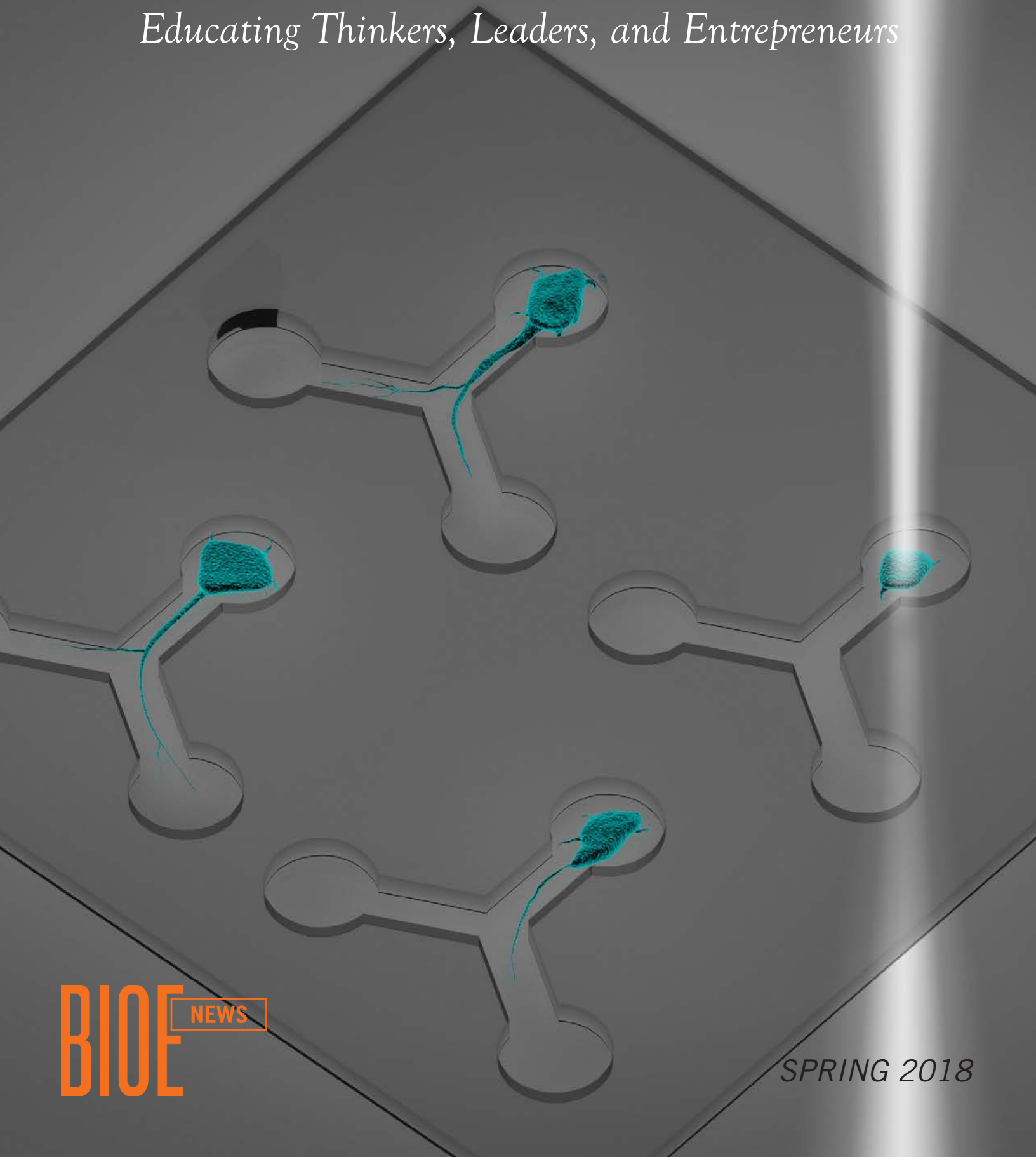


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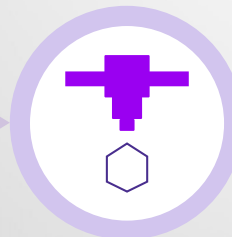


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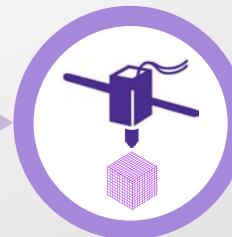
Medical Grade
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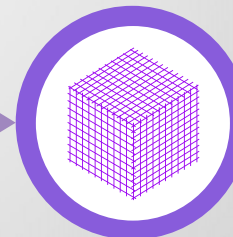
3D Printing
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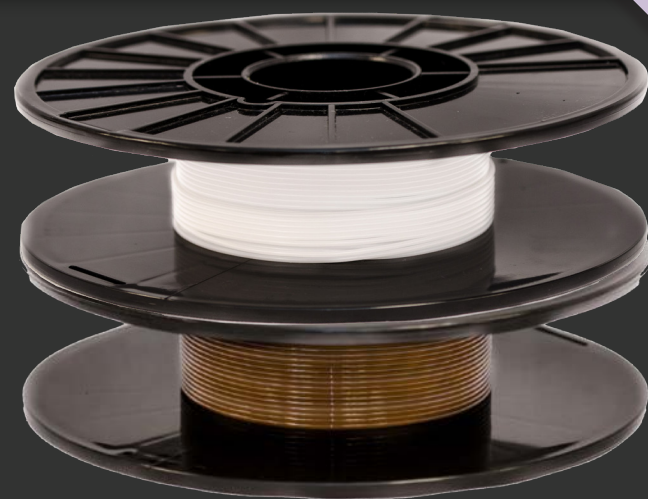


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Martine LaBerge, *Chair,*
Department of Bioengineering

Jenny Bourne, *Editor*

Olga Reukova, *Cover illustration*
and design

BIOENGINEERING RANKS 4TH IN THE NATION FOR VALUE

By Paul Alongi

Clemson University came in fourth among the nation's 50 best value schools for biomedical engineering, according to a new ranking from bestvalueschools.com.

The ranking included a variety of factors, including graduation rate, accreditation date, degree popularity, engineering popularity and net price.

Martine LaBerge, chair of the Department of Bioengineering at Clemson, said the ranking underscores that students are receiving a high-quality education that remains affordable.

"Best Value Schools has done an impeccable job of describing our program," she said. "The ranking is a result of our faculty's hard work and dedication to giving our students not only the best-in-class instruction and experience but also great value."

The website advised students to "get ready to get hands-on at Clemson University."

"Just about every day at Clemson includes some type of laboratory study, research project, or side-by-side work with faculty," according to the site.

"Coursework doesn't spare the details, either; the curriculum goes far beyond the basics to teach students about orthopedic implants, EKG simulations, medical treatment in developing countries, tissue engineering for human organs, and plenty of other topics that will immediately translate into the work environment.

"And students don't have to wait until graduation to test out their skills. International partnerships enable budding engineers to conduct research in Singapore, work with mentors in Japan, or study bioethics in Spain."

The department graduated 158 students last year, including 106 undergraduates, 37 master's students and 15 doctoral students. It has 26 tenured or tenure-track faculty members conducting bioengineering research and clinically embedded education in partnership with the Greenville Health



System and the Medical University of South Carolina.

Citing numbers from the U.S. Bureau of Labor Statistics, the website reported that demand for biomedical engineers will increase by nearly 25 percent by 2024, which it says is much faster than the average occupation. The average salary for specialists in the field is more than \$85,000 a year, according to the site.

Clemson came in behind the Georgia Institute of Technology, Rice University, and the University of California-Irvine. The University of Utah rounded out the top five.

Anand Gramopadhye, dean of Clemson's College of Engineering, Computing and Applied Sciences, congratulated the bioengineering department on the ranking.

"This is a well-deserved honor that underscores the high return on investment our students receive," he said. "The college will continue to offer access to top faculty, world-class facilities and enriching experiences, while ensuring investment returns remain strong for our students and their families."

To see the full list of rankings, go to: <https://www.bestvalueschools.com/rankings/biomedical-engineering-degrees/>



DIRECTOR OF DIVERSITY AND INCLUSION NAMED

Dr. Angela Alexander-Bryant has been named the department's Director of Diversity and Inclusion. Here, she describes her goals and some of her strategies to augment diversity of faculty and students and to increase the department's level of inclusion.

What would you like to accomplish in your new role?

I would like to increase recruitment and retention of students from underrepresented groups to contribute to a more diverse student body within the department. I would also like to foster an environment that is inclusive, promoting collegiality and engagement of students across all backgrounds.

What would be the advantages to the department and its graduates of being more diverse and inclusive?

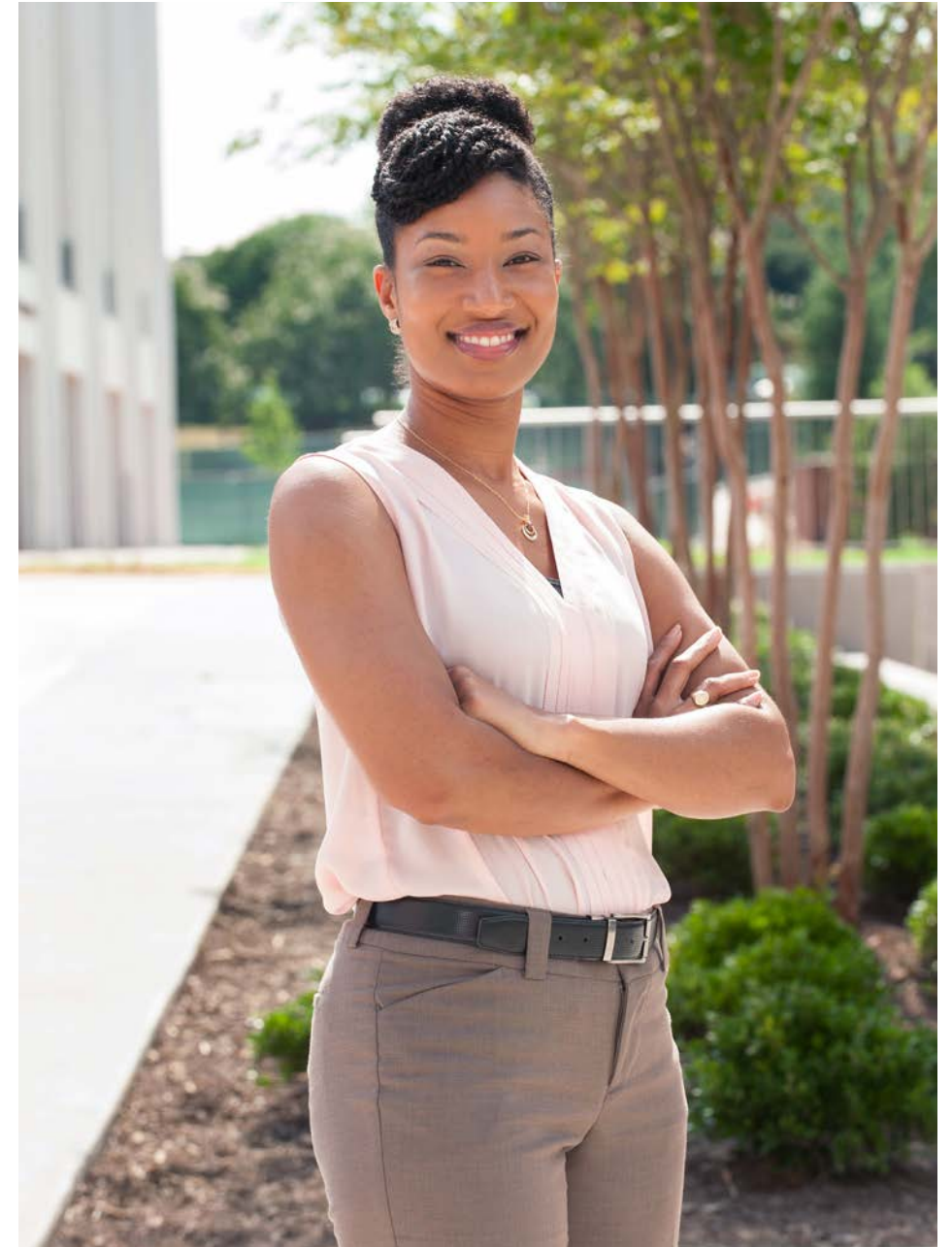
One advantage is that we will benefit from the full diversity of ideas that we will have available to us when we have contributions from the pool of talent that is currently underrepresented. We will also be preparing our students to excel in a diverse and inclusive workforce.

What are some of the ways you will promote diversity and inclusion in the department?

These are not goals that I can achieve on my own; therefore, I will begin by forming a Committee for Diversity and Inclusion comprised of students, faculty, and staff within the department. We will work together to formulate ideas and strategic efforts to promote diversity and inclusion. Our initial diversity efforts will focus on attracting, recruiting, and retaining students from groups historically underrepresented in bioengineering. We will also develop initiatives to foster an inclusive environment in and outside of the classroom.

What can individual faculty, staff and students do to increase, promote and support diversity and inclusion?

I think we can all work to understand the value in diversity and how each of our differences adds value to the department.



I think we can all work to understand the value in diversity and how each of our differences adds value to the department.

Dr. Angela Alexander-Bryant

We can actively seek out different viewpoints and engage in diversity and inclusion-related efforts. A good way to embrace inclusion is to daily interact with someone you wouldn't normally interact

with—e.g., invite someone new to lunch or to work together on a class project. These small efforts can make a huge difference in creating an inclusive environment.

A DISTINGUISHED SCHOLAR DESCRIBES HER PATH

By Hannah Davis

Before bioengineering at Clemson, Julia Brisbane studied piano for 12 years at a magnet school for the arts in Charleston, South Carolina.

Math and science classes were not her top priority then, but attending an EMAGINE event changed everything. EMAGINE — a program offered by the College of Engineering, Computing and Applied Sciences — inspires K-12 students across the state to see the impact they can make on society in STEM careers. Participants work closely with Clemson faculty and students to test their abilities, find solutions to problems, and learn what next steps they can take to prepare for college and a major in engineering.

Brisbane first saw bioengineering as her path to becoming a surgeon. Then she dove into the biomaterials concentration and discovered other ways to make a difference.

“Bioengineers give people new life through orthopedic developments,” Brisbane said. “My long-term goal is to earn a Ph.D. and further advance research and education efforts in this area.”

The transition from high school to college wasn’t always easy, but she credits the RiSE (Residents in Science and Engineering) Living-Learning Community with connecting her to students with similar aspirations who became her closest friends.

Now Brisbane is thriving as a National Academy Engineering Grand Challenge Scholar, which she considers one of her primary undergraduate accomplishments: “My focus is engineering better medicines. I’ve completed four out of the five components, and right now I’m primarily working on research.”

Brisbane’s passion for research ignited the summer before her freshman year officially began. She was on campus for the FIRE program, which is aimed at giving underrepresented engineering and science



students a head start on math, research and campus life.

During those two weeks, she learned about the support systems available through PEER (Programs for Educational Enrichment and Retention) and WISE (Women in Science and Engineering).

“PEER/WISE workshops made me think beyond just earning good grades, and about graduate school and summer research experiences,” Brisbane said.

FIRE is also where she met associate professor Melinda Harman, who helms the laboratory for Retrieval Research and Reprocessing of Medical Devices. Harman asked Brisbane to join her Creative Inquiry team — Clemson University Retrieval of Explants Program and Registry in Orthopaedics — and quickly became a valued mentor.

While collaborating with Harman, Brisbane decided she was most interested in biomechanics, or how internal and external forces act on the body during human movement. Her most recent investigation, for example, focused on a device that analyzes the anatomy of a femur.

“We’re working with orthopedic surgical teams to collect and process explanted medical devices,” she explained. “This allows us to develop tools and techniques for systematic evaluation of implant designs, biomaterials and function.”

For three semesters, Brisbane belonged to another Creative Inquiry project called Clemson Engineers for Developing Countries. As a member of the medical equipment team, she collaborated with a hospital in Haiti to determine its medical device needs.

“Most of their equipment came from older hospitals, and they didn’t know how to use it,” Brisbane said. “We created a medical equipment manual database and even worked on developing an app.”

Brisbane hopes to challenge other minority females to pursue engineering fields.

“There might not be many people who look like me in my degree program,” she said. “But everyone is rooting for you here, and all the resources that are available mean you’re never alone.”

PEDAL POWER: RESEARCH HELPS ANSWER QUESTION ABOUT REHAB FROM ACL TEARS

By Clinton Colmenares

CLEMSON, South Carolina — Former Clemson quarterback Deshaun Watson famously played in a 2014 game with a torn ACL. This season, he was burning up the NFL record book when the ACL in his other knee snapped, ending his season and breaking the hearts of tens of thousands of fans.

The former Clemson University star has a lot of company on the sideline. As many as 250,000 people each year in the United States get benched by an injury to the anterior cruciate ligament, or ACL.

Despite the prevalence of the injury, there continues to be scientific debate about how to more effectively rehabilitate the knee after reconstructive surgery. As a result, methods and outcomes vary; one-third of people recovering from an ACL tear don’t return to sports within a year, and 25 percent who do return will injure their knee a second time.

“Over the course of a year, you may begin to do more activity on your injured leg, but the question is whether the muscles regain full strength,” says John DesJardins, an associate professor of bioengineering at Clemson.

Researchers at Clemson University, where Watson led the Tigers to the 2016 National Football Championship, and nearby Furman University, have taken a step toward understanding the vulnerable ligament, which acts like a seatbelt for the knee, keeping the lower leg bone from flying through the joint during sudden stops.

Previous research showed that people going through rehabilitation after ACL reconstruction avoid using their quadriceps — the group of muscles in the front of the upper leg that allows the leg to extend. They rely on their hamstrings — the muscles on the back of the upper leg that allow the leg to flex. As a result, the quads lose strength and the knee takes longer to fully recover.



Therapists often use a stationary bike in ACL rehab programs, but there are different methods. Sometimes the patient pedals with both legs, sometimes they pedal with only the injured leg.

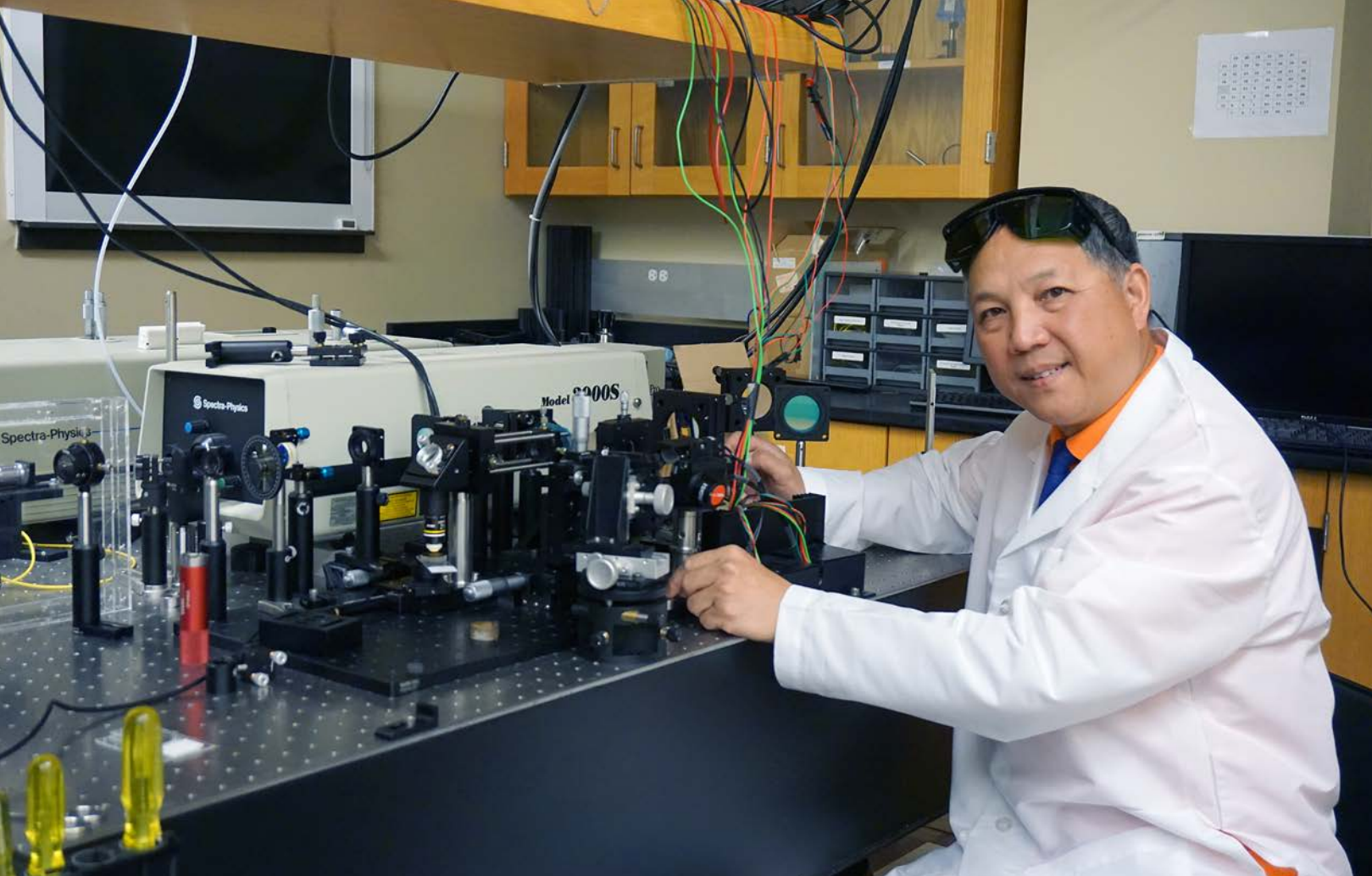
At Furman’s Molnar Human Performance Lab, Randy Hutchison, associate professor of health science, and Clemson’s John DesJardins, associate professor of bioengineering, put 17 people through a stationary cycling trial; seven were within a year of ACL reconstruction surgery and 10 had no history of an ACL injury. Their work was published in the *Journal of Functional Morphology and Kinesiology*.

According to the Clemson-Furman research, people without an ACL injury who pedaled a stationary bike with both legs used their quadriceps muscles much more than their hamstrings. But when they pedaled with only one leg, the reverse was true — hamstrings took over for the quads.

However, people recovering from ACL repair used both quads and hamstrings almost equally, whether they pedaled with one leg at a time or with both.

“This work helped show that therapists could ‘tune’ the treatment options for individual patients, and use both double- and single-legged pedaling to activate the appropriate muscle groups for a more individualized treatment,” Hutchison says.

The goal is to help someone recover fully, and return to activities as soon as possible,” DesJardins says. “The idea that we can work with recovering athletes and physical therapists to make rehabilitation treatments more effective is great.”



SMARTSTATE ENDOWED CHAIR IN BIOFABRICATION: DR. BRUCE GAO

According to Dr. Bruce Gao, nature, including every biological system, builds objects generally through two procedures: adding parts together and/or subtracting parts from the whole. For example, our fingers are formed first through adding various cell types together during embryonic development to create a palm-

by-layer manufacturing techniques have been developed. By using either a 3D printer to add or a laser beam to subtract materials layer by layer at the microparticle level, irregularly shaped objects can be built. Based on these ideas, contemporary biofabrication technologies have been established.

With biofabrication techniques, students' designs will not be restricted by a machine shop's manufacturing capability, and a research apparatus can be made by the students themselves; thus, a student's training can focus on solving actual biomedical problems.

Dr. Bruce Gao

like block, and then the block is carved into fingers through subtracting apoptotic cells in between the forming fingers. Since the industrial revolution, human manufacturing activities have been mainly dependent on machining standard parts (subtractive procedure) and then assembling parts together (additive procedure) to produce industrialized products. Conventional machine tools are suitable to make standard parts only with regular shapes, such as circular or rectangular profiles. However, biomedical objects, such as animal organs, usually have irregular shapes and inhomogeneous compositions, so traditional manufacturing techniques are not suitable for the field of biomedicine. To address this issue, layer-

“The worldwide growth of biofabrication,” stated Dr. Gao, “started at Clemson University in 2003 when Dr. Thomas Boland (assistant professor, Department of Bioengineering) filed a patent entitled Ink-jet printing of Viable Cells.” Dr. Boland’s invention was named one of the “Six Technologies That Will Change the World” by Business 2.0 Magazine in 2004; his research was featured on the Discovery Channel’s program “2057.” Working in parallel with Dr. Boland, Dr. Gao and other Clemson Bioengineering faculty members established a biofabrication program in the Department of Bioengineering. Dr. Gao’s unique contribution to the field of *biofabrication* is the laser guidance-based cell micropatterning system. Worldwide, his

is the only group that can use a laser beam to position various cell types to mimic specific in vivo-like cell-cell-ECM interactions at a spatiotemporal resolution on the submicron and millisecond level. His paper, “Laser-guidance-based cell deposition microscope for heterotypic single-cell micropatterning” was selected as one of eight highlighted articles for 2011 by Biofabrication, the only international journal specializing in biofabrication.

Dr. Gao, a world-caliber scholar in laser-based biofabrication, has been appointed to one of the South Carolina SmartState Endowed Chairs in Biofabrication Engineering to increase the dynamism of South Carolina’s work in biofabrication. Both a prime opportunity and a compelling need, this appointment is part of South Carolina’s effort to establish a SmartState Collaborative Center of Advanced

Using a biochip designed and fabricated in my laboratory, my students recently found that stem cells had the potential to rescue damaged cardiac muscle cells by transferring mitochondria via nanotubes formed between the two cell types. Dr. Bruce Gao

Tissue Biofabrication. Three endowed chair positions, one each for Clemson University, University of South Carolina, and Medical University of South Carolina, were approved. With Dr. Gao’s long-term vision to actuate South Carolina’s potential in biofabrication, he promises to vigorously champion, with the other endowed chairs in the center, South Carolina’s endeavor to extend its leadership in biofabrication to the international level. He said, “My short term goal is to reestablish Clemson’s leadership in biofabrication through technological advancement. The niche that exists in biofabrication research is Clemson’s area of strength — engineering-based technology.” The endowed chair appointment will support the technological advancement required to occupy the niche while securing the preeminent position in the field. Specifically, Dr. Gao plans to contribute to South Carolina’s advanced tissue biofabrication program by developing the following:

1) A laser-based subtractive 3D microfabrication system. Current biofabrication techniques developed in South Carolina are additive: Using various printing methods to fabricate a designed structure. Clemson’s previous contribution to the field was the use of the biological cell as a building block to print biological tissue and organs. However, because building blocks do not exist for all materials, subtractive fabrication techniques are required. Dr. Gao and his collaborators at Clemson have developed numerous laser-based subtractive 3D micro/nanobiofabrication techniques such as a Raman laser biological gel microetching technique and a two-photon surface patterning technique that, at the nanoscale, can manipulate substrate for study of cell-extracellular matrix (ECM) interactions. With these developed techniques, Dr. Gao plans to establish a laser-based subtractive 3D micro/nanofabrication lab for a broad spectrum of materials—from glass to metal, from polymers to bioprosthesis.

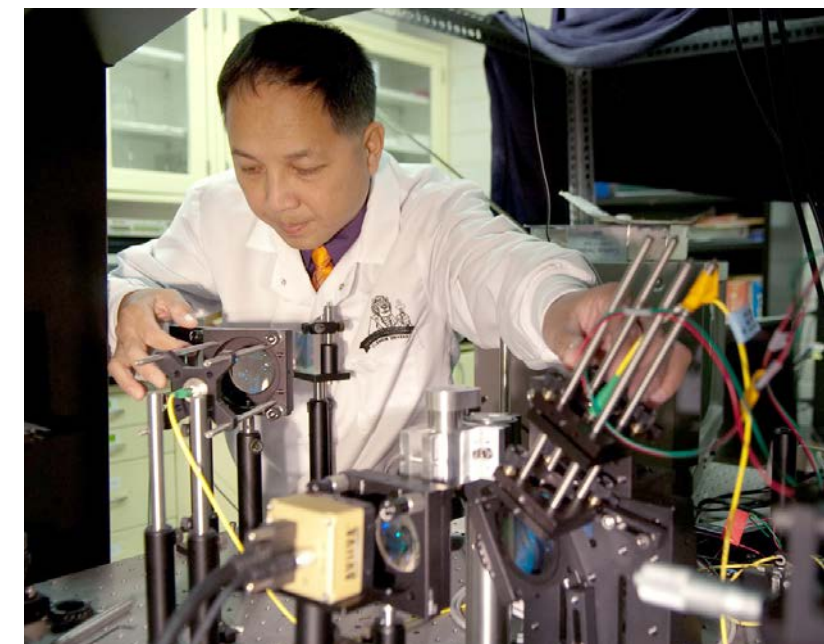
2) A multibeam, laser guidance-based 3D additive cell manipulation system. Current printing-based additive microfabrication techniques lack temporospatial precision and thus cannot be used to study defined cell-ECM interactions, which are essential knowledge for achieving tissue/organ printing. Dr. Gao plans to further develop

his current laser patterning system, using multiple beams to significantly increase throughput.

3) A 3D microfabrication digitization system. Dr. Gao’s previous research is in the forefront of the machine vision field; he will build on the techniques established in his research lab to develop an imaging system for digital design and assessment for 3D biofabrication.

Not only will the endowed chair funding enable the research advancement described above, the biofabrication techniques developed with the financial support will also enhance Clemson’s educational program. With conventional manufacturing techniques, students must undergo long-term training in mechanical design to be able to create their own design for a machine shop to make

their research apparatus. According to Dr. Gao, with biofabrication techniques, “students’ designs will not be restricted by a machine shop’s manufacturing capability, and a research apparatus can be made by the students themselves; thus, a student’s training can focus on solving actual biomedical problems.” For example, he said, “using a biochip designed and fabricated in my laboratory, my students recently found that stem cells had the potential to rescue damaged cardiac muscle cells by transferring mitochondria via nanotubes formed between the two cell types.” To explore the mechanism, the students used the biofabrication techniques developed in Dr. Gao’s lab to fabricate biochips that confine nanotube formation between stem cells and cardiomyocytes and facilitate microscopic observation of mitochondrial transfer via formed nanotubes. The data Dr. Gao’s students obtained from the biochips enabled the interpretation of in vivo observed stem cell rescue effects in both animal and human heart models developed by Dr. Gao’s clinical collaborators.



WORKING FOR THE BETTERMENT OF PATIENTS' LIVES WORLDWIDE: DAN AND AGGIE SIMIONESCU

A tenured professor with the admiration and respect of his colleagues, Dr. Dan Simionescu could be resting on the laurels he continues to amass. However, he and spouse Dr. Aggie Simionescu continue to create projects for themselves in many venues. Aggie and Dan served as editors for the online textbook “Physiologic and Pathologic Angiogenesis–Signaling Mechanisms and Targeted Therapy,” 2017. The book’s second edition has been downloaded 7000+ times; the first, more than 26000. Currently, Aggie and Dan serve as guest editors for the journal Bioengineering, editing the special issue, “Mesenchymal Stem Cells in Tissue Regeneration.” The issue will be published in a 2018 issue of Bioengineering, published by MDPI AG, Basel, Switzerland. Finally, it is notable that the Simionescus have created a lab whose students are known for being tight-knit and loyal. Remarkably, they are also known for warmly welcoming the many students who seek out the Simionescu lab. Editor

This first (heart transplant) paved the way for a new era of life-saving transplantation worldwide and stimulated novel biomedical engineering research into development of tools and machines necessary for the complicated surgery. Dr. Dan Simionescu

On November 1, 2017, a letter left Romania, crossed an ocean and landed in Dr. Dan Simionescu’s mailbox. Opening it brought the surprise and pleasant feelings that attend an unlooked-for honor: “In gratitude for your sustained cooperation and significant support, for your meritorious academic services and for being a model and inspiration to our academia through your personal example, I am delighted to announce you that that the Senate of the University of Medicine and Pharmacy from Tirgu Mures decided to grant you the highest honors, the title of Doctor Honoris Causa.”

At Clemson, Dan is the Harriet and Jerry Dempsey Professor of Bioengineering; a Fellow of the American Institute for Medical and Biological Engineering; Director of the Biocompatibility and Tissue Regeneration Laboratories; and Deputy Director, Clinical Research Programs and Operations for the Department of Bioengineering. In the South Carolina Bioengineering Center for Regeneration and Formation of Tissues, Clemson’s first NIH COBRE Center, Dr. Simionescu directs one of the Center’s two cores, the Cell, Tissue and Molecular Analysis Core. These cores support the target faculty, the Center’s primary concern, in achieving financial independence through research grants.

In Dan’s letter, along with a request to speak at the awards ceremony in Tirgu Mures, came an invitation to attend University Days, a traditional event held annually to “celebrate in a festive, academic way” the long series of events that are of great importance for the University of Medicine and Pharmacy in Tirgu Mures.

Aggie and Dan were already planning to attend a conference in December. Throughout 2017, they served as co-organizers of a meeting in Cape Town South Africa’s Groote Schuur Hospital on December 2-4 celebrating the 50th Anniversary of the 1st Heart Transplant. So, the couple left home for Cape Town on November 27, 2017. On December 4, they served as Chairs and Moderators of the “Cardiac Valve Repair, Remodeling and Regeneration” session (Dan) and the “Tissue Engineering and Regeneration” (Aggie) session of the International Society for Applied Cardiovascular Biology. Each made an oral presentation: Dan spoke on “In vitro regeneration of living aortic and pulmonary valve roots and preclinical testing”; Aggie and Clemson alumnus Chris DeBorde (now at Humacyte Inc., a vascular tissue engineering company) presented “Mitral Valve Tissue Engineering — a model for investigating valve degeneration.”



Dan had this to say about the reasons for the 50th celebration, “The first human heart transplant in the world was performed at Groote Schuur Hospital in Cape Town, South Africa, on December 3, 1967 by Dr. Christiaan Barnard, MD, PhD. Although many groups in the US and elsewhere were experimenting with transplantation in experimental animals, Dr Barnard had the vision and the courage to perform the first transplant in a human. This first surgery paved the way for a new era of life-saving transplantation worldwide and stimulated novel biomedical engineering research into development of tools and machines necessary for the complicated surgery. To commemorate this event, the Groote Schuur Hospital and the University of Cape Town hosted a 3-day program celebrating the 50th Anniversary of the 1st Heart Transplant under the umbrella logo of “Courage and Innovation.”

This unique event brought together under one roof the most outstanding group of transplant surgeons in the world. These surgeons were invited by Professor Peter Zilla, Chief of Cardiovascular Surgery at Groote Schuur, to share their experiences with heart transplantation. On the conference’s 2nd day, December 3, people who knew Dr Christiaan Barnard personally and worked with the “surgeon who dared,” described him throughout the years as kind, ingenious and compassionate. One after another, surgeons from Europe, Asia and the Americas described how after December 3rd, 1967, they started a heart transplant program in their own country.

On the final day of the conference, December 4, a scientific session was hosted by the International Society for Applied Cardiovascular Research (ISACB), on which Aggie and Dan serve as Executive Council Members. The session covered a variety of topics including arterial remodeling, aneurysms, atherosclerosis, cardiac valves, tissue engineering and translational challenges. Notably, ISACB was born in Cape Town exactly 30 years ago, after a transplant meeting commemorating the then 20-year anniversary of the first transplant. Sessions were, among others, “Meeting cardiovascular medical needs in developing nations”; “Transplantation; 50 years on,” in which surgeons discussed the future of the field; and “Assisted circulation; center player at last;” emphasizing the importance of innovation in surgery.

Following the meeting’s close, Aggie and Dan, natives of Romania, needed to be in Tirgu Mures for Dan’s acceptance of his Doctor Honoris Causa. Few may realize that Cape Town to Romania is



virtually a straight shot. Moreover, the length of a continent (by air: 5,413 miles), a splash of the Mediterranean and a bit of Bulgaria are negligible to people headed to a beloved home.

The award ceremony honored Dan and Professor Mark Anthony Slevin of Manchester Metropolitan University, both of whom were granted the Doctor Honoris Causa. In his speech on December 14, Professor Leonard Azamfirei, Professor of UMF Tirgu-Mures, pointed out that the two titles of Doctor Honoris Causa were given to “personalities who have long been distinguished by scientific activity, but equally through the contribution through which their day-to-day, scientific, academic, and professional activity was linked to the good work of the university. “

Dr. Azamfirei also pointed out that UMF Tirgu-Mures has proved “quite parsimonious with the awarding of this title, which represents the highest honorary title that a university can give.” The policy of the university is to grant this title only if those who are proposed to receive such a high distinction have, over time, demonstrated real, concrete, quantifiable involvement in the academic life of our university. For this reason, we now have two personalities of world science who, through their work in the last five or six years, have decisively contributed to the prestige of our university in the country and beyond the country. The two who will receive this title today are Professor Dan Teodor Simionescu and Professor Mark Anthony Slevin. “

Recalling decades of research, Dan said, “Aggie and I have been inspired by these recent events. We will continue to foster courage and innovation in our students and collaborators and target the highest quality research and development of devices and treatments for the betterment of patients’ lives worldwide.”



MEETING CLINICAL NEEDS THROUGH ENTREPRENEURSHIP

By Shannon Pierce, Founder,
New Ocean Health Solutions

Clemson University, CUBEInC, and Greenville have played a vital role in my professional development. I graduated from Clemson University's College of Nursing fully equipped to work in cardiac care and engage in strategic conversations with healthcare and business professionals. The hands-on practical skills combined with the scientific background and leadership training continue to benefit and shape me. It was while practicing as a nurse I recognized we could do more to engage, equip, and empower patients. The communication and problem-solving skills acquired at Clemson enabled me to patent a mobile documentation system and start what is now New Ocean Health System.

The Greenville business community has proven willing to assist and advise all along the way. Initially, I did not know I was starting a company. The nursing process was ingrained in me at Clemson: Assess, Diagnose, Plan, Implement, and Evaluate. When I saw an unmet clinical need, I was able to apply the nursing process systemically. The beautiful thing is, when the nursing process is applied to almost any problem, positive results follow. Not knowing better, I applied the same process to business decisions. As a result, I've been able to quickly identify and minimize risks and ensure we continue to achieve our milestones on time and under budget while realizing a positive return on investment.

When the company was pre-revenue and doing business as CareCam Innovations, I first become aware of CUBEInC and the ambitious goal to combine academia and commerce in a meaningful and proven manner. I was hooked and wanted to take part. Though I am not a bioengineer, I recognized metadata, health information technology, and machine learning would soon play a large role in all things life sciences. I heard Dr. LaBerge speak at an event and immediately applied for a space at CUBEInC.

The CUBEInC facilities permitted me to work within a start-up budget while enjoying the benefits of a state-of-the-art-environment as well as actively engaged clinicians within close proximity. I toured the space with an out-of-town guest who subsequently became our

largest investor and CEO. We now have headquarters in Conshohocken Pennsylvania (outside of Philadelphia) and an Operation Center in Greenville, SC. Even so, I continue to keep my personal office at CUBEInC. It inspires me to work alongside visionary, vibrant, and driven students, faculty, and business leaders. As an entrepreneur, I am humbled and encouraged each day. As soon as I figure out an unknown, three more larger obstacles soon appear. The challenges make the rewards all the sweeter. Confidence and industriousness require intense challenges to take hold and set in. The more I learn, the more I know, and I will never stop learning or struggling to do my best. It continues to be rewarding to work alongside careful, creative, and curious risk-takers.

The best advice I can share is the advice that has carried me along the way...

1. You cannot fail if you resolve not to quit.
2. Consider the costs and what you are willing to give before going all in.
3. The end of a matter is better than the beginning of one: see it through to the end.

PROFESSOR KAZUHIKO ISHIHARA TO BE RECOGNIZED WITH THE SAMUEL F. HULBERT AWARD

Professor Kazuhiko Ishihara of the Department of Bioengineering at the University of Tokyo is to receive the Samuel F. Hulbert award at the Bioengineering Award Banquet to follow Clemson's International Biomaterials Symposium (IBS) April 16, 2018. Internationally known for his work on biomaterials and biointerfaces, Professor Ishihara's Hulbert Award recognizes his contribution to Clemson bioengineering in making possible its research abroad program at the University of Tokyo. Among the many awards the Professor has received in a lifetime of research and teaching is the Clemson Award for Applied Research, one of three awards given annually by the Society for Biomaterials. The award was made at the 2009 annual meeting of the Society for Biomaterials. Clemson's Dr. Jiro Nagatomi presented that award. In 2010, the Professor and Dr. Nagatomi met to discuss a potential research program for Clemson students in Japan. The program was implemented in 2013 and continues, with 26 participants to date. The IBS will take place at Clemson's Conference Center and Inn, the Madren Center. Nine delegates from Japan, including students, will attend.



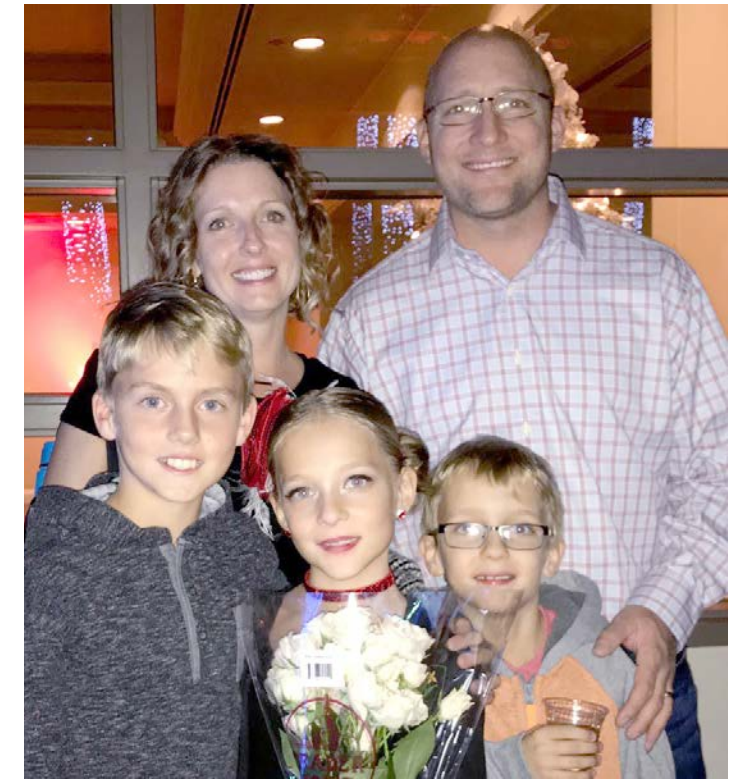
JOSH LOVEKAMP, GORE PRODUCT SPECIALIST

By Josh Lovekamp

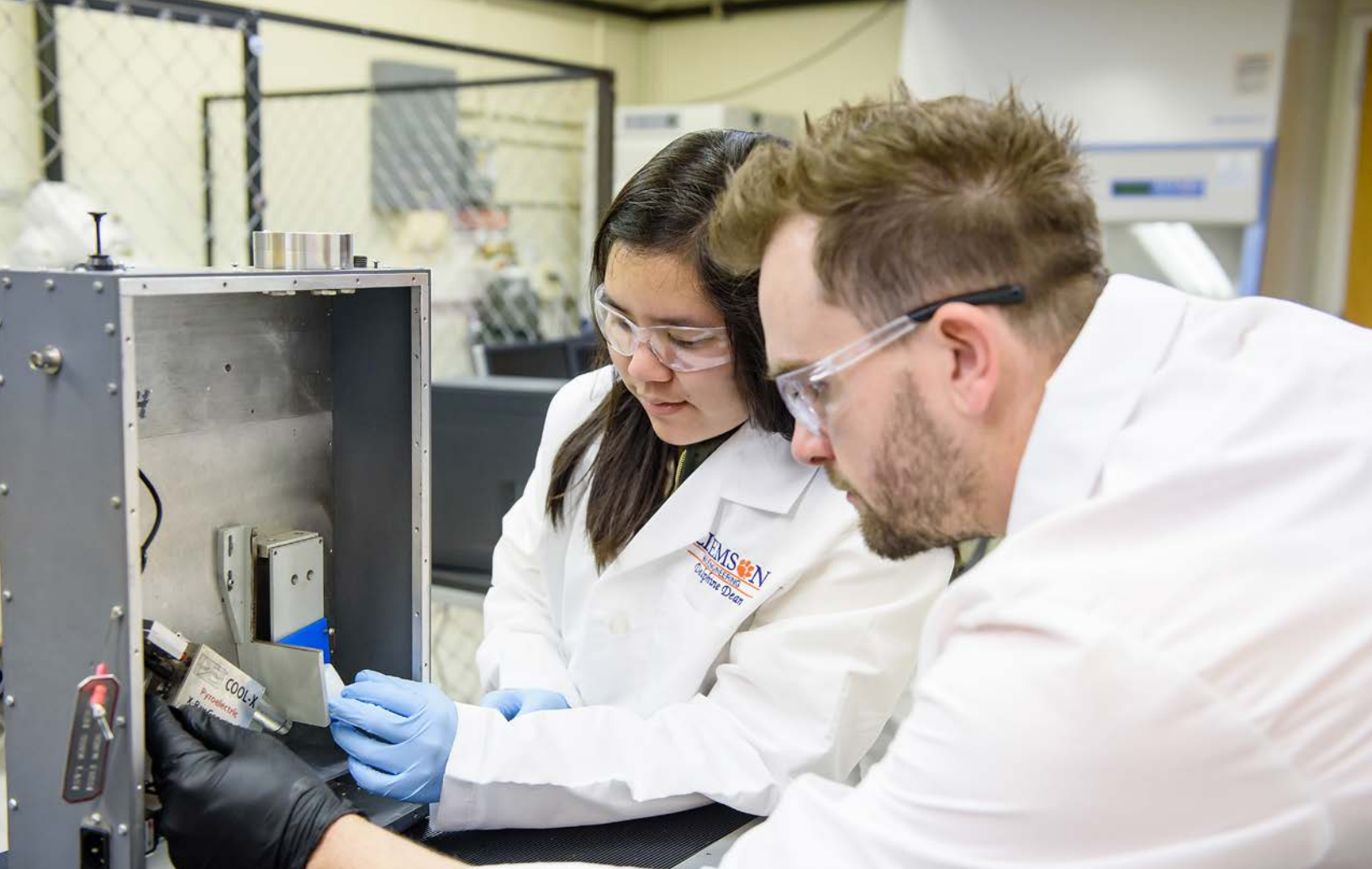
A Product Specialist is just that – the one person in the organization who is responsible for understanding the nuanced details of the diseases or conditions being treated as well as the technology that enables the products that treat them. Josh Lovekamp

After a combined ten years of college and graduate school, it is hard to imagine what life might be like outside of academia. During my first visit to the Medical Products Division of W. L. Gore & Associates, Inc., I learned that it doesn't have to be that different. That was almost 13 years ago today, and since that time I have enjoyed the opportunity to continue in my role as a Product Specialist at Gore. As the name suggests, a Product Specialist is just that—the one person in the organization who is responsible for understanding the nuanced details of the diseases or conditions being treated as well as the technology that enables the products that treat them. This breadth of responsibility requires a lot of collaboration, both with other Gore Associates as well as with physicians and scientists outside of Gore and around the world. Whether working with a team of engineers and scientists to develop new treatment options or sales and marketing teams to ensure the success of existing products, the Product Specialist at Gore remains integral.

With the majority of my time as a Gore Associate spent as a Product Specialist, I have had the opportunity to work with dozens of world-renowned physicians and surgeons leading their respective fields



in cutting edge therapies, some of which I have had the honor to help develop. I have also had the privilege to continue working with numerous fellow Clemson BioE alumni who have since joined me at Gore, all of whom have been excellent ambassadors for the Department. Nothing could be more exciting for me and my wife, who is also a Clemson grad, than bringing a little bit of Clemson to Arizona — one new Gore Associate at a time! Go Tigers!



NEW PRECISION DEVICE COULD ADVANCE LOW-DOSE RADIATION CANCER RESEARCH

By Clinton Colmenares

CLEMSON, South Carolina — Radiation is a powerful weapon against some types of cancer, but using the therapy is still more like a shotgun approach than a surgical strike, shooting a tumor with large doses of broad-spectrum X-rays that damage healthy tissue and cause side effects.

In a study published in the journal PLOS ONE, a team of Clemson University bioengineering and physics students and faculty describe an irradiation fluorescence system they developed that could accelerate research in delivering very specific types of radiation in controlled doses. They also showed that low doses of specific, controlled radiation are safe for healthy cells.

Sources of radiation are everywhere — sunlight, trace amounts of radioactive elements in the soil, medical imaging and outer space, where radiation is a concern

for astronauts. At its most basic, radiation is energy released in the form of subatomic particles. Each atom has its own wavelength and energy; collectively, they comprise a spectrum of radiation.

If radiation were a rainbow of colors, the Clemson team was able to use and measure a very specific shade of the rainbow at a specific low dose consistently. Previous radiation research has lacked detailed information, making the science difficult to replicate and verify.

“In general, researchers haven’t been too worried about the exact energies, wavelengths and dosages of radiation,” said Delphine Dean, an associate professor of bioengineering at Clemson and the senior author of the paper.

Elements absorb specific wavelengths of energy and release others, a process called fluorescence. In their study, the Clemson researchers bounced X-rays off a small plate of iron. The iron absorbed some wavelengths and emitted others onto a dish of fibroblast cells from a well-established mouse line provided by the National Institutes of Health.

For 24 hours after being irradiated, the cells grew slower than cells that didn’t receive radiation. By the third day, however, the irradiated cells were growing at a much faster rate than the non-irradiated cells. The researchers suggest cells slowed growth as a protective measure to minimize DNA damage, then sped up the cell cycle to overcome the damage. By the fifth day, both irradiated and non-irradiated cells were growing at the same rate.

Previous research has shown that cancer cells have a difficult time repairing themselves after low doses of radiation. But the pause and rapid rebound by the healthy cells in the Clemson project was surprising and encouraging, Dean said.

“When we first started working on this, I actually made the students redo the experiments several times because I thought that it didn’t make sense that the cells would start to proliferate faster after irradiation. But it was so nicely repeatable that we knew it was really something there. That’s a lot to do with our system. We know exactly the dose, dose rate and energy every time we do the experiment so there’s no question that what we were seeing was real,” she said.

What made the Clemson study different from others started with a collaboration between bioengineering and physics students.

“I am impressed by how far our students were able to push this research considering that small overlap of the two fields. On the other hand, this makes our collaboration exciting and the results unique and valuable for the scientific community,” said Endre Takacs, associate professor of atomic and medical physics in Clemson’s College of Science.

Katelyn Truong, a senior at Clemson and first author on the paper, said the collaboration between bioengineering and physics was “fundamental” in developing the low-dose X-ray source and performing analytical tests.

“The physics students contributed tremendously by really delving into calculations behind the X-ray spectra analysis. Specifying precise doses and keeping these doses consistent for the cells would have been impossible without their help,” Truong said.

Together, the students determined that using specific, well-characterized radiation was essential. Then, they overcame the challenges of creating a device that can fit within an incubator about the size of a mini-fridge.

“Everything had to fit inside the box that was heated and humid, which is not the way precision physics studies are typically done. It took a bunch of clever reengineering of our first prototype irradiator to do that. The physics team machined the parts and everything is custom so that it can fit and still irradiate the cell cultures,” Takacs said.

“In order to calculate the amount of radiation reaching the cells, the elementary physical processes of the interaction of

x-rays with different materials needed to be considered. This information went into the design of the fluorescent setup, the container holding the cell and the built-in monitoring equipment,” Takacs said.

“We’re really hoping this (PLOS ONE) paper gets other research groups to set up similar irradiation systems where the dose, energy, dose rate, etc., are well-characterized. This will help the field so that it will be easier to compare results between groups,” Dean said.

Suzanne Bradley, Bryana Baginski, Joseph Wilson, Leon Zheng and R. Kevin Wilson also were authors of the paper.

The study was funded through the Clemson Creative Inquiry student research program and an NSF CAREER Award to Dean.

END

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MAKING A DIFFERENCE, ONE COUNTRY AT A TIME

By Paul Alongi

One of the hallmarks of the college experience is making new friends, but not everyone gets to do it in Tanzania.

Carson Brewer is one of the fortunate few.

The bioengineering major went to the East African nation for nearly seven weeks with two other students at the end of her sophomore year, and the experience made a lasting impression.

“We lived in the communities,” Brewer said. “We became one of the Tanzanians and got to learn everything about them—their culture, their health care system and how we can take a step in fixing the broken links.”

Brewer, a senior, has made the most of her Clemson experience. She has traveled abroad, been heavily involved in research, played intramural sports and still found time to work as a nursing assistant on the cardiac floor at AnMed Health Medical Center.

John DesJardins said Brewer shows up early for design class, even though it starts

at 8 a.m. He said he sometimes wonders, “Where do you get your energy?”

“She’s always got questions, and she’s always got ideas,” said DesJardins, the Robert B. and Susan B. Hambright Leadership Associate Professor of Bioengineering.

“She’s endlessly happy and appreciative for opportunities given and always sees the bright side of the situation.”

When Brewer reflected on her time in Tanzania, one person stuck out in her mind. She described him as a “young man named Weston,” who helped her and the other students bridge the language barrier.

“One evening, he brought the three of us over to his home and cooked a homemade dinner for us and welcomed us in to meet his family, his kids,” Brewer recalled. “That was just such a rewarding feeling. This guy knew nothing about us, other than that we’re just three Clemson kids coming to try to save the world, and he opened his door to us and took us as his own.”

The trip to Tanzania was part of a Creative Inquiry project led by DesJardins and Delphine Dean, the Gregg-Graniteville Associate Professor of Bioengineering.

The information that Brewer and her team gathered led to the development of a portable patient monitor for doctors on medical missions. The device has a hand crank to generate its own power. It measures blood pressure, temperature and blood-oxygen level. The monitor, now on its second prototype, also includes an electrocardiogram.

As graduation approached, Brewer was considering whether she wanted to work for a year or go directly into medical school.

Dean said Brewer is one of those students she will remember for a long time.

“There are a lot of opportunities at Clemson, whether it’s in academics or outside academics,” Dean said. “Carson is a great example of a student who went out and did all the things she wanted to do and then some by looking around and keeping her eyes open.”



DR. NAREN VYAVAHARE HONORED BY BOARD OF TRUSTEES

The Board of Trustees annually recognizes the achievements and contributions of Clemson University’s faculty and staff. The purpose of the Board of Trustees Award for Excellence is to identify and acknowledge faculty and staff whose vision, accomplishments, and efforts have brought honor to Clemson University. At the 2017 award session, Dr. Naren Vyavahare was awarded Excellence in Sponsored Program Expenditures, 2013-2017.

Dr. Vyavahare, Hunter Endowed Chair and Professor, said “I am honored to be recognized, but I think my award really goes to the outstanding faculty that participate in our COBRE center. Their active participation made it possible to achieve success in attracting major funding to Clemson University.”

The department will hold its annual **Design Expo** May 4 in Greenville’s TD Convention Center from 1:00-4:00 p.m. in room 102ABC. Come see novel biomedical devices from over 25 teams of bioengineering student designers in partnership with clinicians from the Greenville Health System, MUSC, Roper St. Francis and others!

CITADEL ENGINEERING UNDERGRADUATES ELIGIBLE FOR A MASTER OF SCIENCE OR MASTER OF ENGINEERING DEGREE FROM CLEMSON

By Jordon Gilmore

Dr. Jordon Gilmore is one of BIOE's newest tenure-track faculty. Among Key Personnel on Sarah Harcum's National Science Foundation EPSCoR Track II Advanced Biomanufacturing grant, Jordon was PI on a 2016 Tiger Grant. Clemson-Citadel Joint Program Director, Jordon is an alumnus of both The Citadel's Electrical Engineering program and Clemson's Bioengineering program. His interests include orthopedic tissue engineering, biomedical textiles, bioinstrumentation and control engineering. Editor

As the state's life science engineering and technology economy quickly evolves, Clemson University and The Citadel are partnering to prepare our students for cutting edge careers. This new partnership is beginning with an exciting opportunity created by Clemson Bioengineering and The Citadel's Electrical and Mechanical Engineering programs. The BS/MS program that has been such a success for CU BIOE undergraduates has been expanded to include Citadel engineering undergraduates seeking a Master of Science (MS in Bioengineering) or Master of Engineering (MEng in Biomedical Engineering) degree from Clemson.

Through The Institute for Graduate Education (TIGE), a collaboration of South Carolina colleges and universities, Citadel undergraduates will take Clemson graduate courses as a part of their BS degree program in electrical or mechanical engineering. Upon completion of the BS, the students enrolled in this five-year program will finish their MS or MEng degrees at the Clemson main campus or at Clemson's affiliated graduate campuses in Charleston. Students interested in pursuing graduate level research opportunities may do so through the BS/MS program, working with Clemson Bioengineering faculty on the main campus or at MUSC. Those students primarily interested in industrial or regulatory opportunities can pursue the BS/MEng degree and focus on design-based projects incorporating Clemson-Citadel student teams.

The Institute for Graduate Education will foster collaboration between institutions and degree programs and facilitate the transfer of graduate coursework. The participating universities developed the Institute in response to the continuing education needs of professionals working in South Carolina companies and government organizations. The collaborating institutions, The Citadel and Clemson University, offer a variety of graduate courses that lead to master's and doctoral degrees. In addition to a primary focus on South Carolina's working technical professionals, The Institute seeks to use the digital availability of its courses to enhance learning at the participating universities.

The Clemson-Citadel BS/MS program is the perfect start to a state-wide collaboration with potential for success in so many areas. Bioengineering education is only the beginning. During my time at



The Citadel, I benefited from personalized engineering instruction and world-class leadership training, both of which have empowered me to pursue my career goal in the academy. Opportunities at The Citadel allowed me to pursue both industry-focused education and undergraduate research. And, as South Carolina's life science technology economy quickly expands, the timing is perfect to formalize these opportunities for more students. I believe both institutions are uniquely equipped to address the need for life science engineering and technology training in a way that connects the resources available in the Lowcountry and the Upstate. I am also excited about the potential for business innovation and entrepreneurship education that will grow from joint projects and program curricula. Together, all of these elements will help us to achieve the goal of positively impacting South Carolina professionals and companies.

I am excited about the potential for business innovation and entrepreneurship education that will grow from joint projects and program curricula. Dr. Jordon Gilmore

SENIOR DESIGN PROGRAM EXPANDS TO MUSC

Clemson Bioengineering senior design program just went state-wide. Following on years of successful partnerships with upstate healthcare institutions, the program recently expanded its partnership with the Medical University of South Carolina (MUSC).

"We are in our 7th year of partnering with clinicians to identify and design solutions to critical healthcare needs," said Dr. John DesJardins, director of Clemson Bioengineering's Senior Design program and Hambricht Leadership Associate Professor in bioengineering. "In 2011, the program had 48 seniors working with the Greenville Health System (GHS). Now there are more than 120 seniors, and we have the capacity to engage many more clinical partners and expand the impact of this award winning program."

The design program has seen many successes, with teams winning awards and accolades in the BMESTart competition, Engineering World Health Design Competition, Collegiate Inventors Competition, and VentureWell E-Team Program. "Our students complete a rigorous 2-semester design process that is modeled on FDA guidelines and industry standards" said DesJardins, "They investigate a clinical need, and together with their clinical, industry and academic mentors, they produce innovative solutions with the potential for commercialization."

In 2012, two of Clemson's teams worked with MUSC clinical partners from the intensive care unit, and the resulting design solutions were exceptional, according to Dr. DesJardins. Five years had passed since a collaboration with MUSC and the senior design program, and it was a Clemson alumna who sparked the renewed collaborative effort. Chelsea Ex-Lubeskie, MS ('12), a licensing manager at the MUSC Foundation for Research Development (MUSC FRD), said she saw a clear opportunity to bridge the partnership between student and clinician. "We have truly innovative clinicians here at MUSC, and I thought, if the program is working with GHS, why can't it work with MUSC, too? I loved the senior design process. It inspired me to follow a career in healthcare innovation, and it is advantageous to both the students and clinicians." Chelsea and Dr. Michael J. Yost, Ph.D. FAIMBE, Associate Professor of Surgery and Bioengineering and Vice Chairman for Research, serve as the innovation and clinical leads for the students' interaction with MUSC clinicians. The process is underway, with six Clemson teams actively collaborating with MUSC clinicians in the 2017-2018 design cycle.

In addition to the two-semester design process, the Clemson-MUSC partnership will also support the summer needs-finding program, DeFINE, Design Fundamentals in Needs Finding Experience. This immersive six-week program allows a select group of bioengineering students to spend their summer shadowing clinicians, to identify



We are in our 7th year of partnering with clinicians to identify and design solutions to critical healthcare needs.

hundreds of opportunities for innovation, and to bring these lists back into the design program for further development. Now in its fifth year, this NIH-funded program led by Dr. DesJardins has been recognized by Clemson University as the 2017 Service Learning Program nominee for the South Carolina Commission for Higher Education award.

"We are very excited to have MUSC as a new partner in our design program," said Dr. DesJardins. "The future of bioengineering innovation in South Carolina is strong."

The 2018 annual Bioengineering Design Expo will take place on May 4, 2018, at the TD Convention Center in Greenville, SC.

About the MUSC Foundation for Research Development

FRD has served as MUSC's technology transfer office since 1998. FRD has filed patent applications on more than 400 technologies, resulting in over 150 U.S. issued patents. Additionally, FRD has executed more than 150 licenses and spun out more than 50 startup companies. Products by MUSC startups have been approved by the FDA acquired by publicly traded corporations, and have attracted substantial investment dollars to South Carolina.

(Senior Design) inspired me to follow a career in healthcare innovation, and it is advantageous to both the students and clinicians.

Chelsea Ex-Lubeskie '12

THE CLEMSON UNIVERSITY BIOENGINEERING SENIOR DESIGN PROGRAM: INNOVATION IN EDUCATION

By Dr. John DesJardins

When the undergraduate program in bioengineering was established in 2007, the Senior Design Program was a mere twinkle in the eye of Dr. John DesJardins, now Hambright Professor in the College of Engineering, Computing and Applied Science. By fall semester 2011, the program was established in its current form; to date, approximately 500 BIOE seniors have participated. Editor

As engineers, we like to make things. Cars, planes, bridges, medical devices; you name it, we can make it. To design something however, requires that we have a plan in place, and that we have identified a clear need worth solving. The goal of a needs-based design cycle is to identify unmet problems within an active system and then design innovative solutions to solve that need or problem. In bioengineering, the clinical environment is the perfect place to have students engage physicians and patients as stakeholders, work with them to identify problems and needs, and then design solutions to those needs.

For undergraduate students, engaging in clinically based needs finding can be challenging. Healthcare facilities are usually not accustomed to interacting with dozens of undergraduate students, and it is often difficult to engage sufficient numbers of clinical mentors to give students access to clinical staff and opportunities for shadowing or environment-immersion experiences. In 2011, our bioengineering program partnered with the Greenville Health System to develop a collaborative design program that allows students to directly engage with clinicians, problems, and environments and through hands-on collaboration, to solve real problems in the healthcare community.

Over the last seven years, we have developed a robust, outcomes-based, multi-semester design program that incorporates an innovative combination of clinical, educational and entrepreneurial processes to accelerate a student-led, service learning model of biomedical device design and enhance the students' understanding of civic responsibility through biomedical design.

The Senior Design program engages a surprising diversity of stakeholders in the university and community. Each year, an estimated 300 people from the university, community, healthcare facilities, industry and government actively participate in diverse roles. The multi-semester program incorporates an innovative combination of clinical, educational, and industrial processes to accelerate student-led translation of needs-based surgical devices.

The specific components of this department-wide program now include: 1) A six-week summer clinical/entrepreneurship immersion program with the Greenville Health System and university technology transfer office for 10-20 design-track focused rising



2) A two-semester senior design experience that uses clinical needs-based problem identification to match up to 25 teams of students with regional clinicians to develop biomedical-device solutions through prototyping, testing and validation; 3) A two-semester graduate curriculum to accelerate exceptional designs towards commercialization, 4) a diversity of K-12 outreach activities and events that include products from these design programs; and 5) significant community participation as mentors, advisors and participants in our end-of-year senior design symposium. In addition, between 2011 and 2015 the Clemson Department of Bioengineering had a two-semester freshmen design experience program.

During a typical two semesters of senior design, we have over 25 teams of four to five students partner with over 30 clinicians in the community. The students shadow and collaborate with clinicians during the semester (some have the opportunity to shadow for up to 6 weeks during our NIH-supported DeFINE [Design Fundamentals

The teams follow an industry-modeled design gate process, and over the next eight months, novel products are designed, manufactured, tested and presented to peers and the community.

Dr. John DesJardins



With each of these projects, clinicians have seen the power and promise of biomedical device design and how it could improve their care and treatment of patients. Dr. John DesJardins

in Needs Finding Experience program]) to identify hundreds of opportunities for innovation. From these clinical needs, students perform needs assessments and select opportunities that have the highest potential clinical and economic impact. The teams then follow an industry-modeled design gate process, and over the next eight months, novel products are designed, manufactured, tested and presented to peers and the community. A typical design-year might include over 20 pre-patent disclosures, ten national design competition entries, 1 patent disclosure, and hundreds of mentions on our graduating students' resumes. Some specific examples of novel surgical devices that have been designed include A Post-arthroscopic Arterial Wound Closure Device, A Breast Nipple Reconstruction Patch, A Laparoscopic Extraction of Tumor Masses, A Sternal Chest Cutting Guide, A Chest Tube Port Stabilization Device, and An Abdominal Fascia Closure Device.

In addition to the students, faculty and graduate student mentors have been recruited and engaged for each design team and project. In recent years, one to two bioengineering faculty and two to three graduate students have been recruited for each team. For 2016-2017, we had 15 faculty and 24 graduate students; each is assigned to mentor two teams.

We have had over 150 teams and technologies developed over the last seven years. Each of these design projects is not something that students or faculty thought might be fun to make; rather, each represents the potential solution to a critical clinical problem or need for which our students spend thousands of dollars and two semesters to develop a novel device. Products by MUSC startups have been approved by the FDA and acquired by publicly traded corporations and have attracted substantial investment dollars to South Carolina.



CLEMSON BIOENGINEERING COURSES AT PEKING UNIVERSITY

At the invitation of Peking University (PKU), spouses Dr. Jeoung Soo Lee and Dr. Ken Webb will be teaching this summer in the PKU Globex Julmester in Beijing. Globex offers courses that focus on two core elements: engineering and science and China-focused study. The Globex Julmester website provides this perspective, "Engineering and science generate new knowledge and skills for society to advance and prosper (10 engineering/science courses). Societies everywhere are being profoundly impacted by China as it grows to become the world's largest economy. Globex offers students an opportunity to study China and its peoples (2 China focused courses)."

Globex aims to promote international academic exchange. It recruits faculty from around the world to offer specialized technical courses ranging from biomedical engineering to robotics to smart materials. It is designed to provide students with a study-abroad experience by allowing them to take 1-2 courses over a period of about 3 weeks in July, getting 3-6 university credits. The program consists of a suite of English-language classes as well as other activities.

Dr. Lee will teach *Drug and Gene Delivery in Biomedicine*, and Dr. Webb will teach *The Tissue Engineer's Toolkit: Design and Evaluation of Regenerative Therapies*. According to Ken, "the Globex program offers a remarkable opportunity to engage with students and colleagues from all over the world in an environment that combines a rich history and culture with a rapidly expanding hi-tech, knowledge-based economy." In addition to teaching, they intend "to embrace Chinese culture and cuisine," including a professional tour sponsored by PKU that is expected to include the Great Wall and the Forbidden City.

Describing what they hope students will take from their courses, Dr. Webb and Dr. Lee said "In our teaching, we both try to really convey a fundamental understanding of the state of the art in the field and the ability to critically examine the literature. We want not only to share knowledge and skills, but also a conceptual framework for integrating the potential of newly discovered technologies with the realities of commercial development and clinical translation."

In our teaching, we both try to really convey a fundamental understanding of the state of the art in the field as well as a conceptual framework for integrating the potential of newly discovered technologies with the realities of commercial development and clinical translation. Drs. Ken Webb and Jeoung Soo Lee



SIMULATION-BASED TRAINING PROMISES IMPROVED PATIENT OUTCOMES

By Dr. Joseph Singapogu

Medical errors are now the third leading cause of death in the US.

Dr. Joseph Singapogu

My lab focuses on creating tools that aid clinicians to enhance their clinical skill in order to ultimately improve patient care. Towards this goal, we specialize in the development of technologies at the interface of human-computer interaction, state-of-the-art sensors, robotic technology and computational tools. Two key research questions that our lab focuses on are

1. Can clinical skill (e.g., robotic surgery, needle insertion) be accurately assessed by integrating sensors, robotic technology and computational methods?
2. Can sensor data from simulators enable improvement in clinical skill?

The underlying premise for our work is based on the fact that the skill of a clinician is critical to successful patient outcomes. It is imperative, therefore, that our clinical workforce be effectively and efficiently trained. In view of this goal, there is an ongoing movement by leading medical education stakeholders to use advanced tools to create standardized, objective and structured training. This tangible need, combined with burgeoning medical technologies like surgical robots and smart operating rooms, has generated the field of medical simulation. Another factor that propels the need for simulation-based training is the growing problem of medical errors, now the third leading cause of death in the US alone. Simulation-based methods are currently being explored in a plethora of medical disciplines as a means of enabling a skilled workforce.

Our work is highly transdisciplinary in nature, since development of meaningful tools is possible only through close collaboration with clinicians. Further, our collaborators span the disciplines of human factors psychology, electrical and industrial engineering and computer science.

One current project we are working on is to develop a simulator for hemodialysis cannulation. Most patients in the US with end stage renal disease require dialysis multiple times a week for survival. One of the primary contributors to the inordinately high rate of complications among dialysis patients is unskilled cannulation at dialysis clinics. Training nurses and dialysis clinic technicians in locating and accurately cannulating patients holds the promise of greatly improving patient outcomes. Towards this goal, we are developing a simulator for effective palpation and needle



Dr. Joseph Singapogu demonstrates training on a medical simulator for Dr. Naren Vyavahare and Dr. David Cull.

insertion during cannulation by integrating hardware and software components.

Another project addresses the need to train suturing skills of novice surgeons by integrating video, motion and force sensor data. To facilitate the characterization of suturing skill, a novel platform was developed that captures synchronized video, motion and force data during suturing at various depths. This device permits the use of standard surgical tools during suturing and quantifies performance using sensor metrics. Several preliminary studies with residents and attending surgeons using the platform have demonstrated promising results for the viability of the system for skills assessment.

A recent exciting development is the work we have begun with Drs. Venkat Krovi and Rick Groff on using a da Vinci surgical robot to examine skills training. Clemson provides a unique environment that fosters interdisciplinary collaboration because of our relationships with Greenville Health System and other departments beyond bioengineering. And, lay people seem to "get" the significance of what we aim to achieve through our research because the goal of improved patient outcomes is universally relatable.

SAM INSIGNARES REVELS IN THE CO-OP EXPERIENCE

By Sam Insignares, bioengineering undergraduate and CUBEInC Co-op

My co-op experience has been one of the best I have had since becoming a Tiger. Many of my friends in engineering enter the co-op program, and they encouraged me to do it as well.

Academically, I am very comfortable in a classroom setting, but I had no idea what a graduate or an industry experience would be like. I was hoping to gain knowledge of what it's like working in the medical device industry and to make many connections through the co-op program. Co-oping with CUBEInC is not like working for a medical device company, but rather working as graduate student. I became involved on individual projects in two labs, both of which I continue to work on while I am back at school for the semester.

If you are considering graduate school or want wet lab research experience, I would highly encourage this co-op because you get a first hand feel of what graduate school would be like; also, you make personal connections with graduate students studying for their Master's and PhD degrees. They tell you the ins and outs of graduate school that you will not get from a tour. One unexpected opportunity at CUBEInC was observing both the Steadman Hawkins Surgical Training and Innovation Center and the Bioimaging Lab. In the Steadman Hawkins lab, I was able to watch orthopedic surgeries on cadavers and afterwards dissect one and look at human anatomy. This is an experience every bioengineer should have. In the Bioimaging Lab, I saw how cardiovascular sonographers take noninvasive diagnostic scans, providing me insight into the technology we have available in the medical field today.

I am the CUBEInC liaison, and my role is to represent the bioengineering department at Clemson University. Whenever visitors want to come to our Patewood campus, I am the primary contact for them. I give them a comprehensive tour of the labs and their research, the companies on the floor and an overview of bioengineering at Clemson. I am also the primary contact for the Principal Investigators on the floor if they need help with moving supplies into a lab or have a special delivery coming to their lab. Because of our location, I have also interacted with representatives from GHS, residents of ATI Physical Therapy, and the Steadman Hawkins fellows.

I originally came into college studying Biological Sciences on the pre-med track. I had an interest in bioengineering, but I had my mind set on a track I thought was the best track for medical school. Spring of my freshman year, I decided to attend a seminar in Rhodes Annex 111 to hear a company, CorMatrix, talk about their products concerning regenerative medicine. After



Sam Insignares and Nicole Meilinger are doing co-ops at CUBEInC this academic year. Editor

the seminar, I knew that this high level thinking and research was something I had to get involved in while I was an undergrad. I switched majors after the spring of my freshman year. After graduation, I plan to apply to medical school and pursue a career in the medical field, either in medical research or in medical practice.

The best thing about being a bioengineer at Clemson is the sense of community in a department made up of researchers and students from all parts of the world. Sam Insignares

The best thing about being a bioengineer at Clemson is the sense of community in a department made up of researchers and students from all parts of the world. Even with the many diverse backgrounds we all come from, my professors and my classmates are always willing to talk and lend advice when needed.

NICOLE MEILINGER ENJOYS HAVING ENDLESS OPPORTUNITIES

There are countless conferences to attend, research projects to join, speakers to learn from, and connections to be made! Nicole Meilinger

What academic goals were you hoping to achieve through your CUBEInC Co-op? What have you actually achieved?

When I first heard about CUBEInC, I was intrigued by its unique platform with Greenville Health System and its integration of the different aspects of bioengineering. As a result, I made it my main academic goal to get a better understanding of the research, industrial, and medical perspectives of bioengineering. So far, I have collaborated with Dr. Melinda Harman, Dr. Jeoung Soo Lee and their respective graduate students on several projects and headed up a research project of my own in Dr. Lee's 4D Lab. With this research came the opportunity to be trained on equipment such as the electrospinner, Bose, Instron, Cryostat and laser cutter.

In addition to the research, I have begun to fulfill my goal of acquiring an industrial perspective by interacting with some of CUBEInC's partners like Diaxamed and by witnessing a few medical device demonstrations/sales in the Steadman Hawkins Bioskills Lab. Lastly, I have been able to shadow a few of the academic meetings with ATI Physical Therapy and Steadman Hawkins and sit in on a couple of cadaver surgeries. Although I have learned a lot, I realize that there is still so much more I can learn from this Co-op.

What is your main purpose at CUBEInC, and how do you accomplish it?

My main purpose at CUBEInC is to represent Clemson's bioengineering department and act as a liaison between Clemson and GHS, CUBEInC's industrial partners, Steadman Hawkins, ATI, and anyone else interested in working alongside CUBEInC. I accomplish this by giving tours of the facility and answering any questions regarding the equipment and staff on the floor.

What made you decide to study bioengineering?

Ever since I was a little girl, I have always been drawn to medicine and helping others. Originally I was going to major in Biology and then head off to medical school. However, my senior year of high school I was invited to a Clemson Engineering event at CUICAR and got to learn about the different fields of engineering. After the event I began to research bioengineering, and realized it had everything I wanted for my education. I loved how it combined critical thinking, innovation and medicine.

What are your plans after graduation?

I am currently deciding between getting my Master's in biomedical engineering and attending medical school. I would honestly be happy with either career path!



Nicole Meilinger and Sam Insignares are doing co-ops at CUBEInC this academic year. Editor

Bioengineering... had everything I wanted for my education. I loved how it combined critical thinking, innovation, and medicine.

Nicole Meilinger

What do you think is the best thing about being a bioengineer at Clemson?

I would definitely say the endless opportunities the bioengineering department gives us to further develop ourselves as engineers. There are countless conferences to attend, research projects to join, speakers to learn from, and connections to be made!

ALUMNUS TIM OLSEN: “ALWAYS LEARN — IT’S ALWAYS REWARDING!”

By Tim Olsen

Being a bioengineer is special because you have an engineering mindset with an appreciation of biology.

Describe your work experiences since graduation.

I graduated from Clemson University with a PhD in Bioengineering from Dr. Frank Alexis's lab in May 2015. My first job was with a 3D Bioprinting startup company in Philadelphia, BioBots. There, I was the lead scientist aiming to develop a portfolio of bioinks that could be used to print a variety of tissue types. After about a year, I moved on to another startup company, called RoosterBio, located in Frederick, MD. RoosterBio is a regenerative medicine company with a focus on adult human stem cell manufacturing technologies. At RoosterBio, I began as a Scientist in Process and Product Development, working on everything from stem cell isolation, to cell culture media development, to expansion of stem cells in 3D microcarrier-based bioreactor systems for upscaled manufacturing.

When I was hired, we had about 10 employees, so I got to work on many projects and wear many hats. I got to do some science, marketing, customer service, manufacturing, and operations work—even though it wasn't exactly in my job description. Being open to jumping in and working on these projects gave me a taste of what each job was like and helped me decide the direction I wanted my career path to go in. In less than a year, I was promoted to Senior Scientist and was the lead on an \$8.1M Department of Defense-funded research contract for the scalable expansion of human mesenchymal stem cells in 3D microcarrier-based bioreactor systems to meet commercially and clinically relevant lot sizes.

I have always been interested in the business side of things in the biotech world. Thus, after a few discussions with our CEO, Margot Connor, she gave me an opportunity to work on a few business projects on the side, for which I am extremely grateful. In short, I really enjoyed being able to leverage my technical expertise and RoosterBio Process and Product Development knowledge to understand our customers' experiments, technical pain points, and how RoosterBio's products can streamline their work. As of February 2018, I switched over to the RoosterBio Sales team as the Regional Account Manager. I am really looking forward to this opportunity at RoosterBio to learn about how the biotech business world operates, which will ultimately expand my skill set and professional experiences.

What is it like having been out of school for this long vs. your first year out?

To be honest, it feels like I graduated just a few months ago. Time flies! The last 3 years I have been working in industry, which requires a different mindset than an academic environment. Our



mission at RoosterBio is to radically change how stem cells are used in regenerative medicine. We are laser focused on delivering the highest quality human stem cell **products** to enable researchers to get to the clinic faster with shorter development timelines. Having the end customer in mind and developing a product that will give the end user the best experience is key. Aligning my thinking with this mindset has been the biggest adjustment from working in an academic lab.

What did you learn at CU that has repeatedly been valuable?

Throughout Clemson's Bioengineering PhD program, I constantly had to give presentations about my work. Sometimes I had to be highly technical, like when speaking to my thesis committee, and sometimes I had to be simple, like when speaking to friends and

Having this skill set and the drive to continuously learn in your career will allow you to get involved with a wide variety of projects and get up to speed quickly—making you very valuable and marketable.

family. Learning to communicate science effectively to different audience types is an extremely valuable skill, and I developed this base at Clemson. At RoosterBio, I communicate with scientists and business colleagues all in the same day. Being able to continuously translate ideas in particular languages, so that both can understand, is critical for success in industry!

What about your first job was unexpected?

My first job after graduating was with a very early stage 3D Bioprinting startup company, called BioBots. They have since changed their name to Allevi. The goal of Allevi is to democratize 3D Bioprinting, making this once exclusive technology easily accessible to any researcher. What was unexpected about this particular job was the network of high-level industry and academic researchers I was exposed to. One particular memory stands out that was important for my career. I was the lead scientist at BioBots, and I worked on a research grant to pair our desktop 3D bioprinter at BioBots with another company's high quantity and high quality cryopreserved human stem cells for 3D bioprinting in outer space (yes, there are

tons of cool experiments going on in space!). While we did not get the research grant, I did make the connection with the collaborating company on the grant. This company was RoosterBio, and that initial connection with the grant landed me my next job with them. In short, always be willing to network because you never know when you will need to tap into it!

What would you tell current students about life after graduation?

Just because you are out of school does not mean you should stop being a student. I graduated with a PhD in Bioengineering and had a heavy focus on tissue engineered blood vessels. My first job was in 3D bioprinting, and now I am working in stem cell manufacturing. Being a bioengineer is special because you have an engineering mindset with an appreciation of biology. Having this skillset and the drive to continuously learn in your career will allow you to get involved with a wide variety of projects and get up to speed quickly—making you very valuable and marketable.

ALUMNUS NICK ERDMAN: GET THE TRAINING!

Describe experiences with your work and your family since graduation.

After graduating, finding work in the Greenville area in the field of bioengineering was extremely challenging. While sending out resumes and interviewing, I worked part time as a math tutor. Eventually, after 7 months of looking for work, I was able to secure a position as a scientist at Kiyatec Inc.

If there are opportunities to learn a new scientific skill, be sure to get the training. You may not need the skill at the time, but having the experience will make you more marketable when searching for a job. Nick Erdman

What it is like having been out of school for this long vs. your first year out?

I've only been out of school about a year-and-a-half. In that timespan a lot has changed for me. I got married and purchased my first house.

Is there something you learned at Clemson University that has repeatedly been valuable?

Be sure to take advantage of every opportunity that presents itself. Try and attend as many workshops or lectures that you can. If there are opportunities to learn a new scientific skill, be sure to get the training. You may not need the skill at the time, but having the experience will make you more marketable when searching for a job.

What about your first job was unexpected?

I think the amount of time it took to find full-time employment was the most unexpected thing I've encountered. I would highly recommend polishing your resume well in advance of graduation. One great resource that I was introduced to was the book, "Knock 'em Dead," by Martin Yate.

What would you tell current students about life after graduation?

Life after graduation for me is very similar to graduate school, minus the twelve-hour work days. If you go into industry, the eight-hour work day is probably the biggest difference. You will have a boss similar to your research advisor. Make sure that wherever you end up working, you are working on a project that you find interesting. If you don't enjoy what you are doing, it can make for very long days.

REBECCA DELEGGE: VARIETY KEEPS THIS BOARD MEMBER INTERESTED

By Rebecca DeLegge

Becky DeLegge, Founder and CEO of DeLegge Medical, is a current member and past president of the department's External Advisory Board. She gives the impression of having a vast store of energy. How fortunate that she enjoys spending some of it on the department and its students! Editor

1. What do you enjoy most about your work? The variety keeps it very interesting. I get to work in bioengineering medical device design in many different areas. Right now I am working in GI, urology, oral surgery, and orthopedics. We are also starting a new company in Veterinary this year. Very exciting time in that field!

2. What drew you toward becoming a member of the CU BIOE Advisory Board? I am so excited about helping the Department of Bioengineering prepare the workforce. Many things have changed with the department in the last ten years that are good for the bioengineering workforce and for bioengineers in South Carolina. Serving on the board has reconnected me with Clemson and connected me with many BIOE alumni who are serving in the c-suite of medical device companies.

3. What were your challenges as board president? I think the board could do more to help the department, but it is difficult to know what to do because all of the board is looking at bioengineering academia from the outside. We are familiar with how to make change within our industry or our companies, but academia is totally different.

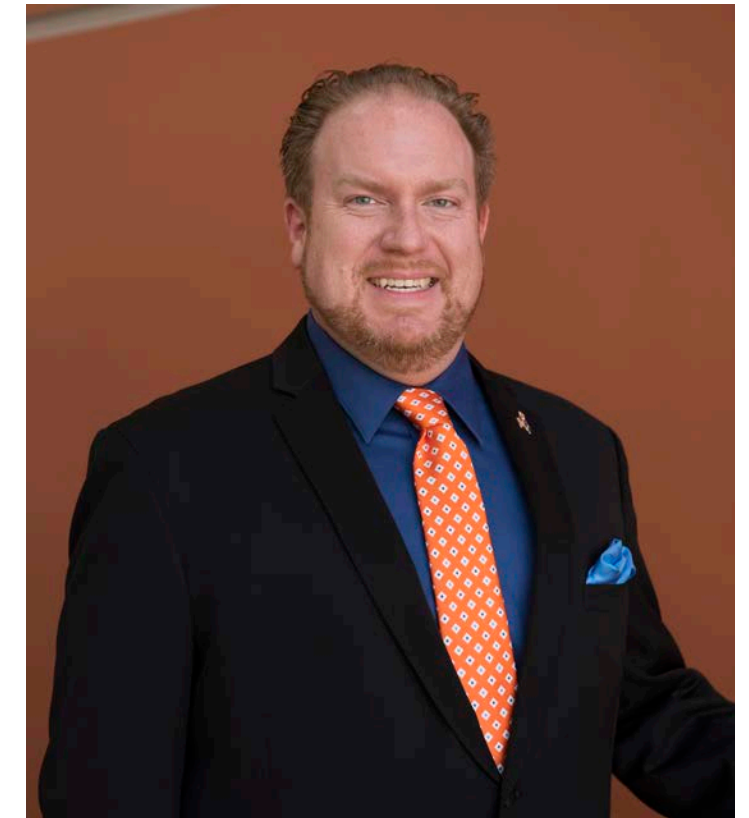
4. What advice would you offer current students? Use internships and shadowing opportunities to prepare yourself for industry if that is the route you choose to go. Volunteer and get to know the state that you settle in so you can help to build the bioengineering economy in your state. It will in the long run help all of us. If you are feeling unchallenged, switch directions. Try a start up, take on an intern, or switch to a different area of focus, like from soft tissue to orthopedics. It will renew your spirit and make your job more enjoyable.



Bioengineering Teaching Assistants 2018

BOARD OF TRUSTEES BESTOWS AWARD ON CHAD MCMAHAN

Chad McMahan, the department's histologist and safety officer, was recognized by Clemson's Board of Trustees with the Will to Lead award. Mr. McMahan was nominated for the award by his peers across colleges. Central to his being so recognized was Chad's earlier national-level Helping Hand award from the National Society for Histotechnology and Newcomer Supply. According to Chad, his "greatest desire is to assist students in achieving their maximum potential in research."



CREATIVE INQUIRY STUDENTS CONSULT ALUMNUS MATT CUPELLI



Creative Inquiry students (l to r) Kaleb Guion, Ryan Gilbert, Nathan Guion, Ian DeMass

"Undergraduates in the Global Health Design Creative Inquiry met with Clemson alumnus Matt Cupelli at North American Rescue (NAR) in Greer, SC. The students, who have created a portable patient monitor, discussed manufacturing strategies with Mr. Cupelli. He then led them on a tour of the NAR facilities. According to Ian DeMass, a student of Dr. Delphine Dean's, the tour and conversations were inspirational. He said, "We have already begun designing an implementation strategy for our device!"

STUDENTS INSPIRED BY EXECUTIVE DIRECTOR OF AIMBE

Milan P. Yager, Executive Director of the American Institute for Medical and Biological Engineering, visited the department in early March and met several times with our students. Two, Meredith Owen, a graduate student in Dr. John DesJardins's lab, and Cody Dunton, a graduate student in Dr. Jiro Nagatomi's lab, commented on their impressions of Mr. Yager. Editor

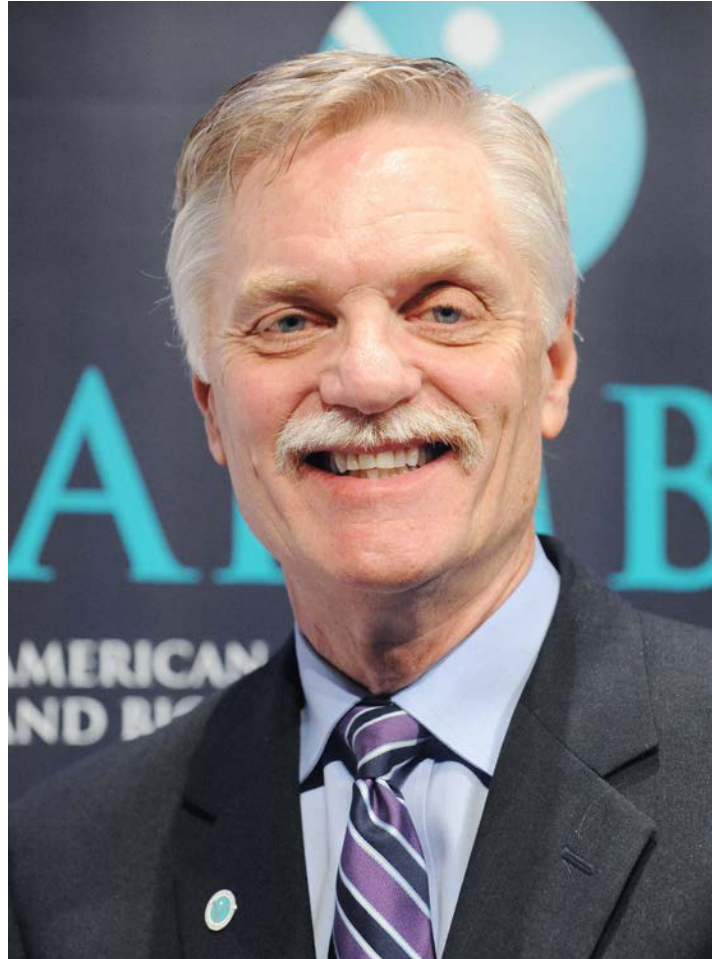
Meredith Owen

The coffee talk with Milan Yager was an extremely informative experience. Mr. Yager highlighted the importance of engaging those outside of our immediate field.

Cody Dunton: Mr. Yager is passionate about advocating the importance of research locally, on a state level, and nationally to ensure the continued progression of scientific research. The current downward trend in government-funded research needs to be addressed by the current generation of students. We cannot stand idly by while less and less funding is funneled into the research departments at universities. This leads to a decrease in scientific discoveries and advancements, and if we do not begin to advocate for change now, even on a community level, then we will be sitting on the sidelines as countries like China and South Korea lead the world into a new age of scientific discovery.

Meredith Owen: Mr. Yager brought to our attention the fact that funding for scientific research has been dramatically reduced and that it is our job as students and researchers in the field to combat this. He even gave examples of simple actions that students can take to help the cause, from simple Twitter campaigns to writing letters to the editor for local newspapers.

Cody Dunton: I was already aware of many of the issues Mr. Yager discussed, such as decreased government spending on scientific research; however, talking with him encouraged a belief that I could be a part of bringing about change. I don't want to speak for all graduate students, but personally I am passionate about research, but apathetic about politics. However, I now realize that I cannot have that attitude if I want the future of research in America to grow. Apathy gets us nowhere, and we need to talk about what we do and why it is important so that people will care about scientific research, and funding will not continue to be cut in favor of other trending policies.



Meredith Owen: Mr. Yager's excitement for promoting scientific research was contagious, and I left the coffee talk with increased enthusiasm and a greater knowledge of how we as students can help.

Cody Dunton: In talking with students after the event, I found that many believed that action needs to be taken to advocate for scientific research, starting in our community and hopefully growing in support.

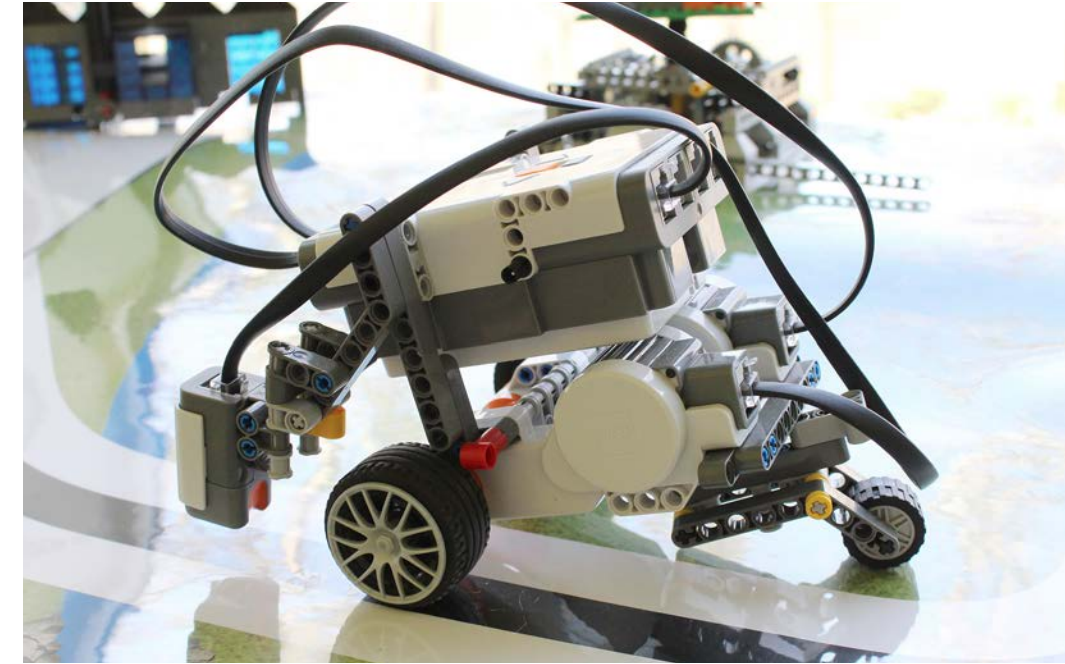
REACHING OUT TO THE COMMUNITY: COACHING 4TH AND 5TH GRADERS

I apply the same ideas when working with the Clemson Bionics Club. We just make robotic prostheses instead of LEGOS.

David McLeod, a junior in bioelectrical engineering at Clemson, is member of Alpha Eta Mu Beta (AEMB), the National Biomedical Engineering Honor Society. Hearing through AEMB about an opportunity to coach fourth and fifth graders at Clemson Elementary, David jumped at the chance. "I just enjoy anything to do with robotics," he said.

Last fall, David coached a group in a FIRST LEGO League Jr. Competition. Each Monday afternoon, he met with the students and other adult coaches. He helped the students solve real-world challenges with research, critical thinking, and imagination by building LEGO models and creating "Show Me" posters to present what they learned.

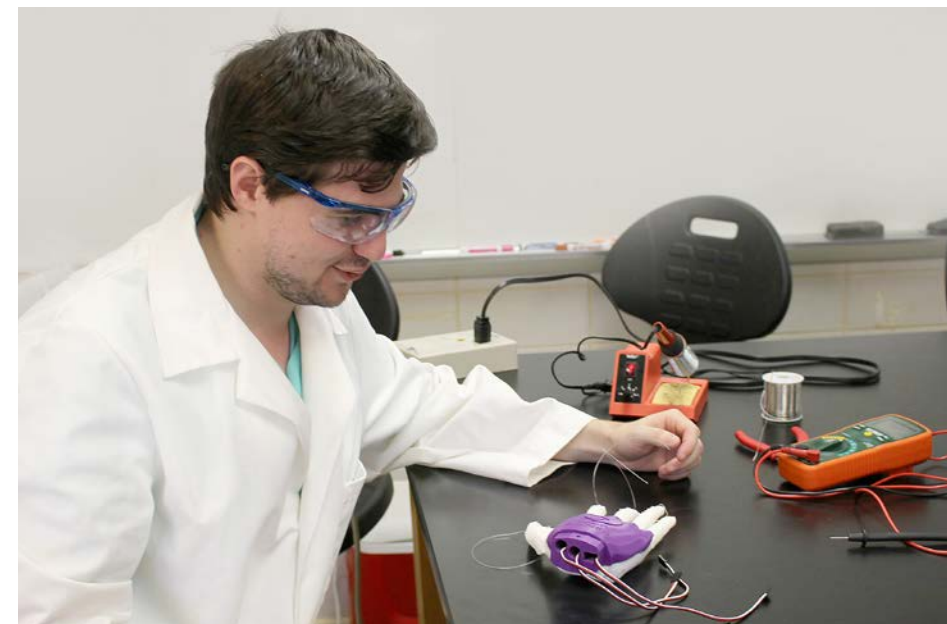
"Using the LEGO building blocks that the students already love," David said, "FIRST LEGO League Jr. focuses on interest in science, technology, engineering, and math. I learned how to break down the challenges from LEGO resources into plans that the students could tackle successfully within their meeting times. I apply the same ideas when working with the Clemson Bionics Club. We just make robotic prostheses instead of LEGOS. The students and I learned the LEGO software together. They learned so fast that I had to stay well prepared!"



When students put their robot down on the board and I see loose wires, it's so hard not to run over and fix it, but they have to learn. David McLeod

David went on, "Competition day was in December at R.C. Edwards Middle School. Robotics groups from many schools presented a short research project and performed various tasks for their robot to

complete in the fastest time. It was intense! From loose parts to failing batteries, many factors can hinder a robot's performance. When students put their robot down on the board and I see loose wires, it's so hard not to run over and fix it, but they have to learn." At the competition, David's role was to provide support and encouragement while evaluating the different challenges and helping the students decide in which challenges their robot would compete well. "The most important thing to me is not that they win, but that they learn and have fun while doing so." Overall, the students did not bring home any trophies, but they came back as a stronger team with a new determination for next year, David said. "We can't wait for next season!"



2018 CLEMSON AWARDS

Excerpted from A Match: A History of the Society For Biomaterials

In the 1960s, Dr. C. William Hall of Clemson University had a vision: He imagined an exclusive group of scientists would come together to communicate research findings and developments in the field of biomaterials science. Through the work of numerous people, especially many of those who gathered annually for the meeting of the International Biomaterials Symposium, the Society For Biomaterials (SFB) came to be. It served as a social and professional community that would produce annual publications in the field and be a catalyst for international bioengineering societies and national student chapters.

The Society For Biomaterials stands on the shoulders of the International Biomaterials Symposium and those of two giants in our field, Dr. Hall and Dr. Samuel F. Hulbert. In 1969, Dr. Hall shared with Dr. Hulbert his vision for forming a society that would aid in the exchange of information related to biomaterials. Also in that year, the International Biomaterials Symposium (first in a series of symposia that would later be called the Annual International Biomaterials Symposium) was held at Clemson University. The symposium attracted 100 people, 17 of whom presented papers. This meeting was characterized by in-depth interchange between clinicians and engineers. At the conclusion of the meeting, Dr. Hall "related his concern that unless there was some format for the interchange of ideas between the biomaterials researchers, significant progress would be slow in coming." Dr. Hulbert named this the first mention of "the possibilities of the establishing of the Society For Biomaterials (SFB)."

During the fifth annual international symposium in 1973, awards for Clinical Biomaterial Research, Basic Biomaterial Research and Contributions to Biomaterial Literature were given for the first time. In 1974, following the Symposium's meeting, the SFB was legally instituted. The society named the annual awards "The Clemson Awards." Since the SFB's founding, the selection of awardees has been made by the Honors and Awards Committee of the Society, which includes a Clemson faculty member as a non-voting committee member. The awards are presented each year at the SFB Annual Meeting by the president of Clemson University or his designee.

This year's awardees to be recognized at the SFB Annual Meeting in April 2018 in Atlanta are the following:

Clemson Award for Applied Research

Mark W. Grinstaff, Ph.D.
Metcalf Center for Science and Engineering
Boston University

Clemson Award for Basic Research

Jason A. Burdick, PhD
Department of Bioengineering
University of Pennsylvania

Clemson Award for Contributions to the Literature

J. Paul Santerre, PhD
Institute of Biomaterials and Biomedical Engineering
University of Toronto



CBS members smiling after a day of hard work on the Habitat for Humanity house.



Local professionals interact with students and provide insight on bioengineering careers in industry.



The Silver Stents converse while making team t-shirts before playing a CBS version of the Newlyweds Game during Newlyweds Night. A major CBS focus is mentoring BIOE undergraduates.

CBS: MAKING A DIFFERENCE

The Clemson Bioengineering Society (CBS) is Clemson's graduate chapter for the Society For Biomaterials (SFB) and the Biomedical Engineering Society (BMES). A student-run organization, CBS provides professional development, community service and outreach, mentorship, and social experiences to members. CBS strives to give members opportunities to complement their personal strengths and research abilities to form more well-rounded bioengineers who are leaders in research and among their peers.



Graduate students watch Clemson take on Syracuse in Death Valley.



A group of students show their tiger pride while exploring the American West.



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