IDEaS

INQUIRY, DISCOVERY IN ENGINEERING AND SCIENCE FALL 2015 COLLEGE OF ENGINEERING AND SCIENCE

A Tree Grows

Happy, healthy and thriving in the city thanks to Clemson researchers.

page 4

CLEMSON
College of ENGINEERING AND SCIENCE

FROM THE DEAN

Engineers and scientists have always risen to the challenges of their time, from putting a man on the moon to providing clean water here on Earth. As technology advances and the world becomes more interconnected, society's grand challenges become increasingly complex. It's our job in the College of Engineering and Science to ensure that students are ready to meet those challenges.

This issue is all about showing you some of the ways we're preparing them.

Meaningful and immersive engagement experiences are a core part of our plan. They keep the students motivated, show them how their skills can benefit society and sometimes spin off businesses that create jobs. Be sure to check our section on sustainability for several examples. In one piece, we profile a group of Clemson students who went to Haiti and built a biodigester that processes potentially dangerous waste, turning it into fertilizer for banana trees and methane gas that fuels stoves in a communal kitchen.

It is also of the highest importance that we provide our students and faculty members with world-class facilities. The facilities play a key role in attracting and securing top talent and doing translational research that takes inventions from the lab to the marketplace, where they can contribute to the greater good. In our sustainability section, you'll learn about a rare piece of equipment: an electron beam ion trap that is in the Kinard Laboratory of Physics. Chad Sosolik uses the machine, also known as an EBIT, to poke atom-size holes in graphene. It could lead to new membranes for desalinating seawater.

Any organization is only as good as the people in it, so in this issue we recognize the unique influence of bringing top talent to the college. Three of our faculty members have won prestigious awards that go only to the nation's top early-career researchers. Be sure to read the interviews with Mark Blenner, Jacob Sorber and Sophie Wang to find out why they came to Clemson and to learn what's next for them.

Speaking of top talent, in these pages you'll find a story that brings together the best of Clemson football and industrial engineering. Tony Elliott, the Tigers' co-offensive coordinator and running backs coach, sat down for an interview with Cole Smith, the chairman of the Department of Industrial Engineering. Elliott, who holds an industrial engineering degree from Clemson, had some advice on how to succeed in the classroom and beyond.

We are also always looking to strengthen our ties to alumni and future Tigers. Both are key to our future success. We feature four remarkable alumni — Imtiaz Haque, Thomas Hash, Robert Mitchell and Bob Stanzione — in a story about the newest inductees into the Thomas Green Clemson Academy of Engineers and Scientists.

You'll also discover in the pages of this issue how we're reaching out to K-12 students to widen the talent pipeline not just three or four years from now, but a decade or more away. Programs, such as "Emagine!" and the STEAM (Science, Technology, Engineering, Arts and Mathematics) Network, are introducing engineering and science concepts to students as young as middle school age.

Our legacy depends on how well prepared students are to meet the grand challenges of the 21st century. We have every reason to be optimistic. This issue contains only a sampling of what we do in the college every day.

As always, I welcome your comments, observations and suggestions.

Anand Gramopadhye, Dean
College of Engineering and Science

IDEAS

INQUIRY, DISCOVERY IN ENGINEERING AND SCIENCE FALL 2015 COLLEGE OF ENGINEERING AND SCIENCE

Clemson researchers use federal grants to make new discoveries.

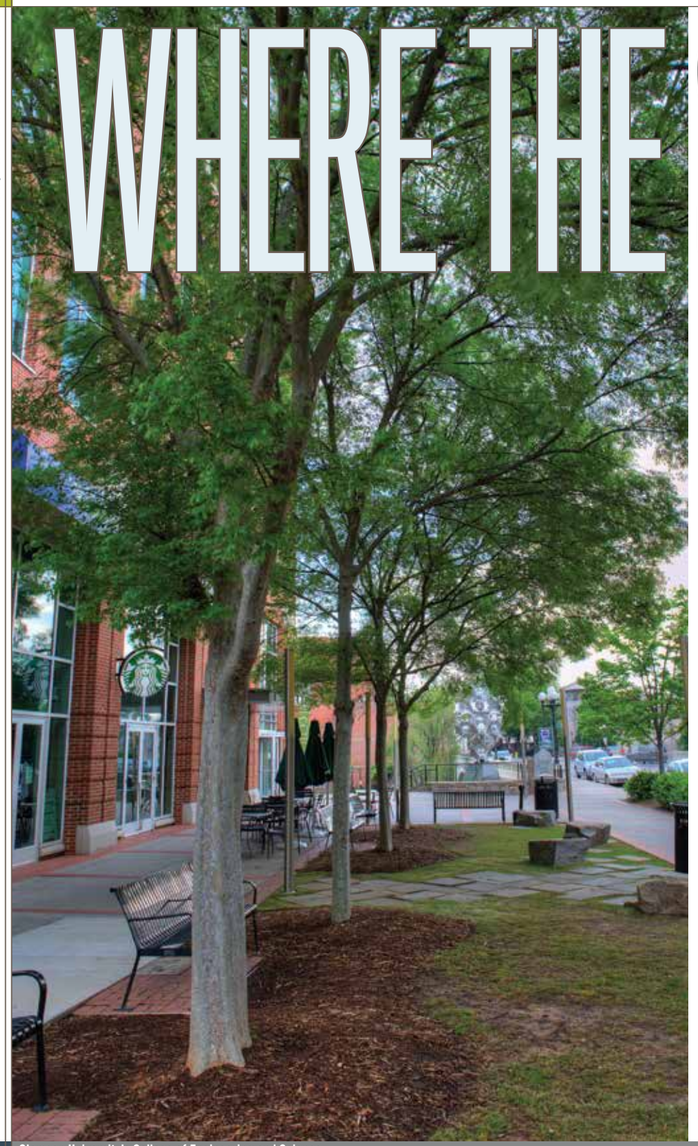
page 12

CLEMSON
College of ENGINEERING AND SCIENCE

IN THIS ISSUE

Achievable, sustainable solutions for a safer, cleaner, more beautiful planet: Clemson faculty tackle some of the world's most pressing environmental problems. Their research, expertise and innovation are leading the future and making a much-needed ...

GREEN CONNECTION



WHERE THE SIDEWALK GROWS

A civil engineer and a landscape architect team up for a solution to growing trees in the city.

by Neil Caudle

It has always intrigued landscape architecture professor Paul Russell how a tree can be taken from a nursery in a happy condition, with healthy roots and strong branches — digging it up, putting it on a truck and moving it to an urban environment — and be expected to thrive, even survive.

"It just isn't normal," he says.

Russell considers urban trees elements in a pleasing, enduring design. Even in a city — perhaps especially in a city. People like the deep, cooling shade and rustling leaves of big trees. Because people like trees, trees are good for business and merchants enjoy seeing their businesses grow right along with the trees. But dead or stunted trees do not gratify anything. So Russell wondered, how do we make a tree healthy and happy, when it's planted in a city or suburb? How do we know what kind of pavement to use around it, and how near should that pavement come to the base of the trunk?

To answer those questions, Russell needed an engineer, and he happened to know one: Brad Putman is a civil engineer who studies various paving materials and how to make them stronger, more durable and more environmentally friendly. He is also a friend of Russell's. So the two hatched a plan. They would study this problem together. They would figure out how to measure, in a systematic way, the relationships between pavements and urban trees.

"We're starting out with a control-type study looking at baseline," Putman says. "We wanted to know how the pavement behaves first. How does the water get into the soil, and what is its distribution? And then, when the tree gets in there, how does that change the game? How does the tree behave?"

Recon from the root zone

Students passing through the courtyard between Lee Hall and its gleaming new addition, Lee III, stop to puzzle over a row of wood-framed boxes resting on a bed of gravel. The boxes, eight feet square and four feet tall, don't seem very massive, at first glance, but each one, full of soil capped with a layer of pavement, will weigh about 20,000 pounds.

The researchers and their students plan to install sensors at multiple locations in each box to track moisture and temperature using technology developed for the Intelligent River project. For that project, a high-tech effort to document and monitor the health of the Savannah River watershed, Putman worked on a green-infrastructure retrofit in Aiken, South Carolina. As the retrofit's pavements expert, he helped design and monitor the porous pavements the team installed downtown, with special attention to protecting some venerable old magnolias.

After monitoring the pavements for several years, Putman and the Intelligent River team confirmed that the retrofits had improved storm-water drainage throughout the city, reducing the potential for sudden jolts of polluted storm water that damaged the environment downstream.

How do we make a tree healthy and happy, when it's planted in a city or suburb? How do we know what kind of pavement to use around it?

"These porous pavements also have the ability to filter out a lot of the contaminants," Putman says, "so the water is not just running into the curb and gutter and picking up all of this stuff along the way and then dumping into the storm sewer and going into the nearest water body."

The idea for his research with Russell is to test various types of paving materials, collect baseline data about their performance and their effect on the soils below, and then to plant the trees.

Sustainability: Where the Sidewalk Grows

"We're going to use *Acer buergerianum*, the Trident maple," Russell says. This species of maple has a reputation for tolerating urban environments, and its form will complement the architecture of Lee III, Russell says.

By adjusting the experimental variables — pavement type and its distance from the trunk, soil composition, water and nutrients, among others — the team will narrow down the options to those that work best and test them in a real-world setting, perhaps in the parking lot of the South Carolina Botanical Garden.

Not a black-or-white issue

When it comes to choosing a tree-friendly pavement, conventional wisdom doesn't always get it right. Anyone who's crossed a road or sidewalk barefoot on a hot summer day knows that white concrete reflects more heat than black asphalt. So if asphalt burns our feet, it must be hotter and worse for the trees, right?

No, not necessarily, Putman says. We have to think about the tree's entire environment, above and below ground, not just the surface of the pavement.

"Everybody always says asphalt is bad for the heat-island effect, but really it just has to do with the pavement, whether it be concrete or asphalt," Putman says. Research in Phoenix and elsewhere has shown that urban heating has more to do with the thickness and density of the pavement, and therefore its thermal mass.

"When you go to an urban area that has more of these very dense materials, it's going to soak up the heat, and it's going to have a much tougher time dissipating that heat at night," Putman explains.

Putman has found that certain kinds of porous pavement, including porous asphalts, may contain 20 percent of their volume as voids. Through these voids, air and water can move, and the pavement has less thermal mass to hold heat.

Modern pavement technologies now offer numerous options, and Putman and Russell will test several of the most promising: porous asphalt, pervious concrete and permeable pavers, which are pavers with wide joints. The permeability is important not only because it allows air and rainwater into the soil but also because it tends to moderate the temperature.

Several feet deep in the soil, temperature remains almost constant, so if air can flow through the soil, natural geothermal heating and cooling will tend to moderate temperatures in the tree's root zone, keeping it cooler in summer and warmer in winter, Putman says.

Environment by design

A successful urban tree installation is not as simple as just choosing a permeable pavement and sticking a tree in a hole, Russell and Putman say. The soil may itself be the No. 1 factor in a tree's health and survival, and not all soils are created equal. In many urban settings, poor, compacted soils will have to be replaced with specially formulated soils engineered to drain, circulate air, maintain good structure, and provide sufficient nutrients. Sometimes, this is a difficult sell, Russell says, for budget-conscious clients.

"The biggest challenge I have is trying to convince someone to spend hundreds of thousands of dollars on soil," he says. "People don't get that."

The landscape itself must be carefully designed and constructed to manage water infiltration and maintain the tree's environment. Poor installations or flaws in the paving material itself can defeat permeability and suffocate the tree, Putman says: "If you've got a lot of sediment-laden runoff flowing across these parking lots with permeable pavements, you're going to clog them up."

But Putman is optimistic that standards for pavement mixes and construction details are improving. He and Russell plan to develop, from the results of their research, guidelines for pavements and urban-tree plantings that would help landscape designers and their clients select the right system for each location.

"We'd like to come up with a design idea or design guidelines, apply those and verify those, and then get them out to practitioners to use later on," Putman says.

The task is especially relevant these days because the trees in some of our most beloved urban streetscapes are declining. Trees don't live forever, and replacing a row of majestic but fragile old centenarians isn't easy — politically, aesthetically or otherwise.

Russell and Putman are hoping their work will help communities design and install urban plantings that look good and improve the environment, whether the job is to replace old plantings or establish new ones.

Russell and Putman are hoping their work will help communities design and install urban plantings that look good and improve the environment, whether the job is to replace old plantings or establish new ones. The team also hopes that their students will learn what they have learned: that a designer and an engineer can work together, despite their different perspectives.

"I've always wanted to engage our students a little bit more across colleges," Putman says, "because engineering students are always going to be dealing with—"

Russell laughs. "Dealing with?"

"*Working with* architects and landscape architects. You hear the stereotypes of architects or landscape architects —"

"What are they?" Russell says, feigning indignant surprise.

"Oh, you know, 'those architects, they want this or that, and it's just not practical.' You hear that a lot. And then you hear the architects say, 'Those engineers, they just don't want to be creative.' So it will be interesting to engage our students together, and use this research as a learning tool."

So far, the strategy of teaming landscape designers with engineers seems to work just fine for Russell and Putman. But it isn't always easy.

"This is kind of pulling Paul out of his comfort zone and pulling me out of my comfort zone," Putman says, "and we're kind of meeting somewhere in the middle here, where we're both learning from each other." ✻

Sustainability: Where the Sidewalk Grows

ECO-BRIEFS

Planning ahead

Leidy Klotz and his team recently announced that they have received $1 million from the National Science Foundation. The grant will fund research into how property owners, developers, engineers, public officials and other decision makers choose whether to make infrastructure sustainable. Klotz is an associate professor of civil engineering and education director for Clemson's Institute for Sustainability.

The research could affect how hundreds of billions of dollars are spent each year to build and retrofit infrastructure. And the results would be long lasting. Once a road or bridge is built, a community is usually stuck with it for decades.

Cost, of course, is always a big factor in infrastructure decisions. But Klotz and his team believe that how questions are posed could also make a difference and deserves further study.

Previous research has focused on individuals, looking at how they save for retirement, choose whether to be an organ donor and behave as consumers. Klotz and his team will extend the research into how groups make decisions. The team includes leading behavioral scientists from Columbia University.

Much is at stake for the environment and quality of life, he explains. "With infrastructure, there are a lot of times we can make it more sustainable without it costing any more," Klotz said. "In fact, it might even cost less. That's where the real transition to practice takes place — making these more sustainable and more cost-effective options more likely to get chosen."

High-tech Haiti

A small Haitian village that was hit hard by cholera is getting water and sanitation services for the first time thanks to a group of Clemson University students who are designing and helping build new systems from scratch.

One of the latest projects in Cange, Haiti, is a "biodigester" that processes potentially dangerous human waste, turning it into fertilizer for banana trees and methane gas that fuels stoves in a communal kitchen.

The biodigester is part of a wider commitment to Haiti by Clemson Engineers for Developing Countries. The award-winning group installed Haiti's first chlorinated municipal water system in Cange in 2012 and the first water testing laboratory in the Central Plateau in 2014.

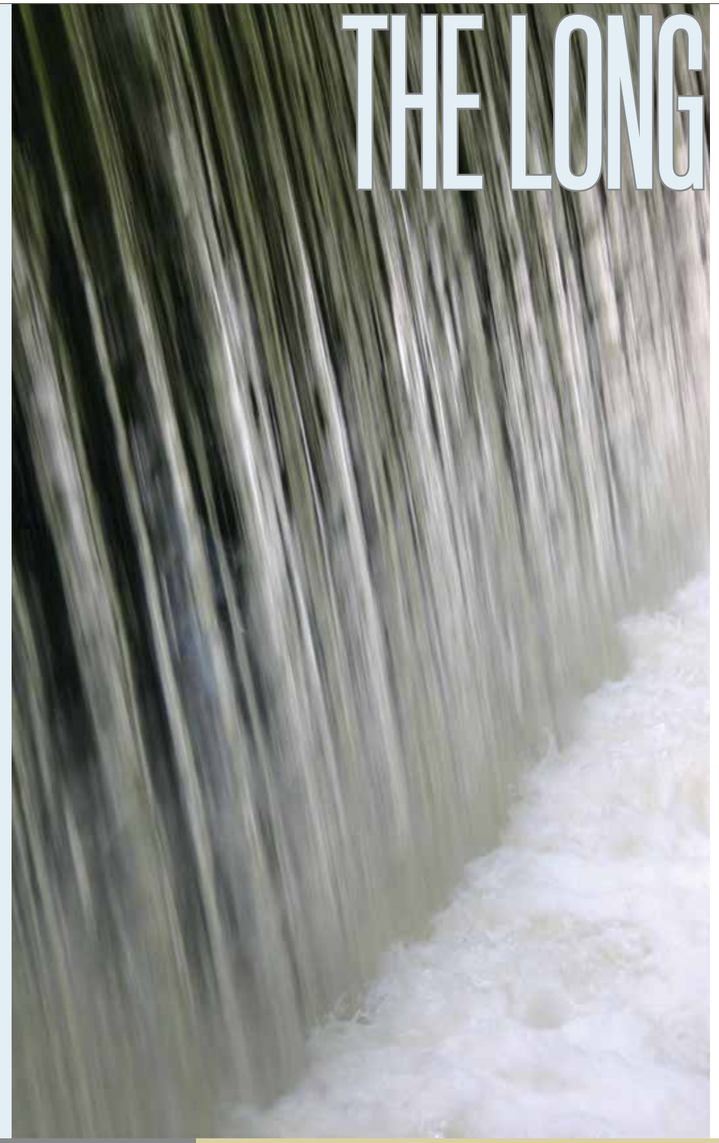
Members are now working with the Haitian government in hopes of improving infrastructure to provide clean water and sanitation to communities across the country. They could soon begin building smaller versions of the biodigester in communities near Cange.

Jennifer Ogle, an associate professor of civil engineering, said the Cange biodigester has proven so successful that residents of other communities have asked for their own versions.

"We were really excited to see the Haitians asking for these facilities," she said. "What we're trying to do now is figure out the proper proportions and size of the biodigester bags for smaller installations."

Aaron Gordon, a junior civil engineering major, served as an engineering intern in Haiti for seven months. Gordon said that the biodigester has replaced pit latrines, making a nearby school and the whole village a safer place.

"As people get used to such high levels of sanitation, they may find it difficult to imagine not ever having access to these facilities," Gordon said. "For Haitians, the ability to use this advanced piece of technology is huge and cannot be underestimated."



THE LONG VIEW

Endowed Chair Amy Landis takes lead on new Institute for Sustainability

by Paul Alongi

Before she had a Clemson University office, ID or parking pass, Amy Landis was already hard at work creating an institute that many say could be transformational. Landis was recently hired as the Thomas F. Hash '69 SmartState Endowed Chair in Sustainable Development.

As part of her job, she is leading a new Institute for Sustainability at Clemson and serving as a faculty member in the Glenn Department of Civil Engineering. While the institute is in its early stages, Landis expects it will bring together students, faculty members and staff from across the University to find sustainable solutions to a wide range of challenges.

The unique environment at Clemson makes the institute possible, Landis says.

"The leadership here is very interested in sustainability and interdisciplinary research," she says. "They are also very interested in education and student experiences. The new vision is really exciting."

Landis came to Clemson from Arizona State University, where she was an associate professor in the School of Sustainable Engineering and the Built Environment. In her first few days at Clemson, she started drafting a vision for the institute that includes:

- **Education and Outreach**. The institute will help develop a sustainability curriculum, serve as a hub for sustainability programs, manage Clemson's sustainability minor and support the Grand Challenges Scholars program.
- **Interdisciplinary Research**. The institute will bring together faculty members from across the University and support their efforts to pursue research projects, including large grants from the National Science Foundation and the U.S. departments of Agriculture and Energy, among others.
- **Sustainable Business Integration**. The institute will seek industry collaborations that could include sustainability reporting and finding new ways to make supply chains and manufacturing more efficient and environmentally friendly.

"Amy is the consummate team player and unifier, and therefore a natural leader," says James R. Martin, chairman of the Glenn Department of Civil Engineering.

"This is vital, because our future success toward doing the really big things is a function of how well we work together as a community. I see Amy as a tipping point in building this new culture of inclusion." ✻

Landis is continuing to look for new participants, and she welcomes input on what the vision for the institute ought to be. To learn more, contact Landis at 864-656-3000 or *alandis@clemson.edu*.

BEYOND THE POND

Algae research seen as a 'paradigm shift' in wastewater treatment

by Paul Alongi

Using algae to treat wastewater could be an innovative way for small communities across the country to save energy and keep pollutants out of the environment, according to new research from Clemson University's College of Engineering and Science.

Scientists have long known that algae can remove certain pollutants from water and be harvested to create biofuel, but the Clemson study was the first to find several other environmental benefits. The Clemson team analyzed five wastewater treatment scenarios and the environmental impact of each. Ph.D. student Muriel Steele led the study under the advisement of David Ladner, an assistant professor of environmental engineering and Earth sciences.

Steele says what has excited her most about the study is that it analyzes the tradeoffs of various treatment methods.

"A lot of people think of 'environmentally friendly' as meaning one thing," she says. "But I like to look at tradeoffs. Treating your wastewater to this pristine effluent seems like the environmentally friendly thing to do, but if it takes a lot of energy, is it necessary? I like weighing options."

Researchers found that using algae during the primary stage of the treatment process was most promising. It would require the least amount of energy and reduce carbon dioxide emissions that are mainly responsible for global warming. The method would contribute the least to ecotoxicity, which is what happens when chemicals harm the environment.

It was second best in preventing eutrophication, which occurs when excessive fertilizers run into lakes and rivers. The nutrients in those fertilizers can cause an explosion of plant growth that sucks the oxygen out of the water and can kill fish.

"Not only can the algae remove nutrients, but they can help decrease environmental impacts from other wastewater treatment unit processes," according to a paper the team published in *Environmental Science: Processes & Impacts*. "This has not been articulated previously, so the work presented here represents a paradigm shift for the many investigators looking into growing algae by reclaiming nutrients from wastewater." The authors were Steele, Ladner and Annick Anctil, who was an assistant professor at Clemson before taking a position at Michigan State University.

Researchers did caution, though, that the treatment method they found most promising would require lots of land because the tanks that hold the wastewater would have to be much shallower than those at a traditional treatment plant.

The shallower tanks would allow the sunlight to penetrate the wastewater and sustain photosynthesis needed for the algae to grow. One of the main reasons to explore algae use in small systems is they are often in rural areas, where land is more readily available than in urban areas, researchers found.

Another cautionary note from researchers was that the method would require treatment plants to put wastewater through "primary sedimentation" to remove solids. Many small plants do not have the needed equipment and instead use other processes to treat solids.

"This was a creative way to analyze wastewater treatment," says David Freedman, chairman of Clemson's Department of Environmental Engineering and Earth Sciences. "The study broke new ground and could lead to more sustainable treatment methods. It's terrific work."

The Clemson team was the first to look at how algae could be worked into wastewater treatment and also to do a broader "lifecycle assessment" that considered how each scenario would affect ecotoxicity, energy consumption, eutrophication and global warming.

"We're definitely the first to look at some of the details of the process engineering and connect that with life cycle assessment," Ladner said.

To ground the study in a realistic scenario, researchers used the Cochran Road Wastewater Treatment Plant in the city of Clemson as a model. It serves a population of 6,680 customers and is typical for systems found in rural areas.

Researchers have called for further lab and pilot-scale research to move the technology into the real world. Steele is now turning her attention to lagoon wastewater treatment systems in Utah. ✻

ECO-BRIEFS

Fresh science for freshwater

Drought and population booms have a growing number of communities taking a closer look at building desalination plants. Right now, though, turning saltwater to freshwater is more expensive than many would like.

Many researchers believe the magic bullet that lowers costs will be a high-strength membrane that can withstand the intense water pressure needed to desalinate water.

So far, no one has found the perfect membrane, but Chad Sosolik of Clemson University could be on to something. The answer, he said, involves a piece of cutting-edge equipment that simulates stellar conditions on Earth.

Sosolik and his team of graduate students are using an electron beam ion trap, or EBIT, to poke atom-size holes in a strong, carbon-based material called graphene. The holes could be made so small and precise that they would allow water molecules to pass while filtering out the salt, Sosolik said.

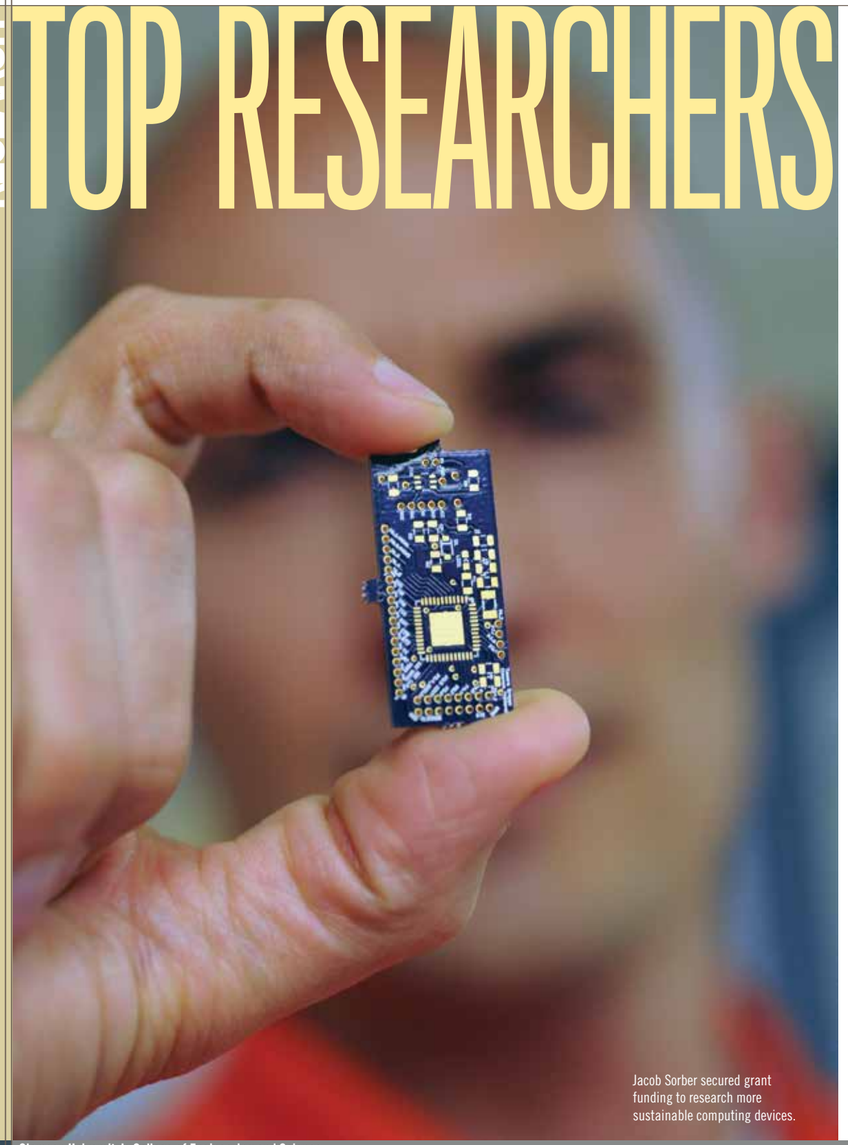
Sosolik, an associate professor of physics, said that he has begun to partner with industry and is launching a major push for government funding to advance the research.

A solution couldn't come too soon. Climate change is making rainfall less predictable and droughts more common, as rising populations increase demand for freshwater.

Mark Leising, chair of the Department of Physics and Astronomy, said that Sosolik is breaking new ground with his research.

"New instruments, even those driven purely by scientific curiosity, often have unforeseen practical applications," Leising said. "Chad was instrumental in getting the EBIT to campus, and now he's finding new uses for it. It's a rare scientific tool that Clemson is fortunate to have on campus."

TOP RESEARCHERS CHOOSE CLEMSON



Jacob Sorber secured grant funding to research more sustainable computing devices.

Federal awards for CES faculty fund leading-edge discoveries

by Paul Alongi

Two separate federal agencies awarded a total of almost $1.4 million in grants to three of the college's faculty members for leading the field with their research: Mark Blenner, Jacob Sorber and Yue "Sophie" Wang.

The work being funded is diverse, but the common thread is that the grants go to the nation's most promising researchers in the early stages of their careers.

Blenner, an assistant professor of chemical and biomolecular engineering, recently had three years of research funded through a $360,000 award from the Air Force Office of Scientific Research.

Sorber and Wang were among the honorees in the National Science Foundation's Faculty Early Career Development (CAREER) Program.

Sorber is an assistant professor in the School of Computing, and Wang is an assistant professor of mechanical engineering. They are working on separate projects, and each has been awarded $500,000 for research.

Blenner, Sorber and Wang took some time recently to answer questions about their work and the motivation behind what they do and why they do it.

How important is hard work to your success? How much do you attribute to things outside your control?

Blenner: Hard work is always important in engineering research, but one of the key attributes to my success in research is creativity. I like to think that we are inspired, but not limited by biology. Many of my research ideas start with a simple question: Why not? I try to teach my students to think creatively about a problem and then put in the hard work to see if their creative idea is realistic.

Sorber: Hard work is critical. I don't know anyone who thinks brilliant thoughts all the time and easily produces great solutions. I keep asking questions, talking to other scientists, generating ideas (good and bad) and sifting through them to hopefully find a few opportunities worth pursuing. Turning good ideas into real science is hard work.

Wang: My hard work is paying off! I appreciate the strong support from the University, the College of Engineering and Science and the mechanical engineering department for our young faculty and feel lucky to be a faculty member at Clemson. My department chair, mentor and senior colleagues always give me very helpful support and guidance. I also have a good research team with motivated students.

What's next for you?

Blenner: We are continuing to pursue novel biomolecular innovations to make chemicals, nutraceuticals and fuels more sustainably. We are also starting to think about ways to use biotechnology to address problems in areas such as water purification and advanced manufacturing.

Sorber: For years, my students and I have been working to demonstrate a better way to build low-power, low-cost, more sustainable computing devices. It's an exciting idea, and the community is starting to pay attention, but the research problems are far from solved. My next goal is to turn this exciting idea into hardware and software techniques that people can actually start using in real applications.

Wang: My goal is to become a national catalyst in the control of human-robot collaboration by integrating human factors analysis into systems and control theory. My next step is to keep publishing in high-quality journals, introducing the technology advances into the classroom, and collaborating with world-class researchers to broaden the research impact.

> *"The faculty and students were noticeably friendlier and happier than at the other schools I considered. It was also clear that Clemson is evolving. The opportunity to take part in guiding that evolution was, and is, very exciting to me."*
>
> —Jacob Sorber

Mark Blenner's research pursues biomolecular innovations that make chemicals and fuels more eco-friendly.

Can you talk about the experience of being recognized as one of the top early-career researchers in the country?

I try to teach my students to think creatively about a problem and then put in the hard work to see if their creative idea is realistic.

—Mark Blenner

Blenner: It's a humbling experience. So many of my colleagues are also doing incredible work, which makes being selected for the Air Force Young Investigator Program Award that much more meaningful.

Sorber: It's always great when other people get excited about your work. Word spreads. You meet new people and get exposed to new ideas, and that opens the door to new opportunities and new and exciting research. It's too soon to say how this will impact my longer-term research efforts, but I'm excited and very grateful for the added momentum.

Wang: I am happy about the success at the beginning phase of my career, and I am motivated to develop a significant research and education program based on this good start. It definitely opens new opportunities, such as more collaboration and more students seeking involvement.

Yue "Sophie" Wang's work on human-robot collaboration is advancing the technology.

Why Clemson?

Blenner: It was clear to me that Clemson University is a rising star. Between its high-caliber students, accomplished faculty and its supportive environment, Clemson is a wonderful place to establish my career.

Sorber: When I visited campus, I was impressed by the culture. The faculty and students were noticeably friendlier and happier than at the other schools I considered. It was also clear that Clemson is evolving. My research seemed to fit well with Clemson's priorities. The opportunity to take part in guiding that evolution was, and is, very exciting to me.

Wang: Clemson University is one of the top engineering schools, and the mechanical engineering department is recognized internationally. We also have good connections and collaborations with the manufacturing industries in the state. These give me very good opportunities to develop my career and are the main reasons that I chose to work at Clemson.

I am motivated to develop a significant research and education program based on this good start. It definitely opens new opportunities, such as more collaboration and more students seeking involvement.

—Yue "Sophie" Wang

FILLING THE TALENT PIPELINE

Next-generation scientists and engineers get started at Clemson

by Ron Grant

Last spring more than 120 engineering universities across the U.S. pledged to educate a new generation of engineers, equipped to tackle some of the most pressing issues facing society. The commitment came in the form of a letter that was presented to President Barack Obama at the White House Science Fair. Among the signatories was Anand Gramopadhye, dean of Clemson University's College of Engineering and Science.

"The next generation of engineers needs a broad skill set to solve the challenges society faces in an increasingly complex and interconnected world," Gramopadhye said.

"The work of our engineers and scientists has helped make the United States a global leader. To ensure that the nation maintains its competitive edge, we must keep the pipeline filled with talent, which is why our K-12 outreach programs are so important."

The college has several active programs that serve to grab the attention of young people and introduce them to the benefits that can be found in STEM (science, technology, engineering and math) careers.

Emagine!

Every spring, a team of dedicated and enthusiastic faculty and students from Clemson University's College of Engineering and Science travels throughout South Carolina to spark the interest of middle- and high-school students and encourage them to "Emagine!" a career in science or engineering.

WISE student LaKwasa Heath works with a mentee.

At each stop, some 200 middle school students learn about engineering and science careers through a series of hands-on activities, such as programming driverless vehicles, creating an air-powered car and using advanced materials to design a shatter-resistant plate. The students also hear from current engineering students and faculty about the rigors of an engineering curriculum and what they can do to prepare for college.

Now in its fourth year, Emagine! has reached nearly 5,000 students and parents across the Palmetto state.

WISE and PEER

The college's WISE (Women in Science and Engineering) and PEER (Programs for Educational Enrichment and Retention) programs are academic support networks for women and underrepresented minorities, but the two organizations also sponsor outreach activities designed to encourage young men and women to consider careers in engineering and science fields and to introduce them to Clemson.

Introduce a Girl to Engineering Day gives girls a chance to try their hands at engineering while matching them with female role models working in the field. Run in conjunction with the Girl Scouts of South Carolina Mountains to Midlands, the program recently celebrated its 15th anniversary.

It's a Girl Thing is a program targeting middle school girls in Anderson School District 5. The program introduces STEM in a safe and encouraging learning environment. The goal is to expose girls to nontraditional educational and professional career fields, while also increasing self-confidence. In addition to career awareness, It's a Girl Thing provides training in career-supporting skills, such as teamwork, oral presentations, social skills and an exposure to cultural and current events.

PEER SnapShot is a one-day recruitment event in which participants are able to attend a college class, have lunch and tour campus with a current Clemson undergraduate and hear presentations from the offices of admissions and financial aid.

Project WISE is a one-week residential camp held for rising 6th- through 8th-grade girls to introduce them to careers in STEM. Attendees receive hands-on learning experiences in science and engineering, which leads to an appreciation and understanding of how technical fields have an impact on them personally, and how exciting and rewarding careers in these fields can be.

STEM Day is a one-day recruitment event held in the spring semester for high school juniors. This program is sponsored by WISE and PEER and allows participants to attend workshops conducted by Clemson professors. They also enjoy lunch with a current Clemson undergraduate.

We Do Math is a one-week residential camp held for rising 9th- and 10th-grade girls to build confidence and skills in mathematics while introducing them to careers in STEM.

WISE Choice is a one-day recruitment event held in the fall semester for high school seniors and in the spring semester for accepted Clemson students. Participants are able to attend a college class, have lunch and tour campus with a current Clemson female undergraduate. They also hear presentations from Admissions and Financial Aid.

> *The next generation of engineers needs a broad skill set to solve the challenges society faces in an increasingly complex and interconnected world.*
>
> **— Anand Gramopadhye**

Clemson University Center for Workforce Development

With manufacturing leading the way to economic recovery, Clemson University's Center for Workforce Development (CUCWD) is developing programs that are helping students in the Palmetto state and across the country learn the skills that employers need in a modern manufacturing environment.

With funding from the National Science Foundation's Advanced Technological Education program, the CUCWD is developing virtual reality simulations as part of a broad curricula that includes online lectures, textbooks and assessments. More than 1,000 students, about half in high school, are now using the curricula. The virtual reality simulations have been used in a quarter of the state's technical colleges and in 17 two-year colleges outside the state. Curricula are provided at no cost. They teach basic skills, such as maintenance and safety, that students will need to get a job in a modern manufacturing plant. Economic development officials see a growing need for workforce education, particularly for workers who are dealing with technological changes.

The good news is that the Internet is opening doors that didn't exist 15 or 20 years ago. Prospective students needn't be held back by work schedules, family obligations or lack of transportation. With the right curriculum, students can study in a place and time of their choosing.

Some students may go directly into the workforce after taking the online and virtual reality courses CUCWD has developed. But the science, technology, engineering and math skills they learn will also position them for success if they should choose to further their education at Clemson.

The 'A' in STEAM

Typically discussions regarding engineering and scientific careers and outreach involve the STEM (science, technology, engineering and mathematics) fields. But more and more often there's been a chorus of voices calling for the addition of an "A" to include mention of the arts: STEM expands to STEAM.

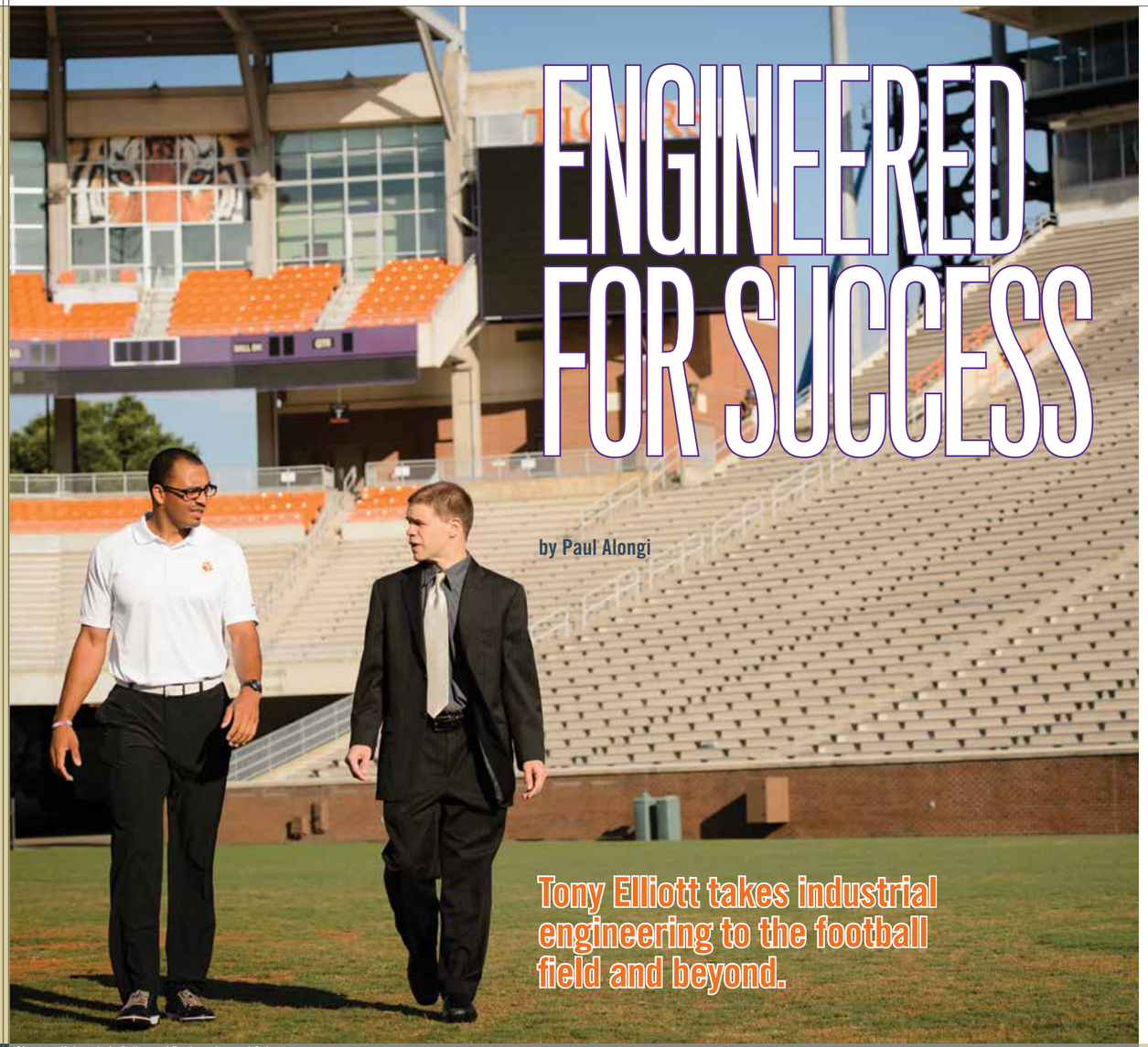
Recently Clemson University announced the launch of its STEAM Network. Some 32 faculty and staff members are coming together to find new ways of adding the "A" for the arts into the STEM mix.

The announcement coincided with the creation of an exhibit for downtown Greenville, S.C.'s Artisphere, which is ranked as one of the top arts festivals in the United States and has proven to be a great place for Clemson University to connect with the community. Throughout the three-day event, parents and educators took advantage of a number of STEAM initiatives.

At Clemson's exhibit, parents and children were able to:

- code "Scribbler Robots" to draw in an elevated sandbox,
- perform dance steps in real life and then program an animated character to do the same,
- use audio files and a cell phone to draw with a robot,
- see how light wavelengths affect pigment on fabric, Skittles and other items,
- create a design with a web-based "morphing tool" then print it to take home,
- admire the inspiring and powerful pictures that show science as art,
- learn about the Indigo Pine sustainable home Clemson students are creating from interlocking plywood,
- hear a sculptor describe how math and science are used to create 3D art and
- watch artists demonstrate printmaking and ceramic techniques.

The goal of the new STEAM initiative is to help inspire creativity and recruit a more diverse mix of students to engineering and the sciences. ✻



ENGINEERED FOR SUCCESS

by Paul Alongi

Tony Elliott takes industrial engineering to the football field and beyond.

Fans of Clemson Tigers football may recognize Tony Elliott. You'll find him alongside Dabo Swinney on Saturdays in the fall, figuring out how to penetrate defenses and move the ball across the goal line.

Elliott serves as co-offensive coordinator and running backs coach, but his connection to the University goes all the way back to his days as a football player and a student in the College of Engineering and Science.

While playing wide receiver for the Tigers, Elliott managed a rare feat: He excelled in one of higher education's most demanding sports and one of its most rigorous academic programs. Elliott graduated with a degree in industrial engineering in 2002 with a team-high 3.55 GPA. He lettered four times, finishing with 34 receptions for 455 yards and two scores. A survey of Clemson players conducted by the *Anderson Independent Mail* in his senior year found that he was the team's "most respected player."

After graduation, Elliott worked for Michelin North America for two years. He later coached at South Carolina State and Furman University before coming home to Clemson.

Industrial engineering is a natural fit for football. Students learn to look at entire systems and processes involved, which are key skills on the field.

Cole Smith, the chairman of the Department of Industrial Engineering, recently sat down with Elliott on the 50-yard line of Memorial Stadium to learn more about his formula for success.

The excerpts have been edited for brevity.

Smith: How did you manage being in one of the most difficult academic programs, while balancing time for one of its most demanding teams?

Elliott: First and foremost, I had tremendous support from the football side, obviously. Vickery Hall provides resources to stay up to speed in the classroom. But then I also had great support from the industrial engineering department and the student body as well. You have to manage a lot. There are a lot of sacrifices that have to be made. When your buddies are going out and hanging out on a Thursday night and a Friday night, you're in the library.

Smith: You had some good mentorships as a student but also professionally. How has that played a role in your career, and what would you recommend other students currently in the program look for in a mentor or mentoring program?

Elliott: Just as in football, in life you can't do it by yourself. You've got to have people that you're connected to who can help you through the tough times, who can give you advice to help you prepare for the future. The advice that I would give to students in the program now is surround yourself with other students within the program who are likeminded, who understand the importance of teamwork. That's how I survived industrial engineering.

> *The advice that I would give to students in the program now is surround yourself with other students within the program who are likeminded, who understand the importance of teamwork.*
>
> —Tony Elliott

'If you want to be successful,' we tell our guys all the time, 'sit in front of the class. Create a relationship with the professor and engage so that you can build that relationship.' If you come upon a tough time, you'll have somebody in your corner to help you.

The thing I learned from industrial engineering that I use every day is just the engineering, the methodical thought process that goes into preparation.

—Tony Elliott

Smith: So you never got to the point where you thought, 'I've got to give up one or the other?'

Elliott: There were plenty of days when I thought, 'Man, what am I doing?' But my journey to get to Clemson was a little bit different, a little bit unique. I started at the Air Force Academy to play football, and then I decided to come to Clemson and (at first) not play football. So when I decided to play football at Clemson, it put it in perspective. I understood that it was a privilege and that it was secondary to my education.

Smith: What lesson from industrial engineering sticks with you the most?

Elliott: The thing I learned from industrial engineering that I use every day is just the engineering, the methodical thought process that goes into preparation. Football is all about preparation. I think a lot of people come in, and they see me on Saturdays, but there are a lot of hours that go into preparing for Saturday. You just make sure you're being effective and efficient with your time, that you have a strategy in place. And the strategy is going to change week to week.

Smith: You must be seeing a huge amount of increased attention on data and analytics and decision-making. How much have you seen come in, especially in the use of technology, in college football?

Elliott: It's changed tremendously. There are a lot of firms and companies that have come into play. They're taking that data and using an engineering perspective to really, really break it down and make it detailed. And it helps us tremendously. You really want to be efficient and effective in your preparation, and now there are services that have created programs to automatically calculate that information.

Smith: How much of your success is due to talent, and how much is due to persistence and hard work?

Elliott: I'd like to say that I've been very blessed from an academic standpoint. Things, especially in the math world, early on came easy to me. But I would say it's more hard work and, again, relationships with individuals who could help me along the way when I didn't understand something. They could put it in a format that I could understand. So I think there is talent, but I would say that hard work will outwork talent. We tell guys all the time: talent is one thing, but it's the hard work and determination that takes that talent to the next level. We all have a certain amount of natural talent, but you can elevate your natural talent to a higher platform if you put that hard work and dedication to it.

Smith: So we've established that there's nothing that you can't do. Give us something surprising that you can do that people don't know about.

Elliott: I don't know if it's surprising, but I like to snowboard. I don't have a whole lot of time, so I'm not very good at it. But I do enjoy snowboarding. There are several things I have to work at. But, ultimately, I think if you put your mind to it and you're dedicated to putting in the hard work that you'll be successful. ✻

News from Around the College

Tata with faculty and students at CU-ICAR

Ratan Tata receives honorary degree at S.C. Auto Summit

Clemson University honored Ratan Tata, chairman emeritus of India's Tata Motors, with an honorary Doctorate of Automotive Engineering at the S.C. Automotive Summit. Tata was the chairman of the major Tata companies, including Tata Motors, Tata Steel, Tata Consultancy Services, Tata Power, Tata Global Beverages, Tata Chemicals, Indian Hotels and Tata Teleservices. During his tenure, the group's revenues grew tremendously and totaled more than $100 billion in 2011-12.

Tata Motors is India's largest automotive manufacturer and is making significant strides in global expansion.

Tata joined the Tata Group in 1962. In 1981 he was named chairman of Tata Industries where he was responsible for transforming it into a group strategy think tank and a promoter of new ventures in high-technology businesses.

Zoran Filipi

Election shines light on state's growing role in auto research

Zoran Filipi, department chair for automotive engineering, has been elected fellow of the American Society of Mechanical Engineers, a distinction that puts him in the top 2.5 percent of an organization that has 136,591 members. The fellowship is expected to draw international attention to Clemson's automotive engineering department at a time when the state's automotive and tire industries are growing.

"This is a great honor and privilege," Filipi said. "It comes at a very exciting time for all of us working on engine and powertrain research since there is a global renaissance fueled by the need to transform the car as we know it."

Experts are seeing an increasing need for research as companies scramble to meet federal fuel-efficiency regulations while still meeting consumer demand for vehicles that are safe, fun, affordable, comfortable and high performing.

Automakers' deadline to meet fuel efficiency standards drives research

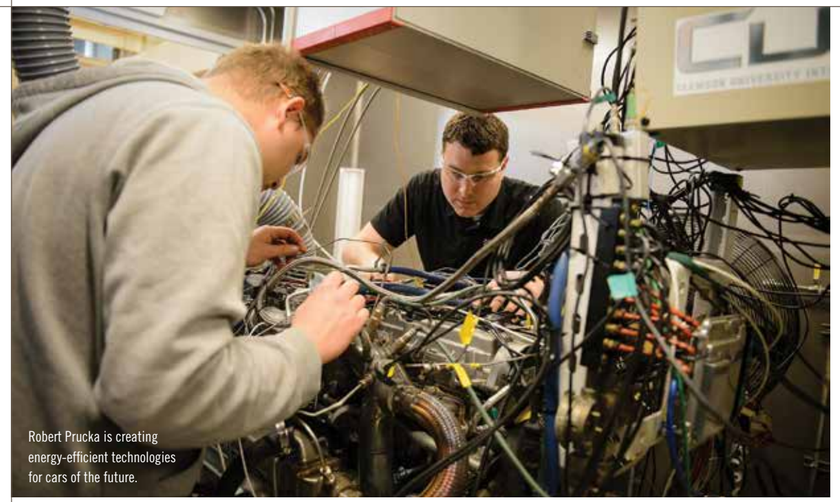
Everyone wants a car that gets great mileage and is a joy to drive, but the research that makes it all possible starts with engineers like Robert Prucka. Prucka is a faculty member in the Department of Automotive Engineering, which is part of the College of Engineering and Science. He and his team are based at the Clemson University International Center for Automotive Research.

What drives his research now is the federal 2025 deadline that automakers face to sell a portfolio of cars and light trucks that average 54.5 miles a gallon.

When Prucka analyzes engines in his lab, he pays special attention to the EGR sensor. EGR stands for exhaust gas recirculation. The sensor measures how much recycled exhaust gas is mixing with fresh air in the engine.

The information is fed into a computer, called the engine controller, that acts as the

News from Around the College



Robert Prucka is creating energy-efficient technologies for cars of the future.

Freshmen engineering students learn more about the Grand Challenges through a hands-on activity on campus.

brains of the car. The computer can then use the data to control the EGR valve, making the engine run more efficiently.

Prucka's sensor research is funded by Bosch and the U.S. Department of Energy.

Engineering deans gather to consider 'Grand Challenges,' diversity

Some 200 of the nation's top engineering experts gathered near Charleston this spring for the American Society for Engineering Education's (ASEE) Engineering Deans Institute. Anand Gramopadhye, dean of the College of Engineering and Science at Clemson University, co-hosted the conference with Tom Katsouleas, professor and Vinik Dean of Engineering at Duke University's Pratt School of Engineering.

The NAE-endorsed Grand Challenges Scholars Program was one of the centerpiece discussion topics at the conference. The program was started by Duke University, Olin College and the University of Southern California's Viterbi School of Engineering in 2009.

It has since spread to 20 other schools, including Clemson, and more than 160 Grand Challenge Scholars have graduated. Women comprise half the program's graduates, although they make up 19 percent of U.S. undergraduate engineering students. Students typically start the challenge program in their freshman or sophomore year, using it to guide their academic experience through graduation.

The ideas shared in South Carolina could affect how engineering is taught at schools across the country.

CU-ICAR students unveil Deep Orange 5 vehicle concept at GM headquarters

Students at the Clemson University International Center for Automotive Research (CU-ICAR) unveiled their newest concept vehicle, sponsored by General Motors, at the GM Renaissance Center in Detroit, Michigan.

Deep Orange 5, the fifth generation of Clemson's concept vehicle program, is designed for generations Y and Z (young adults) who will live in mega cities in 2020. The vehicle enables social networking and mobility to go hand-in-hand, ultimately forming an emotional connection between the user and vehicle.

Deep Orange is a framework that immerses graduate automotive engineering students into the world of a future original equipment manufacturer and/or supplier. Students, multi-disciplinary faculty and participating industry partners work collaboratively to produce a new vehicle prototype each year. The sixth- and seventh-generation Deep Orange concepts are under development and sponsored by Toyota Motor Corp. and BMW Group, respectively.

NSF gives $3 million to support manufacturing pipeline

The National Science Foundation is funding Clemson University in collaboration with technical colleges to advance the talent pipeline in aerospace, automotive and advanced manufacturing.

Collaborators are South Carolina Advanced Technological Education, Greenville Technical College, Florence-Darlington Technical College and Spartanburg Community College.

Deep Orange 5 concept car, Detroit, Michigan

Those from Clemson come from the Department of Industrial Engineering, the Department of Mechanical Engineering, the Department of Engineering and Science Education, and the School of Computing.

The recipient of the funding is CA²VES, which stands for the Center for Aviation and Automotive Technological Education Using Virtual E-Schools.

Anand Gramopadhye, the dean of the College of Engineering and Science, is the principal investigator on the CA²VES grant. Kris Frady is director of operations for CA²VES, and Kapil Chalil Madathil is the technology director.

NSF funding supports CA²VES virtual technology

Four Clemson students awarded Goldwater Scholarships

All four of the Clemson nominees for the prestigious Barry M. Goldwater Scholarship for Excellence in Science, Mathematics and Engineering received the award this year. Three are students in the College of Agriculture, Forestry and Life Sciences. The fourth student is in the College of Engineering and Science.

They are:

- Austin Herbst of Easley, a junior in the department of biochemistry and genetics. He has done research in the labs of Michael Sehorn and Frank Alexis at Clemson and Eric Ortlund at Emory University.
- Kaylee Kotwis from Canal Winchester, Ohio, is a junior majoring in biochemistry. At Clemson she has done research in Julia Frugoli's lab, and she has also worked with Jeff Bartolin at DuPont and Elena Shpak at the University of Tennessee.
- Jennifer Wilson of Charlotte, North Carolina, is a junior studying plant and environmental sciences. She has worked with Hong Luo, Jeremy Tzeng and Paula Agudelo at Clemson and with Sona Pandey at the Donald Danforth Plant Science Center.
- Emily Thompson from Rochester, New York, is a junior in physics. At Clemson, Emily has done research with Jian He. She also worked with Nicholas Bigelow at the University of Rochester and Patrick Sutton at Cardiff University.

President James P. Clements stands with the four Goldwater scholars (from left to right): Austin Herbst, Kaylee Kotwis, Jennifer Wilson and Emily Thompson.

Clemson University professor recognized as outstanding leader

Scott Mason has won the Fellow Award from the Institute of Industrial Engineers. The Atlanta-based institute has about 15,000 members and has bestowed the honor on about 520 members since 1950.

Mason is a professor and the Fluor Endowed Chair in Supply Chain Optimization and Logistics.

The award recognizes outstanding leaders who have made significant, nationally recognized contributions to industrial engineering. A fellow is the highest classification of membership. Candidates must demonstrate outstanding accomplishments in their professional careers and in service to industrial engineering.

Mason is renowned as an expert in semiconductor manufacturing, developing software that several companies use daily. He is also involved in several research projects with industry. His partnerships, for example, have helped a fabric maker operate more efficiently and suggested new ways of delivering meals to home-bound residents.

Mason has graduated nine Ph.D. students and supported them with nearly $5 million in research funding from various sources. Mason has authored or co-authored nearly 50 journal articles, one book and several book chapters. ✲

Endowed chair Scott Mason (right) at the Glen Raven textiles plant

FOUR INDUCTED INTO THOMAS GREEN CLEMSON ACADEMY

Newest members Haque, Mitchell, Hash and Stanzione

By Paul Alongi

Scores of students graduate from the College of Engineering and Science each year, but fewer than one percent go on to become members of the Thomas Green Clemson Academy of Engineers and Scientists. A special honor deserves a special occasion, so the college held a gala on April 30, 2015, to induct four new members: Imtiaz Haque, Thomas Hash, Robert Mitchell and Bob Stanzione.

Alumni Spotlight

Young alumni recognized from the department of materials science: (left) Thompson Mefford with Dean Gramopadhye and (right) Kyle Brinkman.

The college also recognized two outstanding young alumni for performance, achievements and accomplishments. Both of this year's honorees were not only alumni but also faculty members in the Department of Materials Science and Engineering: Kyle Brinkman and Thompson Mefford.

Alumni and supporters came from throughout the country to see the ceremony in the Madren Conference Center. Several faculty and staff members also joined the festivities. Among them was Robert Jones, executive vice president for academic affairs and provost.

Each of the academy's inductees received a plaque and a warm round of applause.

"This award is the highest honor bestowed by the College of Engineering and Science," said Dean Anand Gramopadhye. "And just to illustrate how special this award is, fewer than 0.2 percent of the college's alumni are academy members."

The award recognizes engineers and scientists who have brought distinction to Clemson University through conspicuous success in their careers, significant contributions to society and notable contributions to engineering and science practice.

Here's a look at this year's winners:

Imtiaz Haque

'Clemson allows you to dream'

Imtiaz Haque served on the faculty of the Department of Mechanical Engineering and as its chairman from 2002 to 2008. He then served as executive director and founding chairman of the Department of Automotive Engineering until his retirement in January 2015.

Apart from his scholarly accomplishments, Haque was part of the leadership team that founded the Clemson University International Center for Automotive Research (CU-ICAR) and was instrumental in the development of the Department of Automotive Engineering. Under his leadership, the department was recognized as one of the best in its field.

The National Academy of Sciences named CU-ICAR one of the nation's five best global practices for science and technology parks. The U.S. Department of Commerce named it one of four best practices for facilitating university-industry collaboration.

Haque was the principal investigator on a $98 million award from the U.S. Department of Energy that established the wind-turbine drivetrain testing and research facility at the Clemson University Restoration Institute in North Charleston. It is the largest such facility in the world, and the grant is believed to be the largest in state history.

Haque, who first came to Clemson as a graduate student in 1975, said he was honored to be recognized by his alma mater.

"Clemson grows people," he said. "Clemson allows you to dream, and Clemson supports your dream. And that is really important. I hope we never, ever lose that. Clemson is about people."

Supporting sustainable development

(Left) Thomas Hash

After the birth of his second grandchild, Thomas Hash established an endowed chair in sustainable development at Clemson University with a $2 million gift.

The state used funds from the South Carolina Education Lottery to match Hash's gift with an additional $2 million through the SmartState program. Now his contribution is beginning to bear fruit: Amy Landis was recently hired as the Thomas F. Hash '69 SmartState Endowed Chair in Sustainable Development.

"We are so delighted for her to be here," Hash said. "She has put together an amazing vision."

Hash in 1999 became president and chairman of Bechtel National Inc. and was elected to the board of directors of the parent company, Bechtel Group.

During his tenure, he more than tripled the company's annual revenue from government projects, going from $2 billion in 1999 to more than $6 billion in 2007. Employment also grew, from 3,000 to 16,000.

A 7-year-old's business endeavor

Robert Mitchell

Robert Mitchell said he was first introduced to Clemson at 7 years old. His father, the head of ceramic engineering at Georgia Tech, took him to the Olin Hall dedication. A photographer snapped a shot of him playing with a toy steam shovel in the foyer, and it appeared on ceramic-engineering magazine covers, he said.

Mitchell remembered staying at Clemson House during his visit and noticing that the elevator didn't have an operator. So the young Mitchell and his friend took the job.

"I think that was my first business endeavor," he said. "I was motivated by it, and I've been motivated ever since."

Mitchell returned to Clemson years later for graduate school, where former professor Gil Robinson instilled in him a sense of creativity that helped him in his career.

As president and chairman of the board of Applied Ceramics, Mitchell has hired many Clemson graduates. He was also a founding member of the Fellowship of Companies for Christ, a community of business leaders now in 92 countries.

Deep roots in the Clemson family

(Center) Bob Stanzione

Clemson orange runs deep in Bob Stanzione's family. He married his wife, Kaye, between semesters in his senior year at Clemson. Their three children — Marie, Jennifer and Robert Jr. — all attended Clemson in the 1990s.

Also, Bob's brother, Dan Stanzione, received a Ph.D. from Clemson before going on to become the eighth president of Bell Labs. They are the first set of brothers inducted into the academy.

Stanzione's extended Clemson Family also contains some highly accomplished alumni.

Jim Barker, who served as Clemson's 15th president, was in his fraternity pledge class. David Wilkins, also a "DEAC" fraternity brother, went on to become U.S. ambassador to Canada and served as chairman of Clemson's Board of Trustees.

"It was a group that produced some incredibly successful people," Stanzione said. "We were all interested in having fun together, but we were also focused on the future. We left Clemson with a solid education, a solid background, good values and a drive to succeed."

Stanzione, chairman and CEO of ARRIS Group Inc., has also done well. He has grown the company from a small start-up to the world market leader in cable telephony, high-speed data, and video delivery products. ARRIS recently announced the acquisition of the British tech company, Pace, for $2.1 billion. The combined enterprise is expected to have sales of approximately $8 billion.

Bob and Kaye have contributed generously to Clemson, including a significant grant to ClemsonLIFE to help more students gain access to the program. Kaye serves as a member of the program's advisory board.

Stanzione is a member of the Dean's Leadership Circle. ✻

Departments

Automotive Engineering

Zoran Filipi, Ph.D.
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clemson.edu/ces/departments/automotive-engineering

Fast Facts

Tenured/tenure-track faculty: 12

Enrollment: (Spring 2015)

Undergraduate	N/A
Master's	135
Doctoral	57

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	N/A
Master's	71
Doctoral	5

Research expenditures: $3,417,369 (FY14)

Research thrusts: systems integration, vehicle manufacturing, vehicle design and development, vehicular electronics

Bioengineering

Martine LaBerge, Ph.D.
Department Chair

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Fast Facts

Tenured/tenure-track faculty: 22

Enrollment: (Spring 2015)

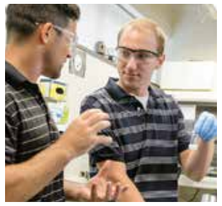
Undergraduate	317
Master's	37
Doctoral	80

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	95
Master's	31
Doctoral	24

Research expenditures: $4,667,874 (FY14)

Research thrusts: biomaterials engineering, bioelectrical engineering



Chemical and Biomolecular Engineering

Douglas Hirt, Ph.D.
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Fast Facts

Tenured/tenure-track faculty: 12

Enrollment: (Spring 2015)

Undergraduate	236
Master's	0
Doctoral	30

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate - 51	
Master's	0
Doctoral	6

Research expenditures: $1,340,704 (FY14))

Research thrusts: advanced materials, kinetics and catalysis, energy, chemical and biochemical separations, molecular modeling and simulation, biosensors and biochips

Chemistry

Karl Dieter, Ph.D.
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Fast Facts

Tenured/tenure-track faculty: 22

Enrollment: (Spring 2015)

Undergraduate	140
Master's	3
Doctoral	85

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	24
Master's	4
Doctoral	7

Research expenditures: $2,785,383 (FY14))

Research thrusts: analytical, inorganic, organic physical chemistry, chemical education, interdisciplinary and nontraditional areas: polymer and materials chemistry, solid-state chemistry, bioanalytical chemistry, bioorganic and medicinal chemistry, computational chemistry, chemical physics

Glenn Department of Civil Engineering

James R. Martin, Ph.D.
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Fast Facts

Tenured/tenure-track faculty: 23

Enrollment: (Spring 2015)

Undergraduate	347
Master's	65
Doctoral	78

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	136
Master's	50
Doctoral	11

Research expenditures: $3,050,794 (FY14)

Research thrusts: sustainable and resilient infrastructure

School of Computing

Eileen Kraemer, Ph.D.
C. Tycho Howle Director of the School of Computing

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Fast Facts

Tenured/tenure-track faculty: 29

Enrollment: (Spring 2015)

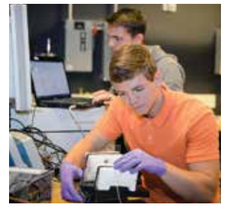
Undergraduate	601
Master's	116
Doctoral	78

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	82
Master's	60
Doctoral	14

Research expenditures: $5,606,262 (FY14)

Research thrusts: computing foundations, data analytics, software engineering, cyberinfrastructure, networking, bioinformatics, computer graphics and animation, eye tracking, visualization, digital arts, intelligent and interactive systems, identity science and affective computing, virtual environments, human/computer interaction, pedagogical tools using tablet PCs and handheld devices



Holcombe Department of Electrical and Computer Engineering

Daniel Noneaker, Ph.D.
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Fast Facts

Tenured/tenure-track faculty: 29

Enrollment: (Spring 2015)

Undergraduate	507
Master's	82
Doctoral	103

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	136
Master's	28
Doctoral	11

Research expenditures: $5,743,314 (FY14)

Research thrusts: optoelectronics, cyberinfrastructure, wireless communications, computer networks, nanoelectronic materials processing, biochips, semiconductor lasers, optical systems, integrated circuit design, high-performance computing, computer security, robotics, image processing, biological modeling, situation and threat assessment, power systems

Engineering and Science Education

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Fast Facts

Tenured/tenure-track faculty: 2

Enrollment: (Fall 2014)

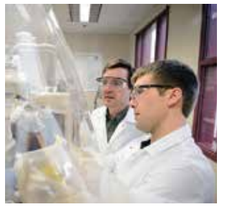
Undergraduate	N/A
Master's	0
Doctoral	9

Degrees awarded: (12/13; 5/14; 8/14)

Undergraduate	N/A
Master's	0
Doctoral	3

Research expenditures: $491,199 (FY 14)

Research thrusts: student motivation, problem solving, equity and gender issues in STEM disciplines, physics identity development, modeling of large-scale data, social capital, students' academic and career development and success



Environmental Engineering and Earth Sciences

David Freedman, Ph.D.
Department Chair

L.G. Rich Environmental Laboratory
342 Computer Court
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dfreedm@clemson.edu

clemson.edu/ces/eees

Fast Facts

Tenured/tenure-track faculty: 22

Enrollment: (Spring 2015)

Undergraduate	196
Master's	64
Doctoral	31

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	60
Master's	28
Doctoral	8

Research expenditures: $3,184,441 (FY14)

Research thrusts: environmental chemistry, environmental fate and transport, hydrogeology, nuclear environmental engineering and science, biosystems engineering, process engineering, sustainable systems

Industrial Engineering

Cole Smith, Ph.D.
Department Chair

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Fast Facts

Tenured/tenure-track faculty: 13

Enrollment: (Spring 2015)

Undergraduate	389
Master's	195
Doctoral	32

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	91
Master's	50
Doctoral	4

Research expenditures: $1,855,477 (FY14)

Research thrusts: supply chain optimization and logistics, human factors and safety in health care and in technologically complex environments, education and learning systems

Departments

Materials Science and Engineering

Raj Bordia, Ph.D.
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Fast Facts

Tenured/tenure-track faculty: 13

Enrollment: (Spring 2015)

Undergraduate	131
Master's	15
Doctoral	47

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	25
Master's	6
Doctoral	11

Research expenditures: $2,734,013 (FY14)

Research thrusts: manufacturing, characterization and structure/property/performance relationships of ceramics, glasses, polymers, photonics/optics, fiber-based materials, thin films, metals

Mathematical Sciences

James Coykendall, Ph.D.
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Fast Facts

Tenured/tenure-track faculty: 47

Enrollment: (Spring 2015)

Undergraduate	182
Master's	29
Doctoral	88

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	39
Master's	32
Doctoral	11

Research expenditures: $1,352,751 (FY14)

Research thrusts: algebra and discrete mathematics, applied analysis, biomathematics, computational mathematics, experimental statistics, operations research, probability and statistics

Mechanical Engineering

M.K. "Ram" Ramasubramanian, Ph.D.
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Fast Facts

Tenured/tenure-track faculty: 29

Enrollment: (Spring 2015)

Undergraduate	736
Master's	126
Doctoral	54

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	160
Master's	59
Doctoral	10

Research expenditures: $2,053,276 (FY14)

Research thrusts: transportation, energy, design, materials, manufacturing, fluids, complexity, multi-scale modeling

Physics and Astronomy

Mark Leising, Ph.D.
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Fast Facts

Tenured/tenure-track faculty: 26

Enrollment: (Spring 2015)

Undergraduate	70
Master's	6
Doctoral	54

Degrees awarded: (8/14; 12/14; 5/15)

Undergraduate	10
Master's	5
Doctoral	12

Research expenditures: $2,941,980 (FY14)

Research thrusts: astronomy and astrophysics, atmospheric and space physics, materials physics, surface physics, theoretical quantum physics

Utah Jazz power forward Trevor Booker is giving $30,000 to his alma mater, Clemson University, to support students in two separate programs. The lion's share of the contribution will benefit The Design and Entrepreneurship Network, also known as The DEN. Some of the money is also earmarked for Emerging Scholars of Clemson University, a program that helps high school students from economically disadvantaged areas of South Carolina get into college.

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The EUREKA program brings freshmen honors students to campus, pairing them with professors to start research before they begin their general studies. Here, Haley Meier and McKinnon Reece work with Rodrigo Martinez-Duarte in his research on origami metals.