clemson releases its latest peach, the CaroTiger, in August. A late-season cultivar that keeps its good looks and sweet disposition while others are losing theirs, CaroTiger is a yellow-fleshed freestone. The red pigmentation around the pit? Anthocyanin pigments, which are antioxidants and good for your health. Desmond Layne evaluated the peach at Clemson's Musser Farm as well as in the orchards of commercial producers such as Cooley Farms in Chesnee, S.C.

meet the peach team

Rootstock to the rescue

Greg Reighard, a horticulturalist and rootstock expert, developed and released the Guardian™ rootstock, which helped peach trees resist short-life syndrome and revived South Carolina's imperiled peach industry. Clemson is still the sole source of the peach pits from which the rootstock grows. Reighard also studies various methods for managing orchard trees, including mechanized thinning to lower costs.

Do peaches need a chill pill?

If peach trees don't get enough hours of winter chill, some will not flower and fruit normally. **Doug Bielenberg,** an environmental physiologist, studies how various peach-tree cultivars respond to cold or a lack thereof.

Fundamentals

The basic biology of a peach tree dictates its performance and its response to changes in the environment. **Bert Abbott,** an emeritus professor who still runs a lab at Clemson, is a leading authority on the genomics of *Prunus*, the genus that includes peaches.

A matter of breeding

Ksenija Gasic, the newest member of the team, breeds peaches specifically for the Southeast, to help growers stay ahead of pests and diseases, and ahead of the competition as well.

The grower's go-to guys

Greg Henderson and **Andy Rollins** advise growers, conduct field trials, and ensure that the results of science reach the orchard. But it's a two-way street. Henderson and Rollins also bring the growers' questions and problems back to the lab.

The test driver

Desmond Layne evaluates peach varieties by putting them through their paces on Clemson's Musser Farm and on the farms of cooperating growers in the peach-growing regions of the state. He is also the team's highly visible advocate, with a peachy website, Everything About Peaches *(URL below).*

Pest and disease patrol

Guido Schnabel, a pathologist, pursues the elusive brown rot, an especially virulent fungus that quickly develops resistance to fungicides. Schnabel's field-test kit, which enables growers to identify the fungus quickly and inexpensively, helps reduce unneeded spraying. **Dan Horton,** from the University of Georgia, is a fruit entomologist. He knows which insects go for peaches and how to limit the damage.

Keeping it clean

A fast route to bad fruit or dead trees is a weedy, buggy, unkempt orchard. **Wayne Mitchem,** a collaborator from North Carolina State University, works with the Clemson team to recommend weed-control measures for the Carolinas. **Simon Scott,** a virologist, works through an organization of growers, the Clean Plant Network, to help protect orchards from various infections that afflict budwood, the part of the tree that bears fruit.

Peach research is based in the College of Agriculture, Forestry, and Life Sciences.

Want to know more about peaches?
Go to Desmond Layne's websites:
www.clemson.edu/peach
facebook.com/peachdoctor

chain of fools?

Exporting our supply chains was more than foolish; it was dangerous.

by Neil Caudle

Today, most vitamins, clothing, shoes, electronics, and a host of other consumer goods come from oversees. Even frozen foods may have crossed an ocean on their way to your grocer. The Easter bunny? Made in China.

Photos by Neil Caudle

Trust. You will not find this word printed on the label when you pick up a package of food. But trust is a necessary ingredient in every product we buy. We assume it is wholesome and safe. And it is, right?

Not necessarily.

This is scary stuff. But Aleda Roth, professor of supply-chain management, did not set out to frighten anybody. She was just doing the job she had done for two decades: studying supply chains and explaining how they work. These days when she studies the chains, especially the long ones behind the food we eat, she finds time bombs.

"I had a number of hunches based on my experience and the data I'd gathered," Roth says. "Something seemed to be wrong with offshoring so many jobs. Why is the U.S. importing so much of its food, at astounding rates over the past decade, from emerging markets like China, which now supplies nearly twenty percent of our food and ingredients?

"I thought, 'I don't care what the economists say. I don't care what the world press says.' My common sense says there is something amiss. So the scientist in me says, 'Let's apply science to this.'"

A supply chain is, at first glance, deceptively simple: a series of steps that transform raw materials into the products we use. But over the last couple of decades, Roth says, many supply chains have grown long and convoluted, increasing safety risks. In January the Coca-Cola Company detected an unapproved fungicide in orange juice imported from Brazil. In this case, a U.S. company found and reported the problem. But hazards in imports from China are harder to detect, Roth says.

Inscrutable links

Let's take one example, which we will call The Globe-Trotting Hen. A farmer in Mexico raises a chicken and sells it to a slaughterhouse. The slaughterhouse freezes the carcass and sells it to an exporter that ships it to China, where a Chinese plant processes and packages the hen and then hands it off to another firm, which ships it to a port in the U.S., where the FDA inspects only about one percent of the imports before they reach the market.

What part of this chain inspires trust?

"Ironically, while food imports have soared almost fifty percent in the past five years, the number of inspectors has dropped twenty percent," Roth says. "And the FDA doesn't appear to require that exporting countries have standards and safety systems equivalent to those required in the U.S."

The Globe-Trotting Hen is not an exception. It is becoming the rule. And some sizable links in the supply chain remain inscrutable, because a factory in China is not an open book to Western eyes, especially if those eyes are focused on cost, not quality.

Last year Roth and her coauthors, John Gray and Michael Leiblein from Ohio State University, published their study of offshore manufacturing in the pharmaceutical industry. In their analysis of data from the U.S. Food and Drug Administration (FDA), they found that drugs manufactured in Puerto Rico were significantly riskier, from the standpoint of quality control, than the same drugs manufactured by the same companies' plants in the U.S.

"Because the pharmaceuticals industry is heavily regulated, quality

Craig Mahaffey

Aleda Roth studies sustainable-supply chain practices and corporate social responsibility. The goal, she says, is to improve quality of life—not only for Americans but for citizens in China and other emerging markets, who may not have a voice. "We need a new mindset about global supply chains," she says. "Their complexity makes them risky, especially when low cost is the dominant concern."

Craig MaHaffey

Lady, Aleda Roth's Chinese Crested Powderpuff, is fine now. But her illness, caused by contaminated dog food, inspired a quest.

should be important to the manufacturer," Roth says. "If we're finding problems in a heavily regulated industry, then what must be happening in industries that are not as regulated? And if inspections are negligible?"

In November 2010 viewers of the CBS show 60 Minutes learned that a GlaxoSmithKline (GSK) plant in Puerto Rico allowed bacteria to contaminate some drugs and used the wrong mix of ingredients for others. One of the company's subsidiaries later pled guilty to distributing adulterated drugs. This was not an isolated incident, Roth says, and the problem was not unique to GSK. Roth's research found that operations managers, pressured by executives to cut costs and accelerate production, did not pay enough attention to the details of maintaining quality at every step, especially when they were doing business in a foreign country.

To dig a bit deeper into corporate decision making, Roth took a fresh look at data she'd collected a decade before. "The executives back then were looking at cost and not quality in their outsourcing decisions," she says. "Now, this was very puzzling to me, because it's a well-established principle in business management that cost and quality are correlated. You can't have low cost without having good quality, because poor quality leads to significant waste and rework. Plus you have the costs of recall, disposal, liability, goodwill, and all the rest."

Why would a company risk it? Roth's research with her Clemson doctoral student and co-author, David Hall, provides an alarming answer. "Partly, it's the bandwagon effect," Roth says. "If everyone is doing it, it must be good. And if I don't do it, I'll look bad. Plus there are powerful internal rewards for cutting costs. It's become the mindset—let's just go for cheap and assume we'll get it right."

When Roth talks about quality, she does not mean products that are necessarily more costly or luxurious. She means products that conform to the consumer's expectations. The aspirin tablet is safe and relieves your headache as expected, is manufactured according to specifications, and free of contaminants—that sort of thing. This is called conformance quality, and without it a company would not survive very long. At least that was the theory. And yet in her data Roth found compelling evidence that quality was, in practice, consistently taking a backseat to cost. Apparently, executives—enthralled by the perceived low cost and market advantages of offshoring—were underestimating the operational risks.

"We found from rigorous, empirical studies that sourcing managers were systematically overconfident in their abilities to manage quality when outsourcing production," Roth says. "Individuals are making *decisions* on the basis of cost and are making *assumptions* about quality. But maintaining quality isn't easy, even in the U.S. In fact, it is very, very hard. And you can't rely on audits and certification. Quality requires a commitment that is difficult to manage from afar, especially when your offshore employees belong to a different culture, with different values and a different language."

As offshore partners go, Puerto Rico is not the riskiest, not by a long shot. That distinction probably belongs to China, the 800-pound gorilla of global trade.

Lady, the Chinese Crested Powderpuff

Before we wrestle that gorilla, let's go back to 2006, when a dog named Lady, Aleda Roth's Chinese Crested Powderpuff, fell ill. (No, the irony of the breed name is not lost on Roth.)

Lady was mopey and lethargic, and the culprit was probably melamine, an ingredient in plastics that had contaminated vegetable proteins imported from China for use in pet food. Ingested melamine causes kidney disease.

"We had Lady tested," Roth says, "and she had elevated kidney enzymes. So I had to find something she could eat. But there was one contract manufacturer making more than two hundred brands, and this toxic stuff was in all of them, in one small ingredient, something at the very end of the label. So I started looking for dog food without this stuff in it. I couldn't find it. And in the process of searching, I realized how much human food was coming from China—at that time, about 20 percent of our ingredients for processed foods. So I thought, is this problem with pet food the proverbial canary in the coal mine? What about people?"

On a melamine-free diet, Lady improved and is fine now, but her illness had launched Roth in a daring new direction. What if all kinds of contaminants from China were hiding like stowaways in human foods? There was plenty of reason to suspect they might be. Of the 152 consumer products recalled by the U.S. Product Safety Commission in 2007, 104 were made in China.

In 2011 *Consumer Reports* found levels of arsenic in apple juice that exceeded federal standards. More than 70 percent of apple juice concentrate consumed in the U.S. now comes from emerging-market countries, including China, with varying levels of regulations and enforcement. (The Juice Products Association says there is nothing to worry about.)

Cover-ups and corner-cutting

Consider for a moment two cornerstone principles of supply chain management: transparency and traceability. Transparency lets us see exactly how the sausage is made. Traceability lets us track with certainty the path of a product and all of its ingredients along the supply chain. Both qualities are scarce in China, where delays and cover-ups are standard procedure any time a defect rears its ugly head. Without transparency and traceability, Roth says, there is no trust.

Roth knew about the well-publicized hazards in Chinese-made goods. And she knew that some Chinese plants used materials banned in the U.S., including highly toxic lead paint, which was found on imported toys. In 2006 drywall made in China began to emit corrosive gasses that attacked metal wires and pipes and made occupants sick. What if these were not isolated incidents? What if they were the norm?

To learn more, Roth began delving into the murky world of Chinese business, where she and her coauthors found a culture obsessed with profits and hypersonic growth. With the tacit approval of their local governments, some Chinese companies take pride in cutting corners. An American food producer with an operation in China told researchers that she could maintain quality in her plant but was being undercut by low-cost competitors in China that broke the rules with impunity.

With few controls on pollution, much of China's air and water are so dirty that producing anything there, food especially, risks exposing it to environmental contaminants. According to a 2008 *National Geographic* report, about 50 percent of the Yellow River is biologically dead. More than 65 percent of the river's water irrigates farms. The U.S. Department of Agriculture found that China is among the world's highest users of chemical fertilizers per hectare, and some of the chemicals applied there have been banned in the U.S. Cancer-causing chemicals used in preserving dried apples, fish containing banned antibiotics, and mushrooms laced with illegal pesticides have turned up in food imported from China. In mainland China, tainted ingredients have been found in products ranging from pharmaceuticals to cooking oil.

"This is what keeps me up at night," Roth says. "I've been to China at least once a year for the last half dozen years. Along with the pace and magnitude of its majestic modernization, and the rise of so many out of poverty, there is a corresponding dark side—its unprecedented levels of pollution. The only time I saw a blue sky was during the Olympics, when they shut down the factories for months. But they had to set up a separate supply chain to feed the athletes. Even the Chinese don't seem to trust their own food."

Why are American companies scrambling to do business in such a place? Roth and her doctoral students have been working to answer that question, not with economic theories and assumptions but by collecting information about how actual sourcing managers make decisions in American companies. Conventional wisdom has it that labor costs drive

"How do you keep your markets if you're not making anything?" Roth asks. "Factories were once the hub of so many communities, and now a lot of them are gone."

David P. Hunt

Benxi City, Shenyang Province, spring 1996. China's pollution controls have failed to keep pace with its rapid industrialization.

the choice to go offshore, but Roth's research with Nick Anguelov, her doctoral student in policy studies, and her colleague William Ward in economics, suggests much more.

"We are still examining the data in the textile industry—once a major job source in South Carolina," Roth says, "but it looks like we will find that many companies go to emerging markets to avoid U.S. pollution controls."

In China emissions have accelerated dramatically since 2002 and now outpace the U.S. rate. Anguelov's dissertation found evidence that pollution from textile and chemical plants is relatively high in China, where the flow of foreign investment in those industries has increased.

When she adds it all up—the quality risk in offshoring, the overconfidence of managers in their purchasing decisions, the bandwagon rush to outsource production to contract manufacturers and avoid U.S. regulation—Roth says the evidence points in one direction. "U.S. companies have been offshoring way too many jobs for the wrong reasons," she says.

One of the consequences of such choices has been the rapid loss of American industries and jobs. Roth is a member of the executive advisory board on the Council on Competitiveness's U.S. Manufacturing Initiative, a group that includes CEOs of companies, presidents of universities, and heads of research labs. Their task is to look at the nation's manufacturing "ecosystem," Roth says. The group's report, *MAKE: An American Manufacturing Movement,* contains a national manufacturing strategy the group shared with the president, members of Congress, governors, and stakeholders in industry, education, and labor.

"How do you keep your markets if you're not making anything?" Roth asks. "Factories were once the hub of so many communities, and now a lot of them are gone. We risk losing the fabric of what I would call innovation and skill competence—our competitive edge. Most people don't understand how much innovation takes place in manufacturing and its process interplay with product innovation. And now we appear to be doing to our community farmers what we did to our factory workers."

All of this has happened almost overnight.

"We began outsourcing jobs in the early nineteen-nineties, when we had this so-called best practice named business-process engineering," Roth says. "Companies were reducing jobs and getting very lean, and then they started offshoring and outsourcing. In effect, they were 'hollowing out' American manufacturing and jobs. I'm not saying that we should never offshore or outsource. But we should understand the serious, unintended consequences of going overboard."

the world in a snack

Even for small, inexpensive products, supply chains encircle the globe. Aleda Roth has found many companies reluctant to divulge information about the sources of ingredients in their goods.

Adapted from John Carey, *Businessweek,* July 30, 2007

A deficiency of skills

Before he died last year, Steve Jobs, co-founder of Apple, told his biographer that the reason he'd built factories in Asia was that he could not find enough engineers in the U.S. Roth blames, in part, the K-12 school systems in the U.S. that were set up for the agrarian era, many of which fall woefully short in science and math.

"Another reason is that we used to have skilled labor in this country and had great continuity," she says. "Vocational and technical training in high school and junior colleges were more prevalent, and this provided an entry point into manufacturing. Afterwards training was continuous in most competitive companies. Now, with so many jobs being offshored, we have escalated the skills deficiency, resulting in a big disconnect."

That's too bad for the farmers and factory workers, but why should the rest of us care, so long as we're finding bargains at the store?

Neil Caudle

Reports of arsenic in imported apple juice prompted FDA testing in 2011. The agency found that 95 percent of samples tested were below 10 parts per billion (ppb) total arsenic, a level considered safe. Two samples from China, however, contained higher levels—47 ppb in one and 23 ppb in another. A December 16 statement from the FDA expressed confidence "in the overall safety of apple juice consumed in this country."

For one thing, the pollution we export to China will not remain there, Roth says. It will follow the goods to our shores. Methylmercury, produced when factories burn coal without adequate controls, is a probable carcinogen that may attack the nervous system. Its potentially toxic particles travel thousands of miles in the atmosphere and descend as acid rain and snow. Roth's new research addresses the potential that food products tainted with minute amounts of heavy metals and other chemical toxins may be reaching our markets daily, especially in foods imported from China and other emerging markets where air and water pollution are severe. Seafood is especially risky, but so is rice and who knows what else. The FDA does not routinely test for heavy metals in imported goods, and many of the companies Roth contacted indicated that they relied on the FDA for such testing. We have little idea how much toxic load arrives directly in our food, animal feed, clothing and other products—and much less what the cumulative effects might be on people and the environment.

But even if the FDA could increase its testing, testing alone would not protect the U.S. food supply, Roth says. Food is not like computers or cell phones. In the electronics industry, a factory can test every device and make sure it works as it should. But to test a piece of food, you have to destroy it, and it is impossible to test for every possible contaminant.

"You just cannot do one-hundred-percent testing with food," Roth says. "You have to go back to quality principles. You have to do it right the first time." Research with her Clemson doctoral student, Tracy Johnson-Hall, found that more than 38 percent of food recalls occurred after the expiration date, when most of the food had already been consumed.

It's only natural that Roth has zeroed in on the public-health risks in the supply chain. Before she moved into business management, she was an epidemiologist and then head of the statistics department of the American Nurses Association. With a foot in both worlds, she can round up data from various sources and generate a plausible hypothesis about how a business practice might affect public health.

Where would she look first, if she were doing epidemiology today? Imported apple and other juices, much of which comes from China and underdeveloped regions, where chemical contaminants are most likely. Roth has a hunch that autism and kidney disease in children and the elderly may be associated with such imported foods. The trends in autism bear a striking resemblance to the trend in imported apple juice, one of the first drinks a child consumes, and Roth thinks the possibility of a connection should be investigated.

She wants to help executives better understand the risks to food from imports. "Airing such possibilities in public will not be welcomed by global food conglomerates that see food as a commodity, seeking the lowest cost," Roth says. But she is not the kind of woman who pulls her punches, especially when the nation's health and economic future are on the line. A dark-eyed Italian with fierce energy, Roth may have found, in this topic, the fight of her life.

She doesn't have a lot of corporate allies in the fight, so far. Their incentives for outsourcing and offshoring have been so lavish as to be "perverse," Roth says, and only a few CEOs will pause to consider the downside risks. The federal government seems unwilling or unable to stand against a tsunami of imports, if doing so would upset big business and raise the price of goods. Even the U.S. military now finds itself at risk from defective imports. As Congress learned during hearings last fall, counterfeit parts and defective electronics made in China imperil U.S. troops. Will Congress hold companies accountable? That remains to be seen, especially with the constant push for less regulation, Roth says.

Faced with such questions, policymakers generally turn to macroeconomists, the people who study economics on the global scale. From a macro point of view, decisions are all about money. Corporations will keep chasing the lowest possible direct costs of production, and for now that means factories in Asia.

The "outsourcing trap," Roth says, will, over time, make it exceedingly costly and difficult to bring production back to the U.S. And Roth thinks the macro researchers see only part of the picture. She studies people and how they make decisions—not at a theoretical level but in the real world. And where in the real world does she find a shred of hope?

In the American consumer. Statistically speaking, that consumer is frequently a woman. "The American woman is our society's first and foremost decision maker," Roth says. "She selects the house, the car, and the neighborhood. She buys the groceries, the medicines, and the clothes. Her choices, day in and day out, will steer the economy, for better or worse."

At the moment, Roth says, American consumers are shopping for bargains, and who can blame us? Every dollar counts. Sure, we hear media reports about hazardous imports, but our government and the companies we trust have dismissed these hazards as anomalies, and we prefer to believe this is so. Why would we ever suspect that a package of Whole Foods frozen vegetables labeled "California blend" actually came from China? (After ABC News reported this fact last year, Whole Foods changed its sourcing.) On the positive side, Roth says, consumers in greater numbers are asking for fresh, healthful food, including foods grown locally or in the U.S. on organic farms.

Where was this tomato grown?

At some point, though, if supply-chain hazards persist, the American consumer may stop trusting brands, Roth says. People all over America will awaken to the fact that many industry conglomerates place short-term profits first. And then we will have a nation of Aleda Roths. Roth has a reputation at her local food market for asking the manager meddlesome questions such as, "Why does the label on this tomato not say where it was grown?"

The bottom line, Roth says, is that while food and drug companies, and government agencies, argue that we have the safest food and drug supply in the world, it's not good enough if a product's production cost is the single biggest factor in decision making. There are costly risks in that line of thinking, even in domestic production. In 2010 the U.S. Center for Disease Control (CDC) estimated 48 million foodborne illnesses a year; of these, 9.4 million are from 31 known pathogens, and the remainder are from unspecified sources.

"We know that food-borne pathogens alone are costing more than a trillion dollars a year," Roth says. Some food-borne illnesses are due to improper handling, not non-conformance in manufacturing, but the point is that cutting corners can be costly, for business and for health. "So while long supply chains are a big problem, we cannot be complacent about domestic production either," Roth says.

Whether the source of supply is domestic or foreign, Roth wants free choice in her purchasing; but she also wants full transparency in food-ingredient sourcing. "I want to know about the prospects of heavy metals and other contaminants in imported foods from countries with low standards and poor enforcement. Armed with this information, I can make informed decisions for me and my family."

For now, that information can be hard to find. When Roth asked for sourcing information from hundreds of food companies, she found only a few willing to reveal the country supplying their ingredients. The consumer, she says, will have to insist.

"I read every label," Roth says. "I want to know where the food was made and where its ingredients come from. If I cannot determine this, I just don't buy."

Roth is planning a book that will help both businesses and consumers avoid risky products by understanding their path to market. Her advice for now: buy local. Her goal: safer products, healthier people, and an end to the wholesale export of American jobs. It's a tall order, but Roth intends to contribute, as a scholar and a woman.

"I think American consumers will figure this out." Roth says. "We will vote with our pocketbooks."

Aleda Roth is the Burlington Industries Professor of Supply Chain Management in the College of Business and Behavioral Science.

The objective? Change the world.

Why not begin with a voting booth anyone can use?

by Tom Hallman

Forget microchips. At the heart of every computer lies a purpose, a human purpose. Some deed that must be done, some task accomplished. Without that human need, no computer would ever feel the pulse of electrons through its processor. No microchip would have a job.

This is the foundation on which Juan Gilbert builds the next generation of computer applications to help people do what they need to do but do it better.

In a cinderblock lab on the ground floor of the School of Computing, teams of students and faculty create new ways to allow people to text one another without typing. They develop software that will alert patients to adverse interactions in over-the-counter medications. They craft a program to help eliminate bias in hiring decisions, another to teach the Cherokee language. And they roll out software that enables all voters—the blind, the elderly, the limbless—to cast a ballot on one single, uniform voting machine.

The voting software has caught the eye of the U.S. Election Assistance Commission, which has tapped Gilbert to direct a three-year, $4.5 million project to improve the design of voting systems nationally.

"Our goal is to change the world," Gilbert says with equal parts fervency and resolve. "That is how we measure success. We're an applied discipline. Our job is to make things better."

This is the mantra for faculty and students alike in the Human-Centered Computing Division (HCC), which Gilbert directs. He greets each with, "We're going to change the world today!" The slogan adorns a twelve-foot banner in the lab.

The students have no doubt they are getting in on the ground floor of something new.

"It's an entirely different way of thinking," says doctoral student Aqueasha Martin. "I started out in computer science as an undergrad, and we were heavily math based. My days were devoted to differential equations.

"But I also really like working with people. Here in the HCC, my work is actually going to help somebody. This kind of software development process requires an ability to work with people and understand their needs before concentrating on designing the software or algorithm."

That's not to discount the importance of accurate algorithms. The science of computers is still very healthy in the HCC division, but the HCC approach to computer software design takes in a good bit more.

Human-centered computing emerged as a discipline in the mid-1990s, birthed from a field called human-computer interaction (HCI).

"Human-computer interaction drew from the fields of psychology and industrial engineering as well as computer science," Gilbert says. "The central issue behind HCI was how to design the computer to make it more usable for human beings—the input devices, the screens, the software. Usability and ergonomics played a large part."

But computer scientists, with academic roots in mathematics, often viewed HCI as a "soft" discipline, he says. It gained steam first in business, not academe. "HCI led to products with a good interface, which was used more and sold more," Gilbert said. "Businesses don't ignore the importance of marketing, and HCI was marketable."

Early HCI products demanded groups of designers, engineers, and evaluators, all trained differently and not always adept at speaking one another's language. This meant that product development often took a long time—not at all what you wanted if you were trying to sell software in a rapidly changing technology environment.

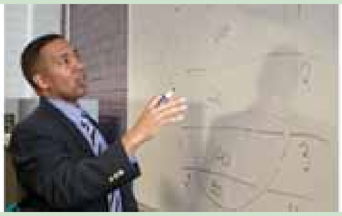
HCC evolved for that reason, preparing students to identify a problem, design a solution, build a proof of concept, and evaluate it—all in one shop.

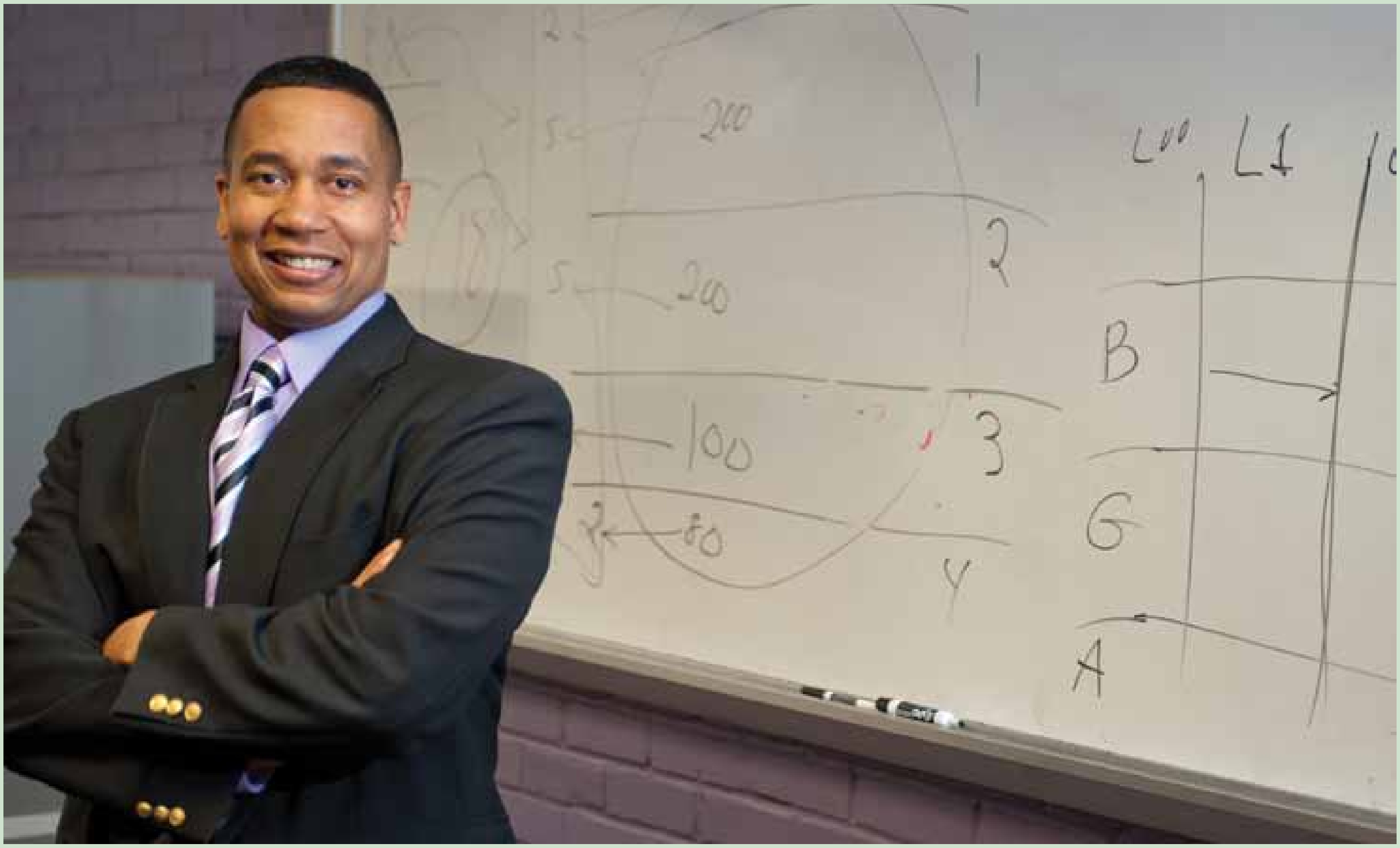
"People don't think we're the techie types," Gilbert says. "They have stereotypes we don't fit. We break a lot of stereotypes just by showing up. You've got to be able to talk with people in different disciplines. If you can't interact with people well, this isn't the discipline for you. I've worked with colleagues in more than thirty-five different disciplines in the past ten years. The math is still important, but it's not all there is."

People skills

No single project required more people skills than the high-profile Prime III voting system, which landed Gilbert between opposing congressional arguments that pitted accessibility against security.

Originally conceived to combine the accessibility afforded by technology with old-fashioned simplicity and ease of use, Prime III employs what Gilbert calls a "universal design" to make voting more accessible, not only for the disabled but for anyone.



Juan Gilbert: "Our job is to make things better."

Photos by Craig Mahaffey

How it works

The Prime III interactive voting booth offers several advantages over conventional methods, Juan Gilbert says.

Accessibility. Voters can choose to follow written or spoken instructions, and they can record their votes either by touching a screen or speaking into a microphone. This enables any voter, regardless of disability, to use the same machine.

Security. Self-contained software for Prime III runs from bootable DVDs. It cannot be reached online or downloaded to a local computer. Voters confirm a printed ballot before it goes to the scanner to be counted. The printed copy, which a poll worker collects face down, is dropped in a secure box so that election officials can audit overall results from a precinct.

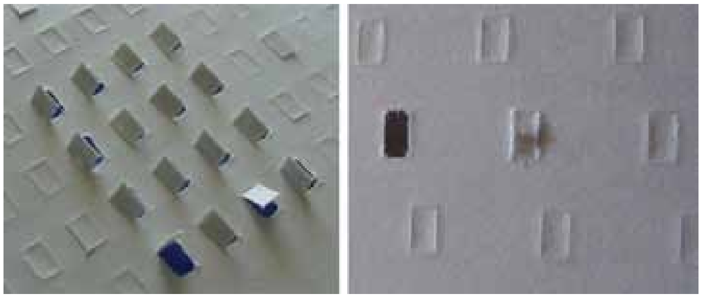
Privacy. Even using the voice-activated ballot, voters don't have to divulge the names of the candidates they support. A series of voice prompts leads voters to say words such as "next" or "vote." Printed ballots contain no identifying information; stickers bearing authenticated serial numbers are applied to each ballot to ensure that only properly cast ballots are retained. Poll workers who assist voters never see the votes that have been cast, only the blank back side of the paper.

Affordability. There is no Prime III machine to buy. "We can run on anything," Gilbert says. Computers, screens, and printers are off-the-shelf products.

Usability. The software was developed through years of usability testing with focus groups that included people with a variety of physical disabilities. In addition to controlled laboratory settings, it has been used in national academic and trade association elections. Public elections are next on the list, first at the municipal level, then in state contests.

Gilbert runs through a touch-screen voting sequence with Jessica N. Jones, a Ph.D. student in Gilbert's lab. "From a design point of view, voting is interesting," Gilbert says. "It has some extremely complex requirements, but in the end, it has to be simple, both for the voter and for the poll workers and election officials."

Douglas W. Jones



The bane of paper ballots: Chads, the punched-out bits of paper, cause trouble in machines. Hanging chads (left) cling to the ballot; a pregnant chad (right) bulges but fail to open.

Voters can choose from touch-screen or voice-activated systems, both of which are menu driven. Prime III feeds the results to a printer to produce a paper ballot that the voter can verify and that polls can retain for recounts as necessary.

"That's how we approach election systems," Gilbert says. "You don't have a disability machine, but one single voting machine. If you can't see, can't hear, can't read, or don't have arms, you can still vote privately and independently on the same machine as anyone else. There's no ambiguity. The ballot is easy to count, easy to verify."

But at first, there was no ballot at all.

"We had developed our first prototype without including a paper ballot," Gilbert recalls. "The disability community said they wanted no paper, but the security community said they required paper. This became a very sensitive and contentious issue politically. The question for us as developers became how we could design a system and provide evidence that would keep everyone happy.

"In the end we settled on a solution that printed a paper ballot for every voter, one which would be easily scanned by optical character recognition," Gilbert says. "That allowed the voter to verify it and retained the hard copy in the event of a manual recount. Above all, it still met the three criteria we set out in the beginning: It must be accessible, secure and indisputable."

Keeping it simple

"From a design point of view, voting is interesting," Gilbert says. "It has some extremely complex requirements, but in the end, it has to be simple, both for the voter and for the poll workers and election officials. It's also interesting because of the misconceptions. For example, contrast security and usability. We've not found a single documented case that someone actually hacked a computer voting machine. Not a single arrest. But there have been plenty of cases where elections were altered because of poor design. Hanging chads. Pregnant chads."

Chads, the tiny bits punched out of paper by a tool or machine, can present big problems during elections. A hanging chad, incompletely punched, remains attached to the ballot. A pregnant chad is a dimple that should have been a hole. Either spells trouble, when machines are reading the results.

But chads aren't the only flaws in paper-ballot systems.

"Sarasota, Florida, experienced a severe number of under-votes in the governor's race," Gilbert says. "It turned out they had translated the paper ballot, which had a line across the paper, directly to the computer screen. But on the computer, people didn't look below the line to find the candidates for governor. It was a simple design flaw, but one with serious consequences. So we see examples where design actually has altered elections."

The legal requirement for accessibility also presents a challenge. Current law requires that voting precincts maintain voting machines accessible to the disabled, but some states have had problems maintaining multiple systems and training poll workers in their use, Gilbert says.

"The Americans With Disabilities Act, the ADA, is the law," he says. "You have to have accessibility. Every precinct had to have an accessible machine, but poll workers in many cases had no experience with the machines. We have actually observed cases where, when they were asked to demonstrate the accessible machine, the poll workers had no idea how to do it. They hadn't had the training. You can't have a 'separate but equal' machine. That wouldn't work. You can't have a poll worker tell a blind voter, 'Here, I'll vote for you.'"

His team's goal, Gilbert says, is to consolidate various ways of voting into one technology, simplifying training and administration. But simplification itself is complex, requiring many kinds of expertise, and Gilbert reaches far beyond computer science for members of his team.

"We have individuals from the social sciences, engineering, and computing," he says. "We have experts in accessibility. We also have experts who deal with administration—training election officials, training poll workers. So this project deals with technology, but as is the case with human-centered computing, it involves more than just the numbers. We want to be able to train election officials to use the best technological solution and to find the processes for which this kind of technology can be integrated within states."

A proving ground for students

Such real-world problems offer graduate students a proving ground. Nearly thirty computer science graduate students now work in the human-centered computing lab, about half with an HCC concentration. Just last summer Clemson established a Ph.D. program in human-centered computing, one of only three in the country (the University of Maryland, Baltimore and Georgia Tech are the others). A dozen doctoral students are already enrolled in the Clemson program.

"Women and minorities were moving away from computing, and studies have indicated that in large part it was because they felt there was little interaction with people in those careers," Gilbert says. "They viewed computing as just sitting in a cubicle and writing code. Clemson is now growing very fast with increased numbers of applications, especially with women and minority students, because HCC shows a clear connection to human beings."

For Martin, a doctoral student, research led to the corner pharmacy. "There's an increasing number of adverse drug interactions with older people, but over-the-counter medications require no oversight the way that prescription medications do," she says. "There's technology to help doctors know if a patient may react to a certain combination of medications, but there's no similar application for the patient when it comes to over-the-counter products.

"If my grandfather buys a cold medicine and cough syrup, the label shows the sugar content in the fine print," Martin says, "but there may be nothing to warn him that this may contribute to his diabetes. My research looks at methods—for instance, a kiosk in the pharmacy—that would easily allow him to scan the bar code on the medication, compare it with his history, and immediately identify the risk."

From the consumer's point of view, it all sounds very simple. But that, Gilbert said, is the point.

"There is all the anticipation of the new product and then people say, 'Is that it?'" Gilbert said. "I tell my students, that's success. That's a compliment, because it's so simple that it doesn't wow you. There's no 'ooh' or 'ah,' and that's by design."

Juan Gilbert is professor and chair of the Human-Centered Computing Division in the School of Computing, College of Engineering and Science. He directs a three-year, $4.5 million project funded by the Election Assistance Commission (EAC). The Election Assistance Commission is an independent, bipartisan commission charged with helping states meet requirements of federal voting law. It sets guidelines, serves as a national clearinghouse of information on election administration, accredits testing laboratories, and certifies voting systems.

Above: Like wildflower blossoms, tents for team members in the Mongolian Aquatic Insect Survey dot grassland at the edge of the Altai glaciers.
Below: the caddisfly (*Brachycentrus americanus),* which is especially sensitive to pollution, has long been one of John Morse's research interests.
Photos by John Morse.

Life at the edges

Insects help lead Mongolia toward cleaner water.

By Taylor Reeves

It's summer in Mongolia, and a convoy of jeeps roars into the outland regions that encompass the country's recently thawed lakes, rivers, and streams. For three weeks, a team of scientists will cross the open landscape, boiling their own water, sleeping on the ground, and bathing in rivers. They bring along cooks who often negotiate with local farmers to buy sheep and fresh produce that will become dinner on the spot. When the team runs out of dirt road to travel by car, they hire horses and camels to traverse the rough terrain. They are armed with nets, shovels,

John Morse

The Mongolian Aquatic Insect Survey team and pack camel, with Olgii, Nairamdal, and Burged Mountains in the background.

traps, and sampling equipment as they survey and collect the rich array of aquatic insects teeming beneath the surface of the unexplored waterways.

For John Morse, an entomologist, the Mongolian Aquatic Insect Survey has constituted a significant part of his life and research for more than a decade. The survey's goal: an inventory of aquatic macroinvertebrates – small animals that lack backbones but are visible to the naked eye. Because they reflect the health of an ecosystem, these insects can help Mongolian scientists evaluate water quality and aquatic life in their country.

What the insects reveal

The survey is a national project years in the making. It began in 2003, when scientists from around the world began cataloguing insect fauna in the Selenge River basin. The Selenge connects Hovsgul and Baikal, two of the world's largest and most biologically diverse lakes with numerous endemic insect species. The team examined more than 200 sites and collected more than 3,000 specimens, many of which had never been catalogued before. In 2008 the survey moved to Mongolia's western terminal basins, which lie to the west and southwest of the Selenge River and allow no outflow to other bodies of water.

Unlike Europe and the Americas, Mongolia has not been able to draw on centuries of research to create detailed catalogues of insect fauna. That has been a liability, since scientists can use such catalogues to gauge how well different species tolerate pollution and monitor water quality by measuring the number of species in different areas. Since little is known about Mongolian insect populations, scientists are unable to monitor the country's water quality efficiently. The Mongolian Aquatic Insect Survey will enable a more accurate water-monitoring system in Mongolia for detecting pollution from mining and herding, which threaten the country's water supply and diminish its biodiversity.

While the team's expeditions into the Mongolian countryside are scientific by design, they are adventurous by nature.

"When you leave town, you'd better have everything you'll need with you because that's all you're going to get," Morse says. "Every day is different, and every day is exciting."

Mongolia's national independence day, Naadam, often occurs during the summer expeditions, and the team celebrates according to Mongolian custom, participating in races and arm wrestling competitions and preparing a special meal of spiced meat wrapped in dough.

"During expedition, we're like a family. We take care of each other and understand each other as we work toward a common goal," says Oyunchuluun Yadamsuren ("Oyuna"), a Mongolian student whom Morse first met while teaching an entomology course there in 1998.

Then a sophomore at the Mongolian State University of Education, Oyuna developed an interest in aquatic entomology through Morse's class and decided to pursue a career in the field. When Morse returned in 2001 to teach a second course, Oyuna volunteered to work as a lab assistant. Her enthusiasm prompted Morse to recommend her to Gelhaus for the initial aquatic insect survey.

Creating a new technique

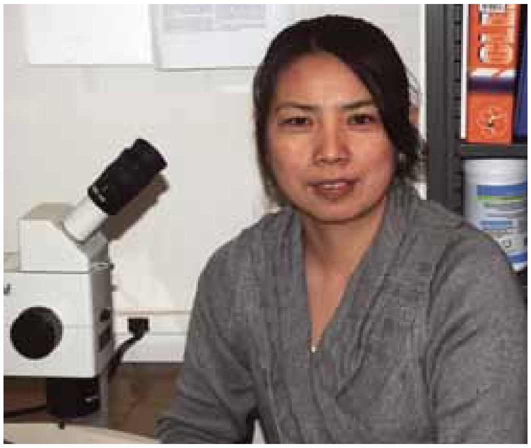
Oyuna, who is working toward her Ph.D. under Morse's direction, explores a new technique of using information collected in the Mongolia Aquatic Insect Survey to monitor the country's water quality. The Environmental Protection Agency (EPA) recommends a metrics-based system for water assessment, which involves numerically evaluating different species' ability to tolerate pollution and calculating average tolerance levels for different areas.

The mayfly, stonefly, and caddisfly species are generally sensitive to pollution and are thus particularly useful for this technique. A large number of taxa from these three insect orders indicates good water quality. In Mongolia, there are about 250 species of mayflies, stoneflies, and caddisflies. Globally, there are more than 3,000 species of mayflies, 3,500 species of stoneflies, and 14,400 species of caddisflies.

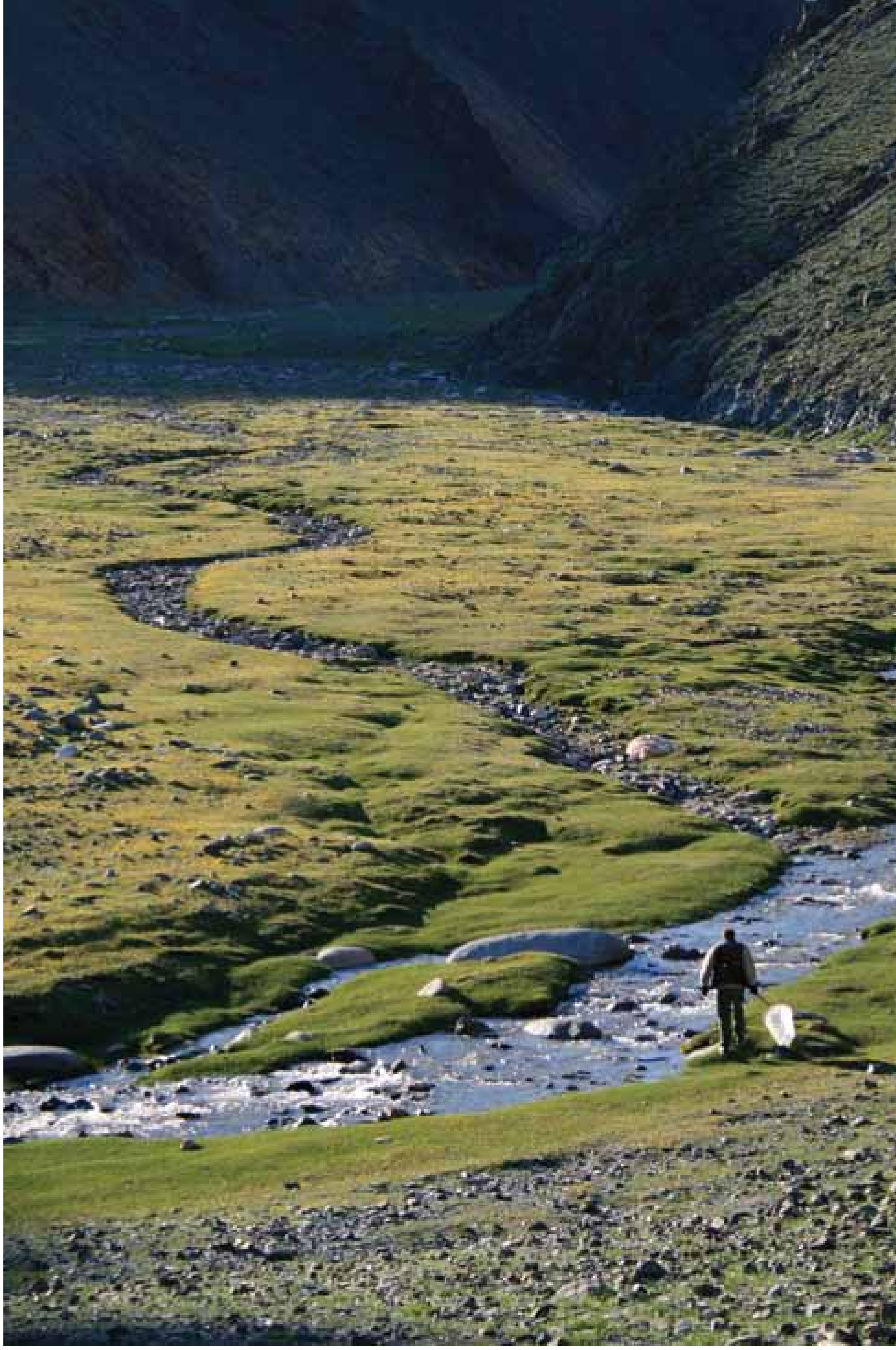
Oyuna proposes to diverge from the metrics-based system in favor of a traits-based system for which she would use the environments and physical characteristics of different species to determine water pollution levels. She will evaluate twenty to thirty biological and ecological traits, such as the temperature each species lives in and how it obtains oxygen, and she hopes to determine which traits are prevalent and which are scarce in polluted environments.

While Oyuna's research could be applied in many locations, the traits-based system is particularly valuable for Mongolia. Tolerance levels used for the EPA metrics system were developed in a different environment than that of Mongolia, where rivers and lakes are situated on flat plains rather than in forests. The EPA system was designed to detect

John Morse



Oyuna will return to Mongolia with a new technology for monitoring water pollution.



Left: John Morse (center) uses topographic maps printed in Russian to guide the team in 2003.
Above: Entomologist Sigitas Podenas of Vilnius University, Lithuania, samples from a stream meandering the Altai Mountains in Mongolia as part of the survey. Photos by Jon Gelhaus.

organic pollution, and Oyuna's system would work to detect mining pollution as well. Although the metrics system works well for countries with a well-established history of taxonomic research, the traits-based system would be adaptable for the special conditions in Mongolia.

When she finishes her dissertation, Oyuna will return home to Mongolia. While the country's modernization isn't new to her, it is different from what Morse encountered when he first visited in 1996 – a country emerging from seventy years of Soviet rule.

"Back then, the buildings were drab, the streets were broken and potholed, and there was limited connection with the outside world," he says. "Now you see five-star hotels, skyscrapers, many international visitors, and of course, loads of traffic in the city center."

Science has changed as well. When Morse first began teaching in Mongolia, there were no scientists engaging in aquatic entomological research there. Today, nineteen freshwater biologists have established their own professional society in the country.

"For me," Morse says, "the opportunity to introduce the whole discipline in Mongolia has been thrilling. I'm meeting academic children and grandchildren every time I go back."

In appreciation of their efforts, Morse and Gelhaus together received the distinction of "Best Scientist for Nature and the Environment" by the Mongolian government in July 2011.

John Morse is professor emeritus of entomology in the School of Agricultural, Forest, and Environmental Sciences of the College of Agriculture, Forestry, and Life Sciences. The Mongolian Aquatic Insect Survey is led by John Gelhaus of the Academy of Natural Sciences at Drexel University, whose research on aquatic entomology in Mongolia began with John Morse in 1996.

Primary funding for the research is from the National Science Foundation.

Taylor Reeves is a senior majoring in English at Clemson.

here comes the *sun*

How thrifty can a building be? We're about to find out. by Neil Caudle

In the corners of Lee 3, small red bulbs are glowing. This means, keep the windows closed. Today is a red-light day, the weather gray and cold. But when spring arrives and sunlight heats the space inside, the lights will switch from red to green. Rows of awning windows near the roof will swing open, prompted by a vigilant computer. Then students and faculty members will stop what they are doing and open, with their hands, corresponding sets of windows near the floor. Convection—the chimney effect that once aired Southern houses—will draw fresh, cool air through the low windows and purge warm, stale air through the high ones.

This is what people did a hundred years ago; they opened the windows. But *today?* Can actual occupants be trusted to operate an expensive public building? It's almost unthinkable. And yet this is what Lee 3 requires.

"This building is a machine," says Robert Silance, associate professor

Above: The Lee 3 addition to Lee Hall, designed by Clemson graduate Tom Phifer, will use geothermal heating and cooling along with advanced energy-conservation measures to push the limits of sustainable design. **Below:** Daylight fills the interior, reducing the need for artificial light. Photos by Annemarie Jacques

of architecture. "It doesn't just sit there. When that light goes green and those windows open, is that an intrusion? We don't know yet. The building is asking us to change how we behave."

For years, students have been sketching and groping their way toward buildings like this—open, distinctive structures with precious little use for fossil fuel; buildings that would ask more of the inhabitants but give more in return. And now the students can work in one.

Measuring up

Tom Phifer was a student here once, learning his chops in the studios of the original Lee Hall, known today as Lee 1. Now a big-time architect and the lead designer for Lee 3, Phifer has set the bar high. The stunning new building, when equipped with a full array of photovoltaic panels, could produce as much energy as it needs. A few years ago, this was the future, theoretical and safely remote. Suddenly it is here.

"The building is way ahead of us," Silance says. "Everybody's expectations are higher now. We will have to measure up."

Part of measuring up has meant furnishing the building to function as intended. With a team of students and colleagues, Silance designed tables and workstations in several configurations and had them fabricated by Sargent Metals of Anderson and Design Solutions, Inc. of Chapin, S.C. On a campus bound by state-government purchasing rules, this took some doing, but the goal of sustainability meant using local suppliers with a stake in the local economy. The team also wanted furniture that encouraged group projects, not isolation.

"The desks became more than desks," says Daniel Harding, a colleague who worked on the project. "They are fixtures of collaboration."

Collaboration will be one measure of success for Lee 3, which will house architects, planners, landscape architects, construction-management experts, real-estate developers, and others. All of them will have adjustments to make.

"The building has such a strong presence that you can get infatuated with it as an object," Harding says. "But it's not so much what the building is as what it does, what it engenders. We'll need to grow into it and not disrespect it."

With all due respect

Disrespect might include, for example, carving open spaces into enclaves for holing up and hiding out, or covering the floors with clutter that could interfere with the flow of radiant heating and cooling from the concrete slabs.

But respect in the case of Lee 3 isn't strictly hands-off. Paul Russell, a landscape architecture professor, wondered at first what to make of a classroom nakedly exposed to adjacent spaces, its most prominent wall made of windows. His solution: a dry-erase marker. Now, when he teaches, people stop to watch him draw on the glass.

Nor is the assignment of spaces sacrosanct. The faculty lounge, with a northern exposure ideal for drawing, may eventually give way to review space. Harding, who has long admired the sunny porches of old Southern houses, plans to roll a canopied coffee cart into an interior courtyard and see who gathers there to take the sun and swap ideas.

The whole of Lee 3 is a laboratory of sorts, and its occupants will run experiments on the building and themselves, learning what works and what doesn't. Whatever direction those experiments take, they will proceed in the open. There is no place to hide in this place, where even the pipes are exposed.

"For some people, the transparency of the building is a little scary," Russell says. "But I like it and expect it will make us all do better work."

Robert Silance, associate professor of architecture, conducts research in product and furniture design. Daniel Harding is an associate professor of architecture and director of the Community Research and Design Center. Paul Russell is an assistant professor in planning and landscape architecture. The firm of Thomas Phifer and Partners, based in New York City, has designed many internationally prominent buildings, including the North Carolina Museum of Art in Raleigh.

how to learn from a building

Lee 3 is designed to test and expand current knowledge of sustainable design and construction. Monitored electrical circuits will report energy use to an electronic dashboard so that students and faculty members can access real-time data on energy consumption. Teams of students will investigate how to operate the building with the least possible energy purchased from the grid. The dashboard's computer will also monitor water use, indoor and outdoor temperature and humidity, and pollen levels.

Energy savings began with the decision to use construction materials, some with recycled content, available from sources within 500 miles of the site. This reduced the carbon footprint of the project, a prime goal of sustainability.

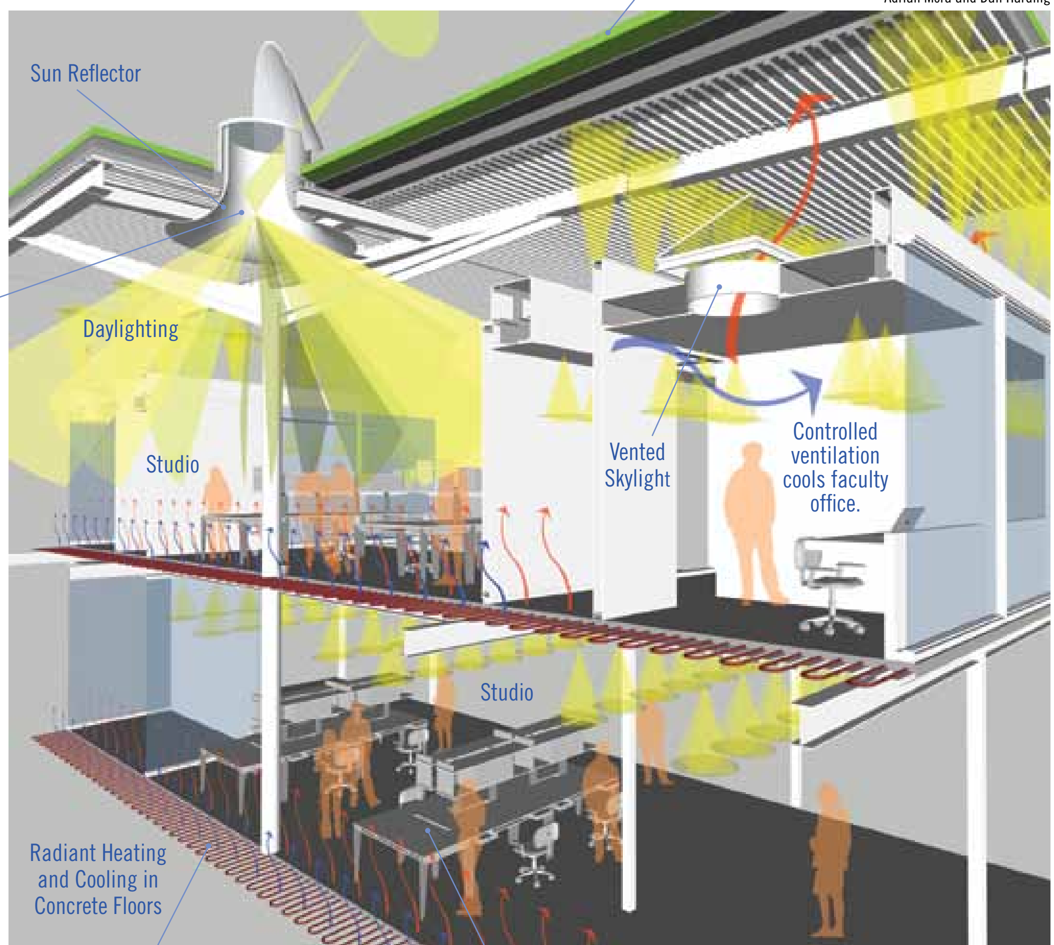
Annemarie Jacques

Shrouds prevent glare and overheating in skylights, directing diffused light into the building. A green roof planted with sedum absorbs and filters storm water, slowing runoff. The roof also lowers heating and cooling costs and is itself a research project: which varieties of sedum will perform best?

Neil Caudle

Inside, 25 skylights collect daylight. The slender, tree-like structural columns are made of seamless steel typically used for high-pressure lines in the oil industry.

Adrian Mora and Dan Harding



Red light glowing, close the windows. Green light, open them.

72,000 linear feet of 5/8-inch tubing carries liquid through the slabs, heating or cooling the building. Forty-two geothermal wells installed to a depth of 440 feet provide approximately 80 tons of heating and cooling and allow Lee 3 to operate without taking energy from the coal-based campus plant.

Neil Caudle

Furniture designed by Rob Silance and his colleagues and students meets the slab with small feet so as not to interfere with energy flow. Two South Carolina companies fabricated the furniture.

bringing it home

Prize-winning teams zero in on housing.

How much energy does it take to run a house? How about none?

That's no pipe dream, according to Ulrike Heine, assistant professor of architecture. Heine and her students design zero-energy houses for the Southeast.

"When we talk about sustainable architecture," Heine says, "we mean architecture that acts with and takes advantage of the laws of nature."

In February two teams of Clemson graduate students from Heine's design studio took first and second place in Design to Zero, an international competition sponsored by Dow Chemical Company. Three additional Clemson teams also received awards. The competition, whose objective was to design affordable, energy-efficient housing, included 131 design teams from 19 countries. Peers ranked the entries. Here are Clemson's winners:

- The Live/Work team, Eric Laine and Suzanne Steelman, won first place and $20,000 with a sleek design that incorporates both commercial and residential functions.
- Daniel Kim and Caitlin Ranson won second place and $10,000 for their Project Zero design, which blurs the boundaries between interior and exterior spaces.
- Honorable Mention went to John Oxenfeld and Adam Wilson for their Partial Submersion design.
- Mike Niezer and Adrian Mora took the Design Integration Award for crafting a serene and clean breathZero house.
- The Built-In Photovoltaic Design Award went to Jason Drews and James Graham for their Below Zero design with optimal solar angles.

Eric Laine and Suzanne Steelman took first place in the Design to Zero competition with a design that integrated commercial and residential spaces.

The winning teams drew on contemporary research in a range of fields, Heine says. Her colleagues Daniel Harding and Bernard Sill advised students on questions of community design, residential construction, and structural systems.

Designing a zero-energy house requires a scientific understanding of environment and materials, Heine says, and students learn to calculate the carbon footprint of various building materials. They begin their research by asking the right questions, such as, "How can a sustainable house beat the rugged humidity of South Carolina?" They review data from field research into climate, materials, and engineering and construction methods, often drawing on the studies of Clemson researchers who work outside of architecture.

"We have all the players here," says Kate Schwennsen, chair of the School of Architecture, "from material science to construction science to civil engineering, and all those disciplines are key to advancing what we know."

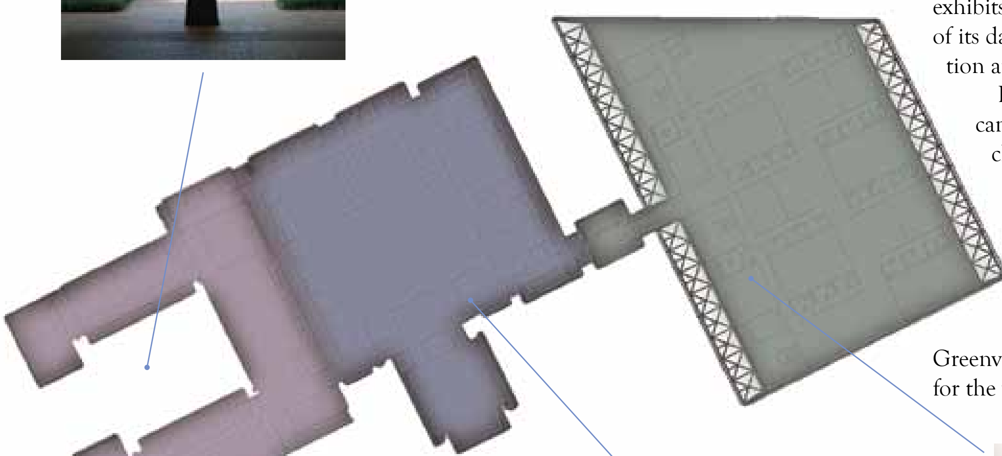
– Mary Catalanotto Parker

3 degrees of Lee

The original Lee Hall embraces a sunken courtyard as its social and creative center.

With its leap toward the future, its courtyards, and its emphatic choice to work with nature rather than against it, Lee 3 takes some DNA from Lee 1, designed by then Dean of Architecture Harlan McClure and opened in 1958. Wrapped around a shady courtyard favored for exhibits and conversation, Lee 1 was the green building of its day, with louvers and operable windows for ventilation and with abundant natural light.

Lee Hall was also the first modernist building on campus, a then-radical design that has since become classic, earning a place on the National Register of Historic Places. Lee 2, completed in 1975, did its job—adding growing room. Today, a portion of Lee 2 has been reconfigured along Broadway, an expansive indoor avenue with alcoves for teaching and exhibits, linking Lee 1 to Lee 3. McMillan Pazdan Smith Architecture of Greenville, S.C. was the local architecture firm of record for the work on Lee 3 and the renovations of Lee 2.


Lee 1 1958

Lee 2 1975

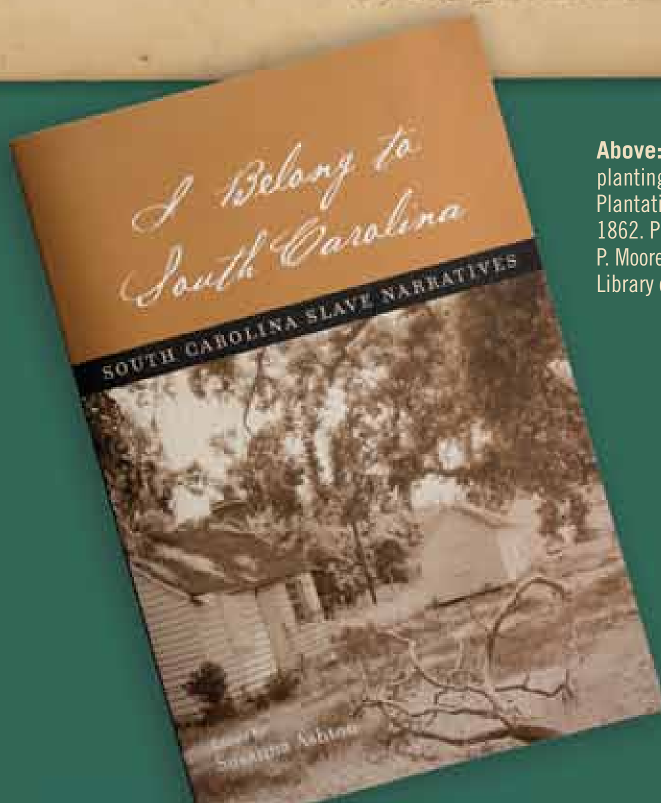
Lee 3 2012

John Jacques

Like the courtyard of Lee 1, the gallery and alcoves along Broadway in Lee 2 draw people together.

Craig Mahaffey

A daylit classroom in Lee 3, where the glass (left) can serve as a blackboard.

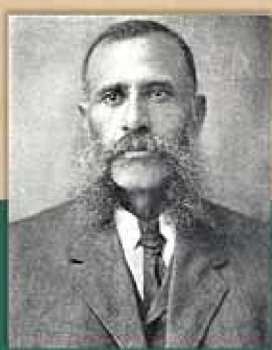


Above: Sweet potato planting, Hopkinson's Plantation, Edisto Island, 1862. Photo by Henry P. Moore, 1833-1911. Library of Congress.

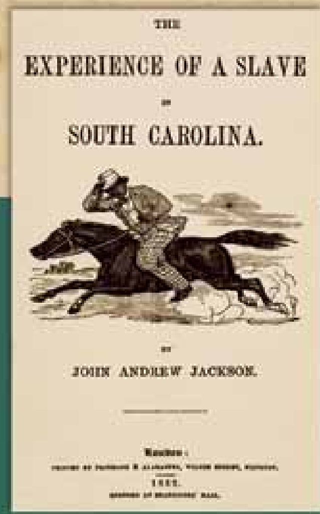
a slave's life

Susanna Ashton and her students gather stories that changed the world.

by Jeff Worley



Irving Lowery


THE

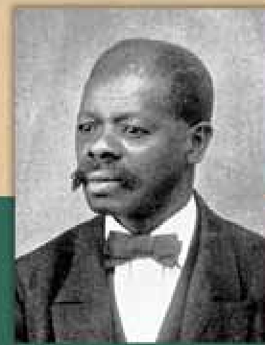
EXPERIENCE OF A SLAVE

IN

SOUTH CAROLINA.

BY

JOHN ANDREW JACKSON.



Jacob Stroyer

The book includes accounts by Irving Lowery, John Andrew Jackson, Jacob Stroyer, and others.

You got whipped for not working fast enough. You got whipped for not admitting to a minor theft you didn't commit. You got whipped for praying, for not obeying quickly enough, for taking a muskmelon to keep from starving. And sometimes you got whipped just for the pure sadistic hell of it.

The brutal treatment of slaves—men, women and children—on South Carolina plantations for nearly a century is a tragic, recurring theme in Susanna Ashton's recently published, award-winning book titled *I Belong to South Carolina: South Carolina Slave Narratives,* published by the University of South Carolina Press.

"One of the most common defenses of slavery from Southern intellectuals and plantation owners was how well taken care of slaves were," says Ashton, associate professor of English. "'Why would we badly hurt or kill our slaves? It's not in our self-interest to do that. Besides, they're part of our family and community after all.'"

This patriarchal defense of slavery seems logical, Ashton admits, but the evidence deeply contradicts these claims. "In reading through hundreds of slave narratives, you find case after case of horrific violence," she says.

Ashton explains that the book's title comes from one of the narratives included, "The Experience of a Slave in South Carolina" (1862) by John Andrew Jackson. After escaping from a Sumter, South Carolina, plantation in 1846, Jackson made his way to the docks of Charleston, where he lurked around the wharves, seeking a northbound boat. Suspicious workers confronted the black man, demanding to know, "Who do you belong to?"

Aware that he could not persuasively identify himself as either a freeman or a Charleston slave, Jackson dodged the question by replying simply, "I belong to South Carolina." As Jackson later explained in his narrative, "It was none of their business whom I belonged to; I was trying to belong to myself."

Although the seven narratives in Ashton's book focus on individual experiences of endurance and escape, each account sought to make the extraordinary suffering of slavery both a personal and a collective horror, Ashton emphasizes.

"The writers were very aware they were also speaking for the many others who couldn't tell their stories, couldn't write, perhaps, so each narrative is also a communal gesture."

South Carolina's slant on slavery

Ashton came to this project in an oblique way.

"I moved from Iowa to South Carolina 14 years ago and immediately loved it here, but could not get a handle on the place. People were very kind and generous, and also forward-thinking, but it seemed to me there were some things that just weren't discussed." She found it interesting, for example, that Clemson University founder Thomas Green Clemson often came up in personal and academic conversation, but not John C. Calhoun.

"I found this odd because, after all, the campus is on John C. Calhoun's former plantation, and Calhoun was one of the biggest proponents of slavery in American history."

Ashton is quick to point out that she is a literary scholar, not an American historian, but in part to better understand her new home she started teaching courses that dealt with slavery or, rather, how slavery

> "It was none of their business whom I belonged to," Jackson wrote.
> "I was trying to belong to myself."

had been represented in American culture, as well as publishing articles about slavery. This interest led her to do research at the University of North Carolina, where an extensive collection of slave narratives had been compiled.

"When reading through this collection, it occurred to me that quite a lot is known about slavery in our border states—North Carolina, for example, and stories from Maryland such as Frederick Douglass' escape—but relatively little can be found about slavery in South Carolina. This is when I started thinking about doing a book so there would be a more complete historical and literary record."

She adds that the culture of slavery in South Carolina is historically distinct from the cultures of slavery elsewhere in the American colonies and, later, in the American states. South Carolina's semitropical climate and historic ties to the British West Indies created a society in which immensely profitable large-scale agriculture demanded a huge labor force—large teams of slaves—working on plantations to raise indigo, rice, or cotton as opposed to the small-scale farm crops that would demand fewer slaves.

To deal with the daunting scope of a project that would demand reading through several hundred slave narratives to identify those which focused on South Carolina, Ashton tapped into Clemson's Creative Inquiry program, in which team-based scholarly investigations by undergraduates, led by a faculty mentor, result in the publication of scholarly articles or a book.

"I interviewed a team of students for this project, and got them to commit," Ashton explains. "And this yearlong project was an intense commitment—we met twice a week on campus for nine months, and they read through hundreds of narratives in collections at UNC and the University of Virginia." Ashton co-edited, with a different student researcher, each narrative included in the book.

Fueling the abolitionist cause

Ashton admits that some of the events depicted in this collection are a bit tough to get through. *I Belong to South Carolina* is not a beach read.

"The two abolitionist narratives—one by John Andrew Jackson and the other written anonymously—are probably the hardest to read since they are such stark testimonials of violence and torture," Ashton says.

Jackson begins his narrative with several instances of harsh treatment he received and witnessed during his time as a slave, including the role of women in the horrors of slavery. He says of the slave owner's wife, "The sight which most delighted her eyes was to see a slave whipped," and one of her daughters grew up to murder Jackson's sister by having her whipped to death.

"Recollections of a Runaway Slave," written and published anonymously in 1838, is a relentlessly specific testimonial to the violence of slave practices and to the ways in which plantation culture enabled such violence. The narrator sets the tone early on in his narrative, recounting being whipped as a child. The whipping cut through his skin, but, the young man writes, "They did not call it skin, but 'hide.' They say, 'a nigger hasn't got any skin.'" In a later passage he describes in blunt and calm terms being forced to whip a young woman and rub salt into her wounds.

Jackson's narrative was first published as an anti-slavery pamphlet by a group in Maine and then picked up by the *Emancipator*, a Boston-based abolitionist publication, Ashton explains. "'Recollections' was also an extremely important record for the abolitionist cause because it represents a specific turn in the reception of slave narratives of the 1830s," Ashton explains. "The text was produced and published in the epicenter of controversies over the accuracy and value of slave narratives." This story was published, in part, in the *Advocate of Freedom* and in full in the *Emancipator*.

"These accounts were published during abolitionist times to generate emotion," says Ashton, "to shock people into action, to do nothing less than change the world—and they did."

A choice book

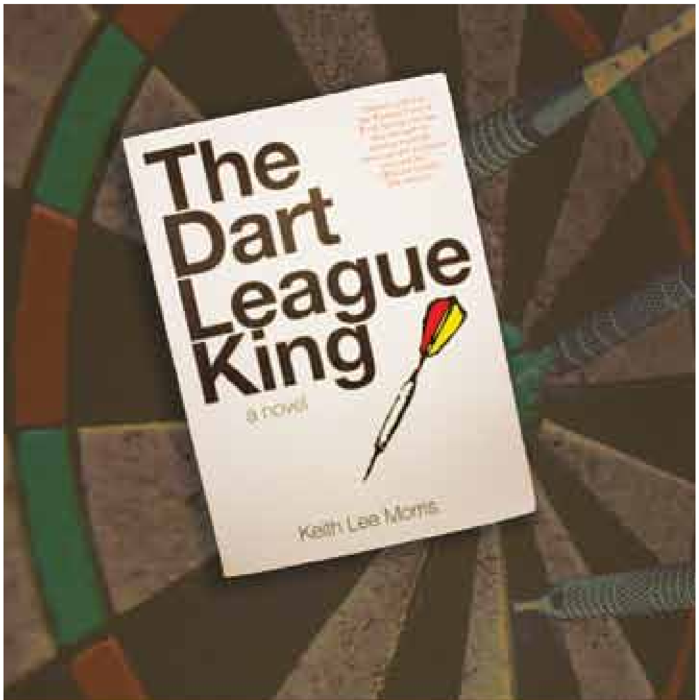
In January 2011, Ashton received a letter that she says "definitely made my day." The letter, from *Choice* magazine, informed her that *I Belong to South Carolina* had been selected as a Choice Outstanding Academic Title for 2010. *Choice* is published by the American Library Association and is considered a trusted source of news about academic books by librarians and scholars nationwide. Only ten percent of the approximately 7,000 works submitted to the magazine each year are selected as Outstanding Academic Titles.

"Capturing with fidelity the texture of life for enslaved South Carolinians has challenged even the most thoughtful scholars of slavery," says Mark Smith, editor of *Stono: Documenting and Interpreting a Southern Slave Revolt*. "*I Belong to South Carolina* is a well-edited collection of rare and under-studied slave narratives, a powerful retelling of the slave experience, and a window into the complex cultural and social topography of one of America's most robust slave societies."

Susanna Ashton is associate professor of English in the College of Architecture, Arts, and Humanities.

Craig Mahaffey

Susanna Ashton: The accounts shocked people into action.



Somebody had to go.

Sure, it's easier to do almost *anything* else (say, mow the lawn), but novelist Keith Lee Morris, author of *The Dart League King,* keeps flinging pointed prose.

A conversation
with Jeannie Davis

close focus

Q *You have said that in* The Dart League King, *your second novel, you started out to write a short story about the character Russell Harmon, but the other characters started crowding in, and the story became a novel. How do you turn those voices off when the novel is finished?*

MORRIS: I was actually talking about that in class the other day. Someone asked, "Do you get attached to your characters?" which I guess is a different way of asking the same thing, and my response is "Yes. Definitely." Sometimes I forget that I've made these people up, and when I go back to my hometown, I'll think I'm going to see them. They're close enough to real life to seem real to me

Q *Many of your readers were pretty upset about what happens to Kelly at the end of* The Dart League King.

MORRIS: Sorry about that. Somebody had to go. Couldn't let everybody off the hook. If you're trying to write a novel where you keep suggesting that something really bad is going to happen to one of these people, then you can't walk away from it scot-free. It won't feel like you've stayed true. Something had to give there, and that ended up being where it went.

Q *I was going to ask you how you handle bad reviews but I couldn't find one...*

MORRIS: Right. Unless you're a big shot, nobody's going to say terrible things about you. There's no point in picking on me; I'm not that well known. It's hard to get books out there—literary books that have some kind of mainstream appeal. Three or four years ago, none of the books on the short list for the National Book Award had sold as many as 5,000 copies at the time they were nominated. Not one. So, we're talking about the most critically acclaimed books of the year, and they had sold practically nothing. There are thousands of books out there; so if critics choose to review your book, often it's because they liked it and they want to have a hand in promoting you and getting your name out there. If they don't like a book, they just don't bother to write about it. Unless you're really well known. If you're Toni Morrison, then everybody's going to review your book, and some of the reviews will be critical. I should qualify that. There are publications like *Publisher's Weekly* and *Kirkus*, that are going to give honest reviews even if the books are by authors who aren't that well known. Those you sweat a little bit.

Q *You've said that you like having written but you don't much like writing and that it is hard work and makes you tired.*

MORRIS: No I don't like writing, and I'm really envious of writers who do like writing.

Q *So why do you do it?*

MORRIS: I feel like if I do it as well as I can, and I put it out there, then that's important to me. Writing happens to be what I'm better at than other things. And I love reading. I love books. It made sense to me to want to put out something that somebody else could enjoy. But I never liked writing, even when I first started. I will do anything to keep from writing. I have found myself mowing the lawn to avoid writing.

Q *You have said that Faulkner is your favorite author. Are you reading much Faulkner these days?*

MORRIS: No. I love *As I Lay Dying, The Sound and the Fury,* and *Light in August*. I don't know if I can point to another author who's written three books that mean as much to me as those three books. So really, when I say I love Faulkner, I'm really saying that I love Faulkner from about 1928 until about 1932. And I've read so much Faulkner, I don't really go back to him much. I just reread *War and Peace*. I'm in the process of

Neil Caudle

Keith Lee Morris at Nick's Tavern in downtown Clemson, the sort of place his characters might frequent: "If you're a stranger in town, and you wander into a place like this, you can watch the people, but you won't really know what's happening between them."

reading Marcel Proust again, *Remembrance of Things Past*, which I've never gotten all the way through.

Q *What else are you reading?*

MORRIS: I'm reading Richard Powers, *The Echo Maker*. I want to read Colum McCann's *Let the Great World Spin*; that's next. Russell Banks has a new book out; I might check that out. I'm always looking for older stuff to read. I fell in love with George Eliot and her longest book *Middlemarch*. My mother liked *Mill on the Floss*; so I want to read that.

Q *You teach fiction here at Clemson. Do your students inspire you? Do your students make you crazy?*

Yes. Both. I've had some great students over the years, some really inspiring students, some students I'm really proud to have taught, students who have gone on to do a lot of wonderful things. Sometimes it's not the really good students who have the most effect, though, it's the ones who struggle the most.

Q *You started the Clemson Literary Festival five years ago in collaboration with another faculty member and a group of undergraduate students. Could you talk a little bit about what you had in mind when you started it, and where you'd like to see it five years from now?*

MORRIS: I wanted the writers to come to Clemson and have a really good time. I wanted people to be able to go see the writers in places that would allow them to have a really good time and hang around afterward and talk to one another and talk to the writers. I wanted the students to be involved, to be able to run the festival—that was a big component of it. I wanted the writers to go home thinking, "Clemson might not have the most money, Clemson might not be the biggest book festival, but I sure had a lot of fun there." And I think it's worked. In Clemson, the Literary Festival can't get huge. It can't become like the Decatur Book Festival, near Atlanta, where the whole town just turns into a book festival for a few days. Their budget is hundreds of thousands of dollars every year, and they've got things going on a seven venues at the same time. But I'd like for our festival to grow, with more people coming in from out of town, drawing more draw more artistic stuff here. Maybe an arty hotel downtown, so that writers and people coming to the festival could stay downtown.

Q *Do you have lucky charms or talismans? Lucky socks? Do you have to write with a certain kind of pen?*

MORRIS: I used to really like to write outside. I used to like to sit outside on a bench in the sun and write longhand. I will sometimes sit down at the computer, but I prefer to write longhand, and then edit onto the computer. I used to like to write in bars, and there are certain places here in town—Nick's—that I would go. If two people are sitting and having a conversation ten feet away from me, I can't write a word because I'm listening to their conversation. But if I'm sitting in a place where a hundred people are having conversations and music is playing really loud, I don't hear any of it. But, I'm not superstitious in the least. Well, I do have the sneaking suspicion that sports teams I want to win are losing because I'm watching them. So sometimes I'll leave the room if I think my team might get lucky. But that's it.

Morris, professor of English, has mixed sports and writing since he covered basketball for his high school newspaper. His novel, *The Dart League King,* and his latest collection of stories, *Call It What You Want,* are available online and from publisher Tin House Books. *The Dart League King* was a *Publisher's Weekly* starred review and Pick of the Week in 2008. In April 2012, the Clemson Literary Festival welcomed headliner Richard Ford, Pulitzer Prize-winning author of *Independence Day*.

zoom out

the explorer's craft

For his expedition into the Savannah River watershed, photographer Anderson Wrangle had to rebuild his motorboat. He also needed a smaller craft, a canoe, for the shallow mountain streams. So he built one. The canoe had to be sturdy enough to carry Wrangle and his gear but light enough for portage. **Above:** Wrangle with his canoe at Fairfield Lake, near Cashiers, N.C. **Left:** a glimpse of his worktable. Photos by Anderson Wrangle. For more about Wrangle and his work, please see page 22.

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