I am excited to share the activities of our faculty, students, and alumni in this Spring 2021 issue of BEconnected. While the past year has been challenging due to the COVID-19 pandemic, our faculty, staff, and students are diligently working to further the mission of our Department and the Speed School of Engineering. Our faculty and students had a highly productive year with 72 peer-reviewed manuscripts published in 2021. We continue to innovate and perform critical research to enhance healthcare, which led to our faculty receiving multiple national grant awards and industry contracts. We are pleased to announce the graduation of our first doctoral student, Dr. Landon Tompkins from the Translational Bioengineering PhD program. Prior to graduation, Dr. Tompkins received two small business innovation grants from the National Institutes of Health.

The Department of Bioengineering and Speed School of Engineering continue to strengthen international educational collaborations. Our Department has signed memoranda of understanding with five international universities for academic collaborations and to offer joint undergraduate and graduate programs. These partnerships enable UofL and our department to expand our presence and improve our ranking. Our Department was ranked 89th in the latest US News and World Report. We are very grateful for the support of our donors and alumni, and we look forward to your continued support to help us achieve our target of raising $200,000. Funds raised from this initiative has been used to establish new awards for our students. Due to the generosity of our donors, we have been able to recognize ten students in 2021 with an award.

We would love to hear from you. Please feel free to contact Betty Nunn to send us your updates, comments, or questions. We wish you all a safe and healthy spring and summer.

Ahmed Shaffie, PhD was recently awarded John M. Houchens Prize for most meritorious dissertation for Spring 2021. The Houchens Prize is a University level honor that is awarded to the doctoral student whose dissertation has potential for significant impact on a field. Dr. Shaffie graduated from Computer Science and Engineering Department and was mentored by Dr. Ayman El-Baz, Professor and Chair of Bioengineering. Dr. Shaffie received his B.S. in computer science and obtained his M.Sc in Engineering Mathematics from University of Alexandria, Egypt. His research involves the use of machine learning approaches to improve lung cancer diagnosis. Dr. Shaffie developed novel methodologies that have resulted in 20 peer-reviewed journal articles and 2 patents. He has previously received a number of awards, including Exemplary Research Scholarship Awards in 2019 and 2020, First Place Awards in the Doctoral Engineering category at Research!Louisville in 2017 and 2018, First Place awards at the Student Research Exposition in 2018 and 2019, and a Second Place award at the Graduate Student Regional Research Conference in 2020.

“I am extremely honored to receive such an important award like The John M. Houchens Prize. I am earnestly grateful for the recognition I've received for my work” said Shaffie. He believes his award is a validation of, not only his hard work, but also a large team in the Bio-Imaging Lab directed by Dr. El-Baz. Shaffie added “I am very passionate about the work that I do and the impact my research can have on people by saving lives. These awards are an affirmation of my research and its impact on society. I am grateful to the Bioengineering Department and Dr. El-Baz to provide this incredible research opportunity and for his mentorship.”
1.) What prompted you to enter the Ph.D. program in Bioengineering?

During my 2 undergraduate studies, I volunteered in a bioengineering research laboratory at the University of Alabama at Birmingham (UAB). This lab introduced me to many different aspects of biomedical research, including developing methods for cardiac regeneration by using induced pluripotent stem cell-derived cardiomyocytes. Within a few months of volunteering, I learned that I had an innate ability to perform experiments and accurately interpret data. After 2 years of conducting research within this lab, it was time for me to graduate from UAB and I was highly encouraged to pursue my passion for research through a Ph.D. program. A collaborator and co-mentor of mine suggested UofL’s program, due to the caliber of research conducted there. After looking into the research that has been performed here at UofL, I decided it was the right fit for me.

2.) Overall, how do you feel about the program?

It is a great program with numerous opportunities for research. I would advise future applicants to contact potential advisors early so you can get a better understanding of the details. I knew the mentor I wanted to work with prior to acceptance within the program, which enabled me to start my research as soon as I arrived at UofL.

3.) What advice can you impart to potential applicants of the Ph.D. program?

It is a great program with numerous opportunities for research. I would advise future applicants to contact potential advisors early so you can get a better understanding of the details. I knew the mentor I wanted to work with prior to acceptance within the program, which enabled me to start my research as soon as I arrived at UofL.

4.) How might the program be improved?

Incorporation of a club that contacts local companies, rehab centers, physicians, etc. for potential project ideas for doctoral students would further enhance the program. While this is done for undergraduate students for capstone projects, this could be extended to the doctoral program as well. Internship experience in product development, from the start of a project (what the customer wants) to a finished product might also enhance the program for students interested in the medical industry.

5.) What has this program helped you to achieve?

This program has allowed me to achieve quite a bit within the 2 years I’ve been here. Early during my Ph.D. studies, I had the opportunity to be heavily involved in research. During this time, I have been very productive and published 3 peer-reviewed journal articles, including two as co-first author. Additionally, I have applied for an NIH F31 fellowship, giving me invaluable experience in writing proposals. Throughout these 2 years, I have also gained knowledge into the molecular biology and functionality of cardiac tissue.

We are pleased to announce the student winners of these awards presented by the University of Louisville and the Speed School of Engineering:

Zachary Long—Joseph Henry Award is Translational Bioengineering
Sienna Shacklette—Rolando “Chip” Cheng Jr. Memorial Scholarship Award
Anna Goestenkors—Jerry and Pat Sturgeon Academic Excellence Award
Joey Breckenridge—Mickey R. Wilhelm Achievement Award
Ekaterina Kovatsenko—Judith Olsen Endowed Scholarship Award
Zach Raich—Biomedical Engineering Society (BMES) Chapter Award
Jessica Miller, Yaser ElNakieb—Best Doctoral Student Peer-Reviewed Journal Paper
Connor Centner—Doctoral Student Inventorship Award
Ahmed Shaffie, Mohammed Shehata, Heba Kandil, Ahmed Alkas, Ahmed Abdullah, Brett Janis, Hunter Miller—Exemplary Research Scholarship Award
Landon Tompkins—Doctoral Student Federal Funding Award
Landon Tompkins—Exemplary Doctoral Dissertation Award

Major Faculty Awards

Dr. Hermann Frieboes, Associate Professor of Bioengineering, received a DoD (U.S. Army Med Research) grant in collaboration with the Houston Methodist Research Institute (HMRI): Nanotechnology-based targeting of breast cancer liver metastases. H. Frieboes and B. Godin (MPIs), Project Period March. 2021 - Feb 2024, Amount $2.3M (total), $763K (UofL). This project implements a new approach to help patients with metastatic breast cancer. Liver metastases occur in more than 30% of patients with metastatic breast cancer. Although some breast cancer patients respond to current treatments, the typical survival is only 1-14 months, which is very poor compared to survival from metastases at other sites. Chemotherapy generally fails to reach liver metastases because they are deficient in blood vessels. However, the tumors are surrounded by immune cells, called macrophages. The function of these cells in the body is to engulf “foreign” objects. This project applies nanotechnology and mathematical modeling to design therapy that uses macrophages to deliver therapeutic nanovectors to target tumors. These cells are like “Trojan horses” to retain drugs in the proximity of tumors in the liver and, consequently, increasing local concentrations of therapeutics. In this project, a system is developed to quickly determine which patients will likely benefit from the proposed approach, and to predict the effect of macrophage-delivered therapy on liver lesions based on tissue samples taken from patient-resected tumors. The proposed approach, in combination with existing therapies targeting the primary site as well as bone, lung, and other organ metastases, will provide a much needed personalization of treatment for patients with breast cancer liver metastases.

Dr. Martin O’Toole, Associate Professor of Bioengineering, California-based medical device company, Qualigen Inc., has licensed a drug technology developed at the UofLs JGBCCs that uses tiny, DNA-coated gold nanoparticles to target cancer. The technology, dubbed “ALAN” (Aptamer-Linked Au Nanoparticles), has shown promise as an agent for radio-sensitizing and magnetic resonance imaging (MRI) contrast, as well as for the treatment of many forms of cancer. In exchange for the technology, UofL will receive cash payments on the achievement of certain milestones and royalties on future sales, as well as potential equity in the company. Qualigen has also sponsored a research agreement with the UofL for further development. “We have very high hopes that working together, with the strengths that we have at Qualigen and what UofL has here with the research center, that we can do something good going forward,” said Michael Poirier, the company’s president and CEO. JGBCCs Dr. Paula Bates, who developed the base technology, said this drug is more targeted than many currently available cancer treatments.
channels that represent paths that cancer cells take to spread through the body. Preliminary work has demonstrated that more aggressive tumor cells are softer, enabling them to spread faster. The investigation of the causes of these cellular changes may uncover new therapeutic routes for glioblastoma, which is currently very difficult to treat and a cure is often not possible. Treatments for glioblastoma typically slow progression of the cancer and reduce signs and symptoms.

Dr. Chen has published over 20 articles in peer-reviewed journals and co-authored over 25 abstracts for presentation at national and international scientific conferences. He has gained recognition for his work in microscopy, and his work was featured as the cover photo for the January 2020 issue of Cancer Research. Dr. Chen also has a passion for teaching and mentorship and has mentored over 15 students, including postdocs, graduate students, undergraduate students, and high school students. After graduation, his mentees have enrolled in medical school, graduate school, or have been offered jobs in biotech companies.

Through his courses (BE 423, BE 450), informal conversations, and research mentoring, he hopes to help his students find their passion and equip them to fully reach their career goals.

Dr. Joseph Chen is the Director of the Tissue and Cell Mechanobiology Laboratory at the University of Louisville, established in 2020. His research laboratory is focused on investigating how changes in tissue and cell mechanics regulate neurodegenerative diseases and brain cancer. His lab leverages bioengineering tools to model diseases in a dish in hopes to identify new therapeutic strategies for these challenging diseases. Dr. Chen joined the department in January 2020 after completing his postdoctoral training at the University of California, Berkeley. He holds a PhD in Biomedical Engineering from Vanderbilt University, and an MS and BS in Biomedical Engineering from Mississippi State University.

Dr. Chen is collaborating with investigators in Neurosurgery, Cardiology, and Engineering to tackle his research questions on changes in tissue and cell mechanics. Dr. Chen has a secondary appointment in the department of Pharmacology and Toxicology. One of his major research projects focuses on creating brain-like culture systems to study how physical features of glioblastoma tumors influence tumor cell metabolism. The careful examination of these relationships can be used to develop metabolism-based therapies for glioblastoma. Another major research project involves dissecting how cell softening or stiffening affects aggressiveness of cancer. Using advanced biophysical tools, microfabrication techniques, and time-lapse microscopy, his lab quantifies the mechanical properties of diseased and normal cells and monitors their ability to traverse tightly confined channels that represent paths that cancer cells must take to spread through the body.

Those treatments also may harm healthy, non-cancerous tissue. “The key is that the ALAN technology can kill cancer cells, but not normal cells,” said Bates, Professor of Medicine at the JGBC. The aptamer itself has been tested previously in more than 100 patients and has had no evidence of severe side effects. At least seven of those patients either saw their cancers disappear or shrink substantially.

Dr. Ayman El-Baz, Chair of Bioengineering - Tamer M.A. Mohamed, assistant professor of medicine in the UofL Division of Cardiovascular Medicine and the UofL Institute of Molecular Cardiology, Ayman El-Baz, Ph.D, Bioengineering, Roberto Boll, M.D, Medicine, and Xian-Liang Tang, M.D., Medicine have received a five-year, $3.8 million grant from the National Heart, Lung and Blood Institute. In 2018, the investigators discovered 4 cell cycle genes that are able to induce cardiomyocyte proliferation. This grant aims to develop a gene therapy for heart failure and test it in mice, rats, pigs, and human heart slices.

Dr. Landon Tompkins (BEng 2010, MEng 2011) became the first doctoral student to graduate in UofL’s Bioengineering Department defending his doctoral dissertation Development of a Pediatric Cardiac Assist Maglev Pump for Use with a Universal Driver System during the Fall 2021 semester under the co-mentorship of Steven Koenig, PhD and Kurt Dasse, PhD. Since starting in the Fall 2015, Dr. Tompkins has co-authored seven peer-reviewed conference abstracts and five peer-reviewed journal articles, co-inventor of six US and international patents and three UofL research disclosures, awarded 1st Place Medical Entrepreneur’s Forum (2018), and co-mentored team of UofL BE students (Top 5 Award Student Design Competition, 2019). Dr. Tompkins is co-founder of MAST LLC (Louisville KY) where he serves as principal investigator (PI) on two NIH SBIR Phase I grants developing novel surgical tools. Dr. Tompkins also serves as an engineering consultant with Cor Habere (Louisville KY), Inspired Therapeutics (Merritt Island FL), and VADovations (Oklahoma City OK) developing cardiovascular medical devices.
Dr. Jonathan Kopecek, Assistant Professor of Bioengineering, DoD CDMP Grant - $0.9M. Over 13 million units of red blood cells (RBCs) are transfused in the U.S. each year, the most common medical procedure in U.S. hospitals. In most cases, blood acquired from donors must be used within 42 days. Frozen storage can extend the shelf-life but this approach is limited by complex processing requirements and slow thawing which is disadvantageous when blood is needed expediently. These limitations are responsible for blood shortages that occur in many hospitals and pose a significant barrier to transfusion medicine, especially in places where refrigeration is not available, such as far forward military operations in austere environments or medical centers in remote locations.

Trehalose is a natural occurring cell protectant found in plants and lower animals (including brine shrimp known as “sea monkeys”) that helps those organisms survive water-limited states such as dehydration or freezing. However, trehalose does not cross cell membranes efficiently and must be actively loaded into cells that do not naturally express transporters for this sugar. To solve this problem we have developed a new method using ultrasound and microbubbles to induce small temporary pores in cell membranes, which enables trehalose to enter the cells before the pores close. Dry preservation of RBCs could revolutionize transfusion medicine for far forward military operations in flexible environments and would also enable transfusions in remote medical centers where long-term storage of blood components is currently impossible.

Dr. Guruprasad Giridharan, Professor and Associate Chair of Bioengineering has received a multi-institutional $2.3 M NIH RO1 grant award titled ‘Selection of flow modulation protocols for patients on continuous flow ventricular assist devices’. Dr. Giridharan is the UofL principal investigator and Dr. El-Baz Bioengineering Department Chair, serves as a co-investigator in this 4 year grant award. A major concern with continuous flow ventricular assist devices (CF-VADs) is the resulting non-physiological flow with diminished pulsatility, which has been shown to be a major risk factor for development of arteriovenous malformations and gastrointestinal bleeding. To address this issue, flow modulation via rapid changes in pump impeller speed has been proposed as a technique to introduce ‘artificial pulsatility’. However, these strategies cannot be adequately evaluated in animal models as they do not reflect human physiology well and are expensive. This grant will evaluate the effects of pulsatility and to identify promising flow modulation approaches in a vascular pulse perfusion model (VPPM) that was developed by Dr. Giridharan and Dr. Palaniappan Sethu (Professor, University of Alabama, Birmingham). The VPPM is an ‘organ on a chip’ system that can culture Human Aortic Endothelial Cells and can replicate physiologic conditions accurately and inexpensively. This grant received an impressive percentile score of 2% during NIH peer review. The UofL portion of the work is approximately $0.8 M.

Dr. Claudia Angeli, Assistant Professor of Bioengineering, has a 5 yr grant with the National Institute of Neurological Disorders and Stroke. Principal Investigators are Claudia Angeli and Maxwell Boakye, MD. “Inter-System Closed-Loop Control of Locomotor and Bladder Function in Individuals with Acute Spinal Cord Injury”. Project Period: 09/15/2020 – 06/30/2025; 2nd year total, $1.6M. More than 1.2 million people in the United States have a spinal cord injury (SCI), and each year there are 10,000 new cases. In the last few years, we have shown that neuromodulation using epidural stimulation of the lumbosacral spinal cord can activate latent neural circuits and restore voluntary movement, standing and stepping in individuals with chronic SCI. However, there are persistent gaps that need to be filled in order to advance the field of neuromodulation. Technological advances to upgrade the stimulator's programming and wireless communication platforms are critically needed in order to integrate multiple training paradigms across multiple systems (i.e. motor and autonomic), as well as take advantage of wireless monitoring technology that could improve the patient experience. For this study, first we will acquire data necessary for the implementation of learning algorithms and closed-loop systems with the implanted neurostimulator. Eight individuals will be implanted and will be assigned to training interventions for locomotion or bladder. Second, 8 additional individuals will be randomized into training interventions for locomotion and bladder. The purpose of this phase is to implement the closed-loop controls and learning algorithms developed with data from phase 1. This two-phase design will allow us to acquire necessary data for the development of technical tools with a group of 8 individuals, and test the closed-loop controls with a second group of individuals that have not received prior training. This trial will upgrade technology for epidural stimulation and make it specific for use by individuals with spinal cord injury.

Dr. Thomas J. Roussel (PI), Assistant Professor of Bioengineering has received funding for two projects: “Development of a Differential Scanning Calorimetry System for Rapid Identification and Differentiation of Specific Causes of Heart Damage – Including Different Types of Myocardial Infarction”. The Co-PI is Nichola Garbett(Medicine) Sponsored by UKRF (NIH) KYNETIC Tranche II, $50k. Start Date: 1/1/2021. He is also receiving a $650k NASA grant award as a co-principal investigator. The grant is entitled “Preparation for a Suborbital Flight Evaluation of a Human Tended Surgical Fluid Calorimetry System for Rapid Identification and Differentiation of Specific Causes of Heart Damage—Including Different Types of Myocardial Infarction”.

We are very proud to announce UofL’s Bioengineering graduates for 2021. Congratulations!!

**BE Graduates 2021**

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<tr>
<td>Hunain Abri</td>
<td>Luke Loughran</td>
<td>Jesse Fisher</td>
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<td>Daniel Benson</td>
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<td>Nathan Alexander</td>
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<td>Jae Blankenship</td>
<td>Kayla Montgomery</td>
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<td>Mariah Clark</td>
<td>John Moore</td>
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<td>Olivia Cooney</td>
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<td>Anna Goestenkors</td>
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<td>Destiny Gibson</td>
<td>Emma Raney</td>
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<td>Sydney Herold</td>
<td>Kara Rehmer</td>
<td>Reid Honeycutt</td>
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<td>Caitlin Howard</td>
<td>Jacob Sebree</td>
<td>Islam Samantha</td>
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<td>Mason Huff</td>
<td>Sienna Shacklette</td>
<td>Zachary Long</td>
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<td>Nicholas Huffman</td>
<td>Dillon Thomas</td>
<td>Winston Rauch</td>
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<td>Clara Jones</td>
<td>Sai Sree Vangoor</td>
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<td>Rianne Kablan</td>
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**BE Donations**

We have established a student endowment with a goal of raising $200,000 in the next 2 years. Due to the generosity of our donors we have raised approximately $45,000 to date. This has enabled us to present ten new BE student awards this year. We are deeply grateful to all our donors for contributing significant amounts to this cause. Your continued support is vital to fulfilling the endowment objective of recognizing meritorious students. For more information about how your donations can help transform the BE Department, please contact Mark Daily or call (502)852-2400.

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