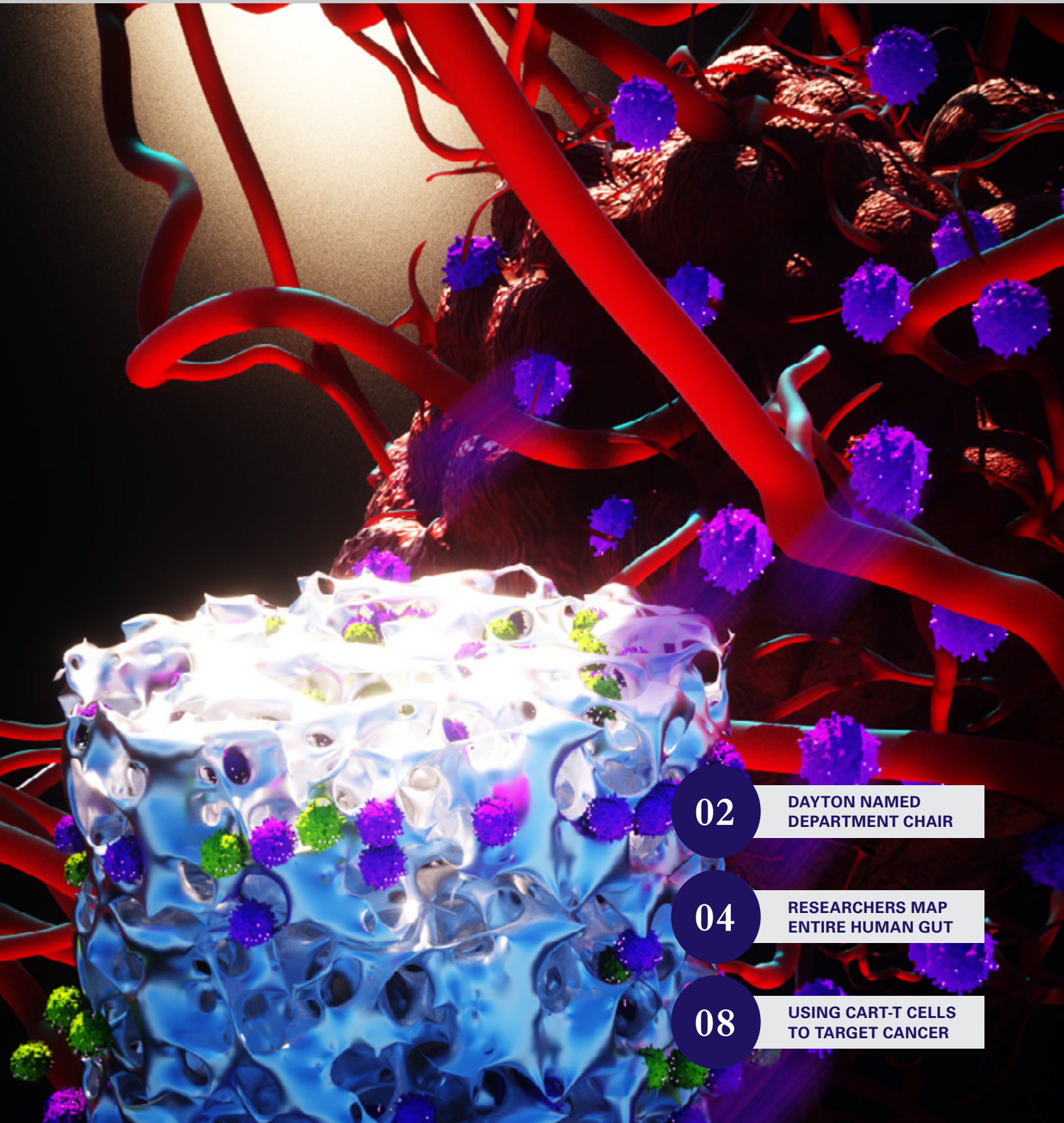
Joint Department of

BIOMEDICAL ENGINEERING

UNC CHAPEL HILL | NC STATE UNIVERSITY

SPRING / SUMMER 2022



IN THIS ISSUE

LETTER FROM THE CHAIR

Paul Dayton

GREETINGS BME ALUMNI AND FRIENDS:

I begin my note with exciting news, both for myself and for the UNC/NC State Joint Department of Biomedical Engineering (BME). This past February, after serving in an interim capacity, I was appointed permanent chair. As part of the announcement made by Louis Martin-Vega, Ph.D., dean of the College of Engineering at NC State; Blossom Damania, Ph.D., vice dean for research at the UNC School of Medicine; and Terry Rhodes, Ph.D., dean of the UNC College of Arts and Sciences, they stated, "This appointment represents a strong affirmation of the outstanding job that he has done in this position during the last two years." While I am grateful for and inspired by these kind words, I truly see them as a robust endorsement of the way the entire UNC/NC State Joint BME Department has thrived and excelled during these recent difficult months. Supporting this notion, with my new appointment the universities committed significant new resources to the Joint Department to leverage its successful momentum into even greater achievements. In particular, six new BME faculty member positions are being created along with additional staff positions and financial resources to support very competitive hires. To make the best use of these new resources, I have named veteran BME Professor Caterina Gallippi to lead a strategic planning effort to evaluate and recommend best ways to target and recruit excellent faculty hires as well as best applications of the other new resources. I anticipate with excitement receiving the BME strategic planning committee's report in the next few months. Another new initiative is an exciting partnership with the Department of Chemical, Biological and Bioengineering at North Carolina Agricultural and Technical State University (NC A&T) in Greensboro, NC. Stephen Knisley, NC A&T chair and former BME faculty member, attended BME's recent research retreat to help start building this relationship which is envisioned to catalyze inter-institutional collaborations in education and research. I am very excited by the potential of this association!

As you read on you will find stories indicative of how BME is thriving after a full academic year back to full-time, in-person research and education. Note exciting research reports of: mapping the entire human gut at single cell resolution; developing artificial blood platelets; tracking how musculoskeletal structure and function changes contribute to impaired mobility; advancing 3D-printing technology for innovative women's health solutions; improving CAR-T immunotherapy benefits with novel fibrin gel; and elucidating how absorbable biomaterials interact with hosts. We announce substantial recent research funding from National Institutes of Health (NIH), Department of Defense, National Science Foundation (NSF), VentureWell and the Chan Zuckerberg Initiative. We proudly relay numerous NIH, NSF and other student fellowships as well as prestigious student and faculty academic awards and honors from sponsors such as National Academy of Engineering Frontiers of Engineering, Institute of Electrical and Electronics Engineers, *Biosensors Journal* (Young Investigator Award), Society for Biomaterials (Mid-Career Award) and Controlled Release Society (Member of the Year Award). The articles just referenced offer a wealth of information about our programs and who we are. I encourage you to contact us with questions or comments regarding these exciting educational and research opportunities as the Joint Department develops them to serve the new decade!

Sincerely,

Paul A. Dayton, Ph.D.
William R. Kenan Jr. Professor and Chair
UNC / NC State Joint Department of Biomedical Engineering

BME
NEWS

DAYTON NAMED CHAIR OF JOINT DEPARTMENT

Paul Dayton, William R. Kenan Distinguished Professor, has been appointed as chair of the UNC/NC State Joint Department of Biomedical Engineering (BME). Dayton has served as interim chair of the department since 2019.

Dayton also holds appointments within the University of North Carolina at Chapel Hill's Lineberger Comprehensive Cancer Center and the Eshelman School of Pharmacy.

He succeeds Nancy Allbritton, who left the chair's position to accept an appointment as dean of engineering at the University of Washington.

Dayton's research involves developing new technologies for imaging blood flow, microvasculature and molecular markers using ultrasound and microbubble contrast agents. Several of his recent contributions to the field include techniques to improve the sensitivity and consistency of ultrasound imaging through optimization of contrast agent size distribution, the demonstration of high-resolution, high-SNR ultra-broadband imaging and techniques for real-time molecular imaging. An additional area of interest is ultrasound-mediated therapeutics with micro and nanoparticles.

Dayton's primary interest is in developing and applying tools for non-invasive assessment of angiogenesis progression and tumor response to therapy. The Dayton Lab is part of the UNC/NC State UltrasoNC Research Consortium.

Dayton's work has been primarily supported by the National Institutes of Health and various other federal funding agencies and industrial organizations. He is also the co-founder of three startup companies, one of which, SonoVol, Inc., was acquired by PerkinElmer early in 2022. A second startup, Triangle Biotechnology, Inc., is now successfully based in North Carolina's Research Triangle Park.

An outstanding scholar and researcher, Dayton was named a senior member of the National Academy of Inventors in 2021 and a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) in 2022. He has served as a member of the IEEE Ultrasonics Technical Program Committee since 2008.

Dayton received his B.S. in physics and comprehensive science (pre-med) from Villanova University, his M.E. in electrical engineering from the University of Virginia and his Ph.D. in biomedical engineering, also from the University of Virginia. He pursued post-doctoral research and was later on the research faculty at the University of California, Davis. He joined the BME department in 2007 as an untenured associate professor and was appointed as associate department chair in 2012, a position he served in until 2019, when he assumed the position of interim chair.

Founded in 2003, the Joint BME Department is part of the College of Engineering at NC State and both the School of Medicine and College of Arts & Sciences at UNC-Chapel Hill.

"This appointment represents a strong affirmation of the outstanding job that he has done in this position during the last two years," said leaders from the two universities in a joint statement. •

SCIENTISTS MAP ENTIRE HUMAN GUT AT SINGLE CELL RESOLUTION

Proteins CFTR (green) and FKBP1A (red) — a primary target of the drug Tacrolimus — in BEST4+ cells in small intestine.

If you get nervous, you might feel it in your gut. If you eat chili, your gut might revolt, but your friend can eat anything and feel great. You can pop ibuprofen like candy with no ill effects, but your friend's belly might bleed and she might get no pain relief. Why is this? The quick answer is because we're all different. The next questions are how different exactly, and what do these differences mean for health and disease? Answering these is much more difficult, but the University of North Carolina School of Medicine Lab of Scott Magness, Ph.D., is revealing some interesting scientific answers.

For the first time, the Magness Lab used entire human GI tracts from three organ donors to show how cell types differ across all regions of the intestines, to shed light on cellular functions, and to show gene expression differences between these cells and between individuals.

This work, published in *Cellular and Molecular Gastroenterology and Hepatology*, opens the door to exploring the many facets of gut health in a much more precise manner at greater resolution than ever before.

"Our lab showed it's possible to learn about each cell type's function in important processes, such as nutrient absorption, protection from parasites and the production of mucus and hormones that regulate eating behavior and gut motility," said Magness, associate professor in the UNC/NC State Joint Department of Biomedical Engineering and senior author of the paper. "We also learned how the gut lining might interact with the environment through receptors and sensors, and how drugs could interact with different cell types."

THE SENSITIVE GUT

Think of a typical pharmaceutical commercial voiceover when the voice actor pleasantly recites possible side effects, such as diarrhea, vomiting, intestinal bleeding and other unpleasant collateral damage. Well, the Magness Lab is attempting to understand why those side effects happen, down to the level of individual cells, their functions, their locations and their genes.

For this research, the Magness Lab focused on the epithelium: the single-cell thick layer separating the inside of the intestines and colon from everything else. Like other cell populations and the microbiota, the

Scott Magness

THE BIOLOGY OF DATA

UNC-Chapel Hill acquired state-of-the-art RNA sequencing technology several years ago for the creation of the Advanced Analytics Core Facility through the UNC Center for Gastrointestinal Disease and Biology, which developed the scientific and intellectual heft — research faculty, staff, postdocs and students — to use state-of-the-art equipment.

epithelium is incredibly important to human health, and for years scientists have been exploring it. But until now, researchers could only take tiny biopsies the size of grains of rice from a few parts of the digestive tract, usually from the colon or limited regions of the small intestine.

"Such exploration would be like looking at the United States from space but only investigating what's going on in Massachusetts, Oklahoma and California," Magness said. "To really learn about the country, we'd want to see everything."

Magness leaned on co-first authors, postdoctoral fellow Joseph Burclaff, Ph.D., and graduate student, Jarrett Bliton, both trainees in the Magness Lab.

"Not only do we want to identify where the cells are located, but we want to know exactly which cell types do what, and why," Burclaff said. "So, staying with the map analogy, we don't want to just say, 'Oh, there's North Carolina.' We want to know where to get the best barbecue. We want a ground level view to know as much as possible."

In the past, researchers would mash up those rice-sized biopsies to identify all epithelial cell types and learn some general features of these cells. Magness's approach was to sample thousands of individual cells from every part of the lower digestive tract (small intestine and colon) to create an atlas and then study the potential roles of these cells through the genes that each cell expresses. Knowing all of this would deepen scientific knowledge about the gut epithelium and hopefully encourage other scientists to explore each cell's function in biology, in disease and in the unfortunate scenario of pharmaceutical side effects.

To do such a deep individual cell dive, Magness needed two things: better technology and the entire digestive tracts of humans.

The Magness Lab acquired human digestive tracts through a research agreement with organ donor services at HonorBridge. When intestines are harvested for transplant and if they are not claimed by higher-priority groups, HonorBridge staff coordinates with the Magness Lab to donate the transplant-grade organs for research.

Six to eight hours after harvest, the Magness Lab receives intact intestinal tracts, each about 15 to 30 feet long. They remove the epithelial layer, which is one long connected piece of tissue despite being only one cell thick. Then the researchers use enzymes to break down the epithelium into individual cells. For this study, they repeated this for organs from three separate donors.

Using sequencing technology to characterize gene expression, the Magness Lab first extracts RNA from each cell while keeping each cell separate, and then they run single-cell sequencing, which takes a snapshot of which genes each intestinal cell is expressing and how much.

"The picture we get from each cell is a mosaic of all the different types of genes the cells make and this complement of genes creates a 'signature' to tell us what kind of cell it is and potentially what it is doing," Magness said. "Is it a stem cell or a mucous cell or a hormone-producing cell or an immune-signaling cell?"

Funding for this research came from the National Institutes of Health, the Katherine E. Bullard Charitable Trust, the Crohn's and Colitis Foundation and the University Cancer Research Fund at UNC-Chapel Hill.

Aside from the aforementioned researchers, other authors are Keith Breau, Meryem Ok, Ismael Gomez-Martinez, Jolene Ranek, Aadra Bhatt, Jeremy Purvis and John Woosley, all at UNC-Chapel Hill. •

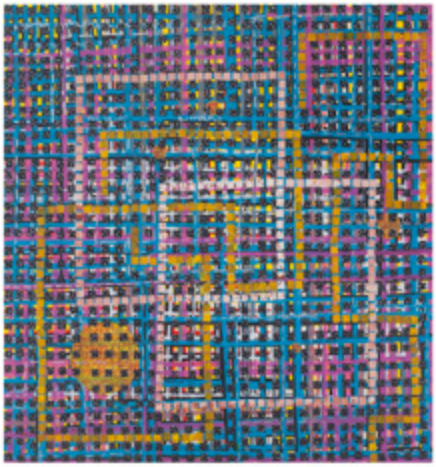
BME holds first Coulter Seminar on the intersection of art, engineering and science

In fall 2021, the UNC/NC State Joint Department of Biomedical Engineering (BME) held its first Coulter Seminar featuring an artist. Working in the intersection of art, science and engineering, Gupi Ranganathan holds an MFA in painting and printmaking from the Massachusetts College of Art and Design, as well as degrees in engineering and management from her native country, India. Ranganathan's seminar Liminal Meanderings: Between Art, Science and Engineering, is based on her collaborations with scientists and researchers on two main projects: *Unfolding* (2009-11), as artist-in-residence at the Broad Institute of the Massachusetts Institute of Technology (MIT) and Harvard, and more recently with the Stanley Center for Psychiatric Research and the Broad Institute for *Cultured Interactions* (2006-19).

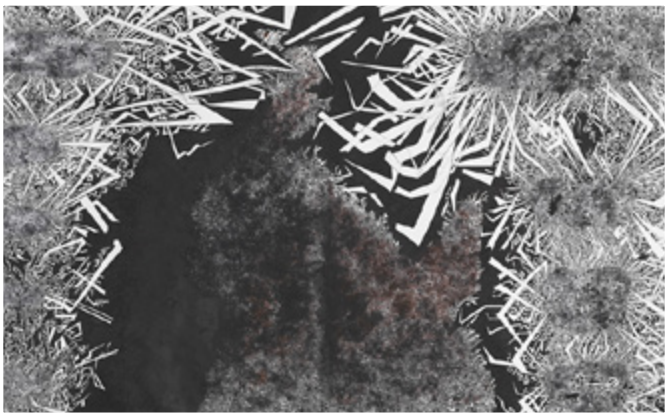
Ranganathan explained the meaning behind the title and the focus of her talk as follows: "My studio practice has evolved to continuously learn and constantly move between art, science and engineering. I have been asking new questions and exploring possibilities beyond 'What is this?' and 'Where is this going?' to 'What if?' and 'Maybe.' While liminal relates to either a transitional or initial stage of a process, meandering refers to an act of following a winding course. As a result, my work has shifted to focus on evolving structures and patterns, becoming more investigative, conceptual and abstract. I have started exploring new ways of working to combine my drawing, painting and printmaking to include wood burning, sculpture and video to create mixed media work. More recently, my collaborative work has focused on site-specific and time-specific projects that include installations and wall drawings."

As an artist in residence at the Broad Institute of MIT and Harvard, Ranganathan worked with Erez Lieberman Aiden on the problem of genome folding. Their visual experimentations grew into a varied body of artworks titled *Unfolding* (2009-11) that contributed to advances in the scientific community's understanding of how the human genome folds. You can watch Ranganathan's video on the problem of genome folding and unfolding by visiting **bit.ly/3KkEp0b**.

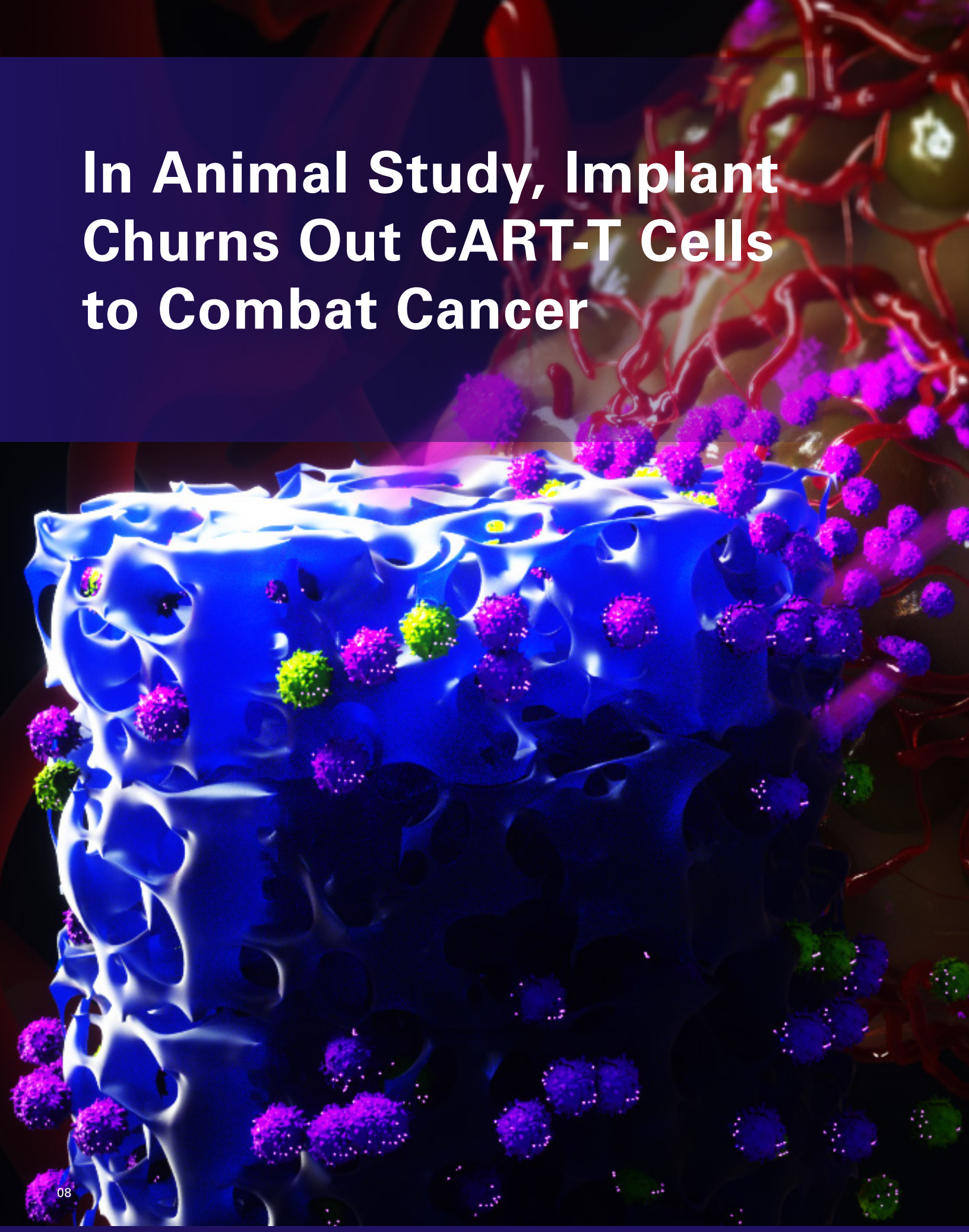
The discussions and questions raised during Ranganathan's Broad residency, and her collaboration with the Stanley Center for Psychiatric Research to design an installation for its 10-year anniversary, broadened the scope of her project *Cultured Interactions* (2006-19), started at MassArt. This second project encompasses two related series: Evolving Landscape and Continuum, which focuses on the problems of processing, connecting, combining and sharing complex genomic and neurobiological information. In anticipation of her talk, she created the following *Cultured Interactions* videos, available at **bit.ly/3NUjQty** and **bit.ly/38xvRoM**.

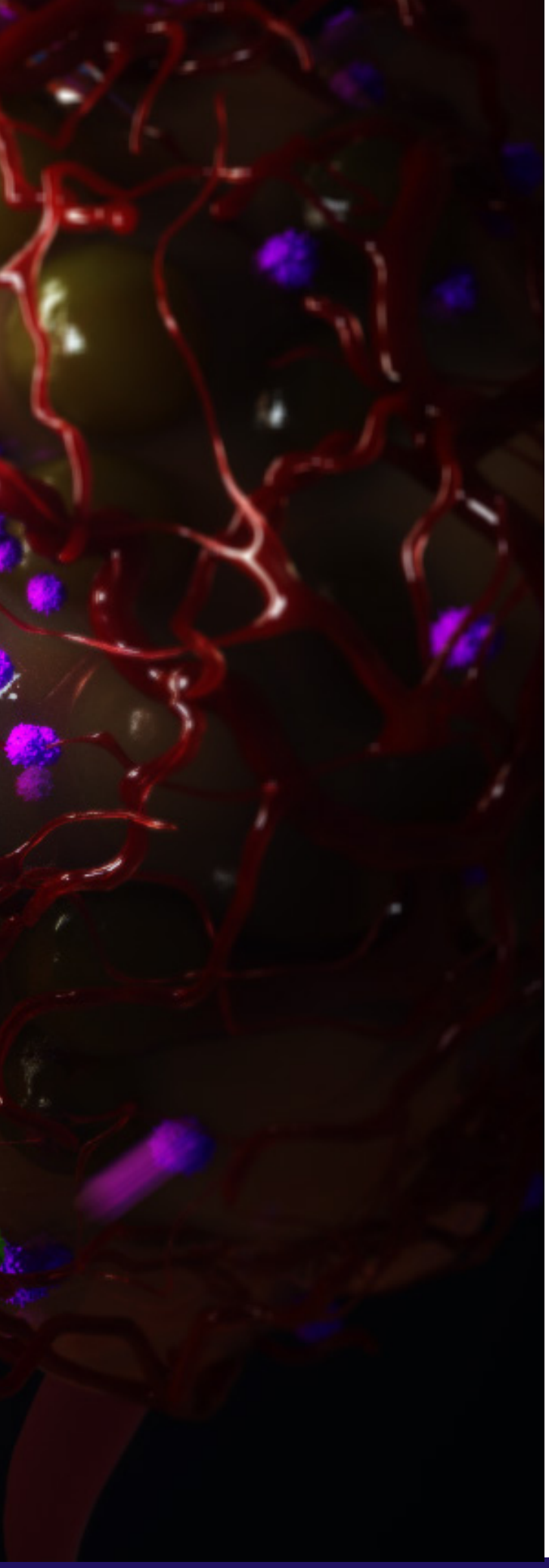


Having exhibited and shared her work in the intersection of art and science in galleries and forums in the United States, China and India, Ranganathan reflects over the last 12 years as part of a larger continuum of interactions and collaborations. "The COVID-19 pandemic has especially highlighted the need to explore more deeply how I can extend myself as an artist to contribute to research projects through the creative process," she shared. "For me, tracking our memories and reflecting on them is a reminder of what it means to be human, how we choose to evolve and bring together our different ways of thinking as part of a larger whole." •



In Animal Study, Implant Churns Out CART-T Cells to Combat Cancer





BME researchers have developed an implantable biotechnology that produces and releases CAR-T cells for attacking cancerous tumors. In a proof-of-concept study involving lymphoma in mice, the researchers found that treatment with the implants was faster and more effective than conventional CAR-T cell cancer treatment.

T cells are part of the immune system, tasked with identifying and destroying cells in the body that have become infected with an invading pathogen. CAR-T cells are T cells that have been engineered to identify cancer cells and destroy them. CAR-T cells are already in clinical use for treating lymphomas, and there are many clinical trials under way focused on using CAR-T cell treatments against other forms of cancer.

"A major drawback to CAR-T cell treatment is that it is tremendously expensive — hundreds of thousands of dollars per dose," said Yevgeny Brudno, corresponding author of the study and assistant professor in the UNC/NC State Joint Department of Biomedical Engineering. "Due to its cost, many people are shut out from this treatment. One reason for the high cost is that the manufacturing process is complex, time-consuming and has to be tailored to each cancer patient individually. We wanted to address challenges in CAR-T treatment related to both manufacturing time and cost."

"Reducing the manufacturing time is even more critical for patients with rapidly progressing disease," said Pritha Agarwalla, lead author of the study and a postdoctoral researcher in the department.

To tackle this challenge, the researchers created a biotechnology called Multifunctional Alginate Scaffolds for T cell Engineering and Release (MASTER). The work was done in partnership with Gianpietro Dotti, professor in the Department of Microbiology and Immunology and co-leader of the Immunology Program at the Lineberger Cancer Center at UNC; and Frances Ligler, former BME Distinguished Professor and now a professor of biomedical engineering at Texas A&M University.

To understand how MASTER works, you have to understand how CAR-T cells are produced. Clinicians first isolate T cells from patients and transport them to a clean manufacturing facility. At this facility, researchers "activate" T cells with antibodies over

several days, preparing them for reprogramming. Once T cells are activated, researchers use viruses to introduce the CAR gene, reprogramming the T cells into CAR-T cells that target cancer cells. Researchers then add factors to stimulate the CAR-T cells to proliferate, expanding their number. Finally, after these manipulations are complete — a process that can take weeks – the cells are brought back to the hospital and infused into the patient's bloodstream.

"Our MASTER technology takes the cumbersome and time-consuming activation, reprogramming and expansion steps and performs them inside the patient," Agarwalla said. "This transforms the multi-week process into a single-day procedure."

MASTER is a biocompatible, sponge-like material with the look and feel of a mini marshmallow. To begin treatment, researchers isolate T cells from the patient and mix these naïve (or non-activated) T cells with the engineered virus. Researchers pour this mixture on top of the MASTER, which absorbs it. MASTER is decorated with the antibodies that activate the T cells, so the cell activation process begins almost immediately. Meanwhile, MASTER is surgically implanted into the patient — in these studies, a mouse.

After implantation, the cellular activation process continues. As the T cells become activated, they begin responding to the modified viruses, which reprogram them into CAR-T cells.

"The large pores and sponge-like nature of the MASTER material brings the virus and cells close together, which facilitates cellular genetic reprogramming," said Agarwalla.

The MASTER material is also impregnated with factors called interleukins that foster cell proliferation. After implantation, these interleukins begin to leach out, promoting rapid proliferation of the CAR-T cells.

"Engineering the material so that it is dry and absorbs this combination of T cells and virus is critically important," Brudno said. "If you try to do this by applying T cells and virus to a wet MASTER, it just doesn't work."

"I feel like we're just scratching the surface of what's possible here."

PRITHA AGARWALLA

In these studies, the researchers worked with mice that had lymphoma. One group was treated with CAR-T cells that were created and delivered using MASTER. A second group was treated with CAR-T cells that were created conventionally and delivered intravenously. These two groups were compared to control group receiving non-engineered T cells.

"Our technology performed very well," Brudno said. "It would take at least two weeks to create CAR-T cells from naïve T cells for clinical use. We were able to introduce the MASTER into a mouse within hours of isolating naïve T cells."

In addition, since cells are implanted within hours of isolation, the minimal manipulation creates healthier cells that exhibit fewer markers associated with poor anti-cancer performance in CAR-T cells. Specifically, the MASTER technique results in cells that are less differentiated, which translates to better sustainability in the body and more anti-cancer potency. In addition, the cells display fewer markers of T cell exhaustion, which is defined by poor T cell function.

"The end result is that the mice that received CAR-T cell treatment via MASTER were far better at fighting off tumors than mice that received conventional CAR-T cell treatment," Agarwalla said.

The improvement in anti-cancer efficacy was especially pronounced over the long term, when mice were faced with a recurrence of lymphoma.

"The MASTER technology was very promising in liquid tumors, such as lymphomas, but we are especially eager to see how MASTER performs against solid tumors – including pancreatic cancer and brain tumors," Brudno said.

"We're working with an industry partner to commercialize the technology, but there's still a lot of work to be done before it becomes clinically available. Further work to establish the safety and robustness of this technology in animal models will be necessary before we can begin exploring clinical trials involving human patients."

While it's impossible to estimate what the cost of MASTER treatment might be if it is eventually approved for clinical use, Brudno said he's optimistic that it would be substantially less expensive than existing CAR-T treatment options.

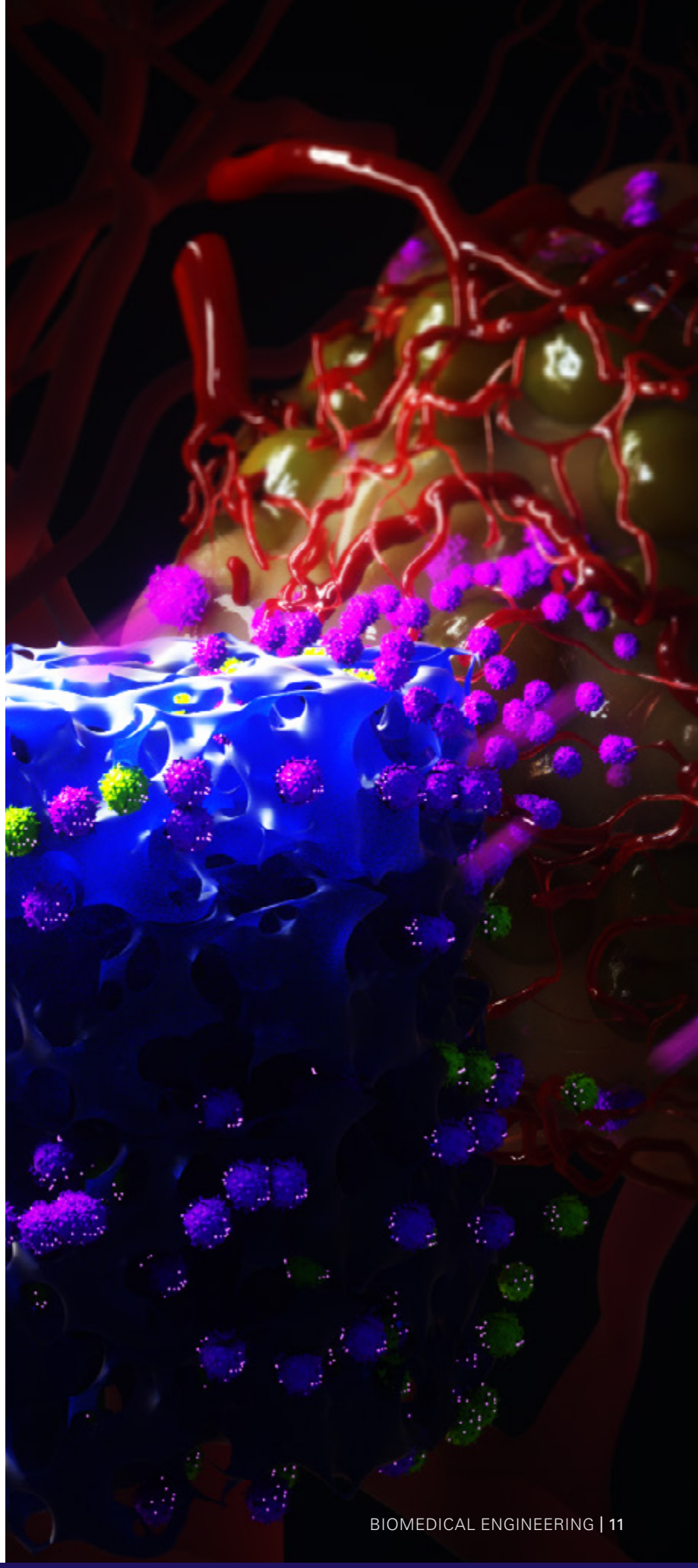
"We're also exploring opportunities with other industry partners for taking the fundamental concepts of MASTER and applying them for use in regenerative medicine and in treating autoimmune disease," Brudno said.

"I feel like we're just scratching the surface of what's possible here," Agarwalla said.

The paper, "Bioinstructive Implantable Scaffolds for Rapid In Vivo Manufacture and Release of CAR-T Cells," is published in *Nature Biotechnology*. The paper was co-authored by Kristen Froehlich, a former undergraduate at NC State; Edikan Ogunnaike and Sarah Ahn of UNC; and Anton Jansson of NC State.

Agarwalla, Dotti and Brudno are inventors on patents related to the use of biomaterials for generation of CAR-T cell therapeutics. Brudno has received an industry-sponsored research grant related to CAR-T cell therapeutic technology (unrelated to this work). Dotti is a paid consultant for Bellicum Pharmaceuticals, Tessa Therapeutics and Catamaran.

The work was done with support from the North Carolina Biotechnology Center, the National Center for Advancing Translational Sciences and the National Institutes of Health. •



FACULTY AND STAFF NEWS

Bandodkar is among *Newsweek's* 50 greatest disruptors

Amay Bandodkar

Amay Bandodkar, affiliated faculty member in the UNC/NC State Joint Department of Biomedical Engineering (BME) and assistant professor in the Department of Electrical and Computer Engineering (ECE), has been named one of America's 50 Greatest Disruptors. *Newsweek* magazine recognized Bandodkar for his work on wearable, battery-free sensors and skin-friendly wearable batteries.

Typically, 90 percent of the size of a wearable device is taken up by the power source, usually a battery. Bandodkar had the idea to save space by using the wearer's own sweat as the battery's electrolyte — the solution that supplies the electrical current. "By carefully selecting the battery electrode materials and using a person's own sweat as the electrolyte I was able to develop a thin, flexible battery cell which has energy capacity similar to that of a coin cell but without the latter's use of toxic chemicals and rigid, metallic housing," he said.

The magazine also lists Elon Musk, CEO of Tesla, Inc., among other visionaries and innovators who are changing the world through technology in ways that will profoundly impact our lives — mostly or wholly for the better. Read more on *Newsweek*'s inaugural list of Greatest Disruptors at **bit.ly/37Z72lm**.

Bandodkar receives Young Investigator Award

Bandodkar also received the Young Investigator Award from *Biosensors Journal*. Bandodkar works at the interface of electronics, materials science and biology to create next-generation wearable sensors with biomedical applications such as disease monitoring. He is part of NC State's ASSIST Center, whose mission is to create self-powered, wearable health monitoring technologies.

Bandodkar received his Ph.D. in 2016 and has an outstanding publication record, comprising 57 publications in peer-reviewed international journals and six international patents. His Hirsch index is 41.

Andrea Giovannucci

Giovannucci receives funding from the Chan Zuckerberg Initiative

The Chan Zuckerberg Initiative (CZI) has announced a new series of grants to support access to imaging technology and to increase regional representation of imaging scientists in the global community. Of the funding, $1 million will support 41 plugin projects for the imaging analysis tool napari, including BME Assistant Professor Andrea Giovannucci's project titled "Real-time and large-scale brain imaging analysis with CaImAn and Napari." Giovannucci will build a napari

plugin to support the interactive visualization of large-scale or streaming analysis of brain imaging data via his CaImAn open source package.

A community-built, Python-based, open-source tool, napari is designed for browsing, annotating and analyzing large multi-dimensional images. The grants will support development and maintenance of napari's growing ecosystem of plugins, and Giovannucci is among the napari Plugin Accelerator grantees who are contributing to provide easy access to reproducible and quantitative bioimage analysis.

"Expanding imaging capacity for biomedical researchers requires advancing imaging software and hardware, expanding access to shared tools and resources, and building capacity for imaging scientists and organizations to advance research in their home countries," said CZI Imaging Program Officer Stephani Otte. "We're excited to welcome our new imaging grantees, from software engineers to imaging scientists, who are furthering the boundaries of understanding health and disease."

Rahima Benhabbour

Benhabbour receives CRS Member of the Year Award

Rahima Benhabbour, BME assistant professor who is also an adjunct professor at the UNC Eshelman School of Pharmacy, has received the 2022 Controlled Release Society (CRS) Member of the Year Award. The CRS grants this honor to a member who has demonstrated an emerging or sustained commitment to equity, diversity and inclusion in their professional activities. The Member of the Year Award recognizes the key role that achievements in ED&I initiatives play in the advancement of science and technology for the benefit of CRS and the greater scientific community.

Benhabbour will be presented with the award during the 2022 CRS Annual Meeting on July 11-15. She shared that, "I am beyond humbled by this award which means the world to me." CRS was founded in 1978 as a not-for-profit organization devoted to the science and technology of controlled release. Today, delivery science and technology is developing into a key multi-disciplinary field with diverse applications and practitioners around the world. The CRS has as a goal to be the premier society world-wide for delivery science and technology.

Ashley Brown

Brown receives Mid-Career Award

Ashley Brown, BME associate professor, has been recognized with the prestigious 2022 Mid-Career Award from the Society for Biomaterials (SFB), which recognizes members who have demonstrated outstanding achievements in and/or contributions to the field of biomaterials research. Nominator Christopher A. Siedlecki said: "Dr. Brown has established a strong reputation for her research program, as evidenced by both her outstanding extramural support record and her remarkable publication record. Brown's research spans both translational and fundamental efforts and draws from multiple scientific disciplines to develop creative and effective solutions to both address critical clinical needs and to elucidate novel fundamental biological mechanisms. Altogether, more than 10 million people suffer from conditions addressed by Brown's research program, with more than $100 billion in health care costs spent on these problems. It's clear that her work has the potential to dramatically improve health care worldwide."

SFB is a multidisciplinary society of academic, health care, governmental and business professionals dedicated to promoting advancements in all aspects of biomaterials science, education and professional standards to enhance human health and quality of life. One of the defining aspects of SFB is its commitment to bridging the gap between academic research and its application within an industry setting to advance the biomaterials field and lead to innovations in research, patient care and policy.

Brown's synthetic platelet research draws interest amid human blood shortages

Brown was also featured by a local television news station for her work developing artificial blood platelets, which could have huge real-world impact in today's blood supply shortage. The American Red Cross declared a "blood crisis" in early 2022 as supplies ran low at hospitals and blood banks.

Blood platelets are one of the four crucial components of human blood, the tiniest of blood cells that control bleeding and plug our injuries until they heal. For eight years, Brown and her lab have been developing the first synthetic platelet material that can precisely mimic platelet shape change specifically at sites of injury. The team has seen success in clinical trials in mice and rats. Their hope now is for more encouraging results with the platelets in pigs. The ultimate goal is to use the synthetic platelets in humans for surviving surgeries, traumatic injuries or blood disorders.

Since the pandemic began, there has been a historically low number of people donating blood, fueling a supply crisis. Brown said that "in a situation like we're in right now, when we have a massive blood shortage, we could take some pressure off of current blood banks." To watch the video and read the full feature, visit the ABC11 website at **abc11.tv/3qAStuC**.

Jason Franz

Franz invited to participate in Frontiers of Engineering Symposium

Jason Franz, BME associate professor, has been invited to participate at the 2022 China-America Frontiers of Engineering Symposium (CAFOE), to be held July 18-20 at the National Academies' Beckman Center in Irvine, Calif. Although this meeting was originally scheduled to be held in China, due to COVID-19-related travel restrictions, U.S. and Chinese attendees will meet virtually from their respective gatherings in California and Chengdu in China.

Sixty early-career engineers from the United States and China will be participating, including organizers and speakers. Participation is limited to better facilitate interactions and contacts among the attendees. During the two-and-a-half days of the symposium, four topics — Additive and Subtractive Manufacturing, Food Safety in the Context of Big Data and Genomics, Water Sustainability, and Wearable Electronics and Human Health — will be covered. Speakers will give presentations on pioneering research and technical work followed by discussion. There will be ample opportunity for discussion among the participants outside of the formal sessions.

The event is intended to facilitate international and cross-disciplinary research collaboration, promote the transfer of new techniques and approaches across disparate engineering fields, and encourage the creation of a trans-Pacific network of world-class engineers. The National Academy of Engineering Frontiers program has expanded to include bilateral meetings with Germany, Japan, China and the European Union.

Dayton elevated to IEEE Fellow

Paul Dayton

BME Kenan Distinguished Professor and Department Chair Paul Dayton is among the newly elevated 2022 IEEE Fellows. Dayton was elected for his contributions to contrast agents and contrast-enhanced ultrasound in medical diagnostics and therapeutics.

IEEE, the Institute of Electrical and Electronics Engineers, is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity. Recognizing the achievements of its members is an important part of the mission of IEEE. Each year, following a rigorous evaluation

procedure, the IEEE Fellow Committee recommends a select group of recipients for elevation to IEEE Fellow. Less than 0.1 percent of voting members are selected annually for this member grade elevation.

Fellowship is the highest grade of membership in the IEEE.

BME M.S. MedTech Program awarded a $27k grant funded by VentureWell

The BME M.S. program in MedTech Innovation + Entrepreneurship received a grant from VentureWell and the Lemelson Foundation in the amount of $27k. The grant funds are to be used for "Development of a new course and underrepresented minorities (URM) recruitment initiatives to support medical device innovation and entrepreneurship" under the supervision of David Zaharoff, BME associate professor and founding director of the M.S. MedTech program, together with Matt R. Penny, the associate director of M.S. MedTech, and Kennita Johnson, assistant professor and director of equity and diversity for the BME department.

The M.S. MedTech program is an 11-month accelerated learning, team-based and project-based curriculum focused on new medical device development, innovation and entrepreneurship. Funding from VentureWell will support the development of a new course within the M.S. program in Medical Device Materials and Manufacturing, which will provide students with a focused immersion into materials and manufacturing techniques that are common in medical devices. In particular, the course will enhance the capabilities of the student teams to develop better proofs of principle which will increase the likelihood of the teams acquiring funding to continue their operations following graduation. A parallel goal of this grant is to recruit URM students in the M.S. program.

VentureWell is the brainchild of Jerry Lemelson. The organization started as one of the foundation's earliest grantees, founded at Hampshire College in 1995 as an autonomous program by a consortium of five colleges called the National Collegiate Inventors and Innovators Alliance. Their ultimate mission is to support faculty in developing programs that cultivate student innovators and promote institutional change.

Congratulations to the M.S. MedTech Program team, David Zaharoff, Matt Penny and Kennita Johnson.

BME spinout SonoVol Inc. acquired by PerkinElmer

BME spinout company SonoVol Inc. has been acquired by PerkinElmer (NYSE:PKI). SonoVol was co-founded in 2012 by then-graduate student Ryan Gessner (Ph.D. 2013) and his graduate school mentor, recently appointed BME Chair Paul Dayton.

Originally launched as a NEO company from the UNC Kickstart program (now called Kickstart Venture Services), SonoVol specializes in high-performance ultrasound and multi-modality imaging systems for the life science tools market. Its product offerings will complement and extend PerkinElmer's existing portfolio of in vivo imaging instruments and reagents, including the industry-leading IVIS optical preclinical imaging platform, the company said.

Gessner developed the concept for the company after spending many hours during his Ph.D. studies in the Dayton Lab using hand-held ultrasound systems with a limited 2D field of view and knew there had to be an easier way of providing disease researchers with critically important data. Gessner's vision was to "use robotics to allow a 3D tissue imaging system as easy to operate as a Xerox® machine," enabling a straightforward biomedical imaging workflow for non-imaging experts. SonoVol received early funding from intramural research grants and later received federal research funding from the National Science Foundation and National Institutes of Health Small Business Innovation Research (SBIR) programs. In 2018, the SonoVol team commercialized their first product, the Vega, a benchtop robotic 3D ultrasound scanning system for preclinical disease research applications.

"SonoVol is an example of the creativity and entrepreneurial spirit cultivated by the UNC/NC State Joint BME Department," Dayton said. Most of the other SonoVol team members are also UNC/NC State BME

alumni, including: Tomek Czernuszewicz (Ph.D., 2015), Juan Rojas (Ph.D., 2018), Chris Moore (Ph.D., 2019), Nathan Beaumont (B.S., 2018), Max Harlacher (B.S., 2015) and James Butler (B.S., 2015).

Gel enhances CAR-T immunotherapy benefits in brains surgically treated for glioblastoma

Edikan Ogunnaike

A recent publication in *Science Advances* by BME postdoctoral researcher Edikan Ogunnaike reports the improvement of immunotherapy's effectiveness by pairing a newly developed gel with immunotherapy that was delivered to post-surgical mouse brains with glioblastoma, a highly malignant and deadly cancer. Nine of 14 mice (64 percent) that received the gel and T cells were tumor-free 94 days after treatment, compared to two of 10 (20 percent) mice who only received T cells. The researchers said if these findings can be replicated in human studies it would result in a great improvement in current treatment rates.

CAR-T cell (chimeric antigen receptor-T cell) immunotherapy involves harvesting immune-system T cells from a patient and genetically re-engineering them in the lab to recognize targets on the surface of cancer cells. In this mouse study, the CAR-T cells and gel were placed to fill in the area where a glioblastoma tumor had just been surgically removed.

"We developed a gel made of fibrin, a protein most often associated with helping blood to clot. Applying a gel substance to an area of the brain to aid CAR-T cell therapy is unique in glioblastoma treatment," said Ogunnaike, who currently works under the guidance of former BME Distinguished Professor Fran Ligler and UNC School of Medicine Professor Gianpietro Dotti, who is also co-leader of the Immunology Program at UNC Lineberger.

"Our approach was beneficial in glioblastoma and we believe that it could also control growth or return of tumors in the brain, eye and other organs," said Dotti, corresponding author of the article, "Fibrin gel enhances the antitumor effects of chimeric antigen receptor T cells in glioblastoma." To read the full publication, visit **bit.ly/3DK1tTy**.

DEPARTMENT DISTRIBUTES 2021 ACHIEVEMENT AWARDS

The Joint Department's Internal Achievement Awards were announced in February. The award committee highlighted the talents and accomplishments of the 2021 awardees in the following categories:

The BME Staff Service Award went to Darlene West. "Darlene is smart, efficient, and takes great pride in her work and her efforts to keep the department running smoothly. She is not only excellent at her assigned tasks, but also excels at treating everyone she interacts with (including the greater community) with respect and making sure that each person she serves has what they need to succeed. The scope of her contributions spans far-and-wide, ranging from financial, travel and human resource administration, as well as on-site work skills trainer, human Google on NC State policy, always handy temp replacement and morale officer extraordinaire."

The BME Staff Teaching and Mentoring Award went to research associate Susan Bernacki. "Susan worked to develop new lab modules to teach cell culture techniques for the BME sophomore and junior design labs, while also managing the NC State COVID-19 response. Susan's dedication and hard work is appreciated by the students she mentors and trains in wet lab techniques."

The BME Faculty Service Award went to associate professor Jason Franz for his work as the BME Well-Being Liaison. "Jason has been maintaining wellness meetings and providing resources to the department during a time where many feel its need. In particular, students appreciated the careful consideration he gave their voice, from hearing the concerns of GSA to taking feedback from individual students. He focused on their needs and provided mental health resources during the semester. For going beyond his

already impressive contributions as a researcher, educator and mentor, we'd like to recognize Jason for his efforts to support the members of our department in the area of mental health."

The BME Faculty Research Award went to assistant professor Rahima Benhabbour. "She has a new R01, an MCI grant and an NCTraCS $50K grant along with seven published papers in 2021, with two others currently under review. Dr. Benhabbour has presented at four international conferences, three webinars and has been invited to serve as a panelist in the National Institutes of Health World AIDS Day, an event that will feature Congresswoman Barbara Lee and several other high-level White House representatives. She has received multiple awards including the Young Investigator Award from the Controlled Release Society and a David Sokal Innovation Award and has been invited to serve as a member of the BMES Diversity Committee. Her startup company AnelleO just landed a $2M Phase II SBIR and was recently featured in the WRAL's Innovation Road Trip and highlighted by Chancellor Guskiewicz in his message to the University."

The BME Faculty Teaching and Mentoring Award went to assistant professor Wesley Legant. "The nominations spoke of Dr. Legant's enthusiasm for teaching and commitment to fostering an engaging learning experience. In particular, students appreciated Dr. Legant's thoughtful lesson plans and creativity in teaching tough material, especially during an unusual semester."

The BME Post-Doctoral Research Award went to assistant research professor Pritha Agarwalla. "Dr. Agarwalla has been an absolute rockstar. She has an encyclopedic knowledge of the literature, a robust work ethic and is actively involved in training students and undergrads, who all love her. Her work has been published in *Advanced Healthcare Materials* (Impact Factor 7.5), but her most exciting work has been accepted for publication in *Nature Biotechnology* (Impact Factor: 55). She is now working on a third, high-impact paper. Her main discoveries have been reproduced by industrial collaborators. These collaborators, Takara Bio U.S.A. and Oxford Biomedica, have signed license agreements with our lab to commercialize Pritha's technologies."

The awards for Ph.D. Student Research went to doctoral student Danielle Howe and postdoctoral research scholar Qiang Zhang. "Danielle has made a number of contributions related to sex-specific differences in the anterior cruciate ligament (ACL) during growth, which have important translational implications for treatments after ACL injury in young patients. Danielle has published three first-author and two co-author manuscripts and received a highly competitive F31 Fellowship from the National Institutes of Health. In addition to her research, Danielle is committed to service; she has served as BME Graduate Student Association president and contributes to many outreach events.

Qiang has made substantial contributions in the area of human muscle force prediction by combining ultrasound and surface electromyography techniques. He has also made breakthrough contributions that allow for the use of ultrasound data in real-time control of functional electrical stimulation and assistive devices. Qiang has published four first-author papers and two co-author papers, with several papers currently under review. Qiang's advisor was extremely supportive of his nomination and ranked him highly among peers. For these and many other reasons, Danielle and Qiang are highly deserving of this award."

FACULTY MEMBERS PROMOTED AND GRANTED TENURE

BME NC State-based faculty members Ashley Brown and Donald Freytes have been named as tenured associate professors, and Naji Husseini has been promoted to teaching associate professor. At BME UNC-Chapel Hill, Xiaogang Hu is now an associate professor with tenure, while Kenneth Donnelly and Devin Hubbard are now teaching associate professors.

Promoted faculty members have met rigorous standards in their realms of responsibility, and tenured faculty members have made a significant impact in their discipline. •

STUDENT NEWS

Anand wins second place at BeAM MakerFest

Keerthi Anand

UNC/NC State Joint Department of Biomedical Engineering (BME) Ph.D. student Keerthi Anand received second place in the "Best All Around" category at the University of North Carolina at Chapel Hill's first BeAM Makerfest. A fourth-year Ph.D. student in the Gallippi Ultrasound Lab, Anand's research interests include development of fast ultrasound imaging technology for preventing strokes, but outside of the lab, he also enjoys tinkering with electronics to make demonstrations with acoustic levitators.

BeAM Makerfest was his first public expo of the levitators: using open-source designs by the Upna Lab in Spain and the University of Bristol in the United Kingdom, Anand shows sound waves by trapping small styrofoam spheres in airborne acoustic vortices. In a phased array transmitter, he has even made the lightweight particles orbit like planets by changing where the sound focuses. Anand hopes to show these acoustic levitator demos at other outreach events to communicate fascinating applications of math, physics and engineering principles to a diverse audience of kids, teens and adults to increase public interest in STEM.

"I want to show by example to all the students unsure about potential career choices that a biomedical engineer can do pretty much anything and be whatever we dream to be. I found an area of science that made me really excited and hope to help others discover theirs, while realizing we can have fun along the way," Anand said.

In fact, since the summer, Anand has been making 30-second TikTok videos on acoustic levitation that have been engaging more people in science. Under the username @beamformer, he has grown his following to over 7.7k. One of his videos shows him sipping water floating in the air and is trending under the hashtag #goodsoup and went viral with more than 600k views. Anand shared that it's harder to get global followers on other social media platforms, while TikTok's video clips are easily shared across the board.

Department gives Excellence in Undergraduate Research awards

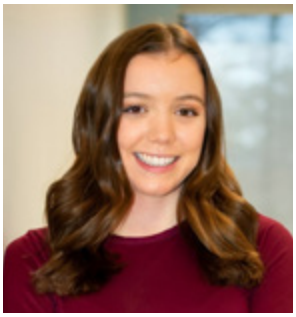
Jennifer Potts

Jake Schulman

The BME undergraduate research committee has acknowledged the outstanding achievements of the following undergraduate researchers with a cash award: Seniors Jennifer Potts (Cole), Jake Schulman (Zaharoff) and Emily Warren (Polacheck), as well as Junior Katherine Eltz (Papadopoulou / Dayton).

"Our main goal is to evaluate the independent study applications, but this year we were also tasked with giving out three to five Excellence in Undergraduate Research Awards," said Brian

Emily Warren



Katherine Eltz

Diekman, BME professor and chair of the undergraduate research committee.

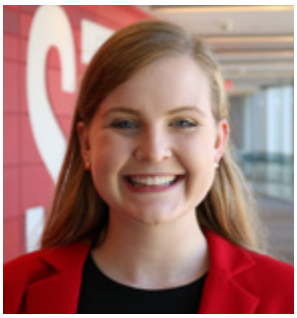
The goals of these awards include: giving students formal recognition to support their next steps (graduate school applications, job applications, etc.) and promoting a culture of BME undergraduate students thriving within research laboratories across both campuses. The committee reviews nominations submitted by faculty members and graduate student/post-doc mentors. The main criterion is evidence that the student candidate has gone "above and beyond" to make significant contributions to their research labs.

Krupenevich receives Award for Research Excellence at UNC

Rebecca Krupenevich

BME postdoctoral fellow Rebecca Krupenevich, working in Professor Jason Franz's Applied Biomechanics Lab, has received one of five 2021 Awards for Research Excellence at UNC. Krupenevich earned her Ph.D. in kinesiology at the University of Maryland, where she investigated age-related differences in walking biomechanics. Her current research focuses on how changes in foot musculoskeletal structure and function contribute to impaired mobility in older adults. Her research aims to increase our understanding of neuromechanical mechanisms underlying age-related mobility impairment to support improving the health and welfare of our aging population. Krupenevich is funded by a National Research Service Award (NRSA F32) from the National Institute on Aging.

The Postdoctoral Awards for Research Excellence at UNC-Chapel Hill are given annually in recognition of the research promise demonstrated by individual postdoctoral scholars. The awards are open to postdoctoral scholars in all disciplines and are designed to assist in professional development by funding conference travel, book and lab supply purchases, or engagement in other scholarly activities that directly enhance the individual's professional growth. Each recipient receives a monetary award of $1,200 along with a plaque.



Sarah Hall

BME student named 2021 Leader of the Pack

BME undergraduate Sarah Hall was named the 2021 Leader of the Pack on the field at halftime during NC State's homecoming football game on Saturday, October 30, 2021.

Hall is a Goodnight Scholar from Cary, NC, in her fourth year majoring in biomedical engineering with minors in French language and biological sciences. During her time at NC State, Hall has been a case design team leader and case manager for the Helping Hand Project, an ambassador and mentor with the Goodnight Scholars Program, an ambassador with the College of Engineering, an undergraduate teaching assistant and an undergraduate research assistant at the College of Veterinary Medicine. She has also participated in Alternative Service Break trips to Ecuador and Trinidad and Tobago and studied abroad in Lille, France.

The Leader of the Pack program honors and recognizes students for outstanding contributions in leadership, scholarship and service. This program has long been a tradition on campus, dating back to the 1990s. While originally known as the Homecoming King and Queen Competition, the award transitioned to a more inclusive and equitable process — removing the gendered structure and focusing on scholarship, leadership, a commitment to creating an inclusive campus community and service to the campus and broader community.

BME Ph.D. student, alumnus awarded at Wolf Den

Wolf Den is a Shark Tank-inspired pitch competition in which student teams have the opportunity to pitch their ventures in front of a live audience and judges. This year, the competition was tough with 17 student teams applying for the competition and only five moving to the final round. BME Ph.D. student Travis McKay and alumnus Taylor Gabaldon were among the finalists who received a $600 Judge Award for their Dynamic Internal Volume Actuator (DIVA).

DIVA is a modified bag valve mask application for emergency medical technicians that optimizes mobile ventilation by being plug-and-play, adaptable and truly portable. Finalists had three minutes to deliver their pitch and convince the judges and the audience that their idea was worth funding. The judge panel this year was composed of NC State alumni Téa Blumer, Ryan Clodfelter and Cathy Gomes. Each judge brought a diverse set of expertise and had four minutes to question the pitching team.

Yarmey receives GAANN Fellowship

BME Ph.D. student Victoria Yarmey has received the prestigious Graduate Assistance in Areas of National Need (GAANN) Fellowship for January-December 2022, renewable for a period of up to one additional year. The NC State GAANN Molecular Biotechnology Fellowship Committee selected Yarmey based upon her fine academic record, demonstrated interest in molecular biotechnology, and upon the recommendation of our BME department.

This fellowship is provided through funding awarded to the Graduate School by the U.S. Department of Education GAANN Program. Yarmey is currently working at the San Miguel Lab in the Department of Chemical and Biomolecular Engineering at NC State.

Rubin wins third at NC State Graduate Research Symposium

BME Ph.D. student Noah Rubin represented the department at the 15th Annual NC State Graduate Research Symposium, where his poster won third place among 34 abstracts in the engineering section. Advised by BME Distinguished Professor He (Helen) Huang and Associate Professor Xiaogang Hu, Rubin presented a poster titled "Validating Motor Unit Decomposition of Surface Electromyography During Dynamic Muscle Activation." His research presents matching pursuit applied to decomposed surface electromyography (sEMG) as a novel step to further validate sEMG decomposition on and quantify the extent to which recorded motor unit action potentials (MUAPs) transform during dynamic muscle activation. Such efforts may improve accuracy in myoelectric control of assistive devices and reliability of noninvasive neurophysiological investigation.

The Graduate Student Research Symposium, held each spring, includes poster presentations from more than 200 graduate students from NC State. The event is sponsored by the Graduate School and the Graduate Student Association and is open to the public. Posters are judged by faculty members, and students receive recognition for top posters. The goals are to showcase the outstanding quality and diversity of graduate-level research at NC State, in addition to providing students with the opportunity to practice and enhance their communication skills with those outside of their discipline.

Students take home NSF Graduate Research Fellowships

BME recipients of the 2022 National Science Foundation (NSF) Graduate Research Fellowship Program (GRFP) are graduate students Austin Mituniewicz, mentored by Professor He (Helen) Huang, and Sarah Howard, mentored by Assistant Professor Rahima Benhabbour. BME undergraduate student winners are Amber Detwiler, mentored by Yevgeny Brudno; Payton Martinez, mentored by Lianne Cartee; and Cameron Angulo, mentored by Matt Fisher. BME undergraduate student Margaret Stanley received an honorable mention.

The purpose of the NSF GRFP is to help ensure the quality, vitality and diversity of the scientific and engineering workforce of the United States. The program recognizes and supports outstanding graduate students who are pursuing full-time research-based master's and doctoral degrees in science, technology, engineering and mathematics (STEM) or in STEM education. The GRFP provides three years of support over a five-year fellowship period for the graduate education of individuals who have demonstrated their potential for significant research achievements in STEM or STEM education. •

ALUMNI AND INDUSTRY **NEWS**

FIRST MEDTECH SHOWCASE HELD

The M.S. MedTech Innovation + Entrepreneurship program held its first annual MedTech Showcase at the North Carolina Biotechnology Center in Research Triangle Park on May 3, 2022.

This event gathered approximately 80 health care professionals, medical device industry professionals, faculty members and venture capitalists to hear about the projects our M.S. MedTech students have been working on for the past year. Four student teams have identified unmet needs through extensive clinical immersion and are developing products addressing thermal regulation of prosthetic sockets, uterine adhesion prevention, catheter placement for ventricular drainage and medication errors for push-dose syringes. The showcase celebrated our students' achievements while enhancing the department's relationships with the Triangle medical device community.

Thanks to our academic and corporate sponsors for their support of this exciting event including Becton Dickinson, Boston Scientific, Gilero, Polyzen, Inc., UNC Rex Health Ventures and the NC State Office of Research Commercialization.

METHODSENSE SPONSORS DESIGN COMPETITION

MethodSense is an RTP-based regulatory affairs and quality assurance consultancy and the developer of LuminLogic software. MethodSense is focused on the medical device and combination product industries and has earned an international reputation for successfully addressing very difficult projects and is fast becoming a premier company for developing a professional career in life science consulting.

Rita King, CEO and senior regulatory consultant, and Russ King, president, have appreciated and benefited from the breadth of skills that BME graduates bring to the workplace. Serving as a mentor to students over the years and being a guest lecturer to design classes on multiple occasions, Russ King has broadened the relationship with the BME department this year by sponsoring the MethodSense Design Competition. The competition is designed to encourage students to think beyond their innovation product to consider the path to market including regulatory concerns, reimbursement, capital needs and more. Student design teams will have the opportunity to compete for recognition and a cash award of $10,000 to further support their innovation.

Thank you, Russ and Rita King, and MethodSense for your generous support of students and encouraging the spirit of innovation and entrepreneurship in BME. •

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DESIGN SYMPOSIUM RETURNS

The BME Design Symposium was held in person for the first time since 2019. More than 300 people attended the event. Students presented their research posters and talked with immense pride about their innovations and products. Six student teams presented to the audience and a private group of judges for the i4 competition and the MethodSense Design Award.

You can visit the BME Design Symposium website at **www.bmesymposium.com** to see the great work that the students presented.

Natasha Bolick, associate director of the Translational and Clinical Sciences Center of Excellence at Becton Dickinson and BME alumna, shared her professional journey and advised the students to take every opportunity to learn and keep a broad view of the world to see where they can grow.

Thank you to our corporate sponsors for their support of the Design Symposium and BME students including the North Carolina Biotechnology Center, bioMérieux and MethodSense, Inc.

We hope to see you at the BME Design Symposium in Spring 2023.

If you would like to become a sponsor of the BME Design Symposium, or explore other ways to be involved with the Joint Department and BME students, please reach out to Laura Schranz at **lschranz@unc.edu** or **lschran@ncsu.edu**.