
CLEMSON
BIOENGINEERING
Educating Thinkers, Leaders and Entrepreneurs
BIOE NEWS
Fall 2018

TABLE OF CONTENTS

Cover illustration — *NIH COBRE SC-TRIMH Virtual Clinical Trials: from molecule to system, pg 15*

CONTENTS

Martine LaBerge, *Chair, Department of Bioengineering*

Jenny Bourne, *Editor*

Olga Reukova, *Cover illustration and design*

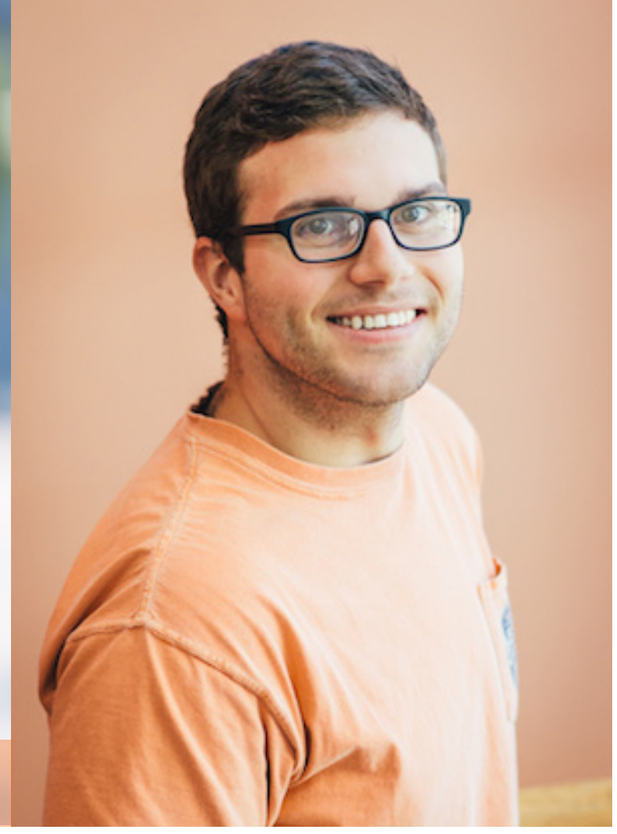
SOUTHEAST REGIONAL BIOMATERIALS DAY

The 4th annual Southeast Regional Biomaterials Day, hosted by Clemson University, the Georgia Institute of Technology, and Vanderbilt University, took place November 8-9, 2018, in Clemson, SC. According to Meredith Owen, PhD student and president of Clemson Bioengineering Society (CBS), "The mission of Biomaterials Day is to foster and promote the development of biomaterials research and innovation and to advocate for increased entrepreneurial ventures and collaborations between universities and industries across the southeastern US." The two-day event, held at Clemson's Madren Center, provided a forum for students, leading researchers, and industry representatives to meet and exchange ideas that promote innovation in biomaterials synthesis, application, and evaluation.

The event's Friday morning session featured student and faculty talks focused on cutting edge research in the field of biomaterials. The afternoon session focused on presentations about translational research, innovation, and entrepreneurship. A keynote address was given to start the afternoon session, and a poster session and reception closed the conference. Session topics included mechanics in biomaterials, regenerative tissue engineering, entrepreneurship, and industry collaborations. Students from colleges and universities in the southeast submitted abstracts for consideration for either a podium talk or poster presentation.

Owen said, "This year we were honored and excited to have Dr. Karen Burg and Dr. Alan Alfano as keynote speakers. Dr. Burg is the Harbor Lights Endowed Chair in the Department of Small Animal Medicine and Surgery at the University of Georgia and Professor Emerita of Clemson University. Her keynote was on the establishment and development of research and innovation in the southeastern US." While at Clemson, Dr. Burg established the SC Institute for Biological Interfaces for Engineering and served as the university's interim vice provost for research and innovation. Her current research interests include absorbable polymers, biofabrication, regenerative engineering, science and engineering education, and 3D tissue structures. Cody Dunton, chair of the

> The mission of Biomaterials Day is to foster and promote the development of biomaterials research and innovation and to advocate for increased entrepreneurial ventures and collaborations between universities and industries across the southeastern US.
> *Meredith Owen*



> We enjoyed hosting the Southeast Regional Biomaterials Day this year in Clemson, SC. It was exciting to see the biomaterials research being conducted by our peers!
> *Cody Dunton*

Dr. Alfano, who delivered a keynote on entrepreneurship and the process of translating academic research to market, is a Technology Commercialization Officer (TCO) at the Clemson University Research Foundation (CURF), where he aids in the process of moving innovative biotechnologies from the laboratory to commercial markets. His background in benchtop research and his biotech business experience afford him unique insight into the southeast's entrepreneurial climate.

Dunton continued, "We enjoyed hosting the Southeast Regional Biomaterials Day this year in Clemson, SC. It was exciting to see the biomaterials research being conducted by our peers! This conference has a reputation for providing a unique forum for trainees from various southeastern universities to cultivate relationships that last into their professional lives."

Wrapping up their comments, Owen said, "Sponsors of the 2018 Southeast Regional Biomaterials Day, including the Society for Biomaterials and the Clemson University Bioengineering Department, generously provided funding and other support for this year's event. We look forward to the Day's continued success. For more information regarding the event, please visit clemsonbiomaterialsday.com."

Biomaterials Day Planning Committee, added, "We were thrilled to have Dr. Burg deliver the keynote address. Her experience in the field of biomaterials and research innovation is a wonderful resource that I hope students in attendance can learn from and take back to their respective universities."

INDUSTRY-UNIVERSITY PARTNERSHIP FOR BETTER-ENGINEERED DRUGS

In August, 2017, Dr. Sarah Harcum was chosen to lead a Clemson team in an effort to better engineer Chinese hamster cell lines to produce vaccines and drugs for diseases such as cancer. Harcum's team is part of a multiuniversity award to Johns Hopkins and three other universities that along with industrial partners, form a center, Advanced Mammalian Biomanufacturing Innovation Center (AMBIC), part of the National Science Foundation's Industry-University Cooperative Research Centers Program (IUCRC). AMBIC implements engineering innovations to enhance the capabilities of our nation to manufacture these important life-extending and life-saving medicines. Such advancements will improve the competitiveness of US biomanufacturing in coming decades, leading to more economic investment by these companies and more jobs for American workers.

AMBIC brings together leading academic and industrial biotechnologists focused on mammalian cell culture manufacturing at a precompetitive research level to address the complex problems in biopharmaceutical manufacturing. Dr. Harcum provided news about some of the Center's progress, "We just added three new members: GSK Vaccines, KBI Biopharma, and NIST, and have a couple of other companies being finalized. Each industry member company pays $50,000 per year in membership fees, plus each university receives $150,000 per year for 5 years from NSF."

AMBIC's mission is to develop enabling technologies, knowledge, design tools and methods that apply and integrate high-throughput and genome-based technologies to fast-track advanced biomanufacturing processes. This multiuniversity-multiindustry partnership allows AMBIC to leverage the skills and the expertise of many faculty members across the Sites. AMBIC is a critical catalyst towards maintaining national excellence in biopharmaceutical production by conducting research in:

1) Understanding Industrially-Relevant Biology (e.g., all -omics, bioinformatics, process and product quality, etc.);
2) Process Monitoring & Control (e.g., analytics, instrumentation, data mining and modeling);
3) Consensus and Standardization Issues (e.g., standards, simple fingerprints, raw material issues, regulatory issues, forensic bioprocessing, clonality).

AMBIC website **http://www.iucrc.org/center/advanced-mammalian-biomanufacturing-innovation-center**

AMBIC is the first I/UCRC dedicated to mammalian cell culture upstream development focusing on Chinese hamster ovary (CHO) cells, the principal biopharmaceutical production host of industry. Dr. Sarah Harcum

This multiuniversity center will allow AMBIC to leverage the skills and the expertise of many faculty members across the Sites. Dr. Sarah Harcum

A TALE OF PANDAS, STEM CELLS, PROBLEM-SOLVING AND MEDICINE: IRENE CHENG'S BOREN FELLOWSHIP

I've learned that my Clemson family is found all over the world! Upon my return I plan on pursuing higher education and a career in translational research. *Irene Cheng*

I chose to study bioengineering because I really appreciated the hands-on aspect of this field. From conducting lab work, tinkering with electrical components, and working on my problem-solving capabilities, bioengineering challenges me everyday, which I love! I worked under Dr. Nagatomi and as an undergrad, I studied the effect of a 3D environment and ECM protein coating on urothelial tissue stratification in vitro. I chose to work with Dr. Nagatomi because of the wide range of projects we have in his lab, and through the last two years, I've had the opportunity to learn so much! I believe Clemson and specifically the close-knit bioengineering department have given me many opportunities for personal, professional, and intellectual growth. I've definitely taken advantage of the encouragement of many professors to expand our horizons and study outside the classroom as well — I studied cancer stem cells at the University of Tokyo thanks to Dr. Nagatomi and traveled to Tanzania to learn about medical equipment in developing countries with Dr. Dean and Dr. Desjardins! I've learned that my Clemson family is found all over the world! Upon my return I plan on pursuing higher education and a career in translational research.

All of this led to my year in Chengdu, China, as a United States David L. Boren Fellow. Boren Awards are sponsored by the National Security Education Program (NSEP), a major federal initiative designed to build a broader and more qualified pool of U.S. citizens with foreign language and international skills. My daily life usually consists of attending Advanced Mandarin class in the mornings and either a history/political science class in the afternoon, my internship, or meeting with language partners. I intern at a traditional Chinese medical clinic, learning about transcultural health practices and the mix of Eastern and Western Medicine. Chengdu is an amazing and growing city—some highlights have been visiting the Panda Research Institute and seeing this year's group of baby pandas, trying authentic Sichuan hotpot (very spicy but delicious!), and learning to make many famous Sichuan dishes. Although I've been here for only two months (of an 11 month program), I've already noticed that many of the skills I acquired through Clemson have come in handy in China: problem-solving in day-to-day life, communication (especially due to the language barrier), and teaching locals a little bit about our healthcare system in the US and technological advances.

Irene is very curious and always seeks the big picture and clinical relevance of the research she is conducting. I also would like to mention that Irene is genuinely interested in learning and very good at communicating her knowledge. *Dr. Jiro Nagatomi*

Clemson University joins consortium to accelerate commercialization of biomedical technologies

Clemson University is working to quicken the commercialization of biomedical technologies through its participation in a regional technology transfer accelerator hub recently funded by the National Institute of General Medical Sciences.

In partnership with XLerate Health LLC, the health care technology accelerator has been awarded $500,000 for the first year of a potential three-year $3.5 million grant from the National Institute of General Medical Sciences (NIGMS), a division of the National Institutes of Health (NIH). It is based in Louisville, Kentucky and participants include the University of Kentucky, University of Louisville and West Virginia University; along with a consortium of 21 academic institutions, including Clemson.

This new grant mechanism creates an online accelerator hub for commercialization of biomedical technologies in the Southeast Institution Development Award (IDeA) region, which includes Arkansas, Kentucky, Louisiana, Mississippi, Puerto Rico, South Carolina and West Virginia. The IDeA program was established in 1993 to broaden the geographic distribution of NIH funding.

This hub will be one of four NIGMS-funded hubs to help IDeA states accelerate early-stage biomedical technology from the laboratory to market. The goal is to enhance the capacity to move scientific results from academic institutions into commercialization and to promote a sustainable culture of biomedical entrepreneurship within IDeA states.


Tanju Karanfil


Chris Gesswein

The Clemson University site leads on this grant are Tanju Karanfil, vice president for research, and Chris Gesswein, executive director of the Clemson University Research Foundation (CURF).

"We look forward to the opportunity to participate in this high impact effort to provide a continuum of education and mentoring resources to our faculty and graduate research community interested in translating their respective research into commercial products and service to the benefit of the public," Karanfil said. "The virtual hub model provides an efficient means to provide a diverse set of commercialization resources to the innovation and entrepreneurial ecosystem at Clemson University and the South Carolina Upstate region."
Said Gesswein: "We look forward to the opportunity to participate in the development of this highly innovative technology transfer and commercialization model. This program aligns well with CURF's focus on providing enhanced support services to the increasing number of biomedical startups coming out of Clemson University. The Southeast regional accelerator hub will serve as a platform for biomedical researchers to gain access to a network of resources that will help them successfully navigate the complexities of bringing life science technologies and services to market."

Clarissa Williams

Dr. Lawrence Boyd, Professor of Practice

Not only is Larry Boyd superbly qualified to guide our students, he will provide support to faculty and staff to assure we fulfill our strategic goal to support economic development through translational research and technology innovation.
Dr. Martine LaBerge, department chair

The department is delighted to welcome Professor of Practice Dr. Lawrence Boyd! His more than two decades of experience leading product development, engineering and business development efforts for medical devices in orthopaedic and spine surgery will be invaluable to our students. Many may find the range of his accomplishments, including earning a PhD 18 years after graduation with a Clemson MS and doing early work on disc replacement, eye-opening and inspirational.

Dr. Boyd is president and founder of Palmetto Biomedical, a medical device design and consulting firm based in Columbia. In addition to having founded two medical device-focused ventures (OrthoClip LLC and View Medical), Dr. Boyd is a prolific inventor, with over 60 issued U.S. patents for medical devices and related procedures. Previously, he was Executive Vice President of R&D for Spinal Elements, a medical device firm based in Marietta, Georgia, and Carlsbad, California. Prior to that position, Dr. Boyd was a Director for Medtown Ventures, an Atlanta-based venture investing and consulting firm.

After receiving his BS in Mechanical Engineering and MS in Bioengineering from Clemson University in 1989, Dr. Boyd became product development group leader and engineer at Dow Corning Wright in Arlington, TN. During his three years there, he developed implants for use in hands, feet, and knees. He then moved on to work for a small start-up company in Memphis, then Danek Medical and later, Sofamor Danek. The company's focus was in an emerging arena for medical implants, spinal fusion. Dr. Boyd worked in the area of intervertebral body fusion and artificial disc replacement.

Holding positions of manager, director and group director, Dr. Boyd focused his efforts on research, development and commercialization of novel medical technologies. To further his leadership skills, he enrolled in a Master of Engineering Management program that offered evening classes at Christian Brothers University. Medtronic later acquired Sofamor Danek and promoted him to vice president of product development.

Dr. Martine LaBerge, department chair, said, "Not only is Larry Boyd superbly qualified to guide our students, he will provide support to faculty and staff to assure we fulfill our strategic goal to support economic development through translational research and technology innovation."

Recognizing the growing importance of recombinant proteins, human tissues and other biologically inspired materials and potential for applications to spine, he started on his PhD in biomedical engineering at Duke University in 2000, working in the laboratory of biomedical engineering professor Lori Setton, PhD. He collaborated with Duke orthopaedic and neurosurgical spinal surgeons in research to elucidate the pathogenesis of spinal degeneration using a mouse model of disc degeneration.

Dr. Boyd has a particular interest in and extensive experience with orthopaedic biomaterials including growth factors, synthetic bioactive bone grafts and human allografts. While at Sofamor Danek, he was responsible for engineering support of preclinical and clinical studies to secure approval for rhBMP-2 (InFuse). He has a certificate in Biomolecular and Tissue Engineering from Duke University. More recently, Dr. Boyd served as Vice President of Engineering and Business Development for the Biologics Division at Spine Wave (Shelton CT) from 2013 to 2015. He has worked on a number of tissue-based materials, including during engagements at the University of Florida Tissue Bank (now RTI) and the University of Miami Tissue Bank (now Vivex).

Dr. Boyd received his PhD in the summer of 2007 and accepted a position as Associate Director of the Center for Entrepreneurship and Research Commercialization at Duke. In addition, he was an adjunct professor for the Biomedical Engineering Department and the Masters of Engineering Management Program at Duke. While at Duke, he developed and taught classes in technology commercialization, risk management, engineering design, and leadership. He established and led the DU Hatch student business incubator, which serves graduate, professional and undergraduate students.

Jenny Bourne

New Faculty: Dr. David Karig

Where were you before coming to Clemson as faculty in the Department of Bioengineering?

I did my B.S. degree at Clemson in electrical engineering. After graduation, I had the opportunity to experience many different types of research jobs in many different places, starting with my graduate degree at Princeton University in New Jersey. During the summer of my first year at Princeton, I did an internship at HP Labs in Palo Alto, California. Then, after earning my Ph.D., I did postdoctoral research at Oak Ridge National Laboratory in Tennessee. Finally, I worked as a senior professional staff member at Johns Hopkins University Applied Physics Laboratory, a University Affiliated Research Center (UARC) in Maryland. I am very appreciative of what I have learned at each of these positions and the wonderful people that I have had the opportunity to work with. I hope to use my experiences to advise students on the breadth of career options available to them if they pursue a degree in bioengineering. Indeed, the world is truly at their fingertips. Of all of the places that that you can go with a Clemson engineering degree, however, I truly believe that "there's something in these hills" (besides the gold that the Bob Campbell Geology Museum tells me about). I am very happy to call Clemson my home again!

…a lot of research is ultimately about learning what you need on the fly.

How did you find yourself working in biology, after having gotten your B.S. and Ph.D. in electrical engineering?

I have always been interested in the interface among engineering, math, and biology. As an undergraduate at Clemson, I did my honors thesis with Dr. Earnest Baxa on wavelet analysis of electrocardiographs. After I had spent most of my first year in graduate at Princeton on computer engineering and security, biology started calling again. During the summer of my first year, my eventual Ph.D. advisor, Dr. Ron Weiss, joined our electrical engineering department and talked about "programming cells." At the time, the term "Synthetic Biology" had not been established. I felt that graduate school offered a unique opportunity to take a risk and work on something totally new, even if the direction and career opportunities were not immediately clear at the time. I jumped into what is now known as synthetic biology.

…in "cell-free" systems, … we create extracts from living cells. These extracts contain the components that are essential for making new proteins. This allows us to do synthetic biology in vitro. One advantage is safety: Cell-free systems cannot self-replicate.

What exactly is your research about now?

I do synthetic biology and microbiome research. The overarching goal of synthetic biology is to apply engineering principles to the development of new biological systems, which is useful for applications in remediation, sensing, biomaterials production, and chemical synthesis.

In synthetic biology, I initially worked on engineering intercellular communication pathways in bacteria. Enabling bacteria to talk to one another is useful for dividing complex tasks among multiple populations of bacteria. It's also useful for engineering bacteria to form patterns of gene expression. After working on engineering communication in bacteria, I began working on "cell-free" systems, in which we create extracts from living cells. These extracts contain the components that are essential for making new proteins. This allows us to do synthetic biology in vitro. One advantage is safety. Whereas there may be concerns with using engineered microbes in the environment for remediation or sensing, cell-free systems cannot self-replicate. There are a number of advantages in terms of the flexibility of cell-free systems as well.

Besides cell-free systems, I have also been working on microbiome research, in particular the human skin microbiome. We are taking an interdisciplinary approach to understanding why individuals have very different microbiomes, how microbial communities vary spatially across the body, and the relationship between skin properties and skin microbes. Overall, this research has relevance not only to issues such as skin diseases and wound infections, but also to vector-borne diseases. For instance, certain bacteria on the skin produce volatile compounds that either attract or repel disease carrying arthropods such as mosquitoes.

What was the transition from electrical engineering to a biology-intensive research direction like?

Moving from purely computational work to incorporating a large amount of experimental biology was a major lifestyle change. It often felt like bacteria controlled my life by deciding when to grow and how to behave. However, once I adapted, it became thrilling to see how living things work. I ended up really enjoying making new DNA constructs and also found microscopy particularly fun. I hadn't taken a biology class since ninth grade. However, a lot of research is ultimately about learning what you need on the fly. I was eventually able to realize the benefit of interdisciplinary work – the ability to come from a different perspective and see things in a different light.

Tell us more about yourself

Outside of research, I love the outdoors and music and, when I can find the time, I enjoy art and painting. My wife, Sharon Bewick, is an assistant professor in biology at Clemson. I also have a one-year-old Tiger in Training who likes restaurants, lamps, fans, Dadda's guitar, and finds books delicious.

In synthetic biology, I initially worked on engineering intercellular communication pathways in bacteria. Enabling bacteria to talk to one another is useful for dividing complex tasks among multiple populations of bacteria. It's also useful for engineering bacteria to form patterns of gene expression.

Going to work at a startup

Because most graduates choose to work in well-established companies, startups remain an intriguing unknown. Diaxamed, a startup medical device company with a focus on the research and development of arteriovenous access systems, employs a number of Clemson graduates in Greenville, SC. Two, Mr. Joshua Davidson BS Mechanical Engineering '17 and Dr. Kayla Wilson PhD Bioengineering '16, took time to share opinions about the work. Diaxamed has labs and offices in the Clemson University Biomedical Engineering Innovation Center. CUBEInC, a state-of-the art facility primarily dedicated to biomedical research and accelerated innovation, occupies the 4th floor of Building C of the Patewood Medical Campus of the Greenville Health System. The strategic location is above two floors dedicated to clinical orthopaedics and rehabilitation (sports and total-joint replacements) and one floor dedicated to vascular surgery and clinical imaging. Jenny Bourne, editor

I to r: BIOE graduates Chadd Clark '16, Kayla Wilson '16, Joshua Davidson '17

According to Mr. Davidson, "As I continue to develop in my professional career, I've learned to approach each task with a daily focus. Our timelines and goals can shift quickly in research and development. As the path of our project changes, I've learned how imperative it is to focus on daily achievement in my personal role rather than getting caught up in the noise of things that I cannot control."

Asked about Diaxamed's location, Mr. Davidson said, "The CUBEInC space at the Patewood campus of GHS contributes to the overall success of Diaxamed. Not only are the labs and offices exceptional facilities, but the collaborative climate among professors, students, and employees cultivates a constructive working environment, which advances our technologies."

Dr. Wilson noted, "Working at CUBEInC is incredibly helpful. The presence of multiple academic labs gives us access to equipment rentals, which is a huge benefit. It's a collaborative environment — everyone is very helpful and wants to see you succeed. The facilities are great—everything is top of the line, including the benches. The location in East Greenville is easy to get to and convenient. Visitors have the choice of a variety of hotels. And when they arrive at CUBEInC, they are not paying for parking. The area has lots of restaurant options.

For me, my focus/drive is always about the patient. Everything that I do is about getting to the point where we can make the patient's life better. *Dr. Kayla Wilson*

"As for working for a startup, "startup" and "entrepreneur" are trendy buzzwords now. For the right person, a startup is a great place to work. If you thrive on changes at the drop of a hat, you will fit in at a startup. What you work on one day isn't necessarily the thing you'll do the next day. You will be exposed to so many things in rapid succession—this broadens you. I'm never doing the same thing. I move back and forth from IT support to clinical to market research to grant writing to biocompatibility.

"For me, my focus/drive is always about the patient. Everything that I do is about getting to the point where we can make the patient's life better. In the last 50 years, dialysis has seen little innovation. The market is an odd one for a variety of reason, but a primary one is that in 1971, Medicare became the coverage option for anyone who needed dialysis. Today, care for these patients, who comprise less than 1% of Medicare's patient population, consumes a disproportionate 7% of Medicare's total budget. Our mission is to revolutionize the world of hemodialysis access to improve the patient's experience and quality of life while lowering the cost burden to Medicare.

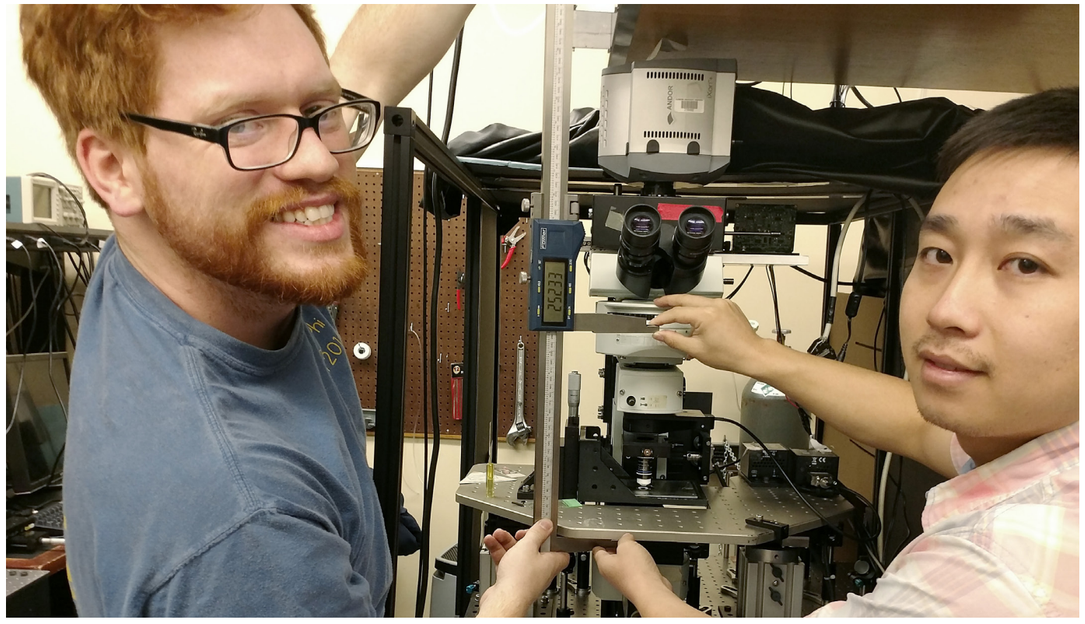
As I continue to develop in my professional career, I've learned to approach each task with a daily focus. Our timelines and goals can shift quickly in research and development. *Mr. Joshua Davidson*

"One of the most important things I did while a BIOE graduate student was to evolve as a researcher and collaborator. I went from being shy and doing everything on my own to someone who knows how to find experts and confidently reaches out for support when appropriate. As an undergraduate student, I went to Dr. Delphine Dean (Gregg-Graniteville Associate Professor) for advice. I was in the bioelectrical concentration and needed a summer internship. Despite barely knowing me, she kindly offered me a position as a Creative Inquiry summer researcher. I spent the summer working on a low-cost blood glucose monitoring project and fell in love with research in a way I hadn't realized was possible. It was an incredible learning experience and truly opened my eyes to the need to take risks. I had taken a chance and reached out to someone, and I got a job. After that, anything that I could possibly say "Yes!" to, I would.

I urge students to see graduate school as "Your No-Lose Scenario." *Dr. Kayla Wilson*

"That project led to an offer for graduate school, also in Dr. Dean's lab. I went from not planning to attend graduate school to completing a Master's, PhD, and cofounding a company in four years. With my new lease on life, I turned grad school into almost a crucible — I tried everything: I co-mentored Creative Inquiry classes, founded and ran new Creative Inquiry classes, worked as a teaching assistant some semesters, and worked as a research assistant others. I attended the DEN (Design and Entrepreneurship Network) meetings, submitted to design competitions, attended and presented at conferences, helped organize outreach events, traveled to Tanzania, and more. I did all that I could to capture every experience available. Some opportunities led to obvious benefits, and others were maybe not as clearly beneficial. But every experience provided a learning opportunity and helped me to grow.

"I urge students to see graduate school as "Your No-Lose Scenario." Not every opportunity will lead to a dream job, but this is the time to test the waters in a variety of areas. Try leading a CI for a semester – if it doesn't work out, don't do it the next semester. If it does work out, you just might be laying the ground work for a startup. Whatever your options may be, take advantage of them!"



Students Adam Baker and Cai Yuan in Dr. Bruce Gao's Biophotonics Lab. Dr. Gao is the S.C. SmartState Endowed Chair in Biofabrication

Deciding Which Kind of Engineer to Be: Austin Hensley Shares his Process

What made you choose the Master's of Engineering in Biomedical Engineering?

One of the most enticing aspects of the MEng program for me was its length: two semesters at 15 credit hours per semester to earn a whole degree is an incredible deal. That in itself made the MEng seem like a great way to ramp up from my BS in bioengineering into whatever lay in my future. The amount of learning and connecting packed into the one-year degree made it that much better. Getting to learn from, present to, and network with industry professionals weekly sounded like the perfect way for me to make a name for myself with some of the top medical device companies in the southeastern U.S.

Spending another year working on a capstone-like project was something I really wanted because I knew it meant honing the skills I had already acquired and getting to spend more time with clinicians. This added time with clinicians and industry professionals would allow me to not only build my skillset, but also become more familiar with the language used in the medical device industry. I also liked the idea of having a second go at a capstone project, but this time doing it with experience and working alongside individuals who shared my drive to succeed. Additionally, I hadn't heard of many people with MEng degrees, so earning one would give me a leg up during the job application process.

This program has helped me define my career goals in a more refined manner and has given me confidence in my life plan for at least the next 5-10 years

Why Charleston?

I chose Charleston not only for the change in scenery and beaches, but also because of the proximity to world-class clinicians and facilities. Being on a medical campus for classes means that I can walk from class to my testing labs to meetings with clinicians to conferences with my advisor within a quarter mile radius. Having all my resources in such a small area means I can spend less time commuting and more time getting things done, a big plus when the goal is to design and test a medical device within nine months.

Another huge factor for me was the amount of networking I could do in a larger city like Charleston. It helped that I knew several people in the area, but there are generally far more opportunities to go out and meet people and expand my network in the metropolitan environment. And finally, I had never really lived in a city, so taking a year to try out city life seemed like a great idea before I decided where I wanted to live during my first job.

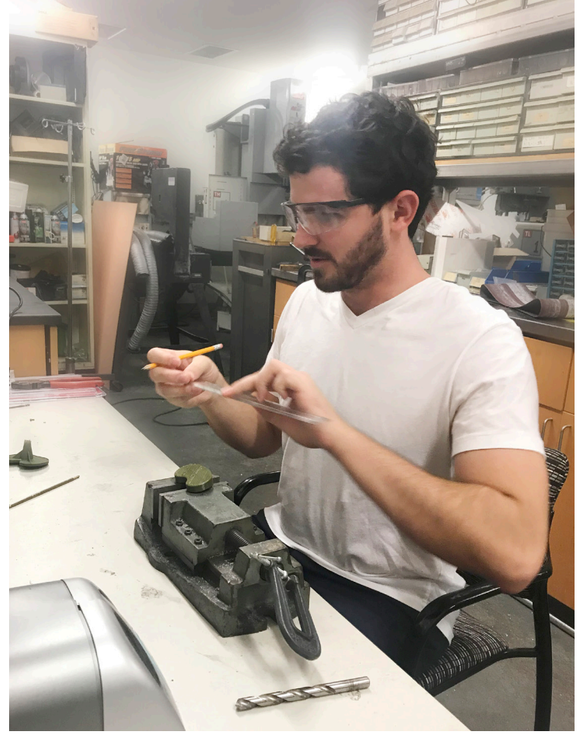
What other options did you consider?

I was excited about pursuing an MEng degree following my senior year. For most of my senior year, I planned to do my MEng at the Clemson/Greenville campus. It wasn't until I saw the facilities in Charleston that I decided to do the MEng at the MUSC campus.

I've gained an in-depth understanding of regulatory pathways, business models, and cash flow in the medical industry. I've also gotten a grasp of how to present and commercialize products.

Near the end of senior year, I received an offer from a company I had previously interned at. The opportunity to have a salary and a certain direction for my future was appealing, but ultimately, I viewed furthering my education as valuable for my long-term success. I chose to turn down the job offer in the interest of improving myself, starting at a better job, and preparing myself to climb through the ranks faster.

I spent all four years of my undergraduate career working in a lab at Clemson and certainly had a passion for research, so jumping into a PhD or MS degree was also attractive. However, I chose to pursue the MEng degree because it gave me an opportunity to build my resume in case I got halfway through an MS or PhD degree, then decided I was tired of research. Plus, the MEng was the shortest time commitment of the graduate degree options, so it seemed like a good way to ease myself into graduate school.



What experiences are you gaining that will qualify you for your career goals?

First, this program has helped me define my career goals in a more refined manner and has given me confidence in my life plan for at least the next 5-10 years, if not the next 20-50 years. I've become surer of the specific positions I want to apply for and end up in before I retire, and I've figured out how to get those jobs.

As far as knowledge gained in the program, I've gained an in-depth understanding of regulatory pathways, business models, and cash flow in the medical industry. I've also gotten a grasp of how to present and commercialize products. All of these are topics that aren't understood well by engineers coming out of their BS degree, but are extremely valuable, especially if you want to work at a startup company or climb the corporate ladder quickly.

The most impactful experiences provided by the program are the opportunities to present to industry mentors and the chances to tour medical device companies. These experiences are what really give MEng students a leg up in interviews and in their first positions. Where many BS students will come into interviews and entry level positions having heard through the grapevine how to succeed, MEng students are talking to their future coworkers and superiors and learning about what skills they need to practice to succeed and make a name for themselves. In addition to these experiences, the introductions to industry mentors are as impactful as any knowledge or experience for someone entering the workforce. Knowing somebody on the inside helps tremendously when applying to a company as an applicant with minimal experience.

$11 Million NIH Grant Creates New Center for Musculoskeletal Research

With an $11 million grant from the National Institutes of Health Center for Biomedical Research Excellence, Clemson University has launched the South Carolina Center for Translational Research Improving Musculoskeletal Health, or SC-TRIMH, a new research center that will bring together scientists from across South Carolina to change the way musculoskeletal disorders are diagnosed, treated and even studied.

The award was announced at a meeting of the Clemson University board of trustees. SC-TRIMH is Clemson's third COBRE-funded center; since 2009, Clemson has received more than $40 million in COBRE funding.

> While the current clinical trial process tells us that a product is unsafe or ineffective, it rarely tells us why or suggests how to improve it. This results in an all-or-nothing mindset in the biomedical industry, which stifles innovation and reduces the number of truly original biomedical projects available to surgeons while increasing costs. *Dr. Hai Yao*

Led by bioengineers at Clemson, SC-TRIMH combines orthopedics and other clinical expertise from the Greenville Health System and the Medical University of South Carolina with computer scientists, computational engineers, biophysicists and other experts to better understand musculoskeletal disorders and to design and evaluate new devices, interventions and drug therapies.

Disorders affecting bones and joints – including arthritis, osteoporosis, chronic back pain and sports injuries – are the leading cause of disability and a major driver of health care costs around the world, especially as the population ages and particularly among poor people. A ***recent national report*** showed that one in two American adults have a musculoskeletal problem, with a price tag of nearly $1 trillion in 2014. By 2040, more than one-quarter of Americans – 78 million – will receive a diagnosis of arthritis, ***according to the Centers for Disease Control and Prevention***.

"Thanks to the talent and determination of Clemson faculty, students and staff, and to our invaluable partnerships with GHS and MUSC, South Carolina is leading this exciting new fight against one of the most significant problems facing Americans and American health care," said Clemson University President James P. Clements. "We are grateful that the NIH has once again acknowledged Clemson University as a leader in academic research, and we look forward to working with our partners to advance innovation and clinical care."

"By working together, we can significantly improve health care and health outcomes in South Carolina and the nation," said Spence Taylor, president of Greenville Health System and himself a vascular surgeon. "These innovative partnerships between Clemson faculty and GHS clinicians allow us to solve clinical challenges by leveraging medical insights with the extraordinary research depth of Clemson. What we do today can pave the way for transformational improvements to health care for generations to come."

"Our team looks forward to deepening our long-standing relationship with Clemson and searching for next-level innovations through this COBRE grant," said MUSC President David J. Cole. "The challenges we face today in the health care domain are bigger than any one entity can solve. It is only through strategic partnerships based on shared vision and collective effort that we can leverage the strengths and capabilities of our individual institutions to successfully move into the future."

Dr. Hai Yao and student

Revolutionizing testing

A major component of SC-TRIMH is the creation of "virtual clinical trials" to reduce the time it takes novel ideas to go from concept to clinical practice, thereby reducing costs while improving care.

Currently, only about 10 percent of new discoveries find their way into practice within 20 years, due in part to a gap in the clinical trial process, in which innovations go through extensive animal testing before they're attempted in humans.

"While the current clinical trial process tells us that a product is unsafe or ineffective, they rarely tell us why or suggest how to improve it," said Hai Yao, Ernest R. Norville Endowed Chair and professor of bioengineering at Clemson University and the administrative leader of the center. "This results in an all-or-nothing mindset in the biomedical industry, which stifles innovation and reduces the number of truly original biomedical projects available to surgeons while increasing costs."

The virtual clinical trial will fill that gap. It's akin to very detailed, very personalized flight simulator training for musculoskeletal diseases. Scientists working in SC-TRIMH will build computer simulation models based on patient data, from the cellular pathology of a disease to how the person's bones and joints move under various scenarios. If the patient needs a hip replacement, surgeons can test various implants in the computer model under different conditions before it's implanted in the patient.

By constructing very specific models of each step at the body, tissue and molecular scales, the scientists will build a catalog of predictive models that can be used in research, thereby creating a continuous loop of data that will improve innovation.

With Clemson's rich history in bioengineering and orthopaedic engineering research – establishing one of the first academic departments in the country, playing a major role in creating the Society of Biomaterials and its faculty and students inventing many biomedical advances and devices – SC-TRIMH will also dedicate resources to finding commercial opportunities to make sure innovations are widely available, said Martine LaBerge, professor and chair of the ***bioengineering department***, which recently was ***ranked fourth in the country for value***.

> The SC-TRIMH initiative has potential to enable truly transformative research by connecting Clemson researchers to our GHS orthopedic researchers. Clinical perspective will inform the work of each junior investigator. So often, this is a missing element in health research. With SC-TRIMH and the Clemson University School of Health Research, we are establishing a new approach to investigating musculoskeletal health.
>
> *Dr. Michael Kissenberth*

Key partnerships and resources

Several factors position SC-TRIMH to revolutionize clinical trials; chief among them are long-standing collaborations between Clemson and its major health systems partners. Finding, facilitating and nurturing partnerships is the role of the ***Clemson University School of Health Research*** (CUSHR), led by Windsor Sherrill, associate vice president for health research and the chief science officer at GHS. CUSHR places the university's basic scientists and engineers with physicians and other biomedical scientists.

In 2011, Clemson and GHS partnered to open a laboratory, surgical training and innovation space called the ***Clemson University Bioengineering Innovation Center*** at the hospital system's Patewood campus in Greenville, South Carolina, in the same building with clinical orthopedics, vascular surgery and imaging. In 2003, the Clemson-MUSC Bioengineering Program opened at the MUSC campus in Charleston, with Yao (the associate chair for the program) and other faculty stationed there full time.

Other key resources are:

- Supercomputing cyberinfrastructure, namely the Palmetto Cluster, which places Clemson fourth among all public universities in the United States in supercomputing capacity;
- Predictive computational modeling, building on the experience of the ***Institute for Biological Interfaces of Engineering*** at Clemson;
- Advanced design, 3-D modeling and rapid prototyping of patient-specific devices in the labs of Georges Fadel in the Clemson ***Engineering Design Application and Research*** Center;
- Miniaturized smart sensors for biomedical applications that will enable the testing of prototypes, led by ***Hai Xiao***;
- Expertise in animal models, ***led by Jeryl Jones***; and
- A human cadaver lab, led by GHS orthopedic surgeon Michael Kissenberth, in the CUBEInC facility.

Three core facilities will be created based on these resources: multiscale computational modeling, led by Hai; advanced fabrication and testing, led by Xiao and Fadel; and, at GHS, pre-clinical assessment, led by Jones and Kissenberth.

Investing in the future

The COBRE grant also funds a pipeline of basic scientists to tackle fundamental questions about musculoskeletal disorders. Five Clemson junior researchers were chosen for positions to be supported by the grant for a maximum of three years, by which time they are expected to apply for and receive their own senior-level funding from the NIH. When a junior researcher "graduates," a new one is chosen in their place.

As a result, Clemson will produce a cascade of new knowledge and untold educational opportunities for undergraduate and graduate students, and new lab technician positions, LaBerge said.

"The SC-TRIMH initiative has potential to enable truly transformative research by connecting Clemson researchers to our GHS orthopedic researchers," said Michael Kissenberth, an orthopedic surgeon at GHS who, along with Kyle Jeray, chair of GHS' orthopaedics department, will lead the clinical advisory committee for the program. "Clinical perspective will inform the work of each junior investigator. So often, this is a missing element in health research. With SC-TRIMH and the Clemson University School of Health Research, we are establishing a new approach to investigating musculoskeletal health. This is a wonderful chapter in orthopedic research at GHS and for South Carolina."

Clinton Colmenares

MARTINE LABERGE HONORED AS FELLOW BY THE BIOMEDICAL ENGINEERING SOCIETY

Martine LaBerge of Clemson University is one of the newest Fellows in the Biomedical Engineering Society, an honor recognizing her for exceptional achievements and experience in biomedical engineering.

LaBerge is chair of the Department of Bioengineering at Clemson and executive director of the Clemson University Biomedical Engineering Innovation Campus, or CUBEInC, in Greenville.

LaBerge was elected Fellow of the Biomedical Engineering Society. She is among 165 Fellows in the society, which was founded in 1968 and now has more than 7,000 members. LaBerge said that she was honored.

"It represents years of dedication and is a result of recognizing bioengineering as a profession," she said. "It shows that Clemson internationally is a major contributor to the field in education, research and economic development.

"I accept this award on behalf of the department and faculty. Nobody can do it by themselves. It's a teamwork approach. My contribution is incremental in our mission."

LaBerge has served as the major advisor of 70 Ph.D. and master's students and has managed a research program of more than $14 million. Twenty new full-time tenure track positions were secured through her leadership.

She has brought to her department four endowed chairs, supervised the construction of two new buildings and developed CUBEInC. LaBerge also developed the South Carolina Translational Medical Technology Program.

LaBerge has received several honors and awards, including the South Carolina Governor's Award for Scientific Awareness and the Southeastern Medical Device Association (SEMDA) Spotlight Award.

She was inducted as Fellow, Biomaterials Science and Engineering by the International Union of Societies for Biomaterials Science and Engineering.

LaBerge has served as president of the Society For Biomaterials and received its Inaugural Service Award. She is a Fellow of the American Institute for Medical and Biological Engineering and served as the secretary-treasurer of the institute's Academic Council.

LaBerge has also been of service to the Biomedical Engineering Society, including a three-year term as board director. She has served as chair of the society's Membership Committee and chair of the 50th Anniversary Celebration Committee. LaBerge is the current chair of the Council of Bioengineering and Biomedical Engineering Departments.

She is a board member of the Clemson University Research Foundation and SCBIO.

Anand Gramopadhye, dean of the College of Engineering, Computing and Applied Sciences, congratulated LaBerge on being elected Fellow of the Biomedical Engineering Society.

"Dr. LaBerge's election shows the level of dedication, hard work and leadership that she brings to her department and the college," he said. "She is a key to educating bioengineering students, supporting bioengineering faculty and accelerating economic development in bioengineering-related industries. This is a richly deserved honor."

LaBerge said she wanted to share the department's mission, which is printed on cards and given to students:

"The department's mission is to educate and prepare students for professional careers in bioengineering for global competitiveness and to develop and disseminate bioengineering knowledge through research and engagement in economic development to advance health innovation and biotechnology in alignment with Clemson's land-grant mission."

Paul Alongi

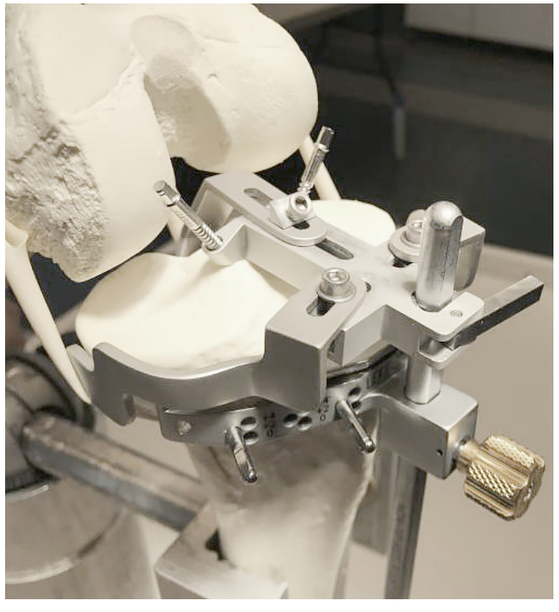
Four Clemson Bioengineering Senior Design Teams Receive National Design Awards in The NIH-Venturewell Design Competition

In a tour de force, four undergraduate bioengineering design teams received honors in the 2018 VentureWell and National Institutes of Health "Design by Biomedical Undergraduate Teams" (DEBUT) competition. Partnering with national and international clinical and industry collaborators, Clemson's bioengineering design programs develop innovative solutions in healthcare. Jenny Bourne, editor

2018 Design by Biomedical Undergraduate Teams (DEBUT) Challenge Winners

Clemson Bioengineering fielded seven design teams in this year's national design competition hosted by NIH and Venturewell. Now in its 10th year, the NIH-Venturewell prizes are considered the top achievement by undergraduate biomedical design teams. Entries were judged on significance of the problem being addressed, impact on potential users and clinical care, innovative design, prototype, market potential and economic feasibility and patentability.

Clemson bioengineering design teams have been recognized with awards or honorable mentions in this competition for five of the last six years, winning 1st place in 2013.



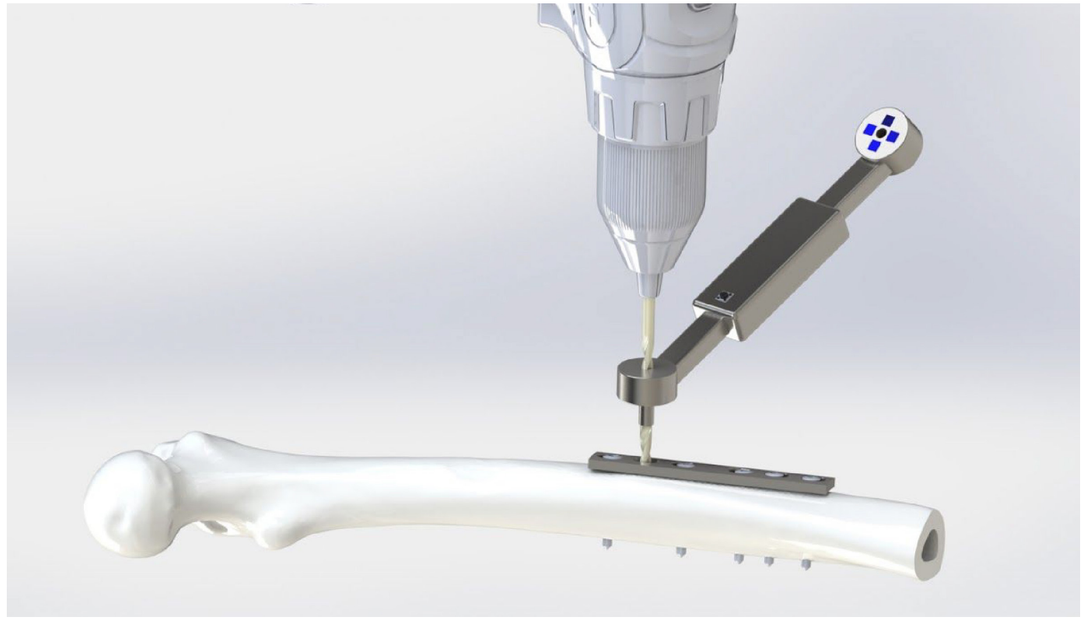
"We are very proud of the 2018 design class," said Dr. John DesJardins, instructor and director of the undergraduate design program. DesJardins continued, "They were an exceptionally motivated and talented group, and their clinical and departmental mentors assisted them in developing particularly innovative solutions in healthcare." The 2018 class fielded seven design team entries, and four were chosen for recognition.

Among the 2018 honors, Clemson teams won the VentureWell Venture Prize, 2nd place in the National Institutes of Health's DEBUT competition, and 2 of the 6 NIH DEBUT honorable mentions. One of these teams also won 2nd place in the Biomedical Engineering Society's undergraduate design competition.

The Venture Prize, $15000, was awarded to the Concentracizor 4 (C4): A Novel Gyroscopic Screw Guide for Long Bone Fracture Fixation by Clemson's Ian DeMass, Kaleb Guion, Bennett Hardymon, Andrew Moore, and Casey Young. The device is designed to help guide surgeons when placing orthopedic screws to set and repair broken bones. A screw that is misaligned with the hole that was initially drilled can lead to unnecessary pain and additional surgeries. The Concentracizor 4 is a simple device that uses gyroscopes to record the drilling alignment and light emitting diodes to guide the surgeon back to the proper angle for screw placement. The device is handheld, light, and can accommodate any size surgical drill.

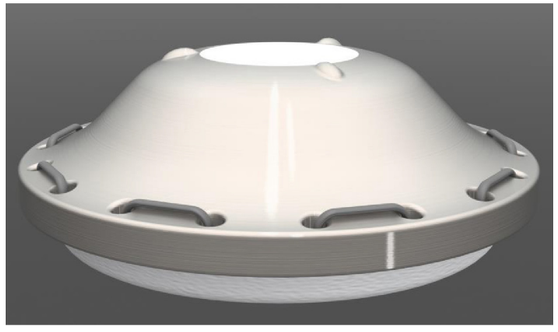
DEBUT's 2nd place, $15000, was awarded to The Voyager: A Tibial Resection Tissue Protector by Clemson's Colin Fair, Mina Gad, Alex Giron, Nick Matel, and Tusharbhai Patel. The device can assist in the resection of the tibia, helping reduce the amount of vein and ligament damage and other complications during total knee replacement procedures. The Voyager also allows for the complete resection of the tibia without other tools or technicians, making the procedure quicker and easier for surgeons.

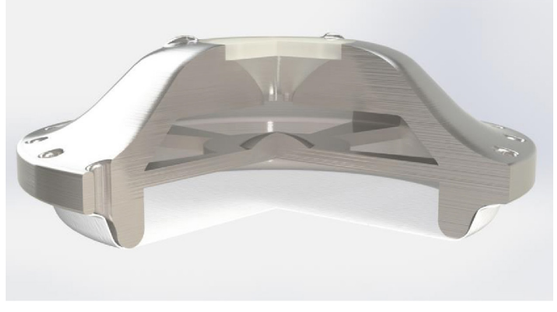
A DEBUT Honorable Mention was awarded to The Smart Snare: A Novel Colonoscopy Polyp Snare System, by Lauren Alford, Sheena Amin, Nicholas Baxter, Bryce Kunkle, John McGreevey and Julia Spieker. The Smart Snare includes a rotatability feature in addition to a novel axial bending component. The Smart Snare's novel features and rotatability give unparalleled control, allowing for quicker and more complete polyp removal during colonoscopy. These features would make approximately half of secondary surgies unnecessary, reducing associated costs and complications.



Other design competition awardees included Johns Hopkins University, Georgia Tech, the University of California Riverside, Drexel University, Columbia University, and University of Texas at Arlington. Each winner provided a video about the design, which can be found at the link below.

https://www.nibib.nih.gov/training-careers/undergraduate-graduate/design-biomedical-undergraduate-teams-debut-challenge/2018-debut-challenge-winners





We are very proud of the 2018 design class. They were exceptionally motivated and talented, and their clinical and departmental mentors assisted them in developing particularly innovative solutions in healthcare. *Dr. John DesJardins, Robert B. and Susan B. Hambright Leadership Associate Professor and director of the undergraduate design program.*

My Ultimate Goal?

To design and produce medical devices for the global health community

Being an M.Eng student so far has been an invaluable experience. It has taught me prominent skill sets that industry specifically looks for in potential candidates.

Alex Harrison is an M.Eng student now. As a Clemson undergraduate, she was one of those students who like to keep many balls in the air at work and at play. However, Alex's work and classroom activities had an impact on many whose needs would otherwise not have been met. She worked, for example, for two years in various jobs for the college's Programs for Educational Enrichment and Retention (PEER) and Women in Science and Engineering (WISE), programs dedicated to educating, recruiting, and retaining underrepresented populations in STEM fields through mentoring, academic coaching, counseling, and academic enrichment. Alex was a PEER/WISE Summer Camp counselor, a WISE mentor and a WISE tutor. She also worked for Dominica, directing a multidisciplinary class in engineering projects in a developing country.

Much of Alex's coursework included designing medical devices with clinical partners, performing FDA regulatory research, market analysis, rendering prototypes in SolidWorks, and getting a provisional patent. Alex said, "As part of a Global Health Design Creative Inquiry course, our team worked to design a breast pump to achieve 3 goals: To design a pump that could be used in both rural and urban settings of Tanzania, to incorporate a method to kill HIV to prevent transmission from mother to child, to store breast milk without refrigeration by killing the harmful bacteria that cause milk to sour. I am very passionate about global health and engagement."

"During my senior year," Alex noted, "senior design courses covered the entire process of medical device design. Working closely with a surgeon helped us prototype our designed device. And, it solidified my career goals for bioengineering and device design. My ultimate professional goal is to one day work in industry to design and produce medical devices to be used in the global health community."

Asked about her choice of M.Eng, Alex said, "Being an M.Eng student so far has been an invaluable experience. It has taught me prominent skill sets that industry specifically looks for in potential candidates. It has allowed me to build off my knowledge in undergrad and further understand how a medical device business runs, how to build my own start-up business around a medical device, and even dives deep into the FDA regulatory process. That is why I chose M.Eng. It is more of a hands-on, project-based learning style rather than just a series of tests. The program is also smaller (fewer students) than other graduate programs, which allows us more individualized learning and to become closer with classmates."

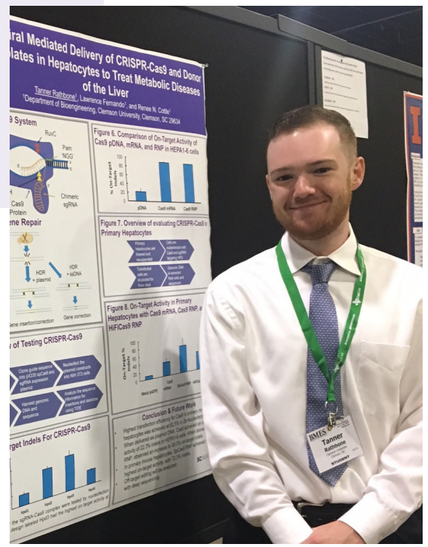
M.Eng: Master's of Engineering in Bioengineering

"I chose to stay in Clemson rather than going to Charleston for the degree because of other projects (Breast pump, ENGAGE, Senior Design patent stuff) I was involved in during undergrad and wanting to continue them during my graduate year. After graduation, I want to work in industry as a design engineer, ideally in a position where I can be a part of the entire development process and have the opportunity to work alongside clinicians," Alex concluded.

After graduation, I want to work in industry as a design engineer, ideally in a position where I can be a part of the entire development process and have the opportunity to work alongside clinicians.

I enjoy my research because I believe we are working on something novel and capable of making a difference in many people's lives.

Tanner Rathbone, PhD student in Dr. Renee Cottle's lab, represented Clemson with a poster presentation at the American Society of Gene and Cell Therapy 21st Annual Meeting in Chicago in May 2018. Tanner's abstract was published in the Molecular Therapy ASGCT 21st Annual Meeting Abstracts.
Molecular Therapy. 2018;26: 369-370
https://doi.org/10.1016/j.ymthe.2018.05.001



The Story of Ryan A. Borem, M.S.

U.S. Army Combat Veteran; NSF Graduate Research Fellow; Ph.D. Candidate/Lab Manager, Laboratory of Orthopaedic Tissue Regeneration & Orthobiologics OrthO-X

We are an award-winning department with much to be thankful for, and not a few of us would include Ryan Borem, whose generosity is an example to all. Jenny Bourne, editor

Some people always knew they wanted to be an engineer, but I was not one of those people. Truthfully, at the time I wasn't even sure of what an engineer was.

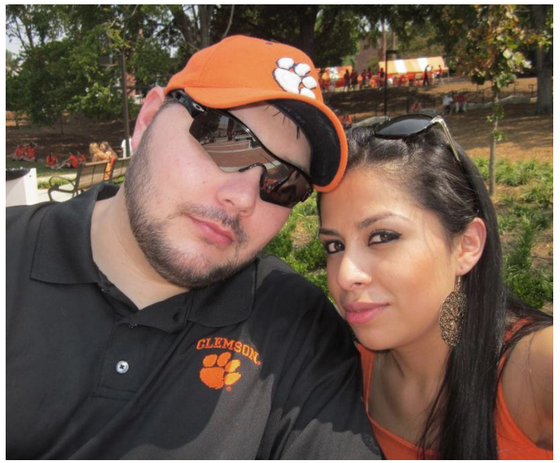
How did you choose Clemson?

My family moved to the Clemson area from Los Angeles, CA, before I graduated from high school. However, when I did graduate from West-Oak High School, I didn't have the money or the grades for scholarships to attend college, so I had to look for an alternative path. This is what led me to the U.S. Army. Once I finished my six-year enlistment, the Post- 9/11 GI Bill allowed me to pursue my college degree. This is when I had to decide between my two favorite colleges: UCLA and Clemson. I was torn between the two, but deep down I knew Clemson was my #1 because of their deeply embedded traditions. Go Tigers!!

Why did you decide on bioengineering?

The truth was I didn't have any idea what bioengineering was when I showed up to Clemson. All I knew at the time was that I wanted to go to college and, maybe one day, medical school. So, my wife and I had just moved from Colorado to Clemson, and I was showing her around Clemson's amazing campus. This is when divine intervention led me to Ms. Karen Thompson. We were walking by an empty Holtzendorff Hall (General Engineering building), and somehow, she just knew to stop us and ask what major I would be pursing at Clemson. At the time I didn't have any particular major in mind, and this is when she directed me towards bioengineering. Some people always knew they wanted to be an engineer, but I was not one of those people. Truthfully, at the time I wasn't even sure of what an engineer was. However, I am thankful every day for her stopping us and putting me on this path that I continue to enjoy more and more every day.

Ryan and mentor Dr. Jeremy Mercuri at 2018 BMES Annual Meeting, Atlanta



Ryan and Rose Borem

What surprised you about Clemson?

The first thing that surprised me was how smart all my classmates were. It just seemed like everything clicked for them. This was a hard adjustment for me and it took a lot of late nights trying to keep up. Luckily, I met my good friend Mitch Scull while an undergraduate. He assisted me along the way, and I am extremely grateful for both him and my wife for continuing to push me to never give up.

Who has had the biggest impact on your life?

The person who has impacted me the most is Dr. Jeremy Mercuri. At the time that I met him, he was a new professor, and I was just a random student he taught in his first class here in the bioengineering department. I like to believe the reason he asked me to join his research lab is that he saw something in me that I didn't know I had at the time, while others might say that since he was new, he probably just needed people to fill the space. Either way, with his guidance over the past 3.5 years, we have been able to accomplish so many milestones that I never even knew existed. Together, we have been able to take a conceptual tissue engineering idea for spinal repair and turn it into a project that has led to multiple publications and conference proceedings, multiple awards from various bioengineering societies, a U.S. and an international patent application. These experiences laid the foundation for my National Science Foundation Graduate Research Fellowship.

What advice would you give prospective students?

Give Clemson a chance. It is small, and it is in the middle of nowhere, but the people in this area make you feel like you're home and with a family you never knew you had. Also, you will never find a better graduate coordinator and friend in the world than Ms. Maria Torres. Lastly, have you not seen our Football Team??

The first thing that surprised me was how smart all my classmates were. It just seemed like everything clicked for them. This was a hard adjustment for me.

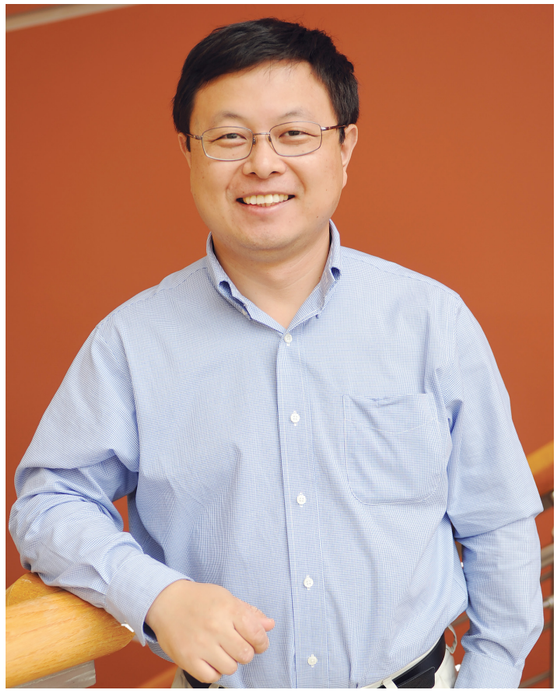
Award to Drs. Mercuri and Ye funds study of detection and treatment of sports injuries

Clemson's Robert H. Brooks Sports Science Institute awarded assistant professors Dr. Jeremy Mercuri and Dr. Tong Ye a seed grant to determine the effectiveness of nonlinear optical microscopy to identify early degenerative damage to knee cartilage. Their labs will also determine the effectiveness of mesenchymal stem cells to promote knee cartilage health in patients undergoing surgical repair after injury.

Asked what they hope to accomplish, they said, "In general, we hope to demonstrate that the nonlinear optical imaging system can detect early changes in cartilage cells and extracellular matrix before the changes can be observed using other conventional techniques. Moreover, we hope to show that stem cells may be able to slow the progression of osteoarthritis when administered soon after the initial traumatic injury."

If Mercuri and Ye accomplish their goals, they may be able to detect soft tissue injuries in patients' knees (typically seen in adolescent athletes) and then treat prophylactically using biologic-based therapies (like stem cells) to delay the onset of osteoarthritis and thus improve patients' quality of life.

Using the nonlinear microscope, Mercuri and Ye recently found that autofluorescence from endogenous molecules of chondrocytes (the only cellular components in cartilage) can help identify if a cell is live or not. They noted, "Previously,

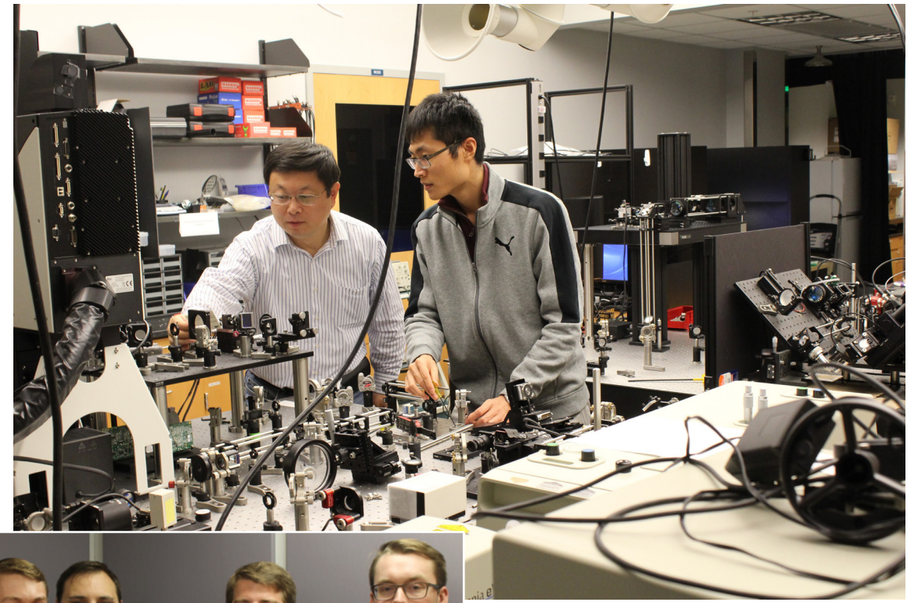


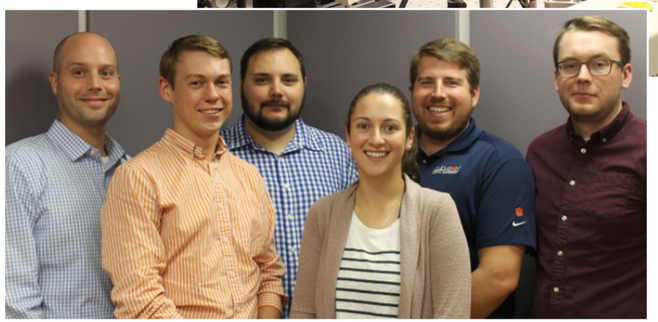
this information could be provided only by dye labeling. Combining with another nonlabeling imaging method, second harmonic generation imaging, we are able to record subtle structural and cellular changes that occur right after injury and to track the normal recovery or osteoarthritis progression due to the injury. This method can be potentially used on patients upon availability of an endomicroscopic system, which we are developing now."

They went on, "Regarding stem cells, amniotic membrane-derived stem cells (the kind we are using in this study) are a relatively new and underexplored stem cell source. We demonstrated previously that they may have an enhanced ability (compared to other sources like adipose derived stem cells) to protect cartilage and cartilage cells from degenerative osteoarthritic changes."

Mercuri described how he and Ye came together, "Tong and I had been talking for a while about osteoarthritis and the work that our respective labs were performing. He was working on ways to detect osteoarthritic changes while our lab was focused on finding ways to prevent or mitigate those changes. It just seemed like natural fit for us to collaborate. Furthermore, the bioengineering department is really collegial and fosters interaction among the faculty here in Clemson and at Charleston."

Combining nonlinear microscopy with another nonlabeling imaging method, second harmonic generation imaging, we are able to record subtle structural and cellular changes that occur right after injury and to track normal recovery or osteoarthritis progression due to the injury. This method can be potentially used on patients upon availability of an endomicroscopic system, which we are developing now.





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BIOENGINEERING

Clemson University
Department of Bioengineering
301 Rhodes Research Center
Clemson, SC 29634

Master of Engineering

M.ENG BME

Biomedical Engineering

Clinically embedded
Industry guided
Student designed

Program Highlights

- 1-year Master's degree program.
- Curriculum developed through industry guidance.
- Establish a working knowledge of medical device development and regulations.
- Mentoring provided by industry leaders.
- Courses delivered by subject matter experts.

Opportunities

- Become a leader in medical device development.
- Significant interaction with clinical stakeholders.
- Immersive, hands-on, design project-based learning.
- Professional development, corporate site visits and internship opportunities.
- Enhancement of student communication skills through board-room style design reviews.

Industry Involvement

Alliance Spine
AngioDynamics
Cartiva
Cook Medical
Corbion Purac
Diaxamed
FDA
Johnson & Johnson
Medpoint, LLC
Medtronic
Stryker
Terumo Medical
Zimmer Biomet

and more...

BIOE 8130 – Industrial Bioengineering
BIOE 8140 – Medical Device Commercialization
BIOE 8600 – Biomedical Eng. Device Design Innovation
BIOE 8610 – Biomedical Eng. Product Translation
BIOE 8620 – Preclinical Assessment & Regulatory Affairs

INTERESTED?

Contact: **Maria Torres**
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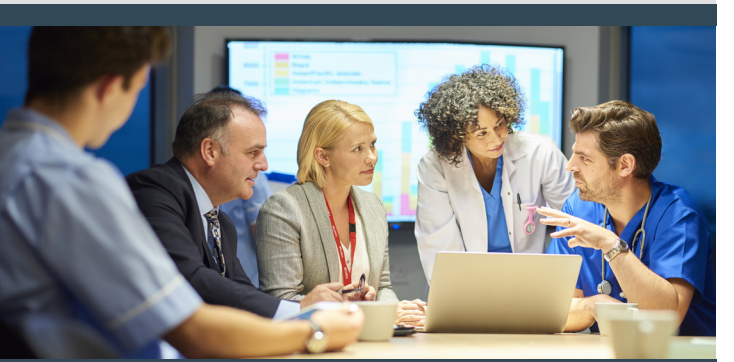
(864) 656-7276
mariam@clemson.edu



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