glimpse

research *and* creative discovery

Clemson University

fall 2015

A small solar house that lives big.

Jim Melvin

solar savvy

A team of student architects, engineers, and builders invents and assembles a futuristic machine for living in tune with the sun. Page 26.

Cover illustration by Will Hinkley

glimpse

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Inside the lighthouse on Sapelo Island, the climb is steep and winding. For the people of a culture known as saltwater Geechee, the struggle to preserve their island heritage has been much the same. Now they are working with a team that includes geneticist Stephen Kresovich to reintroduce Purple Ribbon, a sugarcane first grown on the island two centuries ago. Because rare and desirable varieties of cane are prized by modern chefs and distillers, the project may cultivate an economic opportunity deeply rooted in the past. Page 16.

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Art that reveals the structure and beauty of math.

Listening, to lead

The word leader has long implied one person, strong and decisive, who sets a course for others to follow. The leader speaks, the followers listen. But complex modern ventures rarely work that way, because the challenges are so complex that they exceed the span of any one person's grasp. As Marissa Shuffler is finding (page 56), modern leadership often succeeds best when a coordinated team of people unite their diverse skills and insights into a unified vision and effective action.

Shuffler studies leadership in the context of the military, medicine, and space exploration, but her findings would also apply to a project called Indigo Pine (page 26). For more than two years, students and their mentors from multiple departments have planned, designed, and built their way toward an international showdown, in October of 2015, known as the Solar Decathlon. The decathlon, which is sponsored by the U.S. Department of Energy to promote innovation in energy-efficient housing, is the most complex and daunting endeavor many of our students have ever encountered. And for more than two years now, it has put team-based leadership to the test.

The test was never easy. "We had a lot of strong personalities, and we were always butting heads," says Will Hinkley, a graduate student in architecture. "But we had a common goal, so we figured out a way to work together. And we had a lot of fun."

On the Indigo Pine project, architects learned to hear the engineers and vice versa. Chemists, physicists, social scientists, package designers, and many others all had a say. And listening, they found, was the essential ingredient, the number-one skill that moved the project forward.

Modern science, too, depends on that skill. The effort to reintroduce an heirloom sugarcane to Sapelo Island (page 16), for example, began with listening. The team, which included the renowned geneticist Stephen Kresovich, listened to the Geechee people, and heard about their hopes for a new crop, new employment, and a way to keep their heritage alive. Without that careful listening, even the best ideas can fail to thrive.

At Clemson, we talk sometimes about the will to lead. We intend to lead as a research university, an institution of higher learning, and a force for serving the public good. The will we speak about—a strong determination and resolve—can motivate us as individuals, yes. But even more importantly, we aspire to lead collectively, as a diverse group of people who can listen to each other and, for all our differences, achieve a common goal.

Ashley Jones

R. Larry Dooley
Interim Vice President for Research

Growing room for local farms

Part farm and part research station, the Student Organic Farm is a living laboratory for those who want to learn the rhythms of the land.

locally grown

A student farm cultivates research along with the veggies.

In restaurants and food markets across the country, the labels are popping up more often, these days: "organic" or "locally grown." For consumers, the notion seems earthy and simple: Support your local farmers, help them protect the environment, and keep some risky chemicals out of your family's food.

But organic farming for a local market is far from simple. In fact, the know-how required to grow and deliver high-quality food without the aid of modern chemistry and the economies of large-scale agriculture is formidable—as much an art as a science, so far.

Neil Caudle

Farming year-round

On the coldest day of the year, farm manager Shawn Jadrnicek (left), and Geoffrey Zehnder, a professor and faculty administrator, check seedlings in the greenhouse. Starting crops early helps the farm get a jump on the season—and the weeds.

Ashley Jones

Carly Cox, an undergraduate student in biosystems engineering, picks okra at the Student Organic Farm.

"Right now I see a lot of interest in locally grown food, and we don't have enough to meet the demand," says Geoffrey Zehnder, an entomologist and faculty administrator for Clemson's Student Organic Farm.

Zehnder knows, for example, how quickly an insect pest can strip a field and leave the farmer with nothing to sell. In organic farming, you can't just reach for a bigger hammer, when things go awry. You have to outsmart the weather, the market, and the pests. That's some tricky territory, and Zehnder is trying to help aspiring farmers learn the lay of the land.

"I think we're seeing farmers getting the credit they deserve for how much they have to know about soils, pests, plant physiology, engineering, and all the rest," he says. "Some of the farmers we know, we call them 'star farmers' because they're almost celebrities. People seek them out for their knowledge. Shawn is one of them. He reads and reads and reads."

Rising demand from customers

Shawn Jadrnicek, who has managed the farm since 2011, oversees six or eight students who tend approximately five acres, learning to raise not only a wide range of vegetable crops but also freshwater prawns (often called freshwater shrimp), an innovation that will make use of several outdoor ponds.

Certified organic for each of the last ten years, the farm's main market is a community-supported agriculture program (CSA) in which customers subscribe

Ashley Jones

The Student Organic Farm includes five acres with greenhouses and several ponds.

for regular provisions over two fourteen-week seasons. Demand for the produce has been growing. "We've upped the subscriptions to a hundred and twenty-five members," Jadrnicek says.

The farm started in 2001 as "a little market garden," Zehnder says. "When Shawn got here, he transformed the farm and made it run a lot more efficiently."

In the green profusion of summer, it's easy to glance at the farm as you pass on Perimeter Road and miss the signs of science in progress. But Zehnder and Jadrnicek say that the research they're conducting is helping South Carolina farmers compete for a share of a market with plenty of growing room.

Warming up a cold greenhouse

The research goes year-round. When I visited the farm back in March, on the coldest day of the year, Jadrnicek was testing a new composting system that will yield not only a soil amendment but heat for the greenhouses. Pipes under the compost pile collect heat generated by hard-working microbes and direct it into the greenhouses, where seedlings get a jump on the season.

An organic no-till system that Jadrnicek and his graduate student, Dave Rob, are testing "has tremendous potential," Zehnder says. "You can grow the cover crop over the fall and winter, and then in the spring you've got this big biomass that you roll down, and that serves as the organic mulch to keep weeds from popping up, not to mention the organic matter and the benefits from that."

Another new line of research involves growing a crop of mustard as a fertilizer source. David Thornton, a researcher in Clemson's biofuels program, will use a press to extract the mustard oil to make

Neil Caudle

Even on a cold day, the compost gets hot, warming the nearby greenhouses.

biodiesel, and the farm will apply the meal as fertilizer. "We're trying to be as self-sufficient as possible," Jadrnicek says. "Our goal is to get all of our nutrients from campus or by growing them."

Zehnder says that students on the farm come from various schools and departments. "We get some ag students, but we also get some from liberal arts, from environmental engineering, and other areas. I think the whole local food movement has raised awareness among young people about food and where it comes from. I've been here since two thousand, and every year there's more and more interest. Kids just have a passion for it."

The skills students acquire on the farm have been paying off, Zehnder says. Several graduates have become farmers or farm managers elsewhere, some in the Southeast but others as far away as Alaska.

As new farmers try to meet the demand for organic food locally grown, Zehnder sees a need for research, extension, and education designed to help them succeed. Academically, the research questions are especially challenging because organic farming, he says, depends on a systems approach with many variables, each affecting the rest.

"I think typically it's been easier in agriculture research to kind of compartmentalize and just look at one thing and control everything else," Zehnder says. "But in sustainable agriculture you want to consider everything. For example, what effect is the soil going to have on aboveground insect feeding or disease? It's all related."

Geoffrey Zehnder is a professor and coordinator of integrated pest management and sustainable agriculture programs in the College of Agriculture, Forestry, and Life Sciences. Shawn Jadrnicek is the manager of the Student Organic Farm. David Thornton is a research associate in Clemson's biodiesel program in University Facilities.

–Neil Caudle

Lightning in a bottle

Is the firefly, which gives a summer night its sparkle, fading into darkness? Will tomorrow's children have no dancing, flashing light to chase around the yard, no glowing jars with perforated lids?

Reports about dwindling numbers of fireflies have been circulating for years, and the Clemson University Vanishing Firefly Project is trying to find out what's up. Now in its fifth year, the project has asked the public for help. It invites citizen scientists to count the number of fireflies they see in their fields of vision in sixty seconds and record the data through the project's smartphone app or website.

According to Michelle Cook, project coleader, data will be collected over several years from different habitats across South Carolina, the United States, and other countries to determine the impact of human activity on firefly populations. Topics for study include land-use patterns, soil and leaf litter quality, light pollution, and weather.

To download the counting apps or access more information, visit the Vanishing Firefly Project at www.clemson.edu/public/rec/baruch/firefly_project/.

–Melanie Kieve

Michelle Cook is an associate professor of science education in Clemson's Eugene T. Moore School of Education, College of Health, Education, and Human Development. The Vanishing Firefly Project is a collaboration that includes the Belle W. Baruch Institute of Coastal Ecology and Forest Science, part of Clemson's Public Service Activities.

Ashley Jones

Ken Scar

Deep Orange 5 was unveiled April 22 at the GM Renaissance Center in Detroit.

a car for taming the city

Once upon a time, a car was a ticket to independence. Hit the road, crank up the radio, escape from the crowd. But for many of today's young drivers, it's the socializing, not the solitude, that gets them revved.

That's the idea behind Deep Orange 5, the fifth generation in Clemson's concept vehicle program. The vehicle, designed for generations Y and Z (young adults) who will live in megacities in 2020, is strong on mobility, social networking, and digital media, and brings a world of information, entertainment, and connections to the car.

"Deep Orange Five is about creating a better value proposition for young adults who have little money to spare, less interest in vehicle ownership than previous generations, yet need a personal mobility solution that aligns with their complex lifestyle," says Paul Venhovens, who leads the Deep Orange program at the Clemson University International Center for Automotive Research (CU-ICAR). "The vehicle was designed by the Art Center College of Design, and engineered by automotive engineering graduate students with the characteristics of an urban lifestyle put first and foremost."

Ken Scar

Deep Orange 5 offers reconfigurable seating and digital arrays to make driving, working, and relaxing easy and fun in big cities.

Fit for tight spaces

The team unveiled Deep Orange 5, sponsored by General Motors, April 22 at the GM Renaissance Center in Detroit, Michigan. The concept car's features include:

- reconfigurable seating to enable people to use the vehicle for driving, working, relaxing, and storage;
- a digital cockpit that can display an array of content for both the driver and passengers;
- a color display integrated into both front doors facing outward, allowing the driver and occupants to display digital messages to the outside world;
- double-hinged doors for comfortable egress and ingress in tight urban parking spaces and improved access for users with disabilities; and
- a two-piece rear hatch for access in tight parking spaces.

Janet Goings, associate director of research and development at General Motors, says, "Our experience working with these students was exceptional. They came up with creative and innovative ideas for their defined target consumers. We were very impressed with their holistic approach and final result of this accelerated product development process."

Paul Venhovens is the BMW Endowed Chair in Automotive Systems Integration in the Department of Automotive Engineering at CU-ICAR and the College of Engineering and Science. For more: www.cuicardeeporange.com.

–Brian Mullen

zoom in

a wake-up call *for drowsy drivers*

Ashley Jones

Drew Morris explains how the simulator measures variation in the path of the car.

Drowsy drivers take a heavy toll on the nation's highways, causing an estimated 56,000 crashes annually with more than 40,000 of them resulting in injuries or death. So finding a reliable way to test for fatigue could help save lives.

Previous studies of drowsy or distracted drivers have tended to focus on psychophysiological metrics, including driver eye movements, muscle activity, and changes in heart rate to determine alertness. But some of these kinds of measurements have been shown to be inaccurate and can interfere with driving. Researchers at Clemson found that a reliable, less intrusive way to detect fatigue or drowsiness in a driver is to monitor vehicle behavior rather than the biometrics of the person behind the wheel.

The study tested twenty volunteers whose attentiveness was measured in a vehicle simulator during a twenty-six-hour stretch without sleep. The volunteers drove for about twenty minutes on a fifteen-mile course that included nine curves. Driving performance was assessed for lateral lane position, lane heading, and vehicle heading using a global positioning system (GPS).

"GPS capability is standard technology in many cars, so it's very easy to monitor every movement of a vehicle," says June Pilcher. Pilcher is a psychologist and part of a research team that also includes Drew Morris, a Ph.D. student, and Fred Switzer, a professor of psychology. Their findings were published in the July 2015 issue of the journal *Accident Analysis & Prevention.*

Doze detection

"By employing more accurate GPS technology to pinpoint the vehicle's orientation on the road, the driver could be notified if the driving is getting dangerous," Morris says. "The vehicle may even present information like a video game, with a stream of driving statistics."

The idea of using GPS to detect a vehicle's deviations could help improve safety by warning not only drowsy drivers but those distracted by texting, socializing, or picking things up from the floor, Pilcher says. "Early detection of a vehicle's movement deviation is a step in the direction of preventing a tragedy. Though we can't say this type of detection will prevent an accident from occurring, it can provide a warning to a driver who may not believe danger is imminent."

Drew Morris is a Ph.D. student in human factors psychology, June Pilcher is an alumni distinguished professor of psychology, and Fred Switzer is a professor of psychology, all in the College of Business and Behavioral Science.

–Rick Uhlmann

bring the audience to the artists

Community-supported art gives students a taste of the marketplace.

Damp clay and the baked-earth scent of a fired-up kiln. Bowls, mugs, vases, and a few globular sculptures stacked, variations on a theme. The grind of the pottery wheel. The lap of water. Glaze glistens in the pale light.

Valerie Zimany, faculty leader of the Creative Inquiry team that uses this space full of artworks in progress, describes her department as small but great. It has strong grassroots support, but the campus itself is far from a larger, more metropolitan arts scene, such as the ones in Atlanta, Asheville, or Charleston. But Zimany, not about to let that stop her from helping her students, decided to bring the experts, and the audience, to the artists.

That's how Clemson's Community Supported Art (abbreviated to CSArt, much like the community supported agriculture model it's based on) was born, from the fertile earths of the ceramics department.

Together, Zimany and the students select a juror—a key feature of the CSArt process. The juror brings expertise, an audience, and access to the wider arts community. So far the jurors (Harriett Green, the visual arts director of the South Carolina State Arts Commission; Alan Ethridge, executive director of the Metropolitan Arts Council of Greenville; and, for the coming season, Stephanie Moore, the executive director of the Center for Craft Creativity and Design in Asheville) have fit the bill and then some.

Samples and selections

Drafting an invitation letter, the students set up a speaking event for the juror. A theme is selected and a call goes out to art majors and minors. Students respond, sending proposals and samples. Then the juror selects the artists, not only for the quality of the work but also for how the work functions together as a curated group. The juror's selection is then offered in limited edition, and interested community members and collectors purchase a "share" in the seasonal artist "crop," in order to receive a crate of fresh, local artwork in return at the semester-ending pickup event.

Then, over the course of the semester, blogging and video lets shareholders in on the artists' processes.

"People desire to know where things are coming from, how it is happening, and why," says Lindsey Elsey, a grad student and juried artist who produces functional porcelain.

Learning the business

The Creative Inquiry students learn a variety of professional skills such as web design, blogging, video editing, logo design, and social media marketing. Allison Rupprecht, a Creative Inquiry team member and juried artist who works with slip-cast porcelain, says, "It's really given me a lot of professional experience with emailing people, talking to shareholders, different processes that I'm going to have to use when I'm in the workforce."

And that, according to Zimany, is part of the point.

"Studio courses focus on technical skills and artistic voice, but there was a gap of knowledge regarding professional skills such as marketing and building audiences," Zimany says.

As the pick-up event nears, juried artists labor. Each of the twenty-five pieces (one made for each available share) must be "of a similar spirit and quality to one another," Elsey says. This, Zimany explains, "pushes their studio practice, allowing students to dig in and refine a skill," and, she adds, working under a deadline to meet shareholder expectations can be "stressful, in a positive way."

"I want people to know how hard the team members work," Rupprecht says, "and how truly passionate we are about this project. It means so much to us, so we really appreciate the community support."

Chris Phillips

Team member Hannah Hunt works at the potter's wheel.

zoom in

Courtesy of Brittany Wilund

Bowls created by Brittany Wilund, a member of CSArt.

An exhibition of CSArt artwork over the last three semesters is on view outside the Gunnin Architectural Library, October 19 to December 18, 2015. A pop-up exhibition of the Fall 2015 season will be featured in the Acorn Gallery of Lee Hall from November 12 to 20, 2015. The shareholder pickup event is scheduled for the evening of November 12.

For more about the CSArt program, go to www.clemson-csa.org/. The Annual Bowl Sale is scheduled for November 18, 2015, and the Ceramic Studio Sale for the spring. All proceeds support student professional opportunities.

Valerie Zimany is an assistant professor of art in the College of Art, Architecture, and Humanities. Allison Rupprecht is a psychology major, art minor. Lindsey Elsey is a graduate student in the visual arts. Jemma Everyhope-Roser is the assistant editor for Glimpse.

–Jemma Everyhope-Roser

restoring Hunnicutt

As a campus stream gets new life, student researchers check its vitals.

The project to restore Hunnicutt Creek will take this stream back to a better time.

Previously carved into a straight ditch for agricultural drainage, Hunnicutt Creek's rivulets run through Clemson's south campus and pour through the botanical gardens, meeting near the Walker Golf Course and draining into Lake Hartwell. To mitigate the construction of a nearby chain grocery store, a project was undertaken on the Clemson University main campus to restore three hundred feet of stream and three acres of wetland. Three campus faculty members received funding to monitor and assess physical, chemical, and biological changes in response to these restoration efforts.

That may not seem like much—until you know the workload that goes into restoring an actively flowing stream system.

Don Hagan, Jeremy Pike, and Cal Sawyer head the effort—and the student-driven Creative Inquiry projects associated with it. The project has been going on for three semesters, and this past semester, fifteen students in a Creative Inquiry project got the chance to dirty their boots in the name of science. Balancing the students' strengths, needs, and interests, the three faculty members divided the undergrads into two teams that would test restoration methods: vegetation and stream.

The vegetation team, focusing on removing the invasive species, particularly Chinese privet and silverthorn, established thirty plots, namely reference plots featuring the ideal landscape, control plots overrun by invasives, and the plots for each method being tested. The students set aside control plots overrun with invasives and then, leading teams of community volunteers, experimented with removing the plants via chemical control, mechanical means (pulling weeds), a mechanical-chemical combo, and goats.

Yes, goats.

"We got the goats from Wells Farms, in North Carolina. We had forty goats. It was fun," Pike says.

To measure the methods' effectiveness, the students have been taking stock through stem counts of plant species, and by using the Carolina Vegetative Survey method to determine vegetative coverage.

How did it all turn out?

Gary Pence, a senior who has the opportunity—unprecedented, for a undergraduate—to present his original restoration research at a conference in Chapel Hill, tells me: "We're still collecting data to understand how well these methods worked over extended periods of time."

As of right now, the mechanical-chemical combo wins out. The method, which involves removing invasive plants by hand and selectively painting the cut stalks with a root-killing herbicide, is labor intensive but effective. Although the goats ate their way through some particularly dense thickets, Pence says, "They were not selective at all. They eat a lot of the plants we don't want them to eat. They like our little maple saplings. Those taste really good to them, so they would eat them all up first." The goats also enjoyed munching the Chinese privet, but the silverthorn? Not so much.

Hagan, describing some of these plots as "impenetrable," says, "What the goats did was open it up. They nibble off the branches and the leaves. And they made it much easier for our students and groups of volunteers to come in afterwards with follow-up strategies for eliminating those plants."

Going native

The next step will involve planting native species. Thriving native plants—which would minimize invasive species recolonizing this area—are key to the restoration effort.

Alicia McAlhaney, along with Kelly Daniels, sloshed through the wetland's boundary with a GPS, uploading the data points to make a map. Then, she and her partner were meant to randomly select areas to test for soil types so that students could plant native species where they would flourish. Quickly McAlhaney discovered that, because the area had once been agricultural, the soil was uniform—but moisture levels were not. This made additional soil sampling unnecessary, and McAlhaney and Daniels adjusted their project. McAlhaney realized that drones would be the easiest way to map dam seepage throughout the year. Pike has put in the request to Clemson and is waiting for approval.

"I like hands-on research, which is why I got involved with Creative Inquiry," McAlhaney says. She discovered, through the project, that she wants to work outdoors where "every day is a different experience." McAlhaney, who scored a summer internship with a forestry management company near her hometown, intends to continue her restoration research in graduate school.

As for the stream team, they measured how the vegetative team's efforts affected water quality. Mostly, the students needed to determine if chemicals from the treatment sites leached into the water, if the goat fecal matter contaminated the water, and if the plantings were bringing back native animals. The undergrads did this by monitoring bacteria counts, pH, conductivity, turbidity, and dissolved oxygen, and by counting and categorizing the visible macro invertebrates, or as we commonly know them, bugs.

This testing, with the exception of the bacteria counts, all happened on site. The students took water samples from three sites (upstream, at the restoration area, and downstream from it), tested them, and packed out the dirtied experiment water in a bucket. For the bacteria counts, they brought water back to the lab, mixed it up into cultures, incubated it, and then looked for bacteria such as *E. coli*.

Brett Kelly, a self-proclaimed "fish guy," has been involved with the Hunnicutt Creek project from the very beginning. A freshmen then, he's now going onto his junior year. As part of the stream team, Kelly monitors insects and now amphibian communities.

Hunnicutt Creek Project

Above: During the summer of 2013, the project formed a new channel and laid erosion-control matting on the banks.

Below: Student researchers Nicole Harper (with the hat) and Carolyn Lanza sample water quality in the restored habitat.

Jeremy Pike

So far, so good

To sample the invertebrates, the students would disturb areas upstream and let the current sweep the insects into the D-nets, which Kelly describes as a "three-foot broom handle with a net on it in the shape of an uppercase D." Kelly then dumped the bugs into a tray, picked them out into egg cartons, and identified them. The purpose? To count the varieties of stream-dwelling insects sensitive to water quality. The more sensitive insects, the better the water quality. And so far, it's looking good.

Recently, Kelly has begun documenting the amphibian population. Beside the stream, the students have created artificial frog and salamander habitats using PVC pipe and a cover board. Kelly stops by the sites and notes if they're occupied. So far, every time he's visited, he's found tree frogs happily lodged in the PVC tubes. But, he says, "We haven't found any salamanders under the cover board. It doesn't mean they aren't there. It just means they're not using the cover boards."

These undergrads, who cannot say enough about the benefits of Creative Inquiry, tell me that they'd like fellow students to become more aware of the Hunnicutt watershed. Kelly calls on the campus community to understand how littering affects Clemson's wildlife and aquatic communities.

"Until my sophomore year, I didn't even know this area existed," McAlhaney says. "So, for it to become an open area, with park benches and tables, and for the students to be able to see the beauty of campus, that would be a top goal to me."

—Jemma Everyhope-Roser

Calvin Sawyer is an associate professor and Donald Hagan is an assistant professor, both in the College of Agriculture, Forestry, and Life Sciences. Jeremy Pike is an associate scientist in Department of Forestry and Environmental Conservation. Gary Pence and Alicia McAlhaney are seniors, and Brett Kelly is a junior. Additional undergraduates involved in the research include Bryanne Sidwell, Donald Mcdaniel, Carolyn Lanza, Rebeckah Hollowell, Johnson Dorn, Carly Basinger, Kelly Daniels, and Stephannie Allen. Sources of funding include the Clemson University Experiment Station, Clemson University Facilities, the South Carolina Exotic Pest Plant Council, and Clemson University Creative Inquiry initiative.

Sweet hope
for Sapelo Island

by Jim Melvin

Long ago on a magical island, a three-year-old girl died.

She'd had wide, sparkling eyes and rich, brown skin. But on that day her eyes were clamped shut and her skin was cool. Invisible spirits swarmed around her, twirling in the air like wisps of a dancing breeze. But her family's eyes filled with tears, blinding them to all things, visible or not.

The tragedy had begun innocently enough when her older brother had given her some unripe pears that had tasted fine to the girl but had somehow brought on a mystifying illness that worsened by the moment. Eventually, she quit breathing.

There were no doctors on the island to treat her. Only roots, leaves, and berries. And the spirits, if they were willing.

Members of the community came together to mourn the loss of such a young treasure. They built a small wooden casket and began to prepare for the burial. But one of the girl's relatives, still not ready to give up the fight, stuffed garlic into the child's tiny nostrils. Amazingly, her body responded.

Cornelia Walker Bailey returned to the living. And sixty-seven years later, her blood still flows with vigor. But when she dies for the second and final time, whenever that day comes, it will again be on the island where she was born.

The island is called Sapelo.

And it is truly a magical place.

But Sapelo's cultural heritage, which has survived throughout the centuries, is now fading away. One day it might vanish forever.

Long ago, a little girl's life was saved. Now there's hope for saving her people.

Facing page: Cornelia Walker Bailey, matriarch of Sapelo Island. Photo by William Thomas.

Jim Melvin

In Hog Hammock, Spanish moss casts its spell on an abandoned cottage.

Nestled off the coast of Georgia among a string of barrier islands, Sapelo has remained anonymous, which is both its blessing and its curse.

With isolation comes preservation.

But it can also lead to scarcity.

Though 97 percent of Sapelo is now owned by the state of Georgia, a private community named Hog Hammock still has its place on the island. The inhabitants of this 434-acre tract are a special people. Many are blood-related—through direct lineage—to West Africans savagely torn from their homeland more than three centuries ago and forced into slavery in America. On Sapelo's plantations, they toiled for their white masters beneath a broiling sun, planting and tending a variety of lucrative crops that included a strain of imported sugarcane called Purple Ribbon. Sugarcane, a tropical grass, doesn't thrive in cold weather. But Purple Ribbon resisted Sapelo's relatively cold winters, and so it grew with vigor.

Eventually, the slaves of Sapelo were freed, and afterward many chose to remain on the island. But as the older residents have passed away and the younger ones have fled to the mainland in search of jobs, the descendants of those long-ago slaves have dwindled. Around fifty now live on the island on a permanent basis, but their heritage still clings to existence. They are Geechee people—saltwater Geechees, to be exact—and though they believe that Jesus is their Lord, a few also believe, as their ancestors did, that the spirits of the dead walk among them, some polite and helpful, others dangerously mischievous.

The Geechee of Sapelo, who have retained ethnic traditions that existed in West Africa as far back as the mid-1700s, represent a rare link to America's tumultuous past. Despite its tropical surroundings, Hog Hammock has been frozen in place like a planet at the farthest reaches of its solar system. Stepping off the ferry that transports residents and visitors to Sapelo is like stepping out of a time machine.

And now, on this island, the site of the first commercial production of sugarcane in the United States, the towering grass is poised to make a grand return. And with it comes hope for jobs, income, and Hog Hammock's survival.

Even the spirits would be happy about that.

In the Greenhouse Complex on the campus of Clemson University, renowned geneticist Stephen Kresovich and his assistants inspect plants representing fourteen labeled varieties of sugarcane—each about six to nine inches tall—that Clemson agricultural experts have painstakingly tended for several months. Some of the varieties might be redundant, so there are eighty-eight total plants. The original Purple Ribbon might be among them, though it remains uncertain if it, or any of the other varieties, are exact matches for the cane that first grew on Sapelo in the early 1800s. But Kresovich is confident—via scientific evidence, forensic methods, and instinctive know-how—that the canes are close enough to the original type.

Even better: All the plants are strong, healthy, and free of disease and insect infestation.

"We employ best management practices so that the plants are well taken care of," Kresovich says. "So these are good, sturdy plants that are not chlorotic or stressed by drought. They are ready for the next step of their journey. They are ready to go in the ground."

The morning after the final inspection, the cane is trucked from Clemson to an organic farm in Townsend, Georgia, which will play a crucial yet temporary role in the plants' cycle of life. Georgia Coastal Gourmet Farms is on the mainland, but it is not far from where a ferry makes multiple launches each day to Sapelo Island. The close proximity is no coincidence but rather a critical step in a carefully crafted plan. A crew of experts at the farm will tend the cane from the middle of spring until late summer. After growing from half a foot tall to eight to ten feet or more, it will then be chopped down and barged to Sapelo, its eventual permanent home. Thus, the cane replanted on Sapelo will be of the highest possible quality.

The venerable yet vigorous Kresovich, who had planned to make the six-hour drive to Townsend along with assistants Matt Myers, Kelsey Zielinski, and Alex Cox, is called away at the last minute on other business. But he knows the cane is in good hands. Awaiting the young Clemson trio is Jerome Dixon, co-owner of the Townsend farm, and several of Dixon's employees.

The operation goes smoothly. Dixon, who traces his ancestry to Sapelo, remains intensely loyal to his island's people and has made the work simple for everyone. Before the arrival of the cane, he and his crew have already tilled the sandy soil, laid in drip irrigation, and dug the holes for the cane. Because of this preparation, it takes only a single afternoon to put all the plants securely in the ground.

"My grandfather started this farm," says Dixon, a rugged man sturdy as a tree. "And he always was generous with his community. The people of Sapelo needed a little help to get this going, so we've provided the land and the labor. I'm happy and proud to do this. If Sapelo wins, the community as a whole will win."

It is now late afternoon of April 14, 2015, and the cane is already tentatively testing the rich soil with its roots. But this story doesn't start here. Instead, it began to get interesting about twelve months before. You'll see why in just a bit.

The cast of characters is large, and there are many you have yet to meet:

- David Shields of the University of South Carolina (USC), whose expertise on Southern cuisine is only one of his many calling cards;
- Buddy Sullivan, a former journalist and current historian, who is an expert on Sapelo's storied past;
- Dr. William Thomas, hence known as "Doc Bill," a pathologist who practices in Gainesville, Georgia, but who over the past fifteen years has become one of Sapelo's most dynamic movers and shakers and is a board member of the Sapelo Island Cultural and Revitalization Society (SICARS);
- Fred Hay of the Georgia Department of Natural Resources (DNR), who manages the 97 percent of the island that is owned and operated by the state; and
- last but not least, Cornelia Walker Bailey, Sapelo's magical Geechee matriarch, who was born and raised on the island and who probably cares more about Hog Hammock than anyone else on Earth, though there are spirits who might argue otherwise

You have already met Bailey. And you will eventually meet all the rest. But first, let's visit with Shields and Sullivan.

In the spring of 2014, SICARS invited Shields and several cohorts—including Brian Ward, a research specialist at Clemson's Coastal Research and Education Center in Charleston—to gather on Sapelo Island. The topic of discussion: How can Sapelo's people generate enough income to pay their bills, which include a sudden rise in property taxes virtually unaffordable for many who live there.

With developers circling like vultures ready to pounce on whatever private land might be put up for sale by desperate Hog Hammock residents, Doc Bill and Bailey are eager to enlist the help of experts willing to play a role in stemming this rising tide. Both are banking that the island's rich agricultural heritage will help to provide the financial wherewithal for Hog Hammock to thrive on its own.

Even before the sugarcane project is envisioned, Doc Bill and Bailey have attempted other means of creating jobs and increasing income, including growing a special kind of

Jim Melvin

The Sapelo Island lighthouse, first activated in 1820, was most recently renovated in 1998.

pea that is not only flavorful but also deep red in color. The Sapelo Red Pea is as historically linked with the island as sugarcane. But though the pea project is by no means a failure, its sales do not generate enough income to make a significant difference in Sapelo's fortunes. Clearly, more will have to be done if the island's rich traditions—culinary delights, fishing, hunting, doll and basket making, to name a few—are to be carried on by future generations.

After the meeting, Shields started the research that eventually led to the sugarcane project.

"I began thinking about what could be done to supply Sapelo with what it needed, something that was true to the island in terms of its own history, something that could generate more than one kind of revenue stream," says Shields, the author of *Southern Provisions: The Creation and Revival of a Cuisine.* "And within the first hour of systematically looking at the history of Sapelo's agriculture, I realized that there were three possible crop products that had greater potential for money than the peas: sugarcane, dates, and arrow root. When I started looking at each one, I realized that sugar held the most promise."

To better understand why Shields came to this conclusion, you'll need to take a trip back to Sapelo's past. Buddy Sullivan goes into intimate detail in his book *Sapelo: A History.*

According to Sullivan, the earliest inhabitants of Sapelo were American Indians who had lived on the island for more than 4,000 years. But during the seventeenth and eighteenth centuries, Spain and France laid various claims to Sapelo and its surrounding islands. This, however, was eventually overshadowed by one of the most significant events in Sapelo's more recent history. In 1802, Thomas Spalding, who was of Scottish descent but was born in Georgia, completed the purchase of several thousand acres on the south end of Sapelo. He would eventually come to own all but a small portion of the island.

Spalding became one of the most influential agriculturists of his day, and during his tenure on Sapelo, much of the then-forested island was cleared for cultivation or pasture. At times, Spalding held more than three hundred slaves on the island, providing him with the labor force necessary to turn a tree-laden paradise into an agricultural powerhouse. Spalding's main cash crops became cotton and sugarcane.

After Spalding's death in 1851, his descendants took ownership, but they quickly abandoned the island during the Civil War. When the war ended and slavery was finally abolished, several groups of newly freed black people set up communities on Sapelo.

Over the next several decades, various attempts to reestablish agricultural operations failed. By the early 1900s, the once-cultivated fields had regrown into forests. With the return of the trees came new wildlife, prompting a syndicate of Georgia investors to take control of some of the island and use it as a hunting preserve.

In 1911, Howard Coffin, the developer of the Hudson motor car, purchased a large portion of the island and began restoration projects that included the reintroduction of agriculture and the renovation of many crumbling buildings. But

Jim Melvin

Stephen Kresovich and Kelsey Zielinski, a lab technician, inspect the sugarcane in the Clemson Greenhouse Complex.

new science to revive an old crop

Stephen Kresovich and his team have used molecular forensic testing to validate the genetic characteristics of Purple Ribbon, the cane that first grew on Sapelo in the early 1800s. So far, evidence shows that some of the canes the team has selected are close, if not identical, to the original.

Below: Agricultural associates from Clemson University join Jerome Dixon and his crew to transplant sugarcane on April 14 at Georgia Coastal Gourmet Farms in Townsend, Georgia.

Jim Melvin

William Thomas

Jerome Dixon, co-owner of the Townsend farm, checks the cane.

Jim Melvin

The team planted fourteen varieties of heirloom sugarcane, including Purple Ribbon, in carefully tended rows.

Jim Melvin

Sapelo risks being loved to death.

after the stock market crash in 1929, financial pressures forced Coffin to sell Sapelo.

Enter tobacco tycoon Richard J. Reynolds, who bought the majority of Sapelo in 1934 and vowed to continue Coffin's work. Reynolds also began buying land owned by the black communities, and eventually only Hog Hammock remained as a separate entity.

Meanwhile, in 1953 the University of Georgia established a marine institute on the island to study salt marsh ecosystems. When Reynolds died, his widow sold the northern half of Sapelo to the state of Georgia. And in 1976, the state completed the purchase of the southern end.

In the present day, Hog Hammock's 434 acres are the only privately owned land on Sapelo. The government owns the other 16,000-plus acres.

What interests Shields most is Spalding's sugarcane.

"I took a look at the sugar that he was producing and saw that the two early varieties were a Tahitian sugarcane, which apparently has been extinct since the 1940s, and the Purple Ribbon cane, which became sort of the standard nineteenth-century crop cane and the ancestor of all of the famous canes that are now used throughout the South," Shields says.

The Southern culinary expert began an exhaustive search to find the original Purple Ribbon cane. But try as he might, he could not locate it anywhere. He finally came to the conclusion that his only option was for a scientist to genetically identify, validate, and re-establish Purple Ribbon from an existing collection.

"I instantly thought of Steve Kresovich," says Shields, who became friends with the geneticist during a time when they were colleagues at USC. "So I called Steve and described the project. It had a genetic component to it, it had a great story to it, and it dealt with creating a product. So he almost immediately said yes."

During the summer of 2014, Shields, Kresovich, and Charley Richard, a noted cane expert from Louisiana, joined Clemson's Bradley Rauh and Hannah Mosby to doggedly sift through all the varieties of heritage sugarcane they could find in public and private collections.

"We didn't rest until we had collected all sorts of cane," Shields says. "I wrote to gene banks, herbaria, and museums everywhere. I talked to people in the cane syrup network. And between us, we made the connections necessary to form the selection of cane that was planted in Townsend, Georgia. We even bought one strain of Purple Ribbon from a grower on eBay."

Following the acquisitions, molecular forensic testing has remained under way to validate the genetic characteristics of the Purple Ribbon variety.

"At this point, we're still not certain that we have the exact match because we haven't identified a validated reference from a museum," Kresovich says. "But we're always on the lookout for new candidates, and if we find the original, it can be added to Sapelo's current collection of canes."

It is now April 23, nine days after the sugarcane was planted at the Townsend organic farm.

Doc Bill has chosen this day to visit friends and take care of some business on Hog Hammock. He steps aboard the 8:30 a.m. mainland departure of the Sapelo Island Ferry, which takes about thirty minutes to reach the island's small port. Breathtaking views and warm ocean breezes form an intoxicating brew that makes the trip feel like it lasts more like a minute than half an hour. Doc Bill has brought along a ladder and other supplies—and once off the ferry, he faces a mile-long trek to the truck he keeps permanently on Sapelo. But after just a few strides, a friend drives over and offers Doc Bill a ride, which he gratefully accepts.

Doc Bill, a pathologist by profession and a philanthropist by nature, was not born on Sapelo but has strong familial ties to Georgia's barrier islands. "Every time I come to the island, I feel like I'm stepping back hundreds of years," he says. "The solitude, the pristine nature. A lot of people here still do things the way they used to do them. So the heritage is here, and it's rare and beautiful."

Doc Bill loads up his truck and heads toward Hog Hammock along a bumpy dirt road, eventually reaching one of the island's only paved thoroughfares. Sapelo's residents have named this road the Autobahn after the famous series of highways in Germany, some of which have no speed limit. Sapelo's version of the Autobahn does have a speed limit: twenty-five. And while Germany's Autobahn swarms with traffic, Sapelo's rests quietly as a secluded country trail. Towering trees laced with Spanish moss form natural bulwarks on each side of the road that are so thick only spears of sparkling light can pierce them. Rather than pressing on the gas to go ninety miles per hour, the urge is to step on the brake, pull off to the side, and enjoy the view. Irony can most certainly be delicious.

Though he is not as young as he used to be, Doc Bill remains a cacophonous bundle of energy, a do-something-all-the-time kind of person. He first visited Sapelo fifteen years ago while on his honeymoon, and he and his wife Annita instantly fell in love with the island—much to Sapelo's eventual benefit.

"We became interested in the island and its people," says Doc Bill, who owns several properties in Hog Hammock, including rental cottages called Birdhouses that provide maintenance jobs for Sapelo residents. "And we eventually started working with them to try to help them preserve their heritage. The first project we worked on was a cookbook called *The Foods of Georgia's Barrier Islands* that I coauthored with Cornelia Walker Bailey and Yvonne Grover. This fostered cultural relationships, which helped me gain their trust."

Doc Bill's involvement in Sapelo deepened. Along with Bailey and the rest of SICARS, he searched for ways to create more jobs. This led to the meeting with Shields mentioned earlier.

"With sugarcane, you've got a product that gives you the potential to enhance anything you do," says Doc Bill, whose many talents include being an excellent cook. "You have Sapelo sour oranges brought here by the Spanish in the 1600s. Add sugar to that, and you can make marmalade. You can make orange tea. The sugar allows you to use other crops and make them more valuable. My rationale is, if we don't do it now, it's not going to get done. What's the worst thing that can happen? We'll fail. But we might not fail. And if I have anything to say about it, we won't fail."

Jim Melvin

William Thomas, "Doc Bill," pauses near the ruins of the original Thomas Spalding sugarcane mill on Sapelo Island.

Doc Bill continues his tour of Hog Hammock, a sprawling yet modest community with a pair of Baptist churches, a country store, a small museum, a library, and a private campground among its amenities.

Surrounding Hog Hammock is a land of splendorous delights. There are two beautiful beaches—Nannygoat on the south end of the island and Cabretta on the north. Nannygoat, which is bordered by maritime forest, is the most easily accessible, yet it remains undeveloped. Cabretta, which overlooks Blackbeard Island, is one of the most pristine and extraordinary beaches in the world. There are thousands of acres of pristine forest filled with alligators, feral cattle, and

"Here's where you started. Here are your roots."

–Cornelia Walker Bailey

a staggering variety of song and seabirds. There is the University of Georgia Marine Institute, on the southern end, which is dedicated to the preservation of wetlands and wildlife on Sapelo. There is the Sapelo Island National Estuarine Research Reserve, on the west end, which helps manage Georgia's coastal resources. There is the expansive Reynolds Mansion, once home to the tobacco magnate, which can accommodate up to twenty-nine guests in its thirteen bedrooms and which often hosts weddings, conferences, and corporate retreats. And near the mansion, there is a lighthouse built in 1820 and restored in 1998. Walking up its narrow spiral staircase is not for the faint of heart.

But despite all the surrounding exquisiteness, Hog Hammock remains Sapelo's most alluring asset, for it has an inner beauty as invaluable as it is subtle. Doc Bill knows this well.

As part of his tour, he drives to the DNR headquarters of Fred Hay, the longtime manager of the island. The pair have some business to discuss; and Hog Hammock, of course, is at the forefront. While Doc Bill wants to see Hog Hammock thrive, Hay's job is to make sure it doesn't thrive at the expense of the rest of the island.

"What makes Sapelo unique is the presence of the Hog Hammock community and its legacy on the island," Hay says. "The real question is: What does the future hold? The most vulnerable component of Sapelo is Hog Hammock. Its rich cultural legacy is in danger, not just from within, but from without. The island has the potential to be loved to death."

After finishing his talk with Hay, Doc Bill hops back in his truck and pays a visit to an old friend.

Cornelia Walker Bailey, born on Sapelo seventy years ago, is in her red pea garden hoeing weeds. The day has become uncomfortably warm and humid, but Sapelo's renowned matriarch merrily continues her work as if impervious to heat.

Bailey has spent most of her life on Sapelo, but she has lived other places and traveled to other countries, including Sierra Leone, the West African nation that is believed to be the homeland of most of the people who were first herded to Sapelo and forced into slavery hundreds of years ago. There, she experienced her heritage in person, and it enriched her worldview in ways she still treasures.

From tourist groups to wisdom seekers, Bailey is Sapelo's center of attention, a saltwater Geechee brimming with tales from the past. Doc Bill is a driving force, but Bailey is *the* force. Without her guidance, Hog Hammock has little chance of long-term survival.

"I can trace our ancestry here back to before the Civil War," says Bailey, who is the author of the lovely memoir *God, Dr. Buzzard, and the Bolito Man,* cowritten by Christena Bledsoe. "Legally, it's from the 1870 census record, but I can trace my ancestry back further than that by word of mouth. So my people have been here a long time. And I grew up here, and my parents grew up here, and my parents' parents grew up here. Everybody went to school here. They died here. They were buried here. Our souls are firmly planted in the dirt."

Bailey is enthusiastic about the sugarcane project and is helping to coordinate it. But she is not yet convinced that enough of her fellow islanders are ready to embrace the sweat and tears it will take to tend and harvest the cane in the years to come.

"My only concern about the whole project is labor," says Bailey, who along with Doc Bill is a board member of SICARS. "But I'm trying to bring people back to the island. If this project bears fruit, then we can offer the young people something. Here's where you started. Here are your roots. Now, you have the opportunity to come back, if you want to come back. Somebody will have to clear the fields, somebody will have to plant the cane, somebody will have to harvest it, somebody will have to pack it, somebody will have to account for the whole shebang. I'm too old to cut cane. That's something for the younger generation."

Bailey died when she was three. But she fought her way back to life. And she's been fighting—for her people—ever since.

"Hence I am, and hence I will be," Bailey says. "And my kids and grandkids and great-grandkids and hopefully even the unborn will have a place here on the island. That's my dream. I hope the sugarcane will help make my dream come true."

In early September 2015, up to four tons of top-quality sugarcane, grown to maturity from the original eighty-eight plants, will be cut down at the farm in Townsend and laboriously hauled by barge to Sapelo. There, it will be chopped into billets and replanted in a field that once grew a similar kind of cane more than two hundred years ago.

In its ancestral home, the cane will wait out the winter and then regrow for its first true harvest in 2016.

Bailey, Doc Bill, Kresovich, Dixon, and all the rest will continue to lend help and advice. But in the end, it will be the younger people of Sapelo—the ones still capable of performing the backbreaking labor of their ancestors—who will determine whether the cane becomes a savior or a failure.

This is a story about a proud people who have endured difficult times, both as slaves and afterward as free men, women, and children. But it most certainly hasn't been all bad. They have also experienced the magic of living on one of the most diverse and extraordinary islands on Earth.

Over the centuries, the saltwater Geechees of Sapelo have stood tall and held their heads high. Soon, if the spirits are willing, the cane will rise to join them.

Stephen Kresovich is the Coker Chair of Genetics and director of Clemson's Institute of Translational Genomics. Jim Melvin is a writer for Clemson's Public Service and Agriculture.

Rufino Urib, Wikimedia Commons

the market awaits Sapelo sugar

As any farmer will tell you, marketing and selling a crop can often be more difficult than growing and harvesting it.

The residents of Sapelo Island might produce the best sugarcane in the world, but if they can't sell it at a good price, their efforts will be in vain.

But the crop has already drawn significant interest, thanks mostly to Dr. William Thomas (Doc Bill), who has many friends in high culinary circles.

One of them is Linton Hopkins, a well-known Georgia chef who owns several restaurants, including Restaurant Eugene and Holeman and Finch Public House in Atlanta. Hopkins has become fascinated by the Sapelo project and plans to become one of its first customers.

"The beautiful thing about Doc Bill, David Shields, and their band of outliers is the idea of continuing to research ways to find nuance and distinction in the foods that define us as Southerners," Hopkins says. "Good food and good restaurants should give you a sense of time and place, and I like knowing the people who grow and craft the ingredients I use. When I add sugar to a dish, it's not just going to be granulated sugar off the shelf. It's going to be Sapelo sugar."

Another customer-in-waiting is Scott Blackwell, co-owner of High Wire Distilling Company in Charleston. Blackwell cautions that sugar is a big business, and to "compete with the big guys on price and distribution, it takes a lot of dollars—or a unique offering like fresh Sapelo cane."

Courtesy of Linton Hopkins

Chef Linton Hopkins

Blackwell is confident that the historical heritage of Sapelo's cane, along with its potential for an exotic and unique flavor, will enhance its salability across the region.

"The flavor of fresh cane juice is so much more tropical and will give the taster much more sense about the place and terroir," says Blackwell, who will use the sugarcane juice to make a Low Country take on rhum agricole. "Fresh juice has a green banana and grassy flavor that when fermented will have a crazy aroma that will make a really interesting final spirit. All the additional microorganisms and wild yeasts will add so much more to the complexity and depth."

Doc Bill hopes that Sapelo sugarcane will one day become a household brand. And he believes that its best chance for success lies in its versatility as an agricultural product.

"Once you get sugar, you can build a cuisine around it," he says. "For many dishes, you need a sweetener—and this one will be unique, both in flavor and tradition."

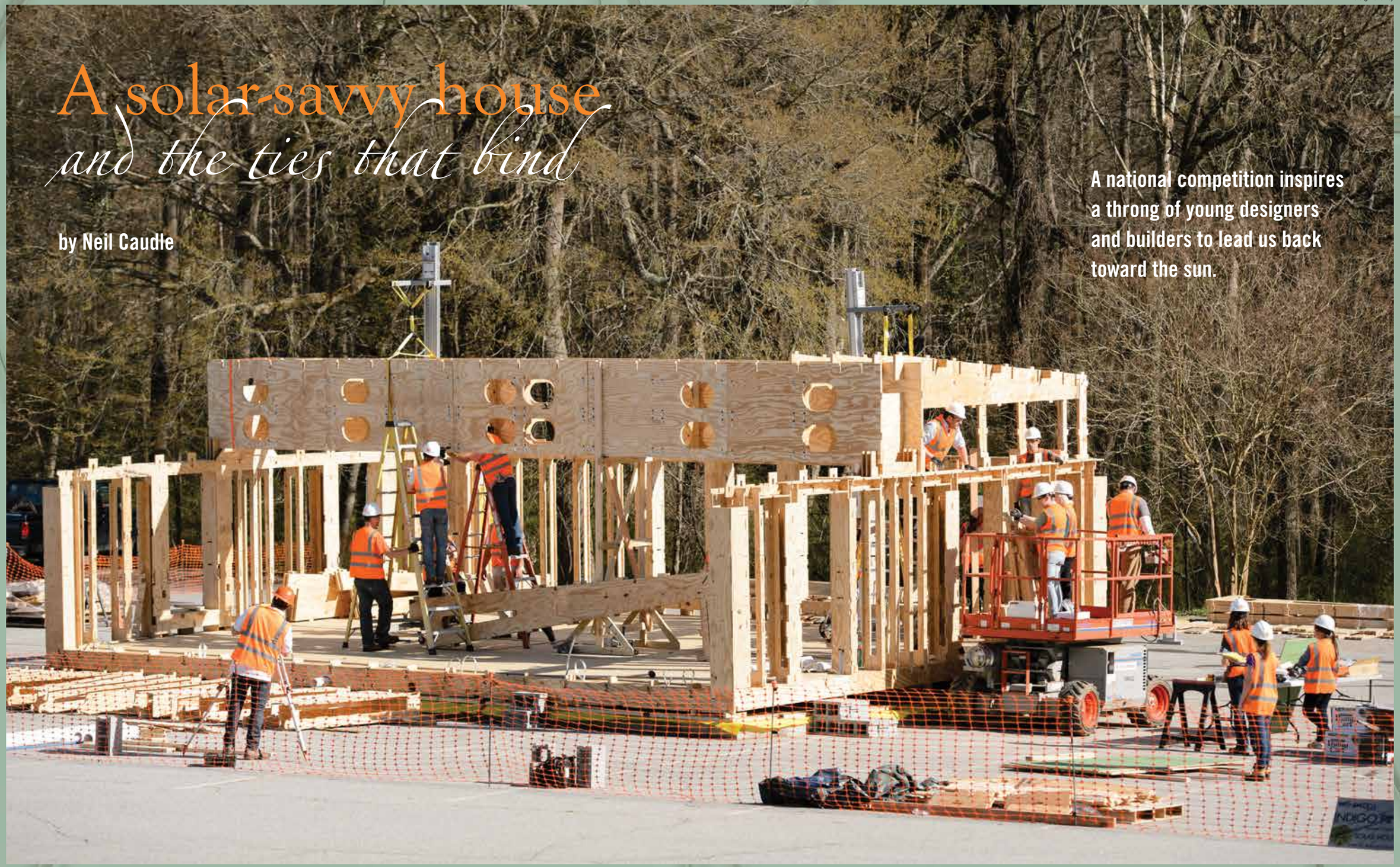
–Jim Melvin

A solar-savvy house *and the ties that bind*

by Neil Caudle

A national competition inspires a throng of young designers and builders to lead us back toward the sun.

Craig Mahaffey



> "Only primitives and barbarians lack knowledge of houses turned to face the winter sun."
>
> *–Aeschylus, 500 BC*

Almost four decades ago, I spent two years of weekends building a modest little passive-solar house on a five-acre woodlot in rural North Carolina. In winter, sunlight angled through a wall of south-facing windows, warming the pavers I'd laid for a floor. As we slept upstairs, the pavers surrendered their heat and kept us warm all night. The house was basic, simple shelter: comfortable, low-tech, and cheap. And it worked.

Two generations later, on a hot day in May, I strap on a hardhat and orange safety vest and climb a gently sloping ramp to investigate another kind of solar dwelling, this one from the future, not the past. The 1,000-square-foot house, a full-scale prototype under construction in the parking lot of the South Carolina Botanical Garden, is only slightly smaller than the 1,200-footer I built when I was about the same age as the graduate students I find balanced in the rafters this morning. And our goal was the same: basic, low-cost housing attuned to the sun.

But the houses could not have been more different. Mine was a shelter I pounded together with a twenty-two-ounce framing hammer. Today's version is a futuristic machine for living, no hammer required. And the thirty-four photovoltaic panels on its roof will crank out two hundred and eighty-five watts apiece, enough to power not only the house but the family car.

So I feel a pang of envy, as I wander this half-finished space, for the people who conceived it. I envy their access to solar-savvy mentors, the ones I badly needed but couldn't find. I envy their swift computers running algorithms, crunching data, and wielding all manner of graphical tools, with which the team has rendered, in three-dimensional models, the house and each of its thousands of structural parts. I envy their access to experts in engineering, forest resources, horticulture, landscape architecture, package design, social science, and more. But most of all, I envy their collective ingenuity.

I worked solo, designing my house. I found a sun chart for my latitude and some tables of data, enough to calculate the rate of heat gain through glass and the known thermal resistance of cedar siding, plywood sheathing, fiberglass insulation, and drywall. I memorized all of the relevant chapters of the residential building code (you could actually do that, back then). I found an architect to critique my drawings and an engineer to check my calculations. I gathered up every book, pamphlet, and article I could find about solar houses and how to construct them. But the sum of my reference material didn't even fill a pasteboard liquor box. To the Indigo Pine team, the full extent of my knowledge back then was so elementary it would amount to the architectural equivalent of *Fun with Dick and Jane.*

A new take on an old idea

Solar-tempered shelter served humankind for thousands of years, until the advent of central heating, after which we came down with a case of collective amnesia. Stop by an old Carolina farmhouse sometime and consider its orientation. Most likely, you'll find it shaded with porches on the south and west, and sheltered with windbreaks on the north. Generous porches extended the living space, welcomed the neighbors, and protected the walls from a blistering sun. Back then, working with Nature was essential, and any self-respecting builder knew it.

But by the time I was laboriously drawing umpteen versions of my house with a number-two pencil on grid paper (eight squares to the inch), most of that commonsense knowledge had vanished, at least from the libraries and bookstores I haunted. And much of what I did find to read turned out to be goofy or just plain wrong. Solar housing was a novelty, back then, the province of well-intentioned hippie builders who cobbled together odd, leaky shelters, hung ghost catchers in their drafty windows, and scoffed at the building code. I remember helping a potter friend roof his new house with sheets of rusted galvanized steel he'd salvaged from a barn. As we teetered on homemade wooden ladders, a thunderstorm boiled up and sent a flood of rusty rainwater plunging down the slope. We descended the ladders blood red from head to toe.

Neil Caudle

Named for two of South Carolina's most famous plants, Indigo Pine is a new house rooted in history, students say.

Alison Martin, health and safety officer for the Indigo Pine project, would not have approved. She has identified, analyzed, and quashed every conceivable workplace hazard. Tall, tippy ladders? No. Use the scissor lift instead. Long, frayed extension cords? No. Use the lithium-powered Bosch drills instead. The competition she and her classmates have entered requires them to comply with OSHA standards for job-site safety, Martin says, and that's cool with her. "We actually have a webcam up there, so OSHA can weigh in on anything we're doing on site," she says, as if issuing a dare.

Mostly, the hammers have been idle, for lack of nails to drive. And the skulls? Encased in hardhats.

That doesn't mean that the workers don't weather some risk. But they are learning to communicate as builders do, with pithy signals that keep the work safely on track. While I'm poking around on the site, Eric Balogh, a second-year graduate student in architecture and a construction manager on the project, is perched on a scaffold with a partner, wrestling a joist into place. To align it, the partner shoves his end of the joist too abruptly, tipping Balogh off balance. *"Dude,"* Balogh says, regaining his footing, "you gotta *warn* me before you do that."

That's the sound of teamwork, and the Indio Pine team will compete, just as Clemson's athletes do, with other schools. The occasion is a competition called the Solar Decathlon, sponsored by the U.S. Department of Energy (DoE), and it culminates this fall, when the students will spend nine days assembling the house in Irvine, California, followed by ten days of on-site monitoring and judging, October 8 through 18. (For more, see the inset, page 44.) In this competition, Clemson will not be the biggest school, the richest, or the highest ranked. But the Indigo Pine team has a tactical advantage, a not-so-secret weapon: They can email their house.

Patrick Wright

Will Hinkley

Right: A rendering of Indigo Pine's light-filled interior. Built-in cabinetry divides the rooms.

Above: Zip ties help hold the structure together.

I didn't have an Alison Martin on my job site. I was lucky to escape with my life, running a Skilsaw one-handed while I leaned way out from a rickety scaffold to trim the rafter tails. I remember risking the backs of my wife and several neighbors when they showed up to help me hoist the heavy beams that would support my second floor. It was pure, dumb luck that none of us wound up in the ER. One day, a hammer toppled off my stepladder and raised a big knot on my head. Another day, a sixteen-penny nail in a snow-buried plank pierced the sole of my boot and impaled my left foot.

On the Indigo Pine project, no one (knock on wood) has yet to suffer more than a splinter. Despite the fact that most members of the crew had never set foot on a construction site before March of this year, when they began assembling the full-scale prototype they call Indigo Pine East, no one has sawed off a digit or dropped a hammer on anybody's skull.

Yes, you read that right. The house can move by email. In fact, the original plan was to email Indigo Pine all the way to California, where a computer-guided router, known in the trade as a computerized numerical control (CNC) machine, would have configured its pieces from locally sourced plywood. But the team found a company in Charleston—Fine and Small Homes—with the CNC equipment and expertise to do the job. Having a South Carolina company on the project will improve the chances that Indigo Pine's email-ready construction techniques will spread across the state, team members say.

When I first heard this claim about email, I was skeptical. Everybody knows you can't email a house. But Balogh set me

straight. As he puts it, "Planning the house is ninety percent of the job. Assembling it is about ten percent." In a very real sense, the team has built its house in the studio, on computers.

Clemson can't teleport its workforce along with its house, so the team will pack their tools and hardhats into a trailer and tow it across the country in a caravan to Irvine, California, where the pieces of Indigo Pine West will be waiting, bundled and stacked like so many plywood Legos, ready for someone to plug them together.

A thrill, right down to the bones

Now here's where I ran into trouble with the concept, at first. Not having been raised as a member of the Lego generation, I am still rather fond of conventional framing, with lumber and nails. Toenailing with a hammer is a hard-won skill I won't easily consign to obsolescence. Why futz around with sheets of plywood that a computer cut like paper dolls? Where's the blade-spinning, resin-scented, hammer-pounding thrill of that?

It's a different kind of thrill that these students are after: the thrill of the new. With their professors, including Dan Harding, whose architecture studio has become the team's home field, they have figured out a way to make a house stronger, greener, and easier to build. They have invented an ingenious system for interlocking sturdy plywood shapes, belting them together with zip ties, and fitting them into the orderly bones of a house.

Walking around in this unfinished space, with all of its bones exposed, I have to admit I can see the appeal. The structure is already routed for wiring, plumbing, and ducting, with almost no drilling or cutting required. And strength? I give the wall a shove; it doesn't even flinch.

Clair Dias, a graduate student in architecture who presides with considerable aplomb as the project's manager of external relations, explains how the prototype I'm touring came together. Digital files created in the studio found their way to a Universal Forest Products plant in Salisbury, North Carolina, where a CNC cutter carved the slabs of plywood into shape.

"Every single piece has its own unique number, cut into it by the CNC machine, and that corresponds to our digital file," Dias explains. "So if you need to know the next piece that goes in, you can go right to the computer, click on that piece in the model, and find the number you're looking for. And if you show somebody how to do it one time, they can automatically look at a piece and sort of assume what it needs to fit into."

The system is frugal. Remnants of plywood removed at the mill are recycled there, eliminating the mountains of scrap you find on other building sites. "Our biggest source of waste is actually the excess stainless steel ends from our zip ties," Dias says. "You hook 'em in and cinch 'em down with a zip-tie gun, and it snaps off the excess stainless steel once you get to the right tension. So that's our biggest waste item—a quarter-inch-wide piece of stainless steel. And you just put that in the little bins and take it for recycling."

Which means no planks full of nails lying around, waiting to skewer an appendage. So yes, I'm impressed. But I don't count. What do the experts say?

I speak with Tom Henderson, Clemson University's building inspector, when he stops by the site to check the foundation on an overcast morning in March. Henderson, under the auspices of South Carolina's state engineer, reviews the plans and construction details of each campus project that costs less than one million dollars to build, and he's qualified to inspect every stage of construction. I ask him about his reaction, when he first saw the drawings for Indigo Pine.

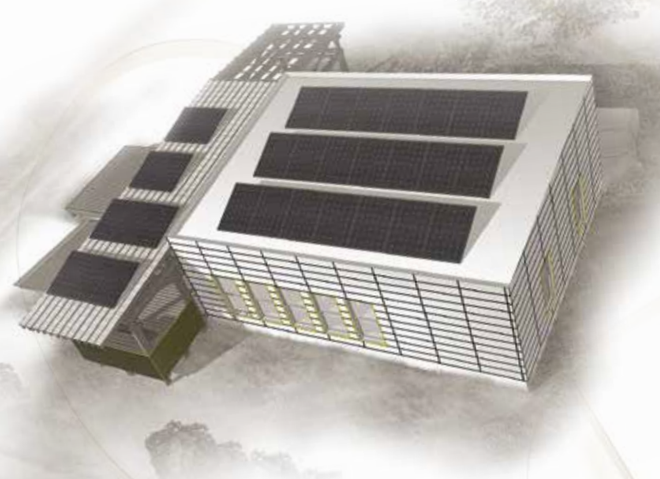
A big, sunny smile breaks out across his face. "I thought, wow, I'm excited to be involved in this," he says.

I ask him if the framing system gave him pause. "I required an engineer's stamp for the structural part of it, and we got that," he says. "But there are no weak spots in this system. It's all built out of plywood, and it fits together like a jigsaw puzzle, like the old mortise-and-tenon or a bunch of Legos. So it's strong."

Ty Monks, who owns a structural-engineering company in Montana, has come to town to oversee construction of the prototype. Monks worked with Dan Harding in Bozeman, where Harding was the founding partner of an architecture and design-build firm. I ask Monks for his take on the frame.

"It is stronger than conventional framing, actually, once we looked at some of the testing," he says. "In compression,

Will Hinkley



Renderings like this one, which shows Indigo Pine's solar panels, were included in a packet of plans, specs, and data sent to the Department of Energy as part of the team's entry in the 2015 Solar Decathlon.

it's about the same as the conventional system, but laterally it's surprisingly stiff."

Lateral forces come into play when strong winds, earthquakes, or impacts try to shove the house sideways, shearing or racking its walls. Lateral stiffness is especially useful in earthquake-prone Irvine, California, where the inspectors are expected to give the system their seal of approval.

continued on page 38

Neil Caudle

collective ingenuity

In a Lee Hall architecture studio, students from several departments gather to report progress and plan next steps. Over two years, as many as two hundred people have contributed to Indigo Pine, Clair Dias says.

Below: The ingenious structural system, called Sim[PLY], was invented in the studio with help from Clemson student engineers. It uses puzzle-like interlocking pieces cut with a computer-guided cutter known as a CNC. The system allows the team to email a house, because the structure is built on computers for quick assembly on site.

Neil Caudle

groundwork day 1

Neil Caudle

Craig Mahaffey

Neil Caudle

Alison Martin, Indigo Pine's health and safety officer, runs through a checklist on day one of construction. She says the project has given her the real-world experience employers value. "Before this project, I'd never dealt with OSHA, or any site safety issues," she says. "We've had a lot of training that will help us get jobs later on."

Neil Caudle

Clair Dias (left) and Alex Latham review the schedule with the team at a studio meeting in February. Dias manages external relations, and Latham worked with Clemson's development offices to raise money. Sponsors have been generous.

Above: The low-cost, low-tech "cooler lung" is a simple array of concrete blocks known as CMUs laid mostly on their sides—a project that family and friends could accomplish, Dan Harding says.

What's the cost?

For Indigo Pine East, the estimated cost is between $250,000 and $270,000, Clair Dias says. But some of that cost was incurred in the testing and tweaking unique to a prototype. "We would love to bring the cost down to two hundred thousand or maybe two-twenty," she says. "That would make the house affordable for more families, especially if they could do some of the work themselves."

woodwork day 5

Marissa DiLoreto

Below left: Lyle McCracken, Jon Pennington (center), and Trent Baker sort parts in the warehouse. Pennington became the expert on CNC and built mockups for structural testing. He also managed the warehouse, organizing parts and packing them ready for the building site.

Below center: Tyler Silvers, architecture project manager, tracked costs and came to be known as Mr. Spreadsheet. Silvers and Clair Dias have been working on the project from its inception.

Above: Roof trusses in place.

Craig Mahaffey

Craig Mahaffey

Marissa DiLoreto

Marissa DiLoreto

Justin Hamrick lugs a precut section of frame that has been numbered by the CNC machine—a computer-guided router—with its exact place in the structure. Hamrick has put several thousand miles on his truck driving back and forth to suppliers.

Left: Eric Balogh and Taylor Sigler set trusses. Balogh, a construction manager on the project, is one of the few students who'd had experience on a building site.

how it works

The structure

Anchored to its side-stacked concrete-block foundation system, the 1,000-square-foot house stands strong while minimizing its impact on the site. Sim[PLY], the structural framework of Indigo Pine, uses standard sheets of plywood cut by a CNC router into a system of specially designed framing members that fit together like a puzzle and are secured with stainless steel zip ties.

The envelope

Indigo Pine is wrapped in aluminum composite material (ACM) siding. CNC-cut from standard sheet sizes, the self-aligning ACM pieces are folded to create an air cavity that allows heat passing through the façade to be vented out before it radiates into the interior of the house. Panels are screwed to the exterior sheathing and can be easily touched up or replaced, if necessary.

The photovoltaic [PV] system

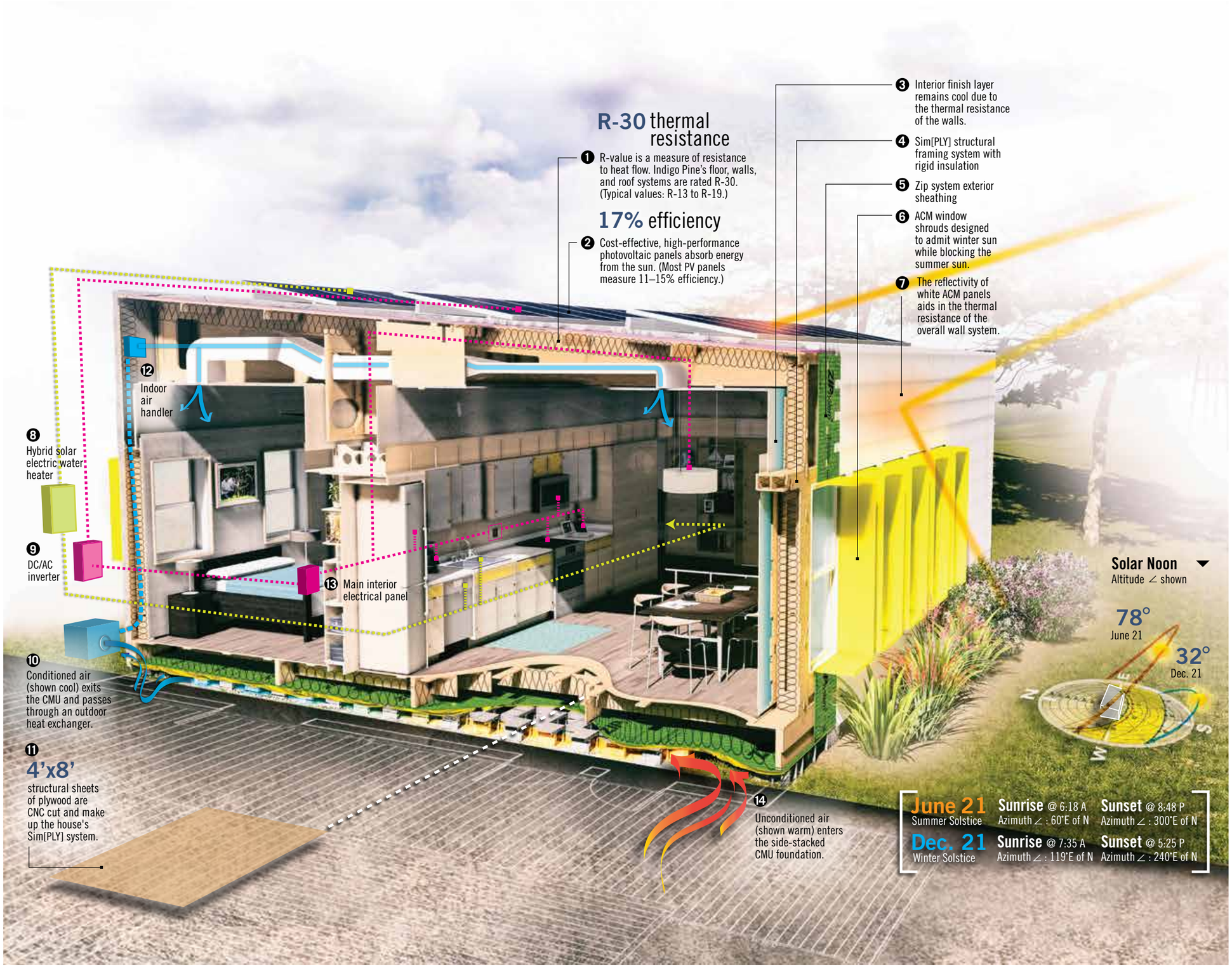
Designed to be installed by a pair of unskilled workers, Indigo Pine's photovoltaic system, which utilizes affordable, lightweight solar panels and micro-inverters, powers all electrical devices of the house, including lighting, the water heater, all home appliances and entertainment systems, as well as an electric vehicle charging station. The system is designed to provide both DC and AC electrical power to optimum efficiency and can produce sustainable energy for the larger electrical grid through net metering.

The HVAC system

Using low-tech solutions to increase the efficiency of existing technology, Indigo Pine's multifunctional foundation, made with concrete blocks called CMUs, pulls unconditioned air under the house, precooling it in the summer and preheating it in the winter before it enters the HVAC system. As a result, overall efficiency is increased. Once mechanically cooled or heated, the air is ready to condition the interior spaces. An integrated control system and manually controlled dampers allow occupants to monitor indoor temperature and to control airflow distribution throughout the multiple zones of the house for comfort.

Illustration by Will Hinkley

www.clemson.edu/indigopine/



taping & roofing day 8

Marissa DiLoreto

Above: Roped in for safety, Alison Martin waits with a roll of roofing paper.

Ken Scar

Dan Harding, whose architecture studio formed the project's core, is also an experienced builder. Here, he fits specially designed metal cladding on Indigo Pine East.

In fact, the question is not whether the house is strong enough but whether it is *too* strong. Students working on Indigo Pine became so enthralled with the brawn of their system that for a while they were bulking it up to rival steel-framed buildings and the very rigid joinery known as moment-frame. Harding has advised them to lighten up.

"Though we're not as strong as steel moment-frame construction, we are *much* stronger than light wood framing," he says. "So don't drive the cost of our system up and overshoot our objective of making it a viable option to replace light wood framing. There's a saying in Montana: When you go on a hike, as long as there's at least one person slower than you are, you're safe from the bears."

Like Harding's students, I couldn't resist, in my youth, the impulse to overbuild. I drove enough nails to construct a small village. On the day the framing inspector arrived, I trailed him around the job site, trying to conceal my anxiety behind a show of tradesman-like detachment. He looked around for a while, signed the green card, and said, "Well, it might rust, but it won't *never* fall down."

The Indigo Pine house, with its stainless steel zip ties, will not rust. And it will never fall down. But to win a contest about energy, the team will have to prove that there's more to their house than good sinew and bone. How will an all-solar house keep its occupants warm in the winter and cool in the knee-buckling heat of, say, August?

Ways to play it cool

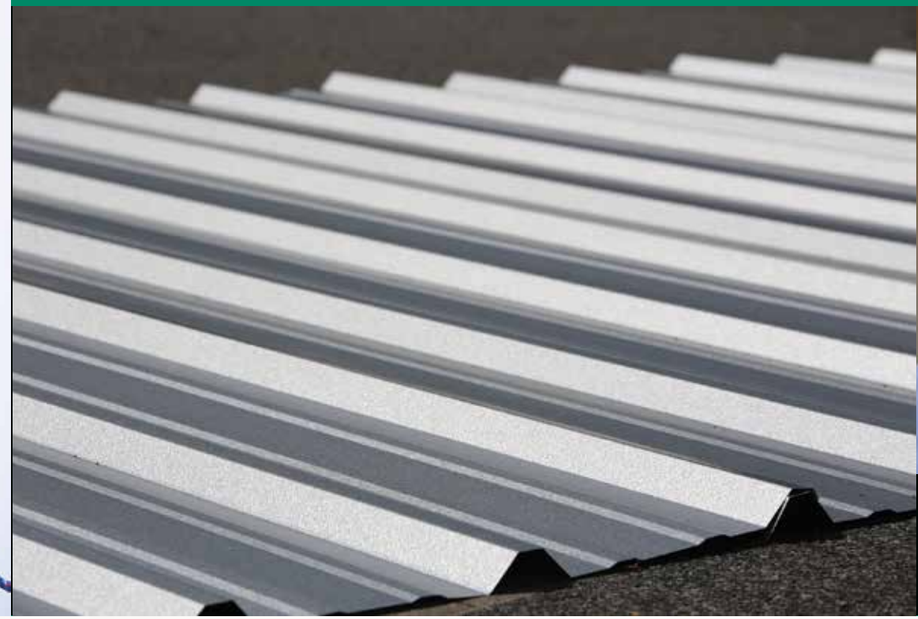
Back in the 1970s, dabblers in solar housing tended to hail from frosty New England, so the few books I found on the topic devoted many more pages to heating than to cooling. I overestimated the need for heat in a heavily insulated, nearly airtight Southern house. Our backup, a Jøtul 118 woodstove, lit only on cold, cloudy days, heaved out so much heat that we opened the windows. We burned about half a cord of firewood a year; the sun did the rest.

But summer's muggy heat exposed a flaw in my design. I had installed six louvered ports near the living room floor to draw in the cool night air, which rose to push heat through a vent in the roof. This worked as planned, but the Yankee texts I'd read didn't warn me about Southern-style humidity. By the end of our first summer in the house, the shoes in our closets and the books on our shelves wore a light fur of mildew. Grudgingly, I capitulated and installed a small air conditioner in one of the ports.

Back then, solar panels using photovoltaic cells (PV) were powering some satellites and off-the-grid signaling and lighting systems. But the panels were far too expensive for low-budget dwellings like mine. Today's PV panels are relatively cheap, cost effective, and efficient, and they have enabled the students to build Indigo Pine as a "net-zero" house, which means it will make as much power as it uses. Employing an efficient new breed of heat pump called a minisplit, the house will put the energy of sunlight to work cooling and dehumidifying the space. That's something my passive system, for all of its virtues, simply could not do.

Of course the roof space and power available from solar panels are limited, on a house so small. So the Indigo Pine team confronted challenges like those NASA engineers face when they build space vehicles to operate on solar power. Every system has to work lean, earn its keep, and stay cool. Waste and excess heat are not an option.

Marissa DiLoreto



Craig Mahaffey

Vincent Blouin, an architect and engineer, saw a way to enlist multiple colleges in an all-out effort to reshape the future of housing.

In the climate of Clemson, South Carolina—or of Irvine, California—that means taking some heat off the house. The less heat invading the interior, the less energy required to keep it cool. Learning from the Carolina farmhouses of long ago, the students designed a porch to provide both extra living space and shade for the western façade. Then they married old with new. After a series of experiments, the team devised a way to use siding fabricated from composite aluminum panels cut and scored on a CNC machine. The supplier couldn't ship enough white panels in time for the prototype house, so Indigo Pine East wears a sleek, dappled skin of rectangles in charcoal, white, and grey. "It's like urban camo," says Will Hinkley, a graduate student in architecture who worked with his classmate Allie Beck on the design.

The panels, secured with rivets, create a cavity between the skin and the sheathing, and the trapped air adds another layer of insulation, Hinkley says. The system deflects so much heat that Harding found a forty-degree drop in interior temperature, after the cladding went up on the prototype. "The difference was staggering," he says.

But the niftiest heat-reduction system may be the cheapest and simplest of all, and it hides beneath the house. Harding and his students, along with Vincent Blouin, have invented a method for using ordinary concrete blocks—510 of them in the prototype—to create what he calls a "cooler lung," which the designers tested separately at first but then incorporated into the foundation. At corners and other key structural points, student workers fitted the blocks with rebar and tie-down straps, and filled them with concrete mixed in wheelbarrows. But inside the perimeter, the team laid blocks on their sides, in a staggered checkerboard pattern that directs air through

limit testing

Ashley Jones

Michael Stoner tests a wall section in the engineering lab.

Neil Caudle

Dustin Albright in Indigo Pine East.

Michael Stoner, who graduated with a B.S. in civil engineering in May, has been working with Dustin Albright to test the structural system. Here, in a Clemson engineering lab, he uses a shear-wall frame to shove the top of a wall structure until it racks and fails. Results from tests like these have helped him identify weaknesses in the structure's joints and recommend improvements.

The testing itself is tricky, because the curving joinery of the Indigo Pine system doesn't offer the usual flat surfaces of an ordinary two-by-four. Stoner has had to figure out where and how to apply the force to get reliable results.

"But I'm confident we'll get the results we need," he says. "There's a learning curve in how you build the walls, and there's a learning curve in how you test them."

Stoner grew up building and admiring wood-frame houses. But he has noticed, in the destruction of tornadoes and hurricanes, that conventional structures don't always measure up. He took an interest in the durable strength of cross-laminated timber, a specialty of Dustin Albright, and plans research on that topic. Plywood, which also derives much of its strength from lamination, makes sense in the Indigo Pine system, Stoner says, because it's "an alternative to wood but still uses wood, in maybe a smarter way."

Albright, who helped the Indigo Pine team develop and evaluate the structure, says the system scores high on ductility—a building's ability to flex and absorb energy, including the forces of high winds or earthquakes. "Each stainless-steel cable tie can take around two hundred and sixty or sixty-five pounds of tensile force before it gives," he says. "And because there are so many of them, there's a lot of redundancy in the system."

Albright plans to continue research and development on the framing system, which is designed with South Carolina's wood-products industry in mind. "We're working with industry in the state to continue to develop the system," he says. "And who knows, we may even bring it to market."

the voids. Water diverted from the plumbing system will drip onto some of the blocks, so that air cooled by evaporation flows to the heat pump.

"It's like feeding the minisplit Gatorade," Harding says.

Harding hasn't collected any data from the system yet, but in theory this low-cost, low-tech lung should take advantage of concrete's well-known capacity to moderate temperature. "This system could be installed under any mobile home or house with a crawlspace and still decrease the energy use," he says.

Like most Indigo Pine components, the lung is designed for easy installation. "In every case possible, we like to use unskilled labor, so that homeowners could do it themselves," Harding says. "We want to get to the point where the money saved can then be applied to more active technologies like solar panels."

For the competition in Irvine, Clemson's entry will stand out for its do-it-yourself simplicity. As other schools park heavy equipment on the site, the Indigo Pine team will make do with the kind of gear a family could tow home from their local rental yard. Eric Balogh recalls meeting the competition, when contestants gathered in Irvine earlier this year to learn the ground rules. "The team next to us approached us and asked if we wanted to share a crane," Balogh says. "We said, 'Nah, we're okay. Thank you, though.'"

Behind the house, another sort of building

This kind of do-it-yourself simplicity is Exhibit A in Indigo Pine's claim to sustainability, because it could, in theory, help make solar housing affordable for families almost anywhere. In architecture, the concept of sustainability is fluid and sometimes fervently debated, but generally it means creating buildings and communities that are, for the long term, socially, economically, and environmentally sound. Homeowners or nonprofit groups such as Habitat for Humanity could build a version of the Indigo Pine house and do most of the work with unskilled labor, team members say. Locally sourced plywood makes efficient use of forest resources, and the house's solar-powered systems and energy efficiency would earn it high marks on the environmental scale.

Attributes like these will tend to make the building sustainable. But to understand what makes a *project* like this one sustainable we'll have to step back from the house.

Indigo Pine's backstory has many chapters, and I cannot do it justice in these pages, any more than I can document the thousands of calculations, choices, and leaps of imagination a team of architects and engineers will make en route to a finished design. But I did find a man who could run through the gist.

One evening last March, as freezing rain and sleet began icing the roads, Vincent Blouin sat in his office until long after dark and patiently answered my questions about the evolution of Indigo Pine. For two years, Blouin has been the project's principal investigator and administrative lightning rod. He did not build the house, but he, along with Dan Harding and their colleagues, built the *capacity* to build the house. That means they wrote the grants, wrangled the money, planned the curriculum, rounded up the corporate partners, cultivated the donors, navigated the federal bureaucracy, and assembled the framework of expertise and administrative wherewithal necessary to enable their students to enter a national competition and delve into something dramatically, daringly new.

For an endeavor this ambitious, it helps to tap the resources of an architecture school with plenty of green-building expertise on hand. Let's pick two examples, among many: Ulrike Heine, an expert on sustainable design, has supplied Indigo Pine with advice and resources, and her students arrived on the project already versed in the principles of net-zero housing; Dustin Albright, who studies the efficient use of wood products such as cross-laminated timber, influenced Indigo Pine's plywood-based structural system and brought his construction know-how to the team. For Blouin, who has a joint appointment in architecture and in engineering, the decathlon was a way to muster this kind of expertise from multiple colleges at Clemson, to step up the science of green building in a visible way.

"Our participation in the Solar Decathlon has the potential to significantly advance the standards of design and construction of market-rate, affordable, zero-energy housing for families in South Carolina and beyond," Blouin says. "We have designed a small Southern home that lives big."

From an academic perspective, sustainability also meant launching a project that would generate useful research, and Indigo Pine has aced that test. Dan Harding can recite a long list of research questions raised by the project, which will yield data on energy production and use, air temperature, passive cooling, construction and workforce economics, and more. The house, he says, is a laboratory. "Just researching the foundation system will be a project with incredible offshoots."

The lab-like nature of the effort became clear one afternoon in March, when I pulled up a chair for one of the Indigo Pine team's weekly briefings in Harding's studio on the ground floor of Lee Hall. As the briefing progressed, I couldn't help but suspect that Harding had brought in a room full of ringers. These were not a bunch of novices muddling through a half-baked class assignment. The students spoke like pros—succinct, business-like, and fluent. In less than an hour, more than a dozen presenters described, in detail, each major aspect of their project.

Alison Martin walked us through the protocols of job-site safety. Jeff Hamrick and Eric Balogh summarized the voluminous documentation they'd submitted to the DoE and gave status reports on structure, architecture, fire protection, mechanical and electrical systems, interiors, landscape, and operations. Will Hinkley and Allie Beck outlined changes to the porch and a series of experiments that refined the cladding to neatly align with the windows and doors. Justin Hamrick and Jon Pennington reported on structural testing. Clair Dias covered logistics and laid out a calendar of milestones and events, including a ribbon cutting in April with President Clements.

As I listened to these students and others in their cohort, I could hear in their updates a pattern of values and themes. They were telling a story about the future of housing, and the

possibilities of architecture—a kind of motivating mythology that had been feeding the project for two years. The story was reaching its climax, a convergence of effort by many students. Some of them had graduated, handed off their concepts and models, and moved on. Over time, the faces at the table had changed. The models and materials had changed. And the school itself had changed, because Indigo Pine was rapacious. As it grew and found its bearings, it stalked every corridor of Lee Hall, gobbling up whatever knowledge and talent it could corner. And now the students who'd inherited this monster were determined to make the mythology real, to give it flesh and let it stand for what they'd learned.

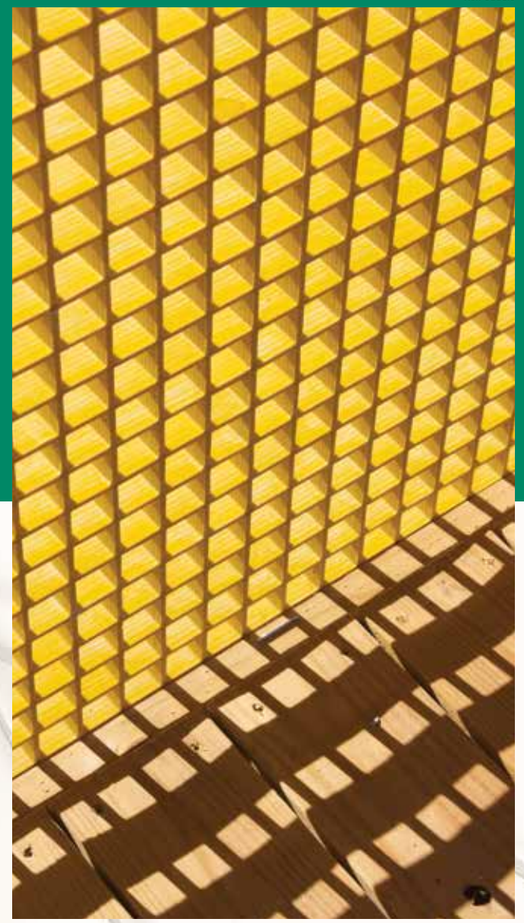
"The project has exposed students and faculty alike to a whole new level of architecture education," Dias says. "It's left its footprints all over Lee Hall."

Architecture students weren't the only ones feeding the beast. When I first arrived on the site of Indigo Pine East, on day one of construction, I found Edward Hoegg, a graduate student in chemistry, wiring breakers and outlets for the temporary power supply. A volunteer, Hoegg had steeped himself in the technology of solar energy during a three-year stint with the DoE's SunShot initiative, and he'd learned electrical work as a lighting and sound engineer for concerts and events.

Like Hoegg, Michael Stoner, a civil engineering student, supplied some much-needed technical expertise. Stoner first learned about Indigo Pine at Clemson's villa in Genoa, Italy, taking a summer-session course with Dan Harding and Clair Dias. He came back from Genoa ready to help on the project, signed on to conduct some research with Dustin Albright, and used his skills to test components of its structure in the engineering lab (see the sidebar, page 40).

Over the course of two years, the contributions of many people, from multiple schools and departments, began to cohere. Students were learning the habits of rigor, inquiry, and creative collaboration that would shape their careers. And that, for a university, may be the ultimate measure of sustainable design.

Neil Caudle



Marissa DiLoreto

Jon Pennington built this rocker for the porch. Like the house, it is CNC cut and fastened together using wood joins and stainless steel zip ties.

Beyond the black hole

Anyone who has built a house from scratch has faced that moment when the project becomes a black hole into which money and time disappear. I became acquainted with the abyss sometime around Christmas of my second year of construction, when I was running out of money and working late at night in bitter cold. By the light of a sixty-watt bulb, in a powdery cloud of white dust, I was sanding down thick, spiny crusts of hardened joint compound I had over-applied to the drywall. The errors of inexperience are costly but instructive.

At last count, the budget for Indigo Pine was faring better than mine did. Donors and corporate sponsors have been generous, contributing most of the materials and equipment. But as the semester wound down through late April into May,

Eric Balogh

Indigo Pine East, a 1,000-square foot, three-bedroom prototype, nears completion in July. The first of two versions to be built by Clemson's Solar Decathlon team, the house is open to visitors at the South Carolina Botanical Garden until the end of the year.

construction did not always proceed according to plan, and the prototype fell behind schedule. Sometimes, materials or equipment failed to show up on cue. Now and then, a gremlin popped out of the woodwork. Leveling the floor joists, for instance, was fiendishly tricky and cost a whole day.

"Also we had a learning moment with the box girder," Dias recalls. "It's about twelve hundred pounds, and getting it into place was something we hadn't thought through. We finally figured out a safe and effective way to install it. We removed a couple of bolts."

Now, on this hot day in May, as I poke around on the site, Eric Balogh calls down from the rafters, asking for a two-by-six joist for the porch roof he's building. The news isn't good. "We're out of those," someone hollers. The best remaining two-by-sixes are wet with freshly painted stain; the only dry one is as crooked as a dog's hind leg. So Balogh climbs down for a water break. "We've had lots of schedule revision," he says with a shrug, when I ask him about the delays. "We actually had to stop for two weeks so that everyone could pass their finals. Now it's nice because no one's stressed out about classes and finals, and it's just six of us here for now. We should have ten for the summer, when everyone gets back from vacation."

Balogh doesn't sweat the setbacks. This is why you build a prototype, he says—to work out the kinks before the competition. He's optimistic that assembly will keep pace with the schedule when the team convenes in California. "Every time we try something new we learn what went right and what went wrong," he says. "I think the biggest lesson we've learned is to spend more time planning and less time actually building. It needs to be more about assembling the house, not building it."

During the nine days of building in Irvine, the team will use two crews of twelve people each, running two eight-hour shifts a day. Balogh will manage one crew and the aptly named Jeff Hammer, a fellow graduate student in architecture, will manage the other.

Unlike most of his classmates, Balogh has a background in construction. He worked for a design-build firm in Augusta, Georgia, for several years before he came to graduate school, and he spent some time on job sites. When he arrived at Clemson, he had his doubts when he first saw the structural system under development in the Lee Hall studio. "I won't lie," he says. "I was a bit skeptical, at first. But it has actually been incredibly smooth, very safe, and very quick. It was this big theory, this big idea, and it's working."

When I catch up with Dan Harding, later that day, he's been packing for another summer in Genoa. "I'll stay in contact with the project," he says, "but this is the end of our third academic studio on the project. The next semester is doing it. So at this stage, the creative thinking has to be on the team's shoulders, or the ownership doesn't get transferred."

The team will manage fine without him, he says. "The crew

that's here right now is as proficient as any group I've ever worked with. If I could take everyone in this studio, I'd start an office, and I know that we would win. There's no doubt."

Harding can't promise a win in California, but the team will be ready, he says. And whatever the outcome of the competition, the students have already achieved more than they'd imagined. Many will emerge from the project transformed. Michael Stoner came to the mix an engineer wary of artsy design types. But after his time sketching buildings in Genoa, and his collaboration with student architects on Indigo Pine, he has a different view of the relationships of architects and engineers.

"My focus as an engineer is different, now," Stoner says. "I've learned to consider how an architect can make something beautiful, if I can help by engineering something that may not be conventional."

Several students have told me about similar transformations. Building a house from the ground up, they say, has changed the way they see the structure. It's not just a concept in pixels or ink, anymore.

Here's how Eric Balogh puts it: "You can draw and draft and look up details to your heart's content, but until you really understand that the pencil-thin line you just drew is actually a thick piece of metal or rebar or something, it really doesn't click. It's kind of that *click*, you know, and it's incredibly important."

That rings true, for me. Most of what I've produced in the last thirty-eight years, including this magazine, I composed within the mental framework, the analogue, of designing and building a house. In some ways, I still dwell there, even though I sold the place and moved to town. But I had forgotten, until I spent a little time with the students on Indigo Pine, that building a solar house is not something you do only for shelter, or bragging rights, or even the credential. You do it to stake your claim to the future instead of the past.

The students headed for Irvine won't have to go it alone. They will have teammates and coaches. They will have the backing of their university, their donors, their industry partners, and their government. They will go armed with some impressive new technology and the know-how to use it. If they win a prize, good for them. But what I'm really counting on is something more: Help us find our way back to the sun.

Vincent Blouin is the principal investigator for the Clemson Solar Decathlon project and an associate professor of architecture and materials science and engineering, in the College of Architecture, Arts, and Humanities and in the College of Engineering and Science.

Dan Harding is an associate professor of architecture and director of the Community Research & Design Center. Ulrike Heine is an associate professor and associate chair of architecture, and Dustin Albright is an assistant professor of architecture. All three are in the College of Architecture, Arts, and Humanities.

The project is funded in part by the Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy, under Award Number DE-EE0006559. For more about Indigo Pine, including sponsors and participants, go to www.clemson.edu/indigopine/.

Neil Caudle, editor of Glimpse, *now lives in an active-solar house that he did not build himself.*

The Solar Decathlon

In the U.S. Department of Energy Solar Decathlon, collegiate teams design and build energy-efficient houses powered by the sun. These teams spend almost two years creating houses to compete in the ten contests of the Solar Decathlon. The winning team produces a house that:

- Is affordable, attractive, and easy to live in
- Maintains comfortable and healthy indoor environmental conditions
- Supplies energy to household appliances for cooking, cleaning, and entertainment
- Provides adequate hot water
- Produces as much or more energy than it consumes

The competition includes ten contests:

- Architecture Contest (juried)
- Market Appeal Contest (juried)
- Engineering Contest (juried)
- Communications Contest (juried)
- Affordability Contest (juried)
- Comfort Zone Contest (measured)
- Appliances Contest (measured)
- Home Life Contest (measured)
- Commuting Contest (measured)
- Energy Balance Contest (measured)

Teams entered in the 2015 competition:

- California Polytechnic State University, San Luis Obispo
- California State University, Sacramento
- Clemson University
- Crowder College and Drury University
- Missouri University of Science and Technology
- New York City College of Technology
- State University of New York at Alfred College of Technology and Alfred University
- Stevens Institute of Technology
- University of Florida, National University of Singapore, and Santa Fe College
- The University of Texas at Austin and Technische Universitaet Muenchen
- University at Buffalo, The State University of New York
- University of California, Davis
- University of California, Irvine; Chapman University; Irvine Valley College; and Saddleback College
- Vanderbilt University and Middle Tennessee State University
- West Virginia University and University of Roma Tor Vergata
- Western New England University, Universidad Tecnológica de Panamá, and Universidad Tecnológica Centroamericana
- Yale University

—U.S. Department of Energy

www.solardecathlon.gov

David Pastre

A new Crop Stop, under construction in Greenville, S.C., uses Indigo Pine technology to provide a lot-cost commercial kitchen for local farmers.

Cooking up a new kind of kitchen

Indigo Pine's DNA has already found its way into another kind of structure, a kitchen to help South Carolina farmers turn produce into market-ready food.

David Pastre teamed up with Harry Crissy to launch a series of "Crop Stops," USDA-approved kitchens equipped with commercial-scale freezers, ranges, ovens, and other equipment for handling local produce. The project responds to research showing that farmers often have trouble marketing their produce locally because they aren't equipped to meet standards set by restaurants and governments.

Crissy's economic analysis revealed that existing commercial-scale kitchens tended to be few and far between, often too far away to make them useful to small farms. He reasoned that deploying a number of smaller, less expensive kitchens around the state would make processing more available, and more profitable, for many farmers.

The first Crop Stop opened this spring on John's Island, in an old mobile home refurbished in Charleston and trailered to the site. The second edition, scheduled to open in Greenville this year, employs the Indigo Pine technology Pastre helped guide through multiple stages of development. "We're applying the same simplified construction method to the new Crop Stop," Pastre says. "We think of this as a replicable model, and there are plans to do a lot of these across the state."

The Crop Stop in Greenville, like the original on John's Island, will be managed by a nonprofit group. It can be moved by trailer and will feature a flash freezer that can reach negative forty-five degrees. Quick freezing helps prevent bacterial growth and retains about 80 percent of the nutrients in the vegetables, Pastre says.

"Usually, small farms can only sell only about fifty percent of what they grow, and the rest goes to waste," Pastre says. "With a Crop Stop, the producers can still sell at the farmers' markets, but whatever comes back they can process and freeze, and then sell that as well. Harry's studies show that within three years they could be doubling their gross income."

David Pastre is a senior lecturer at the Clemson Architecture Center in Charleston. Harry Crissy is an Extension agent in the Clemson Institute for Economic and Community Development. The Crop Stop project originated at the College of Charleston in a farm-to-school initiative funded by The Boeing Company.

–Neil Caudle

BRINGING INDUSTRY TO LIGHT

BY R. R. McCARTHY

Ashley Jones

Wafers like this are part of research that could revolutionize how computers work. Here, a chrome-coated glass substrate holds multiple patterned devices.

IN A CLEMSON LABORATORY, STUDENTS PLAY WITH LIGHT.

They test blue lasers designed to beam data under water. Atom by atom, they sculpt complex patterns in wafers of silica and sapphire that can control, detect, and manipulate light. And it's all part of Eric Johnson's plan to put U.S. industry on top.

Since he arrived at Clemson four years ago from the University of North Carolina at Charlotte, he has become something of an optics and photonics rock star. But Johnson is down to earth and self-effacing. He's comfortable talking both with colleagues and elected officials. He easily collaborates with scientists from other departments about the ways that lasers may have applications for their work, such as automotive innovations. He is comfortable discussing research topics with private industry representatives or recruiting students. With everyone, he conveys the same excitement about what his lab does and what it can eventually do for South Carolina.

"I can't say enough good things about Eric as a professor," says Clemson graduate Aaron Pung, who earned a Ph.D. with Johnson in 2014. Pung now works on classified projects at Sandia National Laboratories in Albuquerque, New Mexico. "He's smart and he always has another card up his sleeve. He has so many ideas, the amount of time and effort he puts in for students amazes me."

Johnson's field, optoelectronics, is the scientific study of electronic devices that produce, detect, and manipulate light. It's a field that has helped create technologies used in national defense, medicine, communications, manufacturing, and in a wide variety of other fields.

His résumé includes past positions directing research and development departments in private industry, where, for example, he helped develop bar code scanners and the technology that enables computers to communicate with each other. His research in micro-optics and nanophotonics has resulted in thirteen patents. He also has had a stint as a program director in the Electrical, Communications, and Cyber Systems (ECCS) Division of the National Science Foundation, where he managed research funding for photonics programs around the country. And he has had faculty positions at other universities in North Carolina and central Florida with flourishing optics programs.

His two-year appointment in Washington gave Johnson a good picture of the state of photonics and optoelectronics in the entire country. Photonics, the scientific study of light and light technology, underpins everything from tools for eye surgery to remote sensing and weapon systems, cell phones, and the Internet. During his time there, Johnson had one of his early suspicions confirmed: A big weakness in national planning here in the United States is a lack of emphasis across the country on photonic manufacturing.

Few companies in the United States can bring such technology to market. Often aided by governments, companies in Asia and Europe long ago invested in the infrastructure needed for such manufacturing. It's no surprise, then, that smart phones aren't made here. The cameras in cell phones use both glass and silicon chips that interface and work together—and it's done inexpensively.

"All of that is done overseas now, not in the U.S. at all," Johnson says. "Putting optics and photonics together in computers, that's a problem that Intel is trying to solve, heterogeneous integration. Those high-volume applications have the real payoff."

Closing a high-tech manufacturing gap

Without the infrastructure of a manufacturing industry, the U.S. won't be able to compete globally, according to Johnson, no matter how many technological breakthroughs there are. Many of the international students who complete advanced engineering degrees at Clemson and other American universities are going to return to their home countries, where jobs are more plentiful.

"The lack of manufacturing stifles development," he says. "All the chip manufacturing is going to Europe and Asia. But I do think we're going to work on closing the gap."

With its investments in faculty, equipment, and facili-

Craig Mahaffey

Research in Eric Johnson's lab develops the potential of lasers and optical fiber in manufacturing. This mid-infrared fiber laser shows green fluorescence under strong optical pumping.

Ashley Jones

A clean room at the Advanced Materials Research Laboratory gives Clemson researchers and students access to microtechnologies.

Eric Johnson works with Kaitlyn Morgan, a Ph.D. student in the lab.

ties—including a clean room, a chamber with no detectable dust or other contaminants, which opened last fall—Clemson University is poised to play a part in changing the manufacturing landscape for photonic devices, Johnson says. In the university's labs at the Center for Optical Materials Science and Engineering Technologies, researchers can make customized optic fiber as well as photonic chips.

"We've taken the first step of getting our facilities up and running, and now we're expanding," Johnson says. "Having the clean room will make a big difference. More importantly, the capabilities are critical to all the microtechnologies out there. Students need to be able to learn how these things are done."

By students, Johnson means high schoolers as well as undergraduate and graduate students. This summer he is using his internal funds to support a local high school student, as he has done in the past with a student from the South Carolina Governor's School for Science and Math, which is part of the SmartState system. The teenager will work alongside graduate students on a project for two months, producing a poster and possibly a peer-reviewed published paper.

"I want bright students to consider studying engineering," he says. "So many kids don't even think about it, it's a kind of brain drain. They learn they can do really cool stuff with optics."

A tiny window to the possible

Take a little thing made by graduate student Indumathi Raghu Srimathi. Her amazing creation is about the size of a fish scale, as clear as a tiny windowpane. When you look at it under a microscope, you could be looking at a 3-D slide of the Grand Canyon's topography. But when you shine a red laser pointer on it, an orange Clemson Tiger paw appears. It looks so simple, but a lot of work went into making it.

Essentially, what Srimathi did, says Johnson, was to mimic a phenomenon found in nature. A butterfly's wings have no color—what you see is diffracted light. What you see in the tiger paw, too, is diffracted light. Srimathi started with a fused silica wafer, a pure form of glass. She used atomic layer deposition to add different materials, atom by atom, to the wafer. She then coated it with photoresist, exposed it to ultraviolet light with a photolithography tool, and washed away the chemicals. Hit it with a laser point and *voilà*, a tiger paw.

Diffraction is an alteration that light undergoes when it passes along the edges of opaque bodies or through narrow slits or, as in the present case, is reflected from irregular surfaces. The result is the production of a potentially infinite number of patterns, each specific to a particular reflecting surface, of which Srimathi's tiny chip is one. Diffraction occurs not only with light but also with anything composed of waves—sound, X-rays, water waves, and so forth.

Diffractive optics has many applications for the private sector—there are companies using it to make just about any logo. Virtual keyboards also make use of diffractive optics and laser technologies. So does remote sensing and industrial machining.

Other students in Johnson's lab are doing research on blue laser wavelength control devices, funded by the U.S. Navy. The navy is interested because, when applied to telecommunications, blue laser control devices are a vast improvement over traditional forms of underwater communication, such as radio frequency waves and acoustic systems, which are easily jammed and easy to detect.

Research and testing have demonstrated the advantages of blue laser devices, which include a higher data rate, increased security, and the potential for multiple channel encoding. Multiple channel encoding means that information can be split among different components, which can be transmitted along the same channel at the same time.

Blue lasers have a shorter wavelength than the traditional red laser used in most electronic applications today. They emit electromagnetic radiation with a wavelength between 360 and 480 nanometers (nm), which the human eye sees as blue or violet. Red lasers emit in the 600–700 nm range. Because the wavelength is shorter, blue lasers allow data to be more densely packed. The result is that storage devices—say, a compact disc—of the same size are able to store two to four times as much information with blue laser technology than they did with red.

The principal student investigator on the project, undergraduate Matthew Byrd, is headed to MIT this fall on a National Science Foundation Fellowship. There, he expects to be exploring silicon photonics, the study of photonic systems that use the element silicon as an optical medium. He plans to work with a professor who's trying to develop silicon chips that have discrete components on them, including a lens, laser diodes, and a control device. It's a toolbox that will be integrated to work together so that it will be possible for the chip to be mass produced, Byrd says.

Lumany, a company in Newport Beach, California, is taking research developed in Johnson's lab and transferring it to the marketplace, says Lumany CEO Paul Rudy. He has known Johnson and his work for fifteen years. Lumany, Rudy says, makes "innovative lasers to replace conventional lasers."

He says Johnson understands how to leverage the resources of an academic institution like Clemson to develop research into commercially relevant technology, in this case, high-powered lasers that are of potential interest for the U.S. Navy. The company is using a multi-phase Small Business Technology Transfer (STTR) grant of about $1 million on the project, which aims to develop lasers that can be more precisely controlled.

"Eric and his team have always delivered, they've always come through with innovative results, which is hard to do," Rudy says. "In fact, it's remarkable."

Eric Johnson holds the PalmettoNet Endowed Chair in Optoelectronics. He also serves as the head of the South Carolina SmartState Center of Economic Excellence in Optoelectronics. R. R. McCarthy is a freelance writer based in Athens, Georgia.

KNOWLEDGE JOBS

Eric Johnson is one of fifty-one professors in the state who receive funding from SmartState, a South Carolina program that combines public and private money for research professor endowments. The South Carolina General Assembly created the SmartState Program in 2002, thinking that the best way to improve South Carolina and its economy would be to give its citizens better jobs, knowledge-based jobs.

To do that, legislators asked the state's three public research schools—Clemson, the University of South Carolina, and the Medical University of South Carolina—to create centers of economic excellence. Today, there are fifty-one centers that focus on topics such as advanced materials and nanotechnology, automotive and transportation, biomedical, energy and alternative fuels, information science, and pharmaceutical advances.

The SmartState Program also includes funding for SmartState Endowed Chairs, like the one held by Eric Johnson, that are also funded by private industry. For Clemson, sixteen endowed SmartState Endowed Chairs have been created, and six of them appointed. Like Johnson, the professors holding the chaired professorships are accomplished engineers and scientists. Their research and innovations are powering the economic excellence centers.

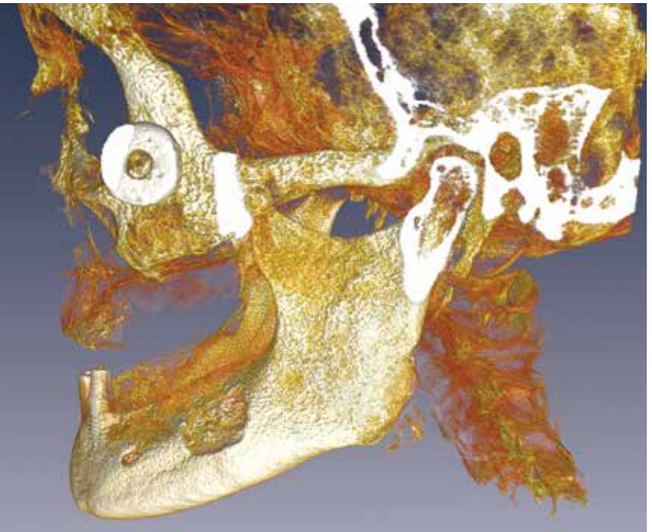
In the past 13 years, the State of South Carolina has channeled $197.6 million in state lottery monies into the SmartState program, and private industry has contributed additional money. The program has been credited with creating more than 10,000 jobs, 4,880 of them knowledge-economy jobs. Studies show that knowledge-based jobs on average pay $78,393 and lead to the creation of other jobs. According to the South Carolina Commission on Higher Education, the entire program has an annual economic impact of $1.5 billion.

open

wide

New research expands the science of our clicking, aching jaws.

by Neil Caudle



Hai Yao uses three-dimensional images of the human skull to study how the jaw works correctly—and how it fails. In this image from his lab, the TMJ is highlighted by a two-dimensional slice through the midline of the condyle of the mandible. The wheel-like form near the cheek is a marker used to align CT and MR images.

For millions of people, the symptoms of a jaw problem—clicking or pain when they swallow or chew—are all too familiar. TMJ (temporomandibular joint) disorders affect about 10 percent of the population. Often, a problem first appears in the teenage years, goes away for a while, but reappears in middle age.

TMJ disorders can have multiple causes, but the jaw joint itself may account for as many as half of the cases, says Hai Yao, a bioengineer who studies the problem.

"This joint is unique in the human body," Yao says. "Basically you have one piece of bone, the mandible, and you have a joint on the left and the right."

When you open your jaw, it not only rotates in three axial directions, Yao explains, but the jaw must also move forward and backward and side-to-side. It is a true six degrees of freedom of motion. A disc-like piece of cartilage called a meniscus normally cushions and positions the mandible. But when the meniscus becomes displaced, it can pop away from the top of the mandible, making a clicking sound and straining the ligaments that hold it in place. In severe cases, inflammation from the stress and strain leads to osteoarthritis.

"Because you need this wide range of motion, you can't use bone to confine it, so that's why the stability is a problem," Yao says. "Compared to the hip joint or the knee joint, it's not very stable. In the hip joint you have the socket and the ball to lock it."

So when the jaw joint causes problems, don't expect to replace it as easily as you could replace a faulty hip or knee. At least not yet. While artificial jaw joints have been tested, they have not been very successful, Yao says. As a bioengineer, he is working toward ways to repair or replace defective jaw joints, but he says that success will depend on a much better understanding of the jaw's biology than we have had in the past. The biology of the joint, he says, affects its mechanics and vice versa. Mechanical loading, as in hard chewing or grinding the teeth, can yield a biological response in several kinds of tissues. Yao and his team are working to understand this, right down to the level of the cell.

Strength and weakness in the matrix

"When you have all of this mechanical loading, you're creating a very complex physical and chemical environment for the cell to sense," Yao says. "The cell can sense the environment and adjust its metabolic activities."

The cells are embedded in extracellular matrix, a kind of scaffold. It is the matrix, not the cells, providing tissue mechanical functions, Yao says. "New matrix is constantly being made by the cells, but it is also degrading, so there's a constant remodeling," Yao says. "This kind of modeling can maintain a balance, which is good, or it can degrade the matrix, which is bad."

To learn how mechanical and biological factors mesh, Yao and his team study the physical and chemical environment of the TMJ and how it responds to pressure and stress. He begins with an optical system in combination of MR and CT imaging to track markers attached to key locations in the teeth and bone, and he observes what happens when a patient moves the jaw. "If you know the motion of the teeth and the anatomy of the jaw," Yao says, "and we can capture the true motion of the TMJ underneath the skin."

He feeds data from this tracking system into a model that predicts various dynamic changes in the joint. "Eventually I can develop the model so that I know exactly what's the deformation and how much stress it can generate inside," Yao says. "Basically I will be able to predict the physical-chemical environment inside this joint."

Surgery isn't always the answer

With the model, Yao will investigate several unknowns about the biology of the jaw. Could deformation in the joint cause changes in the way cells embed in the extracellular matrix? Or could the changes be caused by different nutrient concentrations? Tissues in the joint have few blood vessels, he says, so cartilage, for example, relies on nutrients transported to the cells by diffusion. But various kinds of stress could suppress the flow of nutrients and degrade the tissue, weakening the joint.

The problem of blood-starved cartilage is also a frequent problem in the spine, where large intervertebral disks can degrade under stress, and Yao is studying that problem too.

Surgery, Yao says, is not always the best answer for a dysfunctional TMJ. He is developing ways to assess whether surgery makes sense in a particular case, and how it would affect the complex biology of the jaw.

Regenerating damaged tissue may yield better results than surgical intervention, Yao says. He and collaborators at Columbia University have published the results of a study that found a way to regenerate an entire joint in their animal model, the rabbit. But a successful replacement for the jaw joint may be "twenty or thirty years" in the future, Yao says.

Meanwhile, the best option for combatting TMJ disorders, he says, is probably prevention. Part of his research looks at strategies for changing habits, such as clenching and grinding the teeth, that stress the joint.

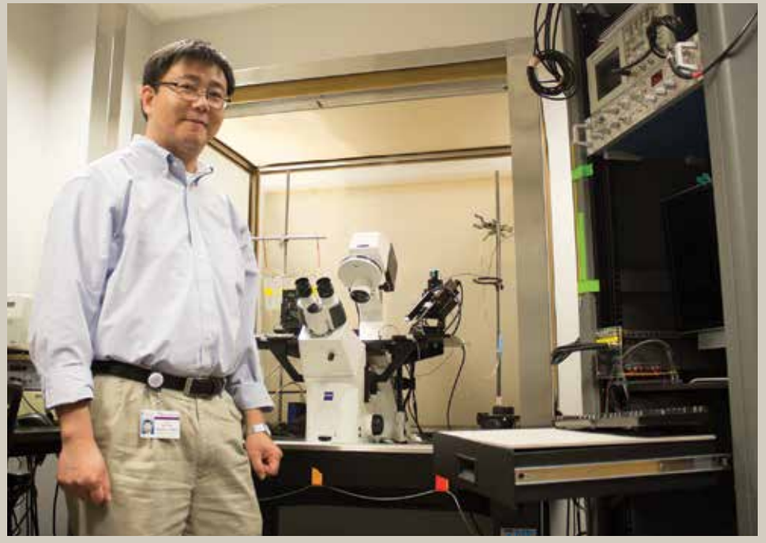
Research into TMJ disorders has lagged behind other fields, Yao explains, partly because the jaw is so complex that it involves multiple kinds of expertise, each with a point of view. "You could relate it to the pain, or you could relate it to the neuromuscular factors, or you could relate it to the joint, to the tissue degeneration in the cartilage or the bone. So there's no specific physician to take care of this problem."

Yao draws on multiple kinds of expertise by collaborating with the Medical University of South Carolina (MUSC) in Charleston, where his lab and the Clemson-MUSC collaborative bioengineering program are based. He and his students—up to twelve of them at a time, along with several postdoctoral fellows—regularly work with physicians at MUSC. For both sides, there has been a learning curve as engineers try to acquire the languages of biology and medicine, and physicians try to understand engineering. But "Team TMJ," as Yao puts it, is building a research program with national prominence, and the team is establishing a clinical research center with five collaborating institutions from around the country.

"This kind of research, if it eventually solves the TMJ problem, it won't be one lab's effort," Yao says. "It will be a group of people."

Hai Yao is a professor and associate chair for the collaborative bioengineering program of Clemson University and the Medical University of South Carolina.

Neil Caudle



Hai Yao in his lab: Knees and hips are simple, compared to the jaw, which does not have the advantage of a ball-and-socket structure. Yao's model will predict the physical and chemical environment inside the joint—a necessary step to effective therapy, he says.

gentler treatment *for* addicted infants

by Anna Simon

Babies born with opioid dependence are inconsolable. They quit cold turkey at birth and start withdrawing within days. Jennifer Hudson sought a way to ease their agony. "I watched babies suffer," says Hudson, director of newborn services at GHS. Symptoms of withdrawal hit hard several days after birth: massive weight loss, seizures, tremors, fever, vomiting, diarrhea, irritability, sleeplessness, breathing problems, apnea, rashes, and more. It's called Neonatal Abstinence Syndrome, or NAS. The Children's Hospital Association calls it a public health crisis.

When Hudson came to GHS, babies of mothers who were being treated for addiction to opiate-based drugs such as heroin or prescription painkillers had to exhibit symptoms before treatment could begin. This remains standard practice at many hospitals. By the time full-blown symptoms of NAS developed, the health of these babies deteriorated rapidly with complications that often led to months in intensive care. "It felt unethical," she says. If doctors know that a mother is being treated with a long-acting opioid, such as methadone, during pregnancy, then why, she wondered, can't treatment start at birth, before the agony of withdrawal begins? She went to a hospital pediatric pharmacist with an idea.

Simply put, the idea was a kinder, gentler approach to treating infants with NAS. For the past eight years, under Hudson's leadership, withdrawal treatment has started at birth for babies born at GHS, when mothers are known to have used long-acting opioids during late pregnancy. Rather than long stays in intensive care, these NAS babies typically go home after one week to bond with their families and continue to receive a slow medication wean at home. Outpatient physicians and visiting nurses monitor the four-week home treatment process. This makes for healthier babies, happier families, and lower costs, Hudson says.

The casualties and costs of NAS

One NAS infant is born every hour, or 3.39 per 1,000 hospital births per year in the U.S., according to the *Journal of the American Medical Association (JAMA)* data for 2009. That's three times the rate in 2000, as opiod drug use rises. In South Carolina, 5.4 of every 1,000 hospital births in 2012 were NAS babies, according to the state's Office of Research and Statistics. The numbers add up to more dollars taken from pockets of families and taxpayers. Average hospital charges for NAS newborns in 2009 were $53,400, compared to $9,500 for all other hospital births, and Medicaid was the primary payer for over 75 percent of charges, *JAMA* reported. The Protecting Our Infants Act of 2015 asks Congress for coordinated national efforts to curb rising drug use in pregnant women and to seek solutions for these babies.

In 2013, a research team led by Rachel Mayo, a public health sciences professor at Clemson University, joined Hudson in a new research partnership to evaluate her approach to treating NAS babies. The partnership, which is one of a growing number of collaborations between Clemson researchers and GHS clinicians, is designed to provide data on the effectiveness of an intervention used at GHS for nearly a decade.

"Dr. Hudson wanted to partner with researchers who know how to evaluate programs to see if this is more effective than the current standard of care," says Mayo, whose research focuses on women's and children's health.

If the team finds that the gentler intervention adopted under Hudson's leadership at GHS produces better outcomes than traditional treatment, they'll pursue answers to a second question as well: Can this method be used as effectively at other hospitals across South Carolina?

Windsor Sherrill, associate vice president for health research at Clemson and chief science officer at GHS, introduced Hudson and Mayo. "Babies born with drug dependence are usually treated in neonatal intensive care units, and this is expensive," Sherrill says. "This treatment alternative has incredible promise for improved outcomes and cost savings."

Is there a better way?

Eight years of data gathered on opioid-dependent babies born at GHS is under analysis by Mayo's research team, which includes Sherrill; Liwei Chen, a biostatistician and epidemiologist in Clemson's Department of Public Health Sciences; Lori Dickes, an economist with Clemson's Strom Thurmond Institute; and Brad Dalton, a medical doctor and postdoctoral fellow at Clemson. Their work is supported in part by a $1.3 million grant from the South Carolina Department of Health and Human Services.

The researchers will look at the retrospective studies and health outcomes in terms of cost, safety, and relative effectiveness compared to the current traditional standard of care, Mayo says. They want to learn whether outcomes are different for NAS babies born at GHS compared to hospitals in the rest of the state and whether the GHS model can be replicated in other South Carolina hospitals.

So far, the team sees several potential advantages to the GHS approach, in addition to the cost savings of infants leaving the hospital sooner. Dalton says that increased maternal interaction, breastfeeding, and bonding with the family in the comfort of the home appear to decrease the withdrawal symptoms. "Anything that can get the baby home sooner is going to be more beneficial for the family as a whole," he says.

Evan Amos

Mothers of NAS babies aren't necessarily the stereotypical drug addicts portrayed on prime-time television shows. A pregnant car wreck victim could need painkillers, Dalton says. Or a woman might be on painkillers for a back injury before becoming pregnant, Mayo says.

"It doesn't take long to become dependent or addicted. It's important for us not to judge," Mayo says.

Hudson explains another complicating factor. "When a mother is using heroin or prescription painkillers illegally, it's often safer to transition to a long-acting opioid during pregnancy," she says. "This removes craving and helps a mother control drug-seeking behaviors that are often risky. The downside, though, is that the baby's system gets used to having that medication every day and is at significant risk for withdrawal after birth."

Support is provided for the mother and the entire family to help the baby through infancy and early childhood so that when he starts school he is ready to succeed, Mayo says. The researchers also can delve into the long-term implications of this intervention because some of the babies born at GHS who are in the study now are in second grade.

The eight years of data on GHS babies could help fill gaps in current knowledge about the effects of drugs on a fetus, Mayo adds. A report in *Pediatrics*, the official journal of the American Academy of Pediatrics, cites "an urgent need for studies of long-term outcomes in these children."

Over time, the data also can help researchers learn more about the impact of ongoing family drug abuse on these children, evaluate school readiness and behavioral problems such as Attention Deficit Disorder, and look at the incidence of placements with the state's Department of Social Services, foster homes, and incarceration, Hudson says.

Mayo says that the project is one of the most rewarding she's been involved in, because of the "potential to turn things around" for our youngest citizens.

Healing tendons, joints, and bones

While Hudson, Mayo, and their team find ways to help some of the state's youngest patients, another Clemson-GHS research team is focused on the problems of aging, working to slow the progression of osteoarthritis, helping patients with massive rotator cuff or shoulder tendon tears, and developing implants for patients with bone and cartilage defects.

Jeremy Mercuri received his graduate degrees in Clemson's Department of Bioengineering. Its strength in the study of biomaterials helped him pursue his passion: advanced medical devices. He worked in the medical device industry for a short time both before and after receiving his doctorate. But the ability to interact with medical clinicians through the GHS partnership, coupled with his motivation to improve upon the technologies being developed in the industry, lured Mercuri back to Clemson as an assistant professor of bioengineering.

"I wanted to be sure our research had an opportunity to have real-world impact down the road, to improve people's lives, improve patient outcomes," Mercuri says. The partnership adds "clinical relevancy to work being done in our Ortho-X lab"—Clemson's laboratory of Orthopaedic Tissue Regeneration and Orthobiologics.

"It's not research in a vacuum," Mercuri says. "In terms of developing biomaterials, we can do cool things in the lab, but the ultimate goal is to develop technologies that can get to the patient. I have a wonderful group of hardworking and motivated graduate and undergraduate students who are really driving these projects forward."

Reviving damaged tissue

Mercuri's lab is working on multiple orthopedic tissue regeneration projects, partnering with doctors at the Steadman Hawkins Clinic of the Carolinas, which is part of GHS, and with clinicians at the Department of Maternal-Fetal Medicine, part of the GHS Women's Hospital.

One project, still in the early "petri dish stage," already has shown promising potential to help patients stave off hip and knee replacements, Mercuri says. The research involves the use of a relatively new source of young stem cells that are gathered, with patients' consent, from amniotic membrane, a tissue that is discarded after babies are born. His goal is to repurpose these discarded cells to slow, and possibly halt, the progression of osteoarthritis.

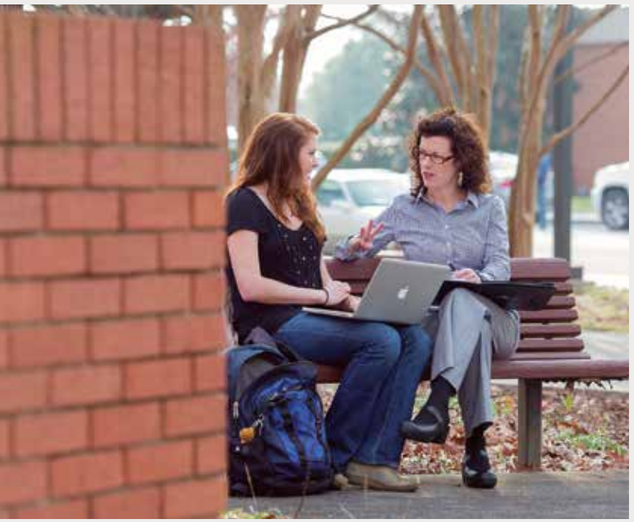
Another project would repair massive rotator cuff or shoulder tendon tears using the patients' own stem cells. Stem cells from the patients' fat would be isolated in the operating room during the tendon repair surgery. Other material from the patient's body would be molded into a scaffold in the operating room during the surgery. Stem cells would be attached to the scaffold and the structure would be placed into the repair site, where the stem cells would be turned into tendon, forming cells to aid repair of the injury.

"It all comes from the patient's body and happens in the operating room during the surgical procedure," Mercuri says. That should lower the risk of rejection, "and hopefully would result in more optimal healing and less risk of transmitting disease." This work also is in the petri dish stage and he hopes to move to representative animal models within the year.

A third project, in a very early, pre-petri stage, involves the development of a biomaterial that could be implanted in patients with both cartilage and bone defects, such as those that occur in someone injured from a fall or other trauma. This new biomaterial would need the ability to mimic both bone and cartilage, Mercuri says. He and Steadman Hawkins clinicians hope to create an off-the-shelf material that can be manufactured on a large scale.

"We're doing the research and the science, but we're also looking ahead at being able to scale it up for manufacturing to make it available to the masses. We're trying to help as many patients as possible," Mercuri says.

Craig Mahaffey



Rachel Mayo (right) with a student: "It's important for us not to judge," she says about the many circumstances of addiction.

Bridging the clinical and the academic

Mercuri builds bridges to connect the academic and clinical worlds for his students too, through a curriculum that includes student interaction with GHS clinicians "so they can truly understand the importance of bringing relevancy back to the lab," Mercuri says. His students—undergraduates and graduate students—also get exposure to research in his labs.

In addition to his lab on the Clemson campus, Mercuri, like the numerous other Clemson faculty involved in research with GHS partners, also has lab space at Greenville Health System's Patewood Medical Campus. "It's a great facility. I absolutely love it," Mercuri says. "It's a great environment that supports collaboration between clinicians and researchers."

His lab is near GHS orthopedic physicians at the Steadman Hawkins Clinic of the Carolinas, and he's been able to be in the operating room with them to see firsthand what surgery looks like for patients with osteoarthritis in their knees. He's also witnessed other surgical procedures related to his research.

"Bringing the different mindsets together is a great way to develop new ideas to solve problems. It's very mind opening," Mercuri says. "It's added value all the way around."

Shaping health care leaders

More than 13,000 people employed at GHS have participated in surveys that will provide thought-provoking data for Marissa Shuffler, an assistant professor of industrial organizational psychology at Clemson. Shuffler, who is interested in leadership development, had barely settled into her faculty position in 2013 when a casual conversation opened the door to a research partnership with GHS Vice President Tod Tappert, chief of staff and chief learning officer for the health system, and Sharon Wilson, director of conscious leadership development at GHS.

GHS has taught conscious leadership, a concept based on social and emotional intelligence or self-awareness, for years. Shuffler will analyze the effectiveness and the stickiness of the method and the message. The findings will be useful for GHS, "and hopefully for health care at a broader level," Shuffler says.

"Health care is an industry that is experiencing tremendous change. The pace of change is accelerating rapidly, and that invites what we often describe as a stress-rich environment. When things are moving fast, that opportunity to strengthen the muscle of self-awareness is really important," Tappert says.

Shuffler brings "a sense of rigor" and research knowledge, and GHS offers "a large population that can be studied over time," Tappert says. "From a data perspective, we offer a lot of value. Greenville Health System is an organization that is committed to developing and growing our leaders."

The partnership with Clemson supports GHS's mission—to "heal compassionately, teach innovatively, and improve constantly," Tappert says. The research "will benefit our commitment to patients and their families."

(For more about Marissa Shuffler's work, see the feature on page 56.)

Building a healthier state

From the newly born to those debilitated by the effects of aging, the wide spectrum of research produced through the Clemson-GHS partnership can provide new knowledge that is spurred by actual need and applicable to real life, Sherrill says.

The partnership includes four primary areas: nursing education, health care research, population health management, and health workforce development. A biomedical collaboration between Clemson and GHS goes back to 1990 and is "one of the huge success stories," Sherrill says. "We want to replicate that partnership. Health research and education is now an intentional focus area across the university."

Plans include expansion of the undergraduate nursing program to accommodate more students and a graduate nurse practitioner program to prepare students to work with underserved and primary care populations, Sherrill says.

The knowledge acquired through these research partnerships will benefit the people of South Carolina through improvements in health care delivery, a better-prepared health care workforce, and healthier outcomes for the population. "This is building a healthier state," Sherrill says.

Jennifer Hudson is a medical doctor and director of newborn services at Greenville Health System. Rachel Mayo is a professor of public health sciences at Clemson University. Windsor Sherrill is an associate vice president for health research at Clemson and chief science officer at GHS. Brad Dalton is a medical doctor at GHS and postdoctoral fellow at Clemson. Spence M. Taylor is a medical doctor and vice president of physician engagement at Greenville Health System and president of Greenville Health System Clinical University. Jeremy Mercuri is an assistant professor of bioengineering at Clemson. Marissa Shuffler is an assistant professor of industrial organizational psychology at Clemson. Tod Tappert is vice president, chief of staff, and chief learning officer at GHS. Anna Simon is a writer based in Pendleton, South Carolina.

Windsor Sherrill: "We are better together."

Craig Mahaffey

Health in a land-grant tradition

Why has Clemson University, with its deep roots in agriculture, engineering, and the land-grant tradition, forged a bold new identity for itself in the arena of health care?

For one thing, Clemson's land-grant mission has long included working in local communities to improve health, says Windsor Sherrill. For another, the faculty has developed a strong interest in topics relevant to medicine and health. Approximately 125 Clemson faculty members conduct health-related research, which has become one of the university's strategic focus areas, Sherrill says.

Clemson and the Greenville Health System (GHS) are now research partners, with Furman University and the University of South Carolina, in the nation's first shared academic health center, a formal relationship announced in late 2013.

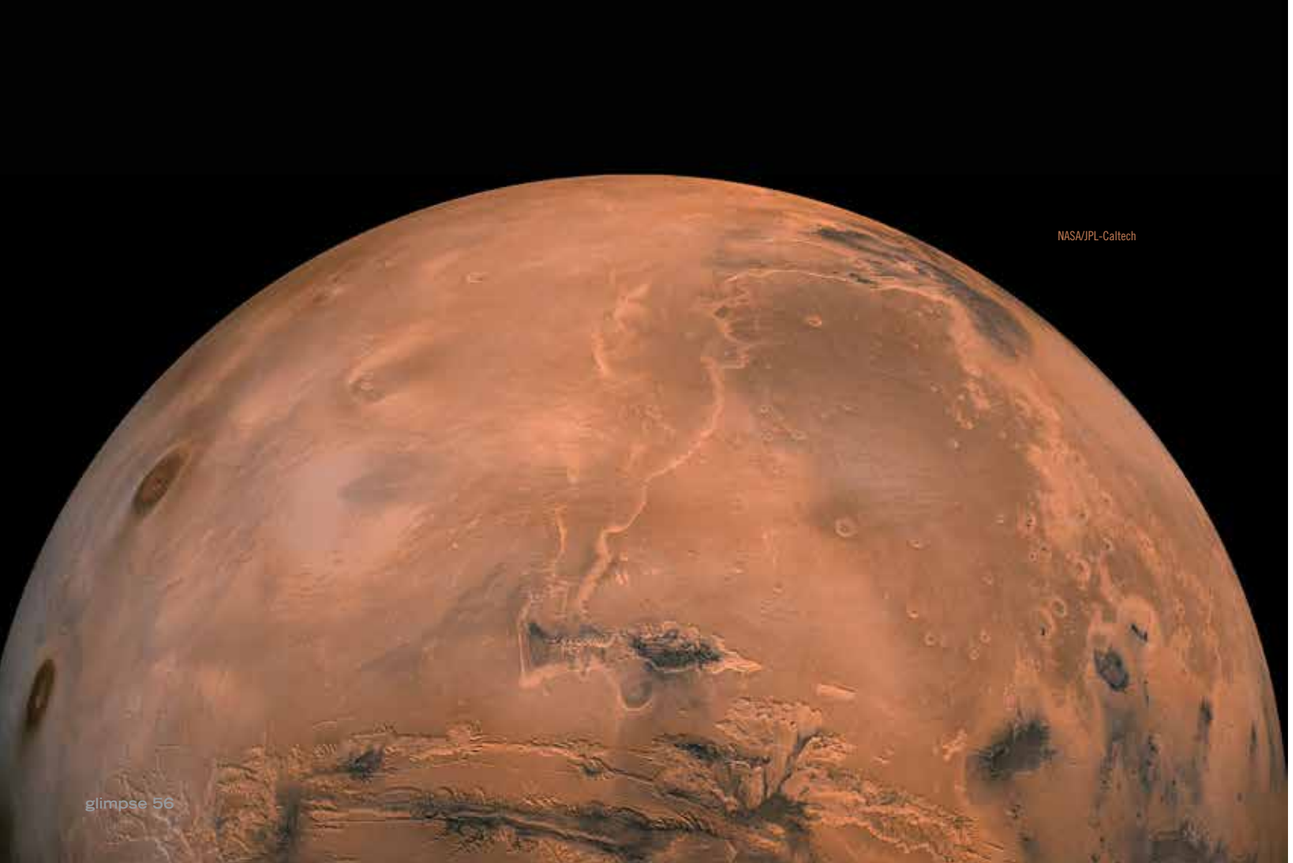
"We are better together," Sherrill says. "GHS has clinical ideas and challenges. Clemson brings the health research expertise to help study the problem, solve the problems through research and publication."

"GHS is committed to furthering Clemson's one-of-a-kind health research," says Spence M. Taylor, vice president of physician engagement for GHS and president of Greenville Health System Clinical University.

LEADERSHIP'S NEW HORIZONS

What kind of leadership will take us to Mars? A constellation, not a star.

BY LAUREN J. BRYANT



NASA/JPL-Caltech

Leadership is a hot topic. Type "leadership" into the books search bar on Amazon.com, and you'll get more than 137,000 results including *Lean In: Women, Work, and the Will to Lead* by Sheryl Sandberg, the full suite of titles by leadership guru Stephen R. Covey, and even Dale Carnegie's 1937 classic, *How to Win Friends and Influence People: The Only Book You Need to Lead You to Success.*

So what's left to say about leadership? Plenty, if you ask Marissa Shuffler. For one thing, she says, in this age of huge, complex, global systems and organizations, there's really no such thing as "a" leader.

"It's very hard to find one person who is very good at all aspects of leadership," Shuffler says. "In my research, I'm thinking about shared or collective leadership. How do multiple people take on leadership responsibilities? What makes a person likely to step up and take on leadership but also willing to step down and be led?"

Surprisingly, Shuffler started studying shared leadership in perhaps the most top-down organization there is: the military. As a consortium research fellow with the U.S. Army Research Institute from 2004 to 2006, Shuffler worked with her mentor Jay Goodwin, chief of the institute's Foundational Science Research Unit, to study the army's leadership process.

It was the post-9/11 period, when the military grappled with frequent deployments and rapid change in a largely unknown environment. The U.S. Army was being forced to transition, Shuffler says, from a "traditional warrior mentality" to a multinational, distributed approach to leading and following.

"The leadership in the United States was trying to direct and provide resources to folks in Afghanistan and Iraq," she says. "How that direction got interpreted was a big issue. That got me interested in how you prepare leaders and team members for environments that can be so challenging and different."

Hello…hello?

When it comes to challenging and different environments, the winner-take-all has got to be outer space, which is exactly where Shuffler is focusing her current research, along with colleagues from the University of Central Florida (UCF). With a grant from the National Aeronautics and Space Administration, Shuffler and her colleagues are exploring leadership in the context of long-duration space missions, specifically NASA's journey to Mars, planned to launch sometime in the 2030s.

Since her work with the U.S. Army Research Institute, Shuffler has developed expertise in the area of "high-risk" leadership—leaders who must function in stressful, demanding environments where errors in judgment can cost lives. Space travel to Mars certainly qualifies. When the human Mars mission launches, four astronauts will be confined together in a space module roughly the size of a large American bedroom for at least eight months. And their isolation will be extreme. The farther they travel from Earth, Shuffler explains, the more tenuous communication with ground control will become.

"On long-duration missions, you go from immediate contact between crew and ground control to looking at a twenty-minute delay each way," she says. "So there is a forty-minute delay between hellos."

What happens if a time-sensitive issue must be resolved? What if the situation is something neither the astronauts nor ground control has ever experienced or anticipated? Shuffler is taking a three-pronged approach to helping NASA answer these kinds of questions before the Mars mission leaves the ground.

First, she and her research team members are looking backward. Taking what she calls a "historiometric approach," Shuffler, her students, and colleagues are analyzing historical examples, such as Arctic explorations, in which teams of people were isolated in harsh environments, cut off from communication. As they explore the historical literature for common themes, ideas, and lessons, "we're thinking about adaptation and other leadership behaviors," Shuffler says. "How did the team anticipate or make sense of their situation? How did they decide to take a particular action, to adapt in new and different ways?"

The team is also studying the more recent phenomenon of round-the-world sailboat racing. The focus here is on how groups of people manage together in very confined spaces.

"The Mars mission will be years in total duration, in very small living quarters, so we're trying to make sure the astronauts don't kill each other!" Shuffler says with a laugh.

More seriously, Shuffler's goal is to identify what astronauts and mission teams can do before and during long-duration flight to build teamwork and leadership skills.

The second approach Shuffler is taking is a more controlled investigation. In her Clemson University laboratory and at a UCF lab, undergraduate students are participating in a three-and-a-half hour computer simulation, designed to study how participants handle leadership responsibilities.

Shuffler describes the computer simulation as a "Star Trek-type game" that mimics a space exploration mission during which participants must deal with environmental factors as they carry out duties resembling scientific research and technological tasks. But there are no leadership roles assigned at the outset of the simulation. The intent is to see how, when, and why leadership emerges. Who steps up, and who steps back?

"One of the big things we're most unsure about with the Mars mission is how leadership will emerge within the NASA crews as they get farther and farther away," Shuffler says.

Data from the computer simulation experiment are still being collected, but Shuffler ventures some observations based on similar research she did while earning her Ph.D. Trust is a "huge player," she says. Team members must trust one another to be willing to "put themselves out there" as leaders as well as accept leadership from others. Personality also comes into play, but not in the way you might think. It's not the "born leaders" with big personalities who emerge successfully, Shuffler notes, but rather, the person who has a strong "social astuteness," understanding when to step forward and when to follow along.

As a third way of studying leadership in outer space, Shuffler and her research colleagues are taking their work to the field, in this case, the Human Exploration Research Analog (HERA) at the Johnson Space Center in Houston.

HERA is a three-story habitat designed to resemble a space exploration environment as realistically as possible, including "simulation of isolation, confinement, and remote conditions of mission exploration," according to the HERA information package.

For two weeks at a time, HERA is inhabited by groups of four people whose age, physical characteristics, and educational background closely match that required of actual astronauts. While inside HERA, the subjects follow a strict schedule during which they carry out flight simulations, research tasks, communication with ground control, and maintenance, as well as sleep and exercise.

Meanwhile, researchers such as Shuffler carry out their own series of tasks, manipulating variables such as sleep deprivation and communication failures. HERA has a surveillance video and audio system, and NASA sends out daily updates to researchers. The HERA subjects also fill out surveys after completing their fourteen-day mission, providing what Shuffler calls a "really nice wealth of information."

The goal of all Shuffler's NASA-related work—archival research, computer simulation, and the HERA test bed—is to better understand leadership dynamics among teams whose members are a few feet and about 140 million miles apart. With greater insight into what it takes to effectively balance and coordinate leadership in such situations, Shuffler aims to provide NASA with recommendations of measures that can be taken to advance leadership development during existing training on Earth as well as during the actual mission. Although her research is ongoing, Shuffler imagines her recommendations will focus on a combination of selection and training. Astronauts are already a select group of people, of course, but Shuffler hopes to add to the list of characteristics that should be taken into account when they are chosen.

What sort of characteristics? Adaptability tops the list, Shuffler says—someone who has the ability to pick up on social dynamics, understanding when social problems arise and how to address those conflicts so that the team can get along. Essentially, Shuffler says, "you're looking for people who have a team orientation, who enjoy working with other people. It sounds really straightforward, but you'd be surprised. It's a big issue."

Developing conscious leaders

When it comes to leadership environments, you might think a brick-and-mortar health care system anchored in South Carolina would be about as different from outer space as you could get, but you'd be wrong, according to Shuffler.

"Folks in health care aren't stuck together in a small physical space for what seems like forever," she says, "but day to day, a lot of folks are making life and death decisions. It has its high-risk component."

That high-risk component is what brings Shuffler to another of her current research projects, studying leadership development within the Greenville Health System. For the last eight years or so, Shuffler explains, GHS has been developing a "conscious leadership" program among the system's approximately 3,500 employees. In Shuffler's words, conscious leadership involves leaders being aware of and attentive to both what is going on in the moment and their own reactions. "It's about regulating your emotions in order to promote a healthy climate for teamwork and accomplishing tasks at all levels of the organization," she says.

GHS reached out to Shuffler to assess how well this approach is working and how it might be further developed or expanded. Last fall, Shuffler surveyed about five hundred GHS leaders to measure where they stood with respect to conscious leadership principles such as openness, honesty, and responsibility. This spring, she conducted a survey of GHS employee engagement. Using data from both surveys, she's now looking for links between leaders' understanding of conscious leadership principles and employee satisfaction.

What kind of behaviors do leaders exhibit? What does leadership look like for a top manager versus a front-line nursing manager? Those are the kinds of questions Shuffler is exploring, and although she is still analyzing all the survey data, she says, preliminarily, that "there is definitely something going on.

"We're seeing that leaders who have a better understanding of conscious leadership have employees who are more engaged and committed," she says. "The question is, what's driving that? Were they good leaders already, or is it the specific conscious leadership approach?"

Shuffler is setting up focus groups and interviews with GHS leaders at various levels to explore whether and how leaders are applying conscious leadership principles in their everyday work. Already, though, Shuffler is sure of one result.

"Whether it's NASA or GHS," she says, "the ability to adapt is huge."

NASA

NASA's Human Exploration Research Analog (HERA).

Patrick Wright

Marissa Shuffler: Shared leadership improves success when the challenge is technically complex.

No 'i' in leader

These days, health care environments are constantly changing, from policies to medical procedures to billing processes, and, like outer space, they can be unpredictable, high-demand environments where shared leadership is essential, Shuffler says. She calls it "collective leadership," pointing out that it's been around for a long time.

"We've been doing it for years and years," she says. "Look at the top management teams of major organizations. There's not just one person, but multiple people sharing responsibilities. We see this even in our own everyday work groups, where there may be a formally appointed leader, but someone else steps up."

Collective leadership centers on leaders who also operate as team members and who pay attention to context. What works in one situation is not going to work in every situation, Shuffler notes, and the leader who assumes she or he can just do the same thing all the time won't succeed. On the other hand, successfully sharing leadership has strong positive effects on performance and outcomes, Shuffler says.

So why is it that so many teams function badly?

Because we're not paying attention. Too often, that "works well with others" line on a résumé just isn't true. A team may be together, Shuffler says, but "focused on jumping in and getting busy on the task." Instead, "we need to figure out how to work together as a team first. Who knows what? How are we going to share that information? What's the best way to communicate?"

To build a team this way takes time and sensitivity, Shuffler says, especially in the 21st century, when so many teams are virtual, united only through emails and videoconference screens. Building trust with such virtual teams is distinctly challenging, a reality that Shuffler focuses on during her "Teamwork in the 21st Century" course.

During the course, Clemson students participate on virtual teams with students from other universities. Shuffler notes that most students find it a "very eye-opening experience" to "feel like a team" without depersonalizing remote team members or blaming them when something goes wrong. It's not always a smooth process, but Shuffler says, "I'd rather they learn about that here in the classroom so that their first time dealing with virtual teamwork isn't on the job."

As steeped as she is in the complexities of leadership qualities, good and bad, it could be hard for Shuffler to identify someone she thinks of as a great leader. When asked that question, however, she has a ready reply.

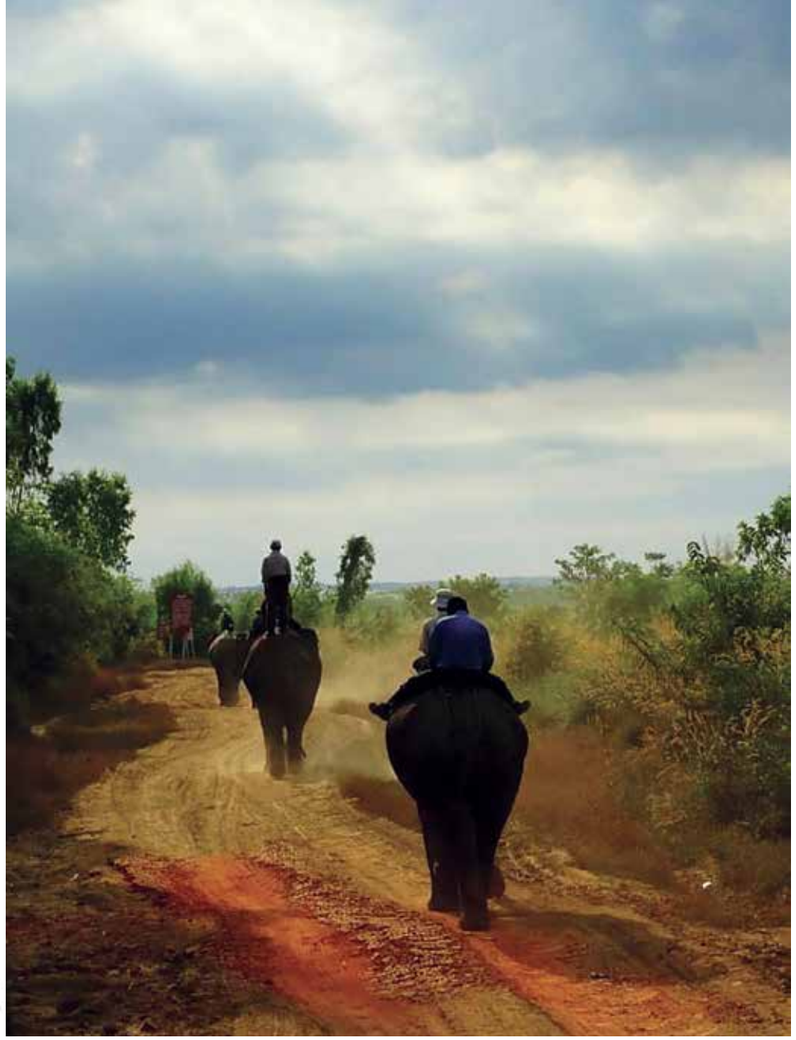
"Honestly, I would say my dad. He's an engineer, and I spent a summer working for him prior to starting graduate school. Engineers aren't typically known for their social skills but my dad is very adept, keeping people in the office engaged, showing care and concern, but also keeping everyone on task and moving forward. I definitely admire his leadership."

Marissa Shuffler is an assistant professor of industrial and organizational psychology in the College of Business and Behavioral Science. Lauren J. Bryant is a writer in Bloomington, Indiana.

Making peace with the giants

When Christie Sampson tracks a herd across Myanmar, the fabled vampire elephant is the least of her worries.

by Jemma Everyhope-Roser
photos by Christie Sampson



Above: The team on the trail of wild elephants.
Left: In this excerpt from a project map, each point represents the GPS position of an elephant, and each color a different elephant. The collars automatically update locations once an hour.

"THE FIRST WORDS I USUALLY LEARN in a country are 'hello,' 'thank you,' and 'run,'" says Christie Sampson, a Ph.D. student in biological sciences who studies human-elephant conflict, most recently in Myanmar. "People think this is a glamorous project. Riding on elephants all day. But a lot of the time, like most biology projects, you're out looking for scat, or dung."

Once, in Sri Lanka, Sampson used dung to do population estimates by walking kilometer-long transects. "You walk in a straight line and you look on each side, and every time you see a dung pile, you measure it and mark it down." Sampson, intently focused on staying on course and accurately noting each dung pile, became oblivious to her wider surroundings. Until, that is, a lookout jogging alongside her shouted, "*Run!*"

Sometimes, a nervous or irritable elephant will trumpet. Or stomp and stir up dust. Or rip out grass and throw it. Sometimes. But not always. Sometimes, elephants charge without warning.

"If they feel aggressive, if they feel scared, they'll charge you," Sampson says. "I'm not a very good tree climber. So I usually end up hiding under bushes."

Then one of the team uses fire crackers to scare the elephant off.

In North America, we tend to regard elephants as wise, gentle giants, but the reality of living alongside these animals can be intense. Sampson works closely with villages experiencing human-elephant conflict, where 38 percent of the farmers lose 50 percent or more of their crop to foraging elephants.

"These people," Sampson says, "are some of the poorest people in the world. When they lose an entire crop, they can't feed themselves, they can't feed their families, and that was all of their income for the year."

Then, there are the deaths. Usually about three to six per year, in the thirty-four villages.

Newcomers are often fearful

Sampson is part of a team that includes researchers and staff from Clemson University, the Smithsonian Conservation Biology Institute, and the government of Myanmar. Sampson has administered a survey—with the help of her government liaison and translator U Aung Kyaw—to determine not only the extent of the damage but also to assess overall attitudes toward elephant conservation and villagers' willingness to participate in management strategies. The survey, tried and true, has twenty-five questions, five of which address demographics while the other twenty focus on the issues at hand.

Sampson found that most villagers are newcomers, drawn to the area for the same reason the elephants are: water. The government, to tide the ex-capital of Yangon over during the dry season, built a reservoir. "It was right in elephant habitat," Sampson explains, "so you're creating the largest water bowl for elephants."

As these incoming farmers are unfamiliar with elephants, they're also terrified by them, a finding also backed by Sampson's experiences in Myanmar. One time, Sampson says, when seeking confirmation of radiotelemetry data from some collars, "I had two trackers with me and an elephant popped up about a hundred meters away. The trackers took off running in the opposite direction, they were so terrified. And the whole purpose for us being out there was to find the elephant and make visual observations. But their mindset is that elephants are absolutely terrifying, and that's one of the things we have to overcome."

Probably the legend of the vampire elephant doesn't help.

When reviewing the translated survey answers, Sampson couldn't believe what she'd stumbled across. A vampire elephant? Sampson flipped through the translation, and the story kept cropping up. "It's not something you expect to hear, so I was like, 'Are you sure you're getting that word right?' Yes, it really was vampire."

A couple of villages believe that a vampire elephant kills people and drinks their blood.

"As soon as we find the vampire elephant, all of our problems will be solved," Sampson says, laughing.

If only it were that easy.

Currently, management techniques in this area consist of driving the elephants back from the fields. Sometimes farmers do this using trucks, captive elephants, or firecrackers. But this doesn't prevent hungry elephants from returning the next night, or the next, in search of a mouthful of delicious sugarcane.

As a result, many locals are in favor of translocating *all* elephants (but especially the vampire elephant).

To translocate a solitary male, a team darts the elephant, hauls it up onto a flatbed truck, and moves the elephant to another location. But, Sampson says, data from the satellite GPS collars shows that elephants turn around and go right back home. Sampson cites the example of an elephant in Sri Lanka, Homie, who was removed several times from the premises of the garbage dump he was terrorizing. Eventually, Homie was found shot, presumably for attacking people.

But translocating females, who live in herds with their calves and adolescents, presents other obstacles. Moving these herds can take months. In what's called an elephant drive, people will follow behind an elephant herd, throwing firecrackers at them daily to get the elephants to move away from a populated area over to a more remote location.

"It can really traumatize herds to be followed for months," Sampson says. "And it can make them very aggressive. Constant bombardment. Loud noises. Scary things."

What's more, these elephants are relocated into unsuitable habitats, such as mature forests. Unlike African elephants, which roam the savannah, these elephants prefer secondary forest, the scrubby brush that pops up after logging, burning, or farming. This means that, by their very nature, Asian elephants are suited to human-altered environments.

Sri Lanka provides an example: Researchers worked with locals whose traditional farming method, called chena, involved cultivating a patch of forest for a few seasons and letting it lie fallow. As a compromise, elephants would chomp on the leftover crops. "It was very congenial," Sampson says, "and it reduced a lot of tension." Of course, now that corporations are installing monocultures such as banana fields or oil palm, this system is breaking down and violence is spiking.

As for Myanmar, "these elephants don't have anywhere else to go," Sampson says. "They can't move anywhere else in the country. There are other elephants and other people there. Habitat is being lost and fragmented everywhere, and there's just no place to go."

The team forms a capture plan after locating a wild elephant.

Above: Veterinary staff assess the health of a sedated wild elephant.
Below: Christie Sampson (center) studies a map with U Aung Kyaw (left) and Melissa Songer from the Smithsonian.

Suzan Murray

Good fences make good neighbors.

Alternatives to scaring elephants back or to translocating elephants include forms of fencing: temporary electric fences, bee fences, buffer crops, and living fences. Sampson, who favors the temporary electric fencing option, critiques bee fences, which consist of hives hung along fences to dissuade elephants. The problem with bee fences, Sampson explains, is that human-elephant conflict tends to occur at night, and bees don't fly at night. Buffer crops consist of planting a crop unpalatable to elephants around the crop a farmer is interested in protecting. For example, elephants love rice paddies but hate chilies. So, planting chilies around a rice paddy may protect it. The living fences option, which involves cultivating a thick, impassable briar around crops, has its own drawbacks. Often, the plant species used as living fences are invasive.

Why temporary electric fencing?

It needs to be temporary so that it can be removed when it's not in use. This conserves wear-and-tear on the fence, prevents locals from harvesting wire from the fence in off-seasons (thereby destroying it), and also ensures that when the fence is up, it's on.

Why is that last part so critical?

Well, elephants are intelligent. "If you don't have the electric fence turned on all the time and you're not maintaining it, they will quickly learn you can push it over and nothing bad is really going to happen. One elephant was actually observed pushing females into the fence to knock it over, and then walking over the fence."

Powered by solar and easily portable, temporary electric fencing can be moved to accommodate shifting agricultural plots and fallow fields. It's also got a proven track record in Sri Lanka as a workable management strategy.

When determining where the fences would be most effective, the researchers must watch how elephants use the landscape. Sampson and the others do this by collaring elephants and tracking their movements. Recently, she and her team collared four elephants. Next time, they hope to do ten. Eventually, the goal is to have thirty collared elephants.

To collar elephants, one must first find elephants. And, Sampson says, for such immense animals, elephants can be remarkably stealthy. The search draws the researchers deep into rough terrain seething with heat. Often the researchers must hike ten to fifteen miles per day through the tropical forests, carrying heavy equipment. The collars alone weigh twenty-six pounds apiece.

But the researchers do have help. "That's where the captive elephants come in handy," Sampson says. Usually the researchers draw on a team of captive elephants—they're not called "tame" because they're not at all tame—from a nearby logging camp. Elephants captured for logging are some of the largest elephants in the country, and the researchers usually have a team of up to fifteen animals with them, the smaller animals serving as pack animals while the larger are ridden.

"They have such great personalities and diverse personalities that you start to forget every once and a while that they are still wild animals inside," Sampson says. "But everything can change in a second. You need to respect the animal. That's something easily forgotten when you're living so closely with them and working with them every day. I would never go up to an elephant without one of their trainers, one of their mahouts, nearby."

With captive elephants assisting, the researchers search for wild elephants. When they do find an elephant, they must assess whether it ought to be collared. Is the elephant sick? Is the elephant a female that's either pregnant or has a nursing calf? They seek out healthy animals. And naturally, Sampson and her team prefer to target conflict elephants.

Then, carefully, the researchers plan an ambush. The set-up must be elaborate and precise, taking into account technical failures such as dart guns jamming. The terrain must be suitable: the elephant must be far from hazards, including water, when he goes down so that he won't injure himself. "After you dart him, you have to be far enough back that he can't turn and come after you. You have to be close enough that you can follow him as he takes off—they run *really* fast—into the forest. This is teak forest. It's dense. Or, you can be going through bamboo, running blindly after the elephant."

Luckily, the darts have VHF trackers, which can help locate the downed elephant. The urgency in reaching the elephant is out of concern for its health. The researchers immediately check to make sure the elephant has fallen into a safe position, not lying on its chest but rather comfortably on its side. The on-site vet carefully monitors the elephant's breath and pulse, looking for a spike or drop.

"We have to be very specific about the time of day we dart them," Sampson adds. "If it gets too hot, it's unsafe for the elephant. It's nice when it's cool."

Now, every minute counts, and every person has a task. The elephant shifts as the research team works. As elephant necks do not articulate, the team cannot lift the dazed animal's head to slide on the collar. Instead, they dig a hole under the elephant's neck and loop the collar around, adjusting it. For a practiced team, this process takes twenty-five minutes.

Not all collars are made equal, Sampson says, and explains that the types of collars her team uses can be divided into two camps: a satellite collar, and a collar that's based on cellphone technology. Each has its benefits and drawbacks. But they're all pricey, clocking in at about six thousand dollars apiece, including equipment, satellite time, and pay for the crew.

Traumas and troublemakers

Sampson and the team are also investigating other measures to minimize human-elephant conflict. A possibility involves translocating problematic elephants to an "elephant jail" within a national reserve. "No, we don't think there's a vampire elephant," Sampson laughs.

Usually there's a couple of male troublemakers. Often an entire herd can bear the brunt a lone male's transgressions, because herds are easier to spot and females are smaller, so make easier targets than the solitary, large males. Removing a single irate bull can improve an entire nearby herd's quality of life, as well as the relations between our two species, immensely.

Sometimes, the elephant becomes a problem not because it's acting out but instead because it's been traumatized by previous interactions with humans. Sampson cites a female, Canahela, who lost her calf to a car. The bereft mother would pursue cars, slamming her trunk into vehicles or throwing things.

Whatever the case, researchers need to be able to identify these individuals so they can capture them and prevent them from doing harm. But how to gain DNA samples from these elephants? You can't ask an elephant for a cheek swab.

Instead, Sampson will be out again (perhaps while you're reading this very issue), searching for dung, swabbing it to collect elephant DNA.

"The DNA will help us address the question of whether it's a couple of animals who are doing most of the crop raiding or causing conflict events," Sampson says. "So we'll collect dung from conflict sites and then compare it to the dung throughout the landscape. If we find the same dung from the same individual from all of these different agricultural areas that were crop raided, then we'll be able to say, 'Okay. It's just one elephant.'"

Soon, with grassroots support, the survey, DNA testing, and tracking collars charting the elephants' movement, Sampson expects that she and the team will be able to develop effective management strategies. Every area has unique issues and concerns that must be accounted for, and the recent survey helped her discover what's important to the locals in this area.

"We've found," Sampson explains, regarding the survey, "that they're overall very supportive of elephant conservation. 'Yes, we want to keep elephants. They're important to nature. They're a very precious animal. But... We want you to move them all from here to another part of the reserve.'"

While translocating elephants may not be possible or practical, Sampson says, "This will help us hone in on which management strategies we should pick, which may be the most effective, and which will help us resolve as much as we can as fast as we can."

Christie Sampson is a Ph.D. student whose advisor is David W. Tonkyn, professor of biological sciences in the College of Agriculture, Forestry, and Life Sciences. The Human-Elephant Conflict project is a collaboration of the Myanmar government, the Smithsonian Conservation Biology Institute, and Clemson University. It is conducted in cooperation with the Nature and Wildlife Conservation Division of the Ministry of Environmental Conservation and Forestry, Myanmar.

U Aung Kyaw

Respecting the culture

These projects don't work if the communities aren't involved in them from the beginning," Sampson says. Here, she speaks to a group of school children about the project.

A township's local forest officer sets up town hall-style meetings where the team can hear people's concerns. In the field, Sampson lives with villagers, often spending her evenings with the children, who try to teach her Myanma.

"Every day you live with these people, you eat with these people, and you learn the culture, you respect the culture," Sampson says, "and figure out what's important to them and how you can incorporate that into your project."

Into the Literary Spotlight in Every Way

Nic Brown enjoys the ride with his new novel.

by Jeff Worley

Cinny Diguiseppi

Nic Brown swapped drumming for the long, quiet solitude of writing novels.

Chapel Hill art student Maria finds herself in a quandary. Unexpectedly pregnant at nineteen and recently stunned by the news of her mother's diagnosis of cancer, Maria decides to give up her daughter for adoption. At loose ends, she agrees to go with her mother to the sleepy coastal town of Beaufort, where the adoptive couple Maria has chosen for her daughter just happens to live. An opportunity presents itself for Maria to accept a position as the couple's nanny, and in this fortuitous way she becomes reunited with her baby.

Many complications follow.

This plot twist is the narrative hook that reels the reader into *In Every Way,* Nic Brown's second novel, published earlier this year by Counterpoint Press. Brown joined the Clemson English department faculty in August of 2014 and, in addition to his own writing, teaches fiction workshops and contemporary literature. Brown explains that his new book was triggered by the birth of his daughter.

"This is the first novel I've written in its entirety since becoming a father," Brown says, "so the main thing on my mind was parenthood." He began writing the story from the perspective of the baby's father, Maria's boyfriend, but soon realized that this wasn't really his story.

"I realized the compass was pointing elsewhere. It was Maria's story, and once I established her as the point-of-view character, events unfolded more easily and naturally."

The irony of Maria becoming the nanny for her own baby was, Brown says, "just something the story needed. As an unmarried nineteen-year-old with a dubious (read: unreliable) partner, she felt she couldn't keep the baby. But the story needs her to see her baby again, so how could I do that, put her in proximity like this?" It was, he adds, a technical problem he had to solve.

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Brown's path to becoming a novelist and university professor wasn't a predictable one. Along the way, you could say, he marched to the beat of a different drummer.

"Yes," Brown laughs, "you could say that all right." His first professional job was as the drummer in a popular and successful rock band called Athenaeum, which formed when Nic was attending Greensboro Day School in North Carolina. He and his public high school bandmates clicked as musicians, soon found themselves playing gigs around Greensboro, and made a demo tape when Brown became a junior.

"We thought we were pretty good," says Brown, a boyish thirty-eight, who sports a trim, black beard and tends to gesture with his left arm when he speaks, almost as if orchestrating his words. "Our demo tape caught the eyes and ears of a few people at Atlantic Records and, amazingly, we signed a big record deal—every high school rock and roll kid's dream—with Atlantic and toured successfully for a decade." The band released their major label debut, *Radiance,* in 1998. A single from that album, "What I Didn't Know," was a minor hit in the United States.

Being a road musician, as the phrase implies, involved a lot of travel but also a lot of down time, Brown explains. Always a voracious reader, when he wasn't behind his set of drums in the studio or in performance he spent a lot of time reading novels and short stories, and in 1999, "between albums," started writing fiction seriously.

"I wrote stories as just another creative outlet and found myself devoting more and more time to doing this," Brown says. He decided that writing was now the creative outlet he most wanted to pursue, and since he had been accepted as a student at Columbia University a few years earlier (but wanted to see how his music career played out), he found out that he had "active deferment status" and so became an English major there. "I knew exactly what I wanted to do—take as many writing courses as possible."

After earning a B.A. in English/creative writing at Columbia, Brown decided to up the ante—he applied and was accepted into the oldest and, many would say, most prestigious M.F.A. program in the country, the University of Iowa Writers' Workshop.

"I was really naïve about getting into an M.F.A. program," he confesses. "I kind of randomly applied to handful of programs and remember it as a great moment when I got the acceptance letter from Iowa, which included the offer of a fellowship."

One reason Brown wanted to pursue an M.F.A., he admits, is that he had no perspective on his writing: Was it any good? How could he make it better?

And at this point in his life, for him literature easily trumped music. When he and his fiancée, Abby, moved to Iowa, that was clearly "the death knell" for his music career, he adds.

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Brown says his interest in literature had been smoldering for quite a while when a teacher in middle school lit him up.

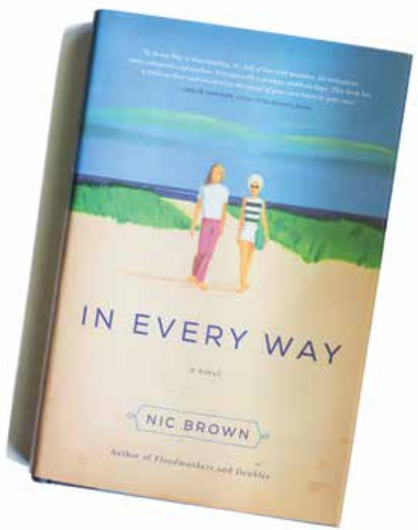
"One man really kindled that fire, introduced me to good books, and made it clear that writing was something a person, if he was serious and dedicated, could do as a livelihood," Brown says emphatically. "Bill Moore made literature come alive for the class. How important is his influence? I'm teaching a gen ed lit class right now, and sometimes I feel he's standing right beside me!" Brown laughs. "Last week when I gave a lecture in my Clemson class on *The Great Gatsby,* I found myself mouthing Bill's lines from twenty-five years ago."

"I vividly remember Nic on our campus," says Moore, who describes himself as a semi-retired teacher and longtime blues musician. "He always had a bounce in his step and an observant, appraising eye. Nic was in my honors American lit class his junior year and wrote elegant, sassy, analytic essays that were wonderful to read for an English teacher who had too many banal essays on his desk to wade through."

Moore adds that Brown stood out as an independent thinker with significant insights and strong literary opinions, and recalls that after taking a creative writing class, Brown entered his work in High Point University's literary contest—and took first prize. "I even remember his winning entry," Moore says. "It was a spooky short story that featured a young man obsessively listening to one mysterious word on a tape cassette."

Years later, another teacher who greatly affected Brown was Chris Offutt, a prize-winning novelist and short story writer who teaches in the Iowa M.F.A. program. "He changed my life as a writer, teaching me the importance of paying close attention to language and structure. I learned from Chris the importance of craft."

"Nic wrote part of his first book, *Floodmarkers,* while in my class," Offutt says. "He's a careful writer, able to surprise the reader while moving relentlessly towards inevitability. In the years since meeting, we've both worked to transcend the natural gap between teacher and student. We've become friends. Our families have become friends. When Nic and I get together, we mainly laugh and laugh," says Offutt, adding that he and Brown recently taught together at the University of Mississippi when Brown was the John and Renee Grisham Visiting Writer in Residence.



A university literature teacher himself now, Brown loves to be in the classroom and says that if he hadn't found a way as a fiction writer to be a teacher, he would have found some other route, and could have been happy teaching high school English.

"That would have been fine too. I like talking about books with students, and trying to get them excited by good literature." Brown adds that the idea of being a professor enticed him even back when he was a drummer in a band. "I'd have my magazine subscriptions sent to Professor Nic Brown, clearly a weird part of my identity back then—I didn't even have an undergraduate degree yet!"

Now that he has advanced by degrees into the life of a successful novelist, what is the biggest challenge for Brown as he moves a novel forward page by page?

"Maybe for me the most challenging thing is to enter the consciousness of my characters in an interesting and believable way," Brown responds. He adds that this was initially "a bit tricky" in his newest novel as he entered the mind of Maria, who is nineteen and pregnant. "I suppose a reviewer might say that it's presumptuous for a male writer to narrate a complicated story from the point of view of a woman, but as a craftsman I felt strongly that this was the best way to tell the story. I was a lot more interested in writing what it is to be human than in gender issues." Brown adds that as a new father he identified with the immediate connection Maria feels for her baby and the young mother's desire to be around her child.

When asked what surprised him the most about writing this novel, Brown pauses. "That's a good question," he says. "Truthfully, the biggest surprise for me was how much I missed it when it was over—missed these characters I'd invented. I felt a void after I was done because I loved writing that book so much."

Nic Brown is an assistant professor of English in the College of Architecture, Arts, and Humanities. Jeff Worley is a poet and writer based in Lexington, Kentucky.

Seeing *Doubles*

Nic Brown's first novel optioned for film

Doubles, which Nic Brown wrote while teaching at the University of North Carolina eight years ago, has been described by reviewers as "a strange and lovely meditation on friendship and love and loss...filled with razor-sharp observation and irreverent wisdom," and as "a refreshing and surprisingly precise take on the daily grind of the pro tennis tour."

The reviews in *Library Journal* and elsewhere were extremely favorable, and now a North Carolina director and film producer, David Burris, is working to secure the movie rights for *Doubles*. In the world of film, Burris is best known for the TV series "Survivor," for which he has produced over a hundred episodes.

It was no accident that *Doubles* came to Burris's attention—Brown sent him a copy.

"I read it immediately and loved the novel," says Burris, who has also written and produced TV documentaries. "I think *Doubles* is perfect to adapt for film because so many scenes are incredibly sad and incredibly funny at same time. That's a powerful mix, and isn't done successfully very often."

Brown and Burris are far from strangers. They met, Burris says, "on tour together," emphasizing the word "tour" and laughing at this glamorous-sounding phrase. "Okay, it was at a rock & roll club in Charlotte," he explains, "when my band and Nic's band played a show together in the late 1990s." Burris was a guitarist in a group called Jolene, and recalls that his first conversation with Nic-the-drummer was about books.

"I was reading a Walker Percy novel for about the third time, and Nic was very enthusiastic and knowledgeable about American fiction. We just clicked."

"My overwhelming first impression of David," says Brown, who believes their first-ever meeting was in Champaign, Illinois, rather than in Charlotte, "was that he was very smart and well read. As I remember it, our first conversation was in the back of a van, at night, on the way to a show—and we talked about literature. It was the antithesis of how people might think of how a couple of rock and rollers spend time together."

Currently, the film adaptation of *Doubles* is in the developmental stage, Burris says. His company, Taking Pictures, is in "pre-preproduction," trying to secure financing and working to get the best cast possible. The process that leads to a completed film is challenging and stressful, he says, but also fun.

"Right now we're beginning to think creatively about how to put the pieces together. The casting game is a lot of fun, and one strength of the novel is that all five of the main characters in Nic's book will definitely appeal to actors. All five are key to the narrative—the interplay among them is multilayered, very rich and substantial." At least part of the film, Burris adds, will be filmed in North Carolina.

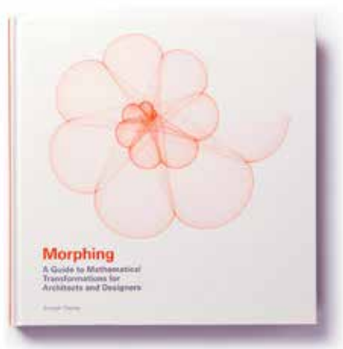
For his part, Brown is currently cowriting the screenplay with Emily Testa, a writer and marketing consultant based in Savannah, Georgia.

"She dreamed up this whole idea to begin with," Brown says. "Emily reviewed *Doubles* for the magazine *Bomb*, and then in 2013 got in touch, asking if I would be interested in adapting my novel to film." He adds that the great thing about working on a screenplay is that, unlike writing a novel, he gets to work with other people. "Writing fiction can be so alienating—you spend hours alone in a room—but this project has involved a different kind of energy, and I like that."

"There's real joy in working with someone as talented as Nic," Burris concludes. "A lot of good art can come out of collaborations like this."

Courtesy of Joseph Choma

Using math to escape the box



Boundaries 02, 2013, Joseph Choma's "inhabitable drawing installation," as he calls it, questions what it means to draw and experience a drawing. Escaping the bounds of an ordinary frame, the sixteen-by-twenty-foot drawing occupies a wall and part of the floor in the Barbara Archer Gallery in Atlanta, Georgia. Thousands of lines are scratched into glossy black paint on medium density fiberboard. Like much of Choma's work, it investigates the blurring of perceived spatial boundaries.

Choma, who first came to Clemson last fall as a visiting professor and joined the faculty in the School of Architecture this year, uses design to engage in epistemology—what knowledge is and how it can be acquired. In his first book, *Morphing: A Guide to Mathematical Transformations for Architects and Designers* (Laurence King Publishing, January 2015), he created a new way to understand and use trigonometric functions as design tools.

Choma studied design and computation at the Massachusetts Institute of Technology, where he became "interested in the inner computational workings behind digital tools," he says. Many contemporary design students are more interested in learning how to use digital tools—computer programs—than understanding how they work and influence the set of possible results. To learn what was "under the hood," Choma says, he "began researching mathematics, as a means to demystify" the software.

In 2009, Choma founded the Design Topology Lab, an interdisciplinary design research practice. His work has been exhibited internationally, including a solo exhibit at the MIT Museum as part of the 2010 Cambridge Science Festival, the 4th Architectural Biennial Beijing, and the 9th International Beyond Media Festival in Florence. In 2013, he was awarded the Emerging Voices citation by the AIA Atlanta for his contribution to the field of architecture through research and experimentation.

Joseph Choma is an assistant professor in the School of Architecture, College of Architecture, Arts, and Humanities. For more about his work, go to www.designtopology.com.

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Ken Scar

Sometimes, you still need a saw.

Dan Harding, whose architecture studio led design work for Clemson's entry in the U.S. Department of Energy Solar Decathlon, uses a chainsaw to tame a balky bit of framing for the outdoor steps of the prototype, called Indigo Pine East. Saws, like hammers, were scarce on the project, which used computer-guided cutting and zip-tied framing for speed and safety. Page 26.