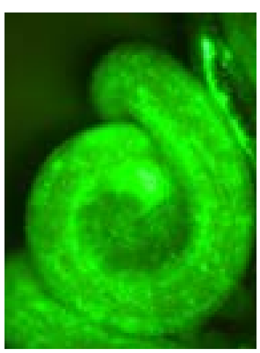
FALL 2020

BME INSIGHTS

20 YEARS OF EXCELLENCE

Department of Biomedical Engineering
COLUMBIA | ENGINEERING
2000–2020



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Photos on cover from top, clockwise. 1) BME Senior Lecturer Aaron Kyle, recipient of the BMES 2020 Diversity Lecture Award and AIMBE Fellowship. 2) Opening session of 4th Annual Engineering in Medicine Symposium hosted by Columbia Department of Biomedical Engineering 3) Members of our graduate student organization GoBME 4) Gordana Vunjak-Novakovic's initial lung bioengineering team that has now increased to more than twenty people. 5) Viral misexpression of green fluorescent protein in the embryonic small intestine. Prof. Nandan Nerurkar's Morphogenesis and Developmental Biomechanics Lab combines such approaches with mechanobiology to understand how molecular cues control physical forces to sculpt tissues and organs during development. 6) As part of his Fulbright independent research project, Bunmi Fariyike '20 will conduct genetic engineering research at Madrid's Centro Nacional de Biotecnología (National Center for Biotechnology) developing a platform for modeling bacterial development of antibiotic resistance in vitro, in order to more accurately predict how and why bacteria develop the ability to withstand treatments. 6) Elisa Konofagou, Robert and Margaret Hariri Professor of Biomedical Engineering and Radiology (Physics) 7) Sam Sia, Professor of Biomedical Engineering 8) Close-up of early Rover photothermal PCR prototype.

Columbia BME in Numbers

1:4
Faculty-to-Undergraduate Student ratio

Over **$20M**
in Annual Faculty Research Expenditures 2019-2020

3
Faculty elected to the National Academy of Engineering

80%
of BS and MS Students Participate in Research

20
Startups Launched by Students and Faculty since 2014

3
Faculty are Editor-in-Chief of prestigious industry journals

15
AIMBE Fellows in Faculty

85 Undergraduates

156 Masters Students

153 PhD Students

A Note From the Chair

When we communicated with you in our last issue of *Biomedical Engineering Insights*, we had just kicked off our yearlong 20th anniversary celebration of our Department. We were in the process of putting final touches on our special anniversary issue of Biomedical Engineering Insights in early March, when the first case of COVID-19 was reported in New York City. At that time, we could not imagine the devastating impact the pandemic would have on our community and beyond. Even so, out of an abundance of caution, in early March we made the critical decision to reschedule our big celebratory symposium from April to October of this year (and now to May of 2021). Through our experiences this past year, we know that the world will never be the same, and we are all adapting to a new normal.

Challenges and crises often bring out the humanity and grace in each of us. We overcame numerous challenges in transitioning into quarantine, planning and executing virtual commencement ceremonies, ramping down and ramping up research, and now navigating hybrid education. We could not be prouder of how our Biomedical Engineering faculty, staff, and students responded to this crisis. Our extraordinary BME community stepped up in so many ways. Just to name a few of these efforts, our faculty, staff, and students contributed PPE to first responders, took leadership roles in COVID-19 task forces and design challenges, and helped develop COVID-19 rapid diagnostics and treatment.

A closer, more united, and stronger Department emerged from this unprecedented pandemic. During the darkest of times, our faculty and students continued to shine with outstanding achievements that brightened our hearts and filled us with hope. Even while we worked remotely, we had much success, with faculty promotions, junior and senior faculty honored with prestigious awards, senior faculty earning well-deserved named professorships, students winning top national competitions, and faculty elections to prestigious professional societies. We are especially proud to have been named the #9 biomedical engineering program in the nation according to *U.S. News & World Report*.

“We are especially proud to have been named the #9 biomedical engineering program in the nation according to *U.S. News & World Report*.”

This year, our Department formed a Committee on Diversity, Equity & Inclusion (DEI). The committee hit the ground running with the mission to nurture and advance a culture in the Department of Biomedical Engineering:

- where diversity is actively embraced and supported,
- where the practice of research and education is purposefully anti-racist,
- where we recognize and overcome prejudice in training and hiring, and
- where discrimination on the basis of, but not limited to, race, color, gender, sexual orientation and disability, is identified and addressed.

As our DEI efforts continue, we are beyond thrilled to welcome Professor José L. McFaline-Figueroa as he joins our Department in January 2021.

As we move into the new fall semester, we are confident that we will continue to prevail and overcome challenges as the COVID-19 pandemic fades away. We are also optimistic that we will be able to welcome you in person to the Columbia Biomedical Engineering Department to celebrate our 20th anniversary together in a safe and socially distanced manner.

Be safe and be well!

X. Edward Guo, Ph.D.
Chair, Department of Biomedical Engineering at Columbia University
Stanley Dicker Professor, Biomedical Engineering; Professor, Medical Sciences (in Medicine); Director, Bone Bioengineering Laboratory

Professor Sam Sia uses data science, microfluidics, and mini-robots to transform medicine

Sam Sia

Professor of Biomedical Engineering; Director, Microfluidics for Point-Of-Care Diagnostics and Therapeutics Laboratory

In a pandemic, quick at-home testing is essential not just for isolating cases but also for compiling big picture data. When COVID-19 struck, however, all the common rapid testing formats were laborious to use and tough for non-specialists to interpret. So Professor Sam Sia, an expert in point-of-care diagnostics and therapeutics, decided to pivot his research to address the crisis. Sia's lab has spent the past few months developing simple tools that yield nearly instant results—a prime example of how his group designs miniature medical devices for major impact.

How would you sum up the big idea animating your research?

Miniaturizing devices will transform medicine the way microelectronics has transformed communication. That could mean anything from developing quick and inexpensive blood tests that can be deployed anywhere, anytime to designing tiny, implantable tech for continuously monitoring and treating patients.

On the testing front, my group, alongside a startup company Rover Diagnostics, has been working hard on a new rapid COVID-19 test based on reverse transcription polymerase chain reaction (RT-PCR). We are now participating in the National Institutes of Health "Rapid Acceleration of Diagnostics" initiative to refine and validate the system.

In terms of implantable tech, we focus on devising miniaturized devices that are biocompatible and controlled wirelessly in the body to monitor people's health and treat various conditions.

Your group has had a lot of success miniaturizing devices by using microfluidics, which manipulates minute amounts of liquids to conduct precise experiments. This field has only been around since about the 1990s. What most captures your imagination about the promise of this rapidly emerging technology?

Medicine in the past has been approached biochemically, but through microfluidics—which are cheap to build and easy to transport—there's a huge opportunity for devices to dramatically improve diagnostics and therapeutics, especially in low-resource field settings around the world. Take the Lyme disease test we developed earlier this year. This test uses a microfluidic chip to create the first point-of-care device that can diagnose Lyme in under 15 minutes.

These are the kinds of tools we want to put into the hands of practitioners. In my lab, we work closely with clinical doctors and combine insights from biology, chemistry, medicine, data science, and consumer electronics to design low-cost, integrated devices that are field ready.

What are some things happening in your lab right now you're particularly excited about?

In the realm of diagnostics, the combination of wearable devices and data analytics is moving from theory to practice; I'm excited that we're situated right at the intersection of this impending transformation. There's two projects in particular that I think are good illustrations of our approach here. In relation to COVID-19, we've been concentrating on making rapid test formats easier to use at home in part through a mobile app leveraging computer vision and machine learning to interpret test images and provide individualized guidance. We're also collaborating with Professor Ken Shepard on a DARPA-funded project to develop an "active" bandage using implanted components and machine learning to help the body heal its wounds faster.

Celebrating Faculty Excellence

Honors, Recognition, and Achievement

X. Edward Guo
Stanley Dicker Professor of Biomedical Engineering

- Inaugural 2020 BMES-CMBE Christopher R. Jacobs Award for Leadership

Elizabeth Hillman
Herbert and Florence Irving Professor at the Zuckerman Institute and Professor of Biomedical engineering and Radiology (Physics)

- Royal Microscopical Society Mid-Career Scientific Achievement Award

Stavros Thomopoulos
Robert E. Carroll and Jane Chace Carroll Professor of Biomechanics (in Orthopedic Surgery and Biomedical Engineering); Director of Carroll Laboratories for Orthopedic Surgery; Vice Chair of Basic Research in Orthopedic Surgery

- American Society of Mechanical Engineers (ASME) 2020 Van C. Mow Medal

Gordana Vunjak-Novakovic
University Professor; The Mikati Foundation Professor of Biomedical Engineering and Medicine

- Order of Karadjordje Star, Serbia's highest honor
- Edison Lecture, University of Notre Dame
- Petit Distinguished Lecture, Georgia Institute if Technology and Emory, Atlanta
- Person of the year in Serbia
- Award of the NCATS-ASPIRE Design Challenge for Biological Assays for Translational Innovation in Pain, Opioid Use Disorder and Overdose (with Kacey Ronaldson-Bouchard, Joriene de Nooij, Naveed Tavakol)
- Innovation and Commercialization Award, Tissue Engineering and Regenerative Medicine Society of the Americas (TERMIS)

Promotions – Tenure

Qi Wang
Assistant Professor of Biomedical Engineering

Promotions – Tenure Track

Tal Danino
Associate Professor of Biomedical Engineering

Faculty Early Career Awards

Nandan Nerurkar
Assistant Professor of Biomedical Engineering

- National Science Foundation CAREER Award

Endowed Professorships

Elizabeth Hillman
Herbert and Florence Irving Professor at the Zuckerman Institute and Professor of Biomedical engineering and Radiology (Physics)

Helen Lu
Percy K. and Vida L.W. Hudson Professor of Biomedical Engineering

Election to Professional Societies

X. Edward Guo
Stanley Dicker Professor of Biomedical Engineering

- Fellow, Biomedical Engineering Society (BMES)

Aaron Kyle
Senior Lecturer, Biomedical Engineering Design

- Fellow, American Institute for Medical and Biological Engineering (AIMBE)

Helen Lu
Percy K. and Vida L.W. Hudson Professor of Biomedical Engineering

- Fellow, Biomaterials Science and Engineering (FBSE)

Teaching Awards

Helen Lu
Percy K. and Vida L.W. Hudson Professor of Biomedical Engineering

- 2020–22 Provost's Senior Faculty Teaching Scholar

Katherine Reuther
Senior Lecturer, Biomedical Engineering

- Finalist for 2020 Presidential Teaching Awards for Faculty

Scholarly Leadership

Gordana Vunjak-Novakovic
University Professor; The Mikati Foundation Professor of Biomedical Engineering and Medicine

- Howard Hughes Medical Institute (HHMI) Scientific Review Board
- Advisory Council of the National Institute of Biomedical Imaging and Bioengineering (NIBIB)

Welcome, José!

Faculty Profile

José L. McFaline-Figueroa is joining Columbia in January, 2021 as Assistant Professor of Biomedical Engineering His laboratory will develop and apply multiplex single-cell genomic tools to investigate the molecular landscape induced by genetic background & drug exposure in cancer.

Where are you from?
I was born and raised in the southwest corner of Puerto Rico, in the towns of Mayagüez, Sabana Grande, and San Germán. Part of my family is from the San Juan area and I spent a large portion of my childhood going from one side of the island to the other. Growing up I really enjoyed this as it gave me an appreciation of all the diversity that can be found even on our small island.

How did you become interested in STEM research and, more specifically, in biomedical engineering?
I became interested in research very early during my undergraduate studies at UPRM Chemistry. I worked in 2 labs during college, one focused on the isolation of natural products and the other a protein biochemistry lab focused on the chemistry of myoglobin. I also participated in a summer research program coordinated by the Hispanic Association of Colleges and Universities (HACU). This summer program allowed me to work in a USDA lab at the University of Mississippi and further my training on the isolation and characterization of natural products. These research experiences convinced me that I wanted to pursue a career as a Scientist. My interest in biomedical engineering developed after college. After graduation I worked at MIT as a research technician in the laboratory of Dr. Peter C. Dedon in the Department of Biological Engineering. This is where I was first exposed to cancer biology and biomedical engineering. I enjoyed how multi-disciplinary the research was and looked to focus on this for my graduate studies, so I joined the MIT Biology Ph.D. program and the labs of Dr. Leona D. Samson and Forest M. White in the Biology and Biological Engineering departments. My training encompassed many different fields – Cancer Cell Biology, Systems Biology, Proteomics, and Data Science – all them applied to determine how an aggressive type of brain cancer resists therapy. I was, and still am, fascinated by how these and many other fields come together in biomedical engineering to address challenging needs in biology and human disease. A recurring theme in my research was how heterogeneity in cellular response hindered our ability to identify changes that occur in tumor cells when exposed to therapy. Looking to expand the toolset that I could apply to this incredibly difficult problem and overcome issues associated with cellular heterogeneity, I decided to pursue a post-doc in single-cell genomic technologies.

How has your LatinX background influenced your experience as an academic professional in STEM?
I am incredibly proud of my Puerto Rican heritage. Anyone I speak to for more than 15 minutes will know I am Puerto Rican. Transitioning from Puerto Rico and from a Hispanic-serving undergraduate institution to graduate school in the continental US, I found my background and experiences were different from the majority of my peers and it sometimes felt isolating. However, I am fortunate to be a part of a group of family members and friends that are also making their careers in academia and have been a constant source of support every step of the way.

What accomplishment(s) are you most proud of, and what do you hope to accomplish in the future?
My thesis defense was a major highlight where I was able to show my family the work that I had been doing all those years in lab, and I am very proud of that accomplishment. I am also proud of the projects that I have been pursuing more recently in the Trapnell lab and the publications that have resulted from this work. I was fortunate to join the field at a time of incredible progress and growth and am very proud to have contributed to that in some way. As I start my lab at Columbia, I aim to continue developing tools for single-cell genomics and multiplex perturbation screens with the goal of applying these to determine potent therapeutic strategies for aggressive tumor types that typically fail the current standard-of-care. During my career, I have had the opportunity to mentor some incredibly talented undergraduates and graduate students. I am incredibly proud to follow their careers, whether they have stayed in research or gone into other fields. I look forward to contributing to the training of future generations of scientists and helping to advance their careers.

Aaron Kyle wins BMES 2020 Diversity Lecture Award

Aaron Kyle, Senior Lecturer in Biomedical Engineering Design at Columbia University was honored with the 2020 Biomedical Engineering Society (BMES) 2020 Diversity Lecture Award. The award honors an individual, project, organization, or institution for outstanding contributions to improving gender and racial diversity in biomedical engineering. The award is given for a broad range of activities, including research, education, and service improving diversity in the biomedical engineering industry and/or academia. The award seeks to recognize lifetime achievements as well as innovative and/or high impact activities.

The award recipient delivers a plenary lecture at the BMES Annual Meeting and the text of the lecture is published in the Annals of Biomedical Engineering. An important purpose of the lecture is to offer a vision of the challenges and opportunities facing greater diversity in biomedical engineering.

Dr. Kyle delivered an inspirational speech that had the virtual audience raving. He reminded everyone that we must get **comfortable with differences**, **fight imposter syndrome**, recognize that quality and diversity are **not mutually exclusive**, and leverage that **we** are the **excellence**.

Prof. Kyle, you are an inspiration to all of us. Thank you for your unrelenting dedication and interminable passion in bringing diversity, equity, and inclusion to the forefront as you help champion so many young URM voices and foster their exploration of the world of STEM.

Fall 2020
Biomedical Engineering Seminar Series

September 18	Roger Lefort, Columbia University
September 25	Daniel Haders II, Nex Cubed | Sway Ventures
October 2	Elizabeth Hillman, Columbia University
October 9	Eduardo Juan, University of Puerto Rico – Mayagüez
October 16	Donna Farber, Columbia University
October 23	Ravi Radhakrishnan, BME Chair, University of Pennsylvania
October 30	Mikhail Shapiro, Caltech
November 6	Todd Coleman, University of California, San Diego
November 13	Rebecca Richards-Kortum, Rice University
November 20	Cullen Buie, MIT
December 4	Anjelica Gonzalez, Yale University

bme.columbia.edu

Researchers Use Lab-grown Tissue Grafts for Personalized Joint Replacement

The temporomandibular joint (TMJ), which forms the back portion of the lower jaw and connects your jaw to your skull, is an anatomically complex and highly loaded structure consisting of cartilage and bone. About 10 million people in the United States alone suffer from TMJ dysfunction due to birth defects, trauma, or disease. Current treatments range from steroid injections that provide only a temporary pain relief, to surgical reconstructions using either prosthetic devices or donor tissue, and often fail to provide long-lasting repair. Researchers have sought a better way to treat TMJ, including investigating biological TMJ grafts grown in the lab that could integrate with the native tissues, remodel the joint over time, and provide life-long function for the patient.

A multidisciplinary team from Columbia Engineering, Columbia's College of Dental Medicine and Department of Medicine, Louisiana State University, LaCell LLC, and Obatala Sciences has now bioengineered living cartilage-bone TMJ grafts, precisely matched to the recipient, both biologically and anatomically. Their most recent study, published today in Science Translational Medicine, builds upon a long series of their previous developments that began in 2005 on bioengineering functional cartilage and bone for regenerative medicine and tissue models of disease.

The authors used the Yucatan minipig to establish their methodology for TMJ reconstruction using the recipients' own cells. The team isolated the stem cells from a small amount of fat obtained from each animal, expanded the cells in culture to obtain a sufficient number for a large graft, and induced them into the cartilage and bone- forming cells. Using imaging-guided fabrication, the researchers shaped a block of clinically used decellularized bovine bone matrix into the exact geometry of the TMJ being repaired. They infused this scaffold with bone-forming cells, while inducing cartilage formation by compacting a 1-mm thick surface layer of condensed mesenchymal cells. They built the matching bioreactor chamber so that the scaffold fitted tightly into it, like a hand in a glove.

Because cartilage and bone form under different environmental conditions, the formation of TMJ grafts required a specialized bioreactor that provided a separate supply of bone and cartilage culture media to the two tissue regions. The researchers optimized perfusion of culture medium through the bone and flow over the cartilage surface in order to meet the distinctly different nutrition and physical signaling requirements of the two tissues. Once all these demanding conditions were met, the team implanted the individualized TMJ grafts into the experimental animals for six months to determine the grafts' ability to structurally and functionally replace the native joint. "What we found in this new work could be transformative," says the team's PI Gordana Vunjak-Novakovic, University Professor, The Mikati Foundation Professor of Biomedical Engineering and Medical Sciences, and Professor of Dental Medicine. "These grafts had a native-like stratified appearance, integrated well with the surrounding tissues, and provided the biological and mechanical function of the native joint. We believe that this methodology could be extended to bioengineering other joints, and to establishing high-fidelity models for studying joint diseases."

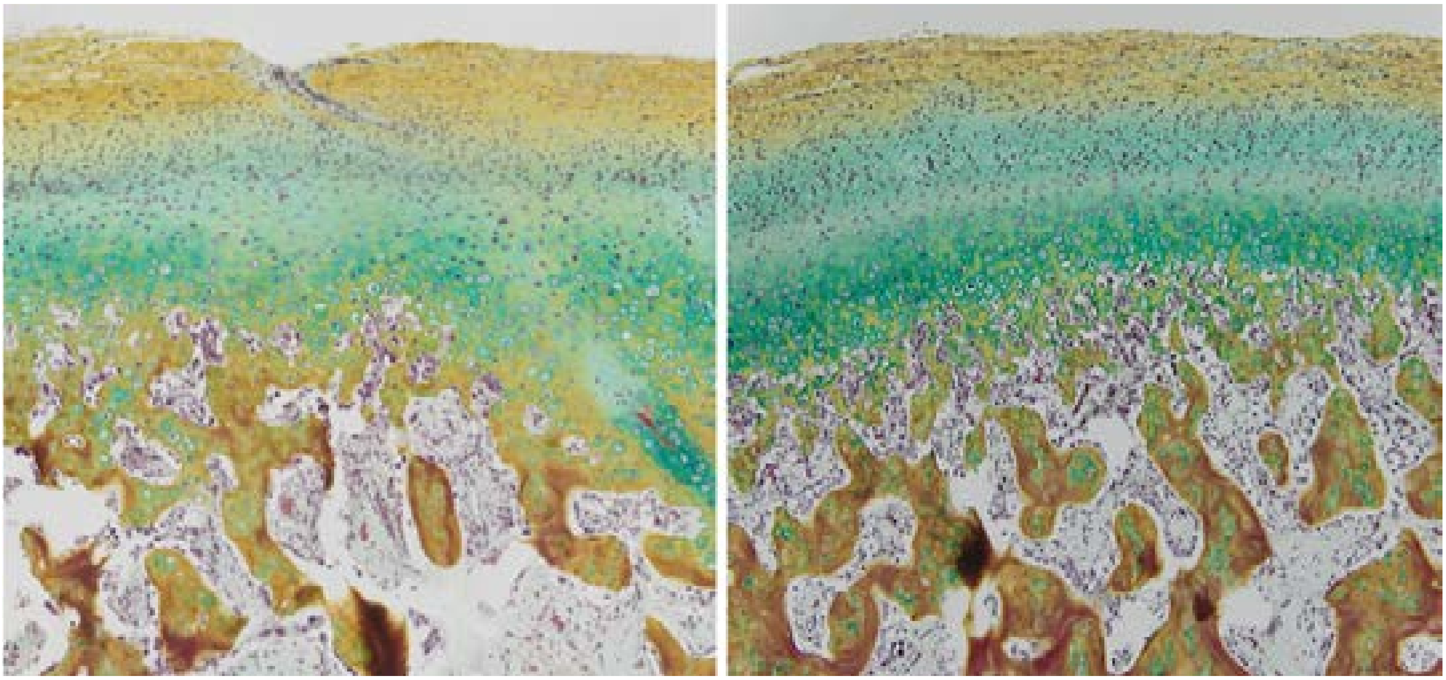
Vunjak-Novakovic noted that the size and profile of the multi-institutional research team of 18 investigators with expertise in bioengineering, surgery, stem cells, imaging, bioreactor design, and mathematical modeling reflects the complexity of this translational project, which took four years to complete.

"What we found in this new work could be transformative...We believe that this methodology could be extended to bioengineering other joints, and to establishing high-fidelity models for studying joint diseases."

The use of the dual-flow bioreactor was critical to the study. "Developing this one-of-a-kind bioreactor was instrumental for the formation of composite cartilage-bone grafts," says Vunjak-Novakovic. "Each tissue was maintained within its own 'niche,' while allowing communication between cartilage and bone by diffusing factors, just like in our body. Acommodating the complex shape of the TMJ was an additional difficulty we needed to overcome, through creative experimentation and modeling studies."

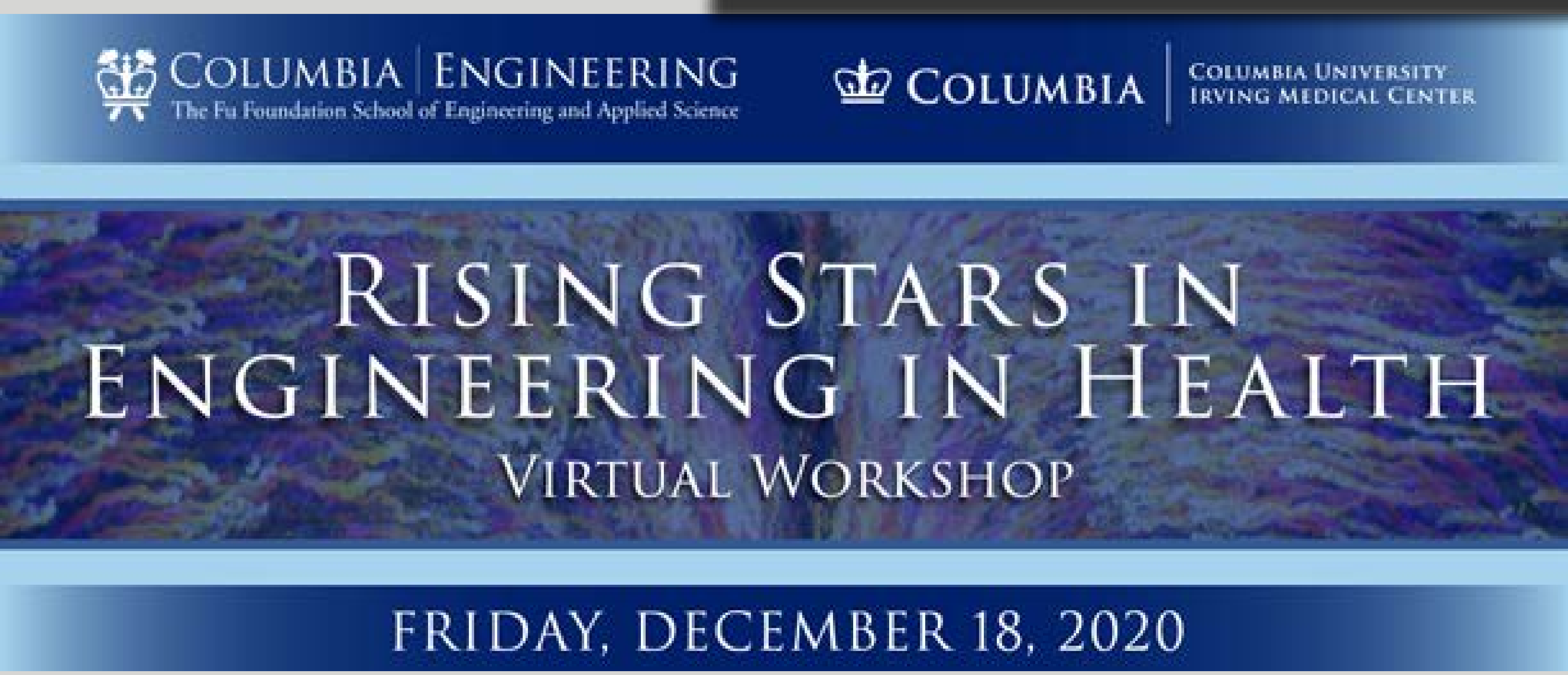
Study lead authors David Chen and Josephine Wu, biomedical engineering PhD students who work in Vunjak-Novakovic's lab, add, "Seeing the evolution of our tissue grafts was tremendously exciting. Each stage felt like a milestone, from achieving a nascent, thin layer of cartilage in the lab, to the first glimpse after implantation into the healed joint space, complete with a fully formed, stratified cartilage." Coincidentally, the study is being published at the time when epiBone, a company launched from the Vunjak-Novakovic lab to develop a pipeline of bone, cartilage, and composite bone-cartilage products, is starting a Phase I/II clinical study to evaluate its bone product in patients with lower jaw continuity defects that require reconstruction. This clinical trial is designed to create living bone grafts that can become a seamless part of a patient's body, based on the same foundational technology as the present study.

The investigators emphasize that more work needs to be done before patient-tailored TMJ grafts can become a clinical reality. Studies over longer periods of time are needed to fully understand the progression of tissue remodeling. In addition, the researchers are interested in extending their methodology to exploring the diversity of the patient population and investigating TMJ repair as a function of age, sex, or the presence of skeletal disease or relevant systemic conditions.



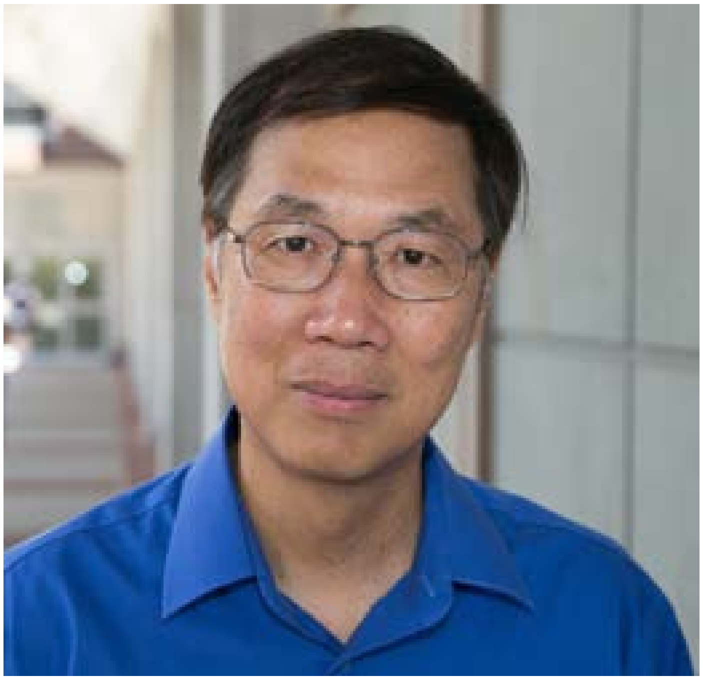
Stratification of the cartilage layer – Detailed morphology of the bioengineered graft 6 months after implantation (left) compared to the native joint (right). Distinct fibrous, proliferative and hypertrophic zones in the cartilage layer are well established. Stain: pentachrome.

UPCOMING EVENT



Experience a day of rapid-fire research talks, educational presentations, and panel discussions with Columbia Engineering and Medicine faculty as you explore a career at the intersection of engineering and biomedicine.

Prof. Kam Leong Elected to the National Academy of Medicine



Kam Leong was honored for his contributions to biomaterials science and engineering, particularly in the areas of drug delivery, gene delivery, and cell topography interactions.

Kam Leong, the Samuel Y. Sheng Professor in the departments of biomedical engineering and systems biology, has been elected a member of the National Academy of Medicine (NAM), one of the highest honors in the fields of health and medicine. Election to the Academy recognizes individuals who have demonstrated outstanding professional achievement and commitment to service. The NAM cited his "contributions to biomaterials science and engineering, particularly in the areas of drug delivery, gene delivery, and cell topography interactions."

"It is a tremendous honor to be recognized by my medical colleagues as an engineer," says Leong, a leader at the forefront of drug and gene delivery as well as regenerative engineering. "My first thoughts were how fortunate I have been in working with such talented students and fellows all these years. I also have been blessed with wonderful collaborations with colleagues who inspired me to tackle important medical problems. Columbia offers such an intellectually stimulating and collaborative environment to research at the interface of engineering and medicine; this motivates me to work harder."

Leong's research focuses on the development of innovative biomaterials for three major therapeutic applications: in vivo gene editing, drug and gene delivery, and regenerative medicine. He uses polymeric biomaterials to deliver gene editing elements, chemotherapeutics, and cells for cancer therapy, immunotherapy, and inflammatory diseases. He also uses tissue engineering principles and stem cell engineering to construct human tissue-on-a-chip for disease modeling and drug screening.

"I am so pleased to see Kam recognized with this great honor with election to the National Academy of Medicine. His pioneering research advances engineering at the nano, molecular, cellular, and tissue scales, and brings these advancements to tackle major challenges in medicine. Kam's work truly exemplifies the field of biomedical engineering and the aspirations of our school to bring engineering innovations to impact humanity," said Mary C. Boyce, Dean of Columbia Engineering.

Biomedical Engineering Chair X. Edward Guo, Stanley Dicker Professor of Biomedical Engineering and professor of medical sciences, added, "On behalf of the Department, I would like to express our heartfelt congratulations to Kam. We could not be happier for him as he receives yet another distinguished recognition of his achievement and leadership. Kam is a fantastic colleague and we treasure his wisdom and humility."

"I am so pleased to see Kam recognized with this great honor with election to the National Academy of Medicine...Kam's work truly exemplifies the field of biomedical engineering and the aspirations of our school to bring engineering innovations to impact humanity."

In cancer therapy, Leong collaborated with Dr. Tadao Ohno, former Director of RIKEN BRC Gene Bank in Japan, to develop a tumor vaccine comprising cytokines and tumor tissue fragments from the patients. It has been used to treat over 350 brain cancer patients in Japan. In nonviral gene therapy, Leong demonstrates the feasibility of using DNA nanoparticles to deliver therapeutic genes including the hemophilia and insulin genes through oral administration in animal models. He has also developed nanomanufacturing techniques to scale up the production of biomimetic and DNA nanoparticles, a critical barrier in the eventual translation of nanomedicine.

In regenerative medicine, Leong pioneers the application of DNA nanoparticles to convert adult cells from one cell type to another, raising the possibility of treating intractable neurodegenerative disorders via nonviral cell reprogramming. He has also recently developed nanoparticle-based gene editing technologies that can delete harmful genes and correct genetic disorders in vivo. The work will impact precision medicine and the development of human tissue-on-a-chip for new drug development.

Leong received a BS in chemical engineering from the University of California, Santa Barbara, and a PhD in chemical engineering from the University of Pennsylvania. He is a member of the National Academy of Engineering, National Academy of Inventors, and the Editor-in-Chief of Biomaterials.

He joins his Columbia Engineering colleagues Van C. Mow, Stanley Dicker Professor Emeritus of Biomedical Engineering and Professor Emeritus of Orthopaedic Engineering (elected 1998), and Gordana Vunjak-Novakovic, University Professor and Mikati Foundation Professor of Biomedical Engineering (elected 2014) in receiving this highly prized honor.

Established originally as the Institute of Medicine in 1970 by the National Academy of Sciences, the National Academy of Medicine addresses critical issues in health, science, medicine, and related policy and inspires positive actions across sectors. NAM works alongside the National Academy of Sciences and National Academy of Engineering to provide independent, objective analysis and advice to the nation and conduct other activities to solve complex problems and inform public policy decisions.

"I have known Kam for nearly 40 years, ever since he was a postdoc in my laboratory," says Robert Langer, David H. Koch Institute Professor at MIT, and Leong's former research colleague and mentor. "He has made enormous contributions to biomedical engineering and his inventions have saved and improved the lives of many people. Yet he is one of the nicest and most humble individuals I have ever met."

Profs. Kyle, Konofagou, and Hess Win Columbia Seed Grant for Diversity Initiative

Columbia BME faculty and DEI Committee leaders Aaron Kyle, Henry Hess, and Elisa Konofagou were recently awarded a seed grant for their project: **Involving Columbia Students in Enhancing Education Equity through Engineering Design**.

ABOUT THE PROJECT

As Dr. Kyle's HYPOTHEKids (Hk) Maker Lab continues to expand into schools, we see an opportunity to enhance minority student education by enlisting the help of Columbia University students. The Goals of the proposed work are to:

1. Recruit, train, and place Columbia students (undergraduates and graduates) in the schools where our engineering design process (EDP)-centric courses are taught in order to support the young underrepresented students' education and foster a culture of education outreach in Columbia students.
2. Create a (virtual and in-person) speaker series in which Columbia students and faculty share their scholarship and STEM journeys with high school students.

This project was funded through the Addressing Racism: A Call to Action for Higher Education initiative of the Office of the Vice Provost for Faculty Advancement.

Ultrasound Solves an Important Clinical Problem in Diagnosing Arrhythmia

Cardiac arrhythmias are a major cause of morbidity and mortality worldwide. Currently, the 12-lead electrocardiogram (ECG) is the noninvasive clinical gold standard used to diagnose and localize these conditions, but it has limited accuracy, cannot provide an anatomical tool to visually localize the source of the arrhythmia, and depending on which clinician is looking at the signals, there might be some interpretation variability.

Researchers at Columbia Engineering announced today that they have used an ultrasound technique they pioneered a decade ago—Electromechanical Wave Imaging (EWI)—to accurately localize atrial and ventricular cardiac arrhythmias in adult patients in a double-blinded clinical study.

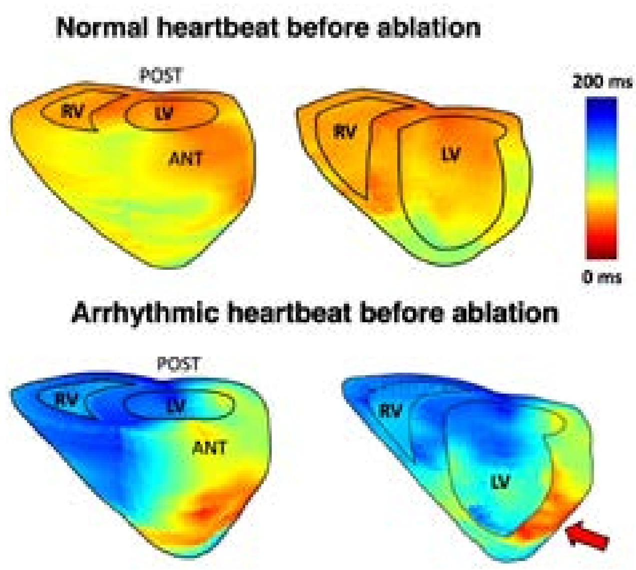
“This study presents a significant advancement in addressing a major unmet clinical need: the accurate arrhythmia localization in patients with a variety of heart rhythm disorders,” says Natalia Trayanova, Murray B. Sachs Endowed Chair and professor of biomedical engineering and medicine, and director of the Alliance for Cardiovascular Diagnostic and Treatment innovation at Johns Hopkins University, who was not involved with the study. “The non-invasive nature of EWI using standard hospital hardware, and its ability to visualize the arrhythmia sources in 3D render it an attractive component for inclusion in the clinical ablation procedure.”

EWI is a high-frame-rate ultrasound technique that can noninvasively map the electromechanical activation of the heart; it is readily available, portable, and can pinpoint the arrhythmic source by providing 3D cardiac maps. The new study, published online in Science Translational Medicine, evaluated the accuracy of EWI for localization of various arrhythmias in all four chambers of the heart prior to catheter ablation: the results showed that EWI correctly predicted 96% of arrhythmia locations as compared with 71% for 12-lead electrocardiogram (ECG).

“We knew EWI was feasible in individual patients and we wanted to see if it made a difference in the clinical setting where they treat many people with different types of arrhythmias,” says Elisa Konofagou, Robert and Margaret Hariri Professor of Biomedical Engineering and Radiology (Physics) who directed the study.

Her group has been working on several studies with electrophysiologists in the cardiology department at Columbia University Irving Medical Center (CUIMC) and for the purpose of this study, the Konofagou team partnered with Elaine Wan, Esther Aboodi Assistant Professor of Medicine at CUIMC and co-senior author, who saw the potential of this new technology and wanted to work together.

“So, we joined forces with cardiac electrophysiologists to determine clinical utility for the first time,” Konofagou explains. “We were able to show that not only does our imaging method work in difficult cases of arrhythmia but that it can also predict the optimal site of radiofrequency ablation before the procedure where there is no other imaging tool currently available to do that in the clinic. Using EWI as a clinical visualization tool in conjunction with ECG and clinical workflow could improve discussions with patients about treatment options and pre-procedural planning as well as potentially reducing redundant ablation sites, prolonged procedures, and anesthesia times.”



Electromechanical wave imaging (EWI) activation maps are capable of localizing the arrhythmic origin and differentiating irregular beats (figure 2) from consecutive normal sinus rhythm beats (figure 1) on the same patient before ablation. Red illustrates early and blue represents late activation (in milliseconds). The red arrow indicates the earliest activated region displayed by EWI, which successfully corresponds to the source of the arrhythmia in agreement with the site that was ablated with the intracardiac ablation site. LV = left ventricle, RV = left ventricle, ANT = anterior, POST = posterior.

The researchers ran a double-blinded clinical study to evaluate the diagnostic accuracy of EWI for localizing and identifying the sites of atrial and ventricular arrhythmias. Fifty-five patients, who had pre-existing cardiac disease including previous catheter ablations and/or other cardiovascular co-morbidities, underwent EWI scans prior to their catheter ablation procedures to generate activation maps of their hearts. The team retrospectively compared EWI maps and 12-lead ECG assessments made by six expert electrophysiologists in a team led by Wan to the site of successful ablation found on the intracardiac electroanatomical maps obtained during invasive catheter mapping.

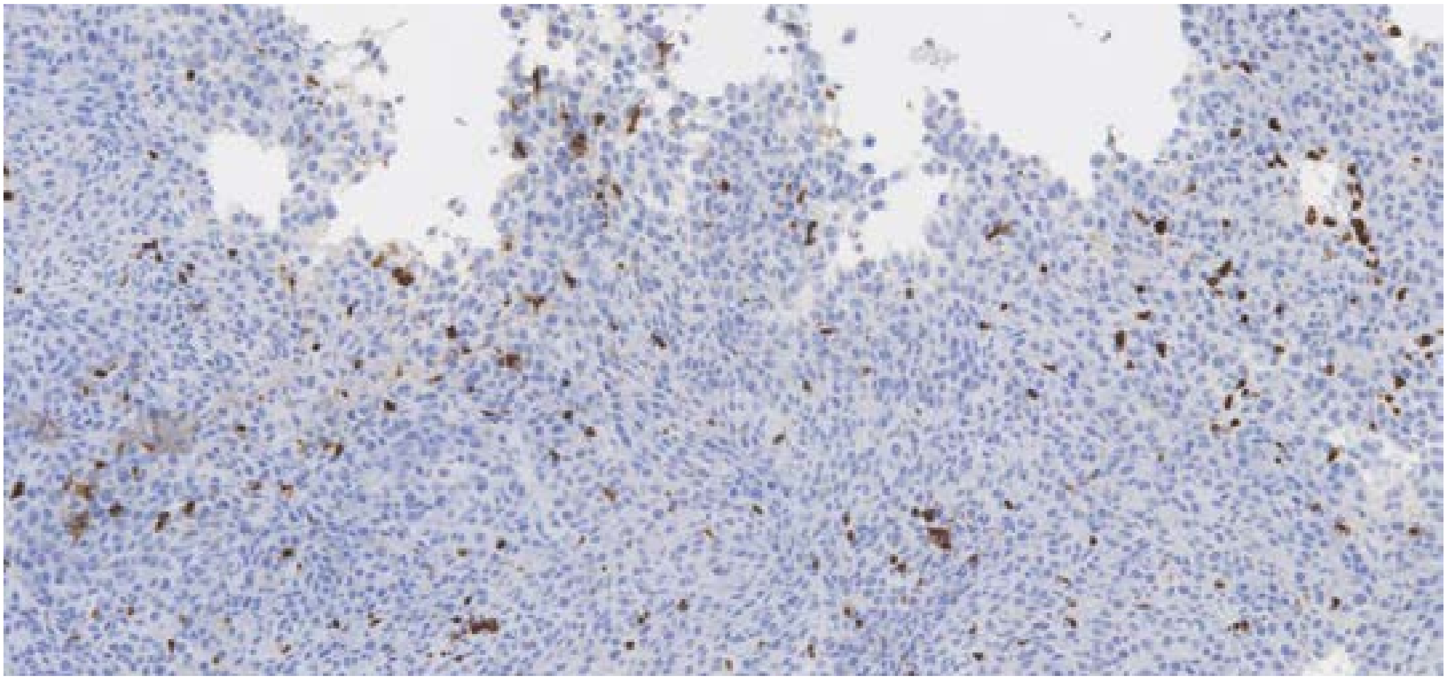
“We were able to show that not only does our imaging method work in difficult cases of arrhythmia but that it can also predict the optimal site of radiofrequency ablation before the procedure where there is no other imaging tool currently available to do that in the clinic.”

“The accuracy of EWI was higher than that of clinical diagnosis by electrophysiologists reading standard 12-lead ECGs,” says the study’s co-first author Lea Melki, a PhD student in the department of biomedical engineering working in Konofagou’s team who teamed up with electrophysiology fellow and co-first author, Chris Grubb, to accomplish that task. “While the inter-observer variability of our expert electrophysiologists may have played a role, we also know that 12-lead ECGs are limited in diagnosing arrhythmias from the posterior side of the heart, while EWI allows for easier anatomical location in 3D. In fact, a big advantage of EWI is the ease with which activation maps can clearly demarcate the earliest sites of interest along with direct anatomic visualization using standard echocardiography scans that clinicians are already trained on.”

The researchers are now planning a long-term clinical study, set to start later this year that will use EWI prediction to improve ablation outcomes by increasing the accuracy of the ablation site and spare normal tissue from ablation. “It’s really clear now that, when used in conjunction with standard 12-lead ECG, EWI can be a valuable tool for diagnosis, clinical decision making, and treatment planning of patients with arrhythmias,” says Melki. “We believe our EWI technique, with minimal training, will result in higher accuracy in the site of ablation, a faster procedure, and fewer complications and repeat visits after the procedure. This is a win-win for everyone, both patients and clinicians.”

Prof. Elisa Konofagou

Designer Probiotic Treatment for Cancer Immunotherapy



Immunohistochemistry staining of T cell populations in colorectal tumor tissue.

Kam Leong, the Samuel Y. Sheng Professor in the New York, NY—February 12, 2020—Researchers at Columbia Engineering have engineered probiotics to safely deliver immunotherapies within tumors. These include nanobodies against two proven therapeutic targets—PD-L1 and CTLA-4. The drugs are continuously released by bacteria and continue to attack the tumor after just one dose, facilitating an immune response that ultimately results in tumor regression. The versatile probiotic platform can also be used to deliver multiple immunotherapies simultaneously, enabling the release of effective therapeutic combinations within the tumor for more difficult-to-treat cancers like colorectal cancer. The study is published today in Science Translational Medicine.

Antibodies that target immune checkpoints, PD-L1 and CTLA-4, have revolutionized cancer immunotherapy treatments, achieving success in a subset of cancers. However, systemic delivery of these antibodies can also cause substantial side effects with high percentages of patients reporting adverse reactions. Furthermore, although combinations of these therapies are more effective than single therapy regimens, they also produce severe toxicities, sometimes leading to drug discontinuation. The team, led by Tal Danino, assistant professor of biomedical engineering, aimed to address these challenges.

"We wanted to engineer a safe probiotic vehicle capable of delivering immune checkpoint therapies locally to minimize side effects," says Danino, who is also a member of the Herbert Irving Comprehensive Cancer Center and Data Science Institute. "We also wanted to broaden the versatility of the system by producing a range of immunotherapeutic combinations, including cytokines that could further elicit antitumor immunity, but are otherwise difficult to systemically deliver because of toxicity concerns."

Bacterial cancer therapy is not a new idea: in the 1890s, William Coley, a New York City surgeon, demonstrated that injection of live streptococcal organisms into cancer patients could shrink tumors. While his method was never widely adopted because radiotherapy was discovered around the same time and antibiotics were not widely available, physicians have been using a tuberculosis vaccine, BCG, as a therapy for bladder cancer for decades.

The Danino lab has pioneered engineered bacteria for cancer therapy, developing methods to characterize different strains of bacteria, therapeutics, and genetic control circuits to effectively release cancer drugs. In this most recent study, led by PhD student Candice Gurbatri, they sought to engineer a translational therapeutic platform that improved upon a previous lysis circuit. Using computational modeling, they first scanned multiple parameters to find the optimal circuit variants to maximize drug release within the tumor. This led to the integration of the circuit into the genome of a widely-used probiotic strain—E.coli Nissle 1917—resulting in a strain they call “SLIC,” or the synchronized lysing integrated circuit. This SLIC probiotic strain is naturally capable of finding and growing within tumors in the body, but the genomic integration of this circuit ensures greater stability of the system and higher levels of therapeutic release.

“We wanted to engineer a safe probiotic vehicle capable of delivering immune checkpoint therapies locally to minimize side effects. We also wanted to broaden the versatility of the system by producing a range of immunotherapeutic combinations, including cytokines that could further elicit antitumor immunity, but are otherwise difficult to systemically deliver because of toxicity concerns.”

“We have demonstrated that the engineered bacteria remain functional and localized within the tumor as the bacteria grow in mice for at least two weeks after treatment, preventing the microbes from affecting healthy tissue,” says Gurbatri. Testing in mouse models further demonstrated that unlike previous iterations of the circuit, SLIC was able to clear tumors after a single dose, adding to its translational potential. Because the circuit is integrated into the genome, the stability of the platform greatly increases, thus negating the need for multiple injections of bacteria.

The research team used this probiotic delivery system to release nanobodies blocking PD-L1 and CTLA-4 within tumors in mouse models of lymphoma and colorectal cancer. It is already known that tumors express these checkpoints to stop the immune system, specifically T cells, from functioning properly. The goal of blocking PD-L1 and CTLA-4 is to remove the “brakes” and enable T cells to attack the cancer. A direct comparison to clinically relevant antibodies against the same target showed that their probiotic therapy was more effective, leading to complete tumor regression and prevention of metastatic formation in early and late-stage mouse models of lymphoma.

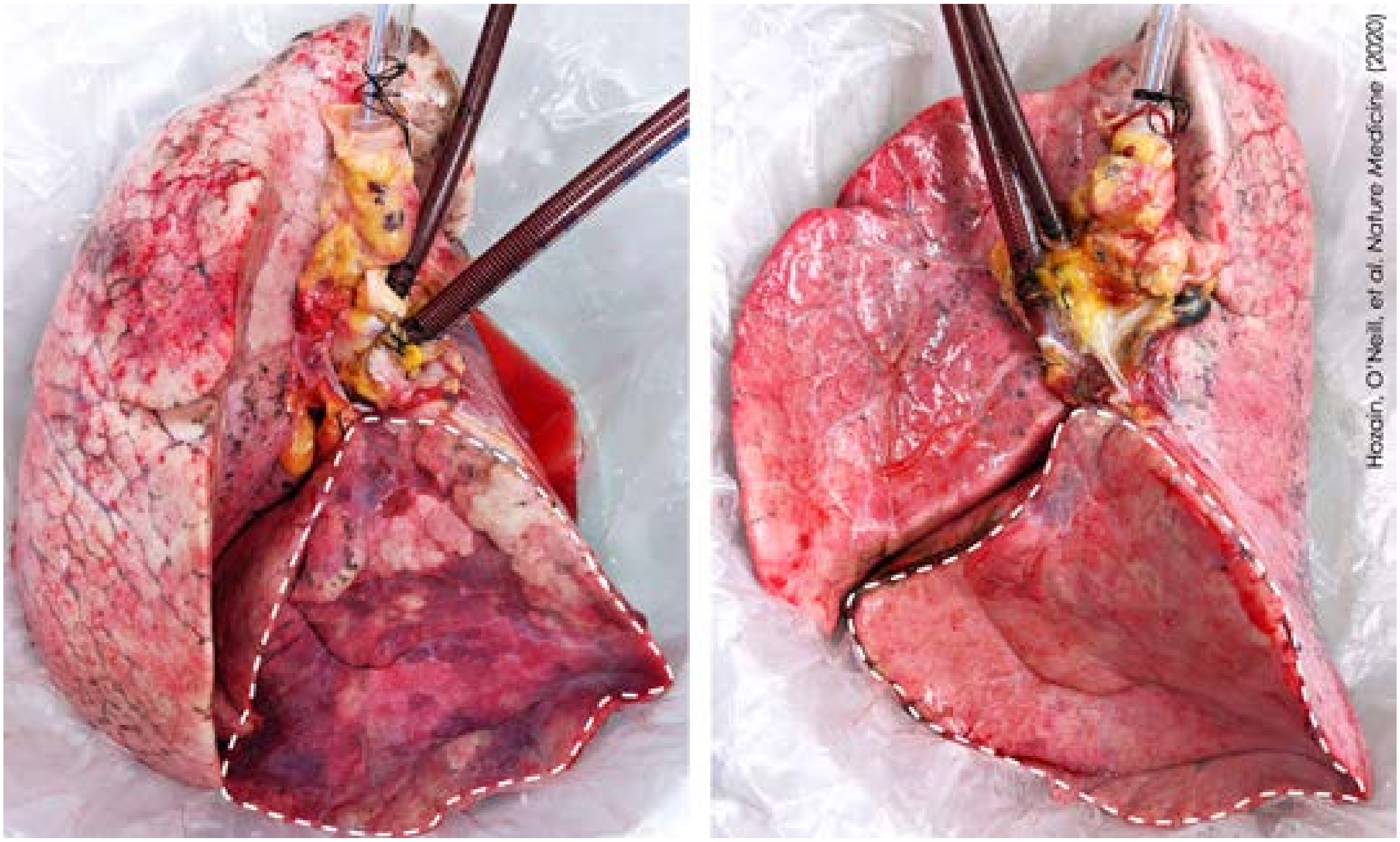
Leveraging the versatility of this system, the researchers sought to treat more difficult cancers, like colorectal, that have been less responsive to traditional immunotherapies. In this additional model, they paired the immune checkpoint nanobodies with a cytokine to further stimulate the immune system. A single dose of this probiotic cocktail resulted in tumor regression with no observed side-effects.

Says Gurbatri, “We showed that a triple combination of immunotherapies could effectively reduce tumor growth in a cancer that is generally less responsive to immunotherapy. We’ve demonstrated that one dose of our probiotic therapy results in continuous localized drug release and clearance of the bacteria population once tumors have cleared. These elements could be particularly beneficial in a clinical setting, where patients want and need minimally invasive and self-sustained therapies.”

The biomedical engineers worked closely with colleagues, including Assistant Professor Nicholas Arpaia, in the microbiology and immunology departments at Columbia University Irving Medical Center. The team is currently performing further safety and toxicology studies of their engineered probiotic in genetically modified mouse models of cancer. They are also collaborating with physicians on the translational aspects of their work and have also founded a company, GenCirq Inc., to translate their promising technology to patients.

Prof. Tal Danino

Severely Damaged Human Lungs Can Now Be Successfully Recovered



Human lung that failed on EVLP (left) and then recovered on cross-circulation (right).

Respiratory disease is the third leading cause of death worldwide, and lung transplantation is still the only cure for patients with end-stage lung disease. Despite advances in the field, lung transplantation remains limited by the low availability of healthy donor organs, and most donor lungs cannot be used due to severe but potentially reversible injuries. Currently, a method known as ex vivo lung perfusion (EVLP) is used to provide lung support outside the body and recover marginal quality donor lungs before transplantation. However, EVLP provides only a limited duration of six to eight hours of support—a time that is too short to recover the majority of severely damaged donor lungs.

A multidisciplinary team from Columbia Engineering and Vanderbilt University has now demonstrated that severely injured donor lungs that have been declined for transplant can be recovered outside the body by a system that uses cross-circulation of whole blood between the donor lung and an animal host. For the first time, a severely injured human lung that failed to recover using the standard clinical EVLP was successfully recovered during 24 hours on the team's cross-circulation platform. The study is published today in Nature Medicine.

The investigators, led by Gordana Vunjak-Novakovic, University Professor and The Mikati Foundation Professor of Biomedical Engineering and Medical Sciences at Columbia Engineering, and Matthew Bacchetta, Surgical Director of the Vanderbilt Lung Institute, attributed the accomplishment of their major milestone to the physiologic milieu and systemic regulation that their unique platform provides to explanted human lungs.

"It is the provision of intrinsic biological repair mechanisms over long-enough periods of time that enabled us to recover severely damaged lungs that cannot otherwise be saved," said the study's lead authors, Ahmed Hozain (surgical research fellow at Columbia Engineering) and John O'Neill (adjunct associate research scientist at Columbia Engineering).

Over the past eight years, the researchers have been developing their radically new method to provide more lungs for patients in dire need of organ transplantation. In 2017, they demonstrated the feasibility of cross-circulation support of whole lungs outside the body. In 2019, they demonstrated the efficacy of cross-circulation by regenerating severely damaged swine lungs, and in 2020, they successfully extended the duration of cross-circulation support to an unprecedented four days.

Now, in this new paper, the team shows that explanted human lungs, already declined for transplantation, can be recovered on their cross-circulation platform, which successfully maintained lung integrity and resulted in functional lung recovery. Throughout the 24 hours of cross-circulation, the team saw substantial improvements of cell viability, tissue quality, inflammatory responses and—most importantly—respiratory function.

“We were able to recover a donor lung that failed to recover on the clinical ex vivo lung perfusion system, which is the current standard of care. This was the most rigorous validation of our cross-circulation platform to date, showing great promise for its clinical utility,” Vunjak-Novakovic said.

This particular donor lung demonstrated persistent swelling and fluid buildup that could not be resolved, and it was declined for transplantation by multiple transplant centers and eventually offered for research. By the time the team received this lung, it had experienced two periods of cold ischemia that totaled 22.5 hours, plus five hours of clinical EVLP treatment. Remarkably, after 24 hours on cross-circulation, the lung showed functional recovery.

“We were able to recover a donor lung that failed to recover on the clinical ex vivo lung perfusion system, which is the current standard of care. This was the most rigorous validation of our cross-circulation platform to date, showing great promise for its clinical utility.”

Vunjak-Novakovic noted that the size and profile of their multi-institutional research team—25 investigators with expertise in bioengineering, surgery, immunology, stem cells, and various clinical disciplines—reflects the complexity of this translational project.

Zachary Kon, Director of Lung Transplantation Program, NYU Langone Health, who was not involved in the study, commented: “As a lung transplant surgeon, I have seen many patients not receive lung transplants they desperately needed. I find this work intriguing and hope this technology will make more donor lungs available."

The investigators emphasize that more work needs to be done before cross-circulation can become a clinical reality. For clinical application of the cross-circulation platform, they envision two clinical scenarios for application of the cross-circulation platform, which they are planning to pursue. One approach is to directly translate the method demonstrated in this new study, with the human donor lung recovered by “xenogeneic” cross-circulation with a medical-grade, pathogen-free animal host. To this end, the safety, feasibility, risk profiles, and outcomes of xenogeneic cross-circulation will need to be evaluated in large numbers of lungs.

Another approach is that critically ill patients already awaiting transplantation on artificial lung support could serve as the cross-circulation host to recover an injured donor lung, which they would receive for transplant as soon as the organ recovers. As described in the paper, the xenogeneic cross-circulation platform may also serve as a research tool to investigate organ regeneration, transplant immunology, and the development of novel therapeutics.

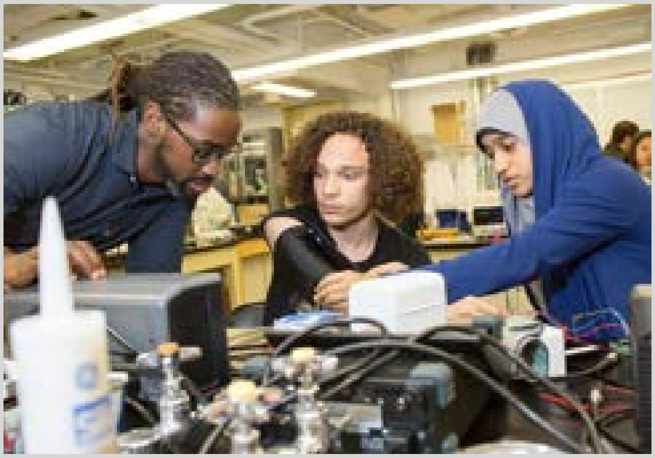
Looking ahead, the researchers hope to extend the benefits of their cross-circulation platform to the recovery of other human organs, including livers, hearts, kidneys, and limbs.

Prof. Gordana Vunjak-Novakovic

FEATURED NEWS

OPEN FACULTY POSITIONS

We Are Hiring!



Open Rank Faculty Position:
Biomedical Engineering & Surgery

We are pleased to invite applications for a tenure-track or tenured faculty position. Applications at the level of Assistant, Associate or Full Professor will be considered. Candidates are sought in the broad area of Tissue Engineering and Regenerative Medicine. The selected candidate is expected to develop and lead an original externally funded research program, and to contribute to the research and educational missions of the Departments of Surgery and Biomedical Engineering.

All applications received by December 1, 2020 will receive full consideration.

UPCOMING EVENT

20TH ANNIVERSARY SYMPOSIUM | 05.04 - 05.06.2021

The Department of Biomedical Engineering turned 20! To celebrate, Columbia Biomedical Engineering is hosting a symposium on May 4-6, 2021.

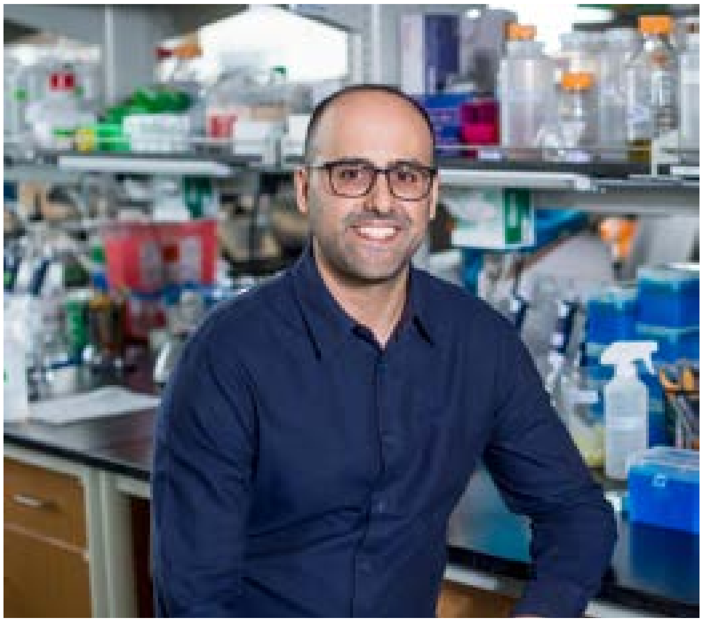
Join us as we reflect on our past and look forward to the future. With sessions on Cell & Tissue Engineering, Drug Delivery, Imaging, Systems Biology, Biomechanics, and Translation, learn from experts from Columbia Engineering and beyond.

For more information, please visit **bme.columbia.edu**.

Department of Biomedical Engineering
COLUMBIA | ENGINEERING
20
Years of Excellence
2000–2020

Prof. Tal Danino Awarded Two Prestigious Grants in Cancer Research

Tal Danino, associate professor of biomedical engineering, has been awarded two prestigious grants that will allow his lab to pursue research in engineering bacteria as a cancer therapy. One of the leading researchers in this field, Danino designs probiotic and other safe bacteria to target tumors and controllably deliver cancer therapeutics from within the tumor, acting as a microbial “Trojan horse.”



Prof. Tal Danino

Danino received a five-year, $1.25 million Lloyd J. Old STAR program grant from the Cancer Research Institute (CRI) in recognition of the outstanding quality and promise of his research. The CRI Lloyd J. Old STAR — Scientists Taking Risks—award provides long-term funding to mid-career scientists, giving them the freedom and flexibility to pursue high-risk, high-reward research at the forefront of cancer immunotherapy innovation.

Danino also was recently awarded a three-year $600,000 Pershing Square Sohn Prize for Young Investigators in Cancer Research from the Pershing Square Sohn Cancer Research Alliance (PSSCRA) to help advance cancer immunotherapy research. The PSSCRA prize is given to exceptional young scientists in New York City who have innovative ideas in the field of cancer research. Danino is one of seven PSSCRA winners who are encouraged to take risks and pursue bold ideas that will lead to new discoveries and approaches in cancer research.

Researchers have long known that because bacteria can selectively colonize solid tumors, they can also locally release high concentrations of immune-stimulating as well as toxic payloads. This localized activity may result in fewer side effects from treatment. Over a century ago, Dr. William Coley, considered the “father of immunotherapy,” discovered that bacteria can induce tumor regression and long-term disease remission by stimulation of the immune system. In 1953, his daughter, Helen Coley Nauts, co-founded the CRI to promote the use of immunotherapies for cancer. More recently, microbiome studies have demonstrated the prevalence of bacteria within tumor tissue, and a number of empirical studies have shown that administered bacteria can home in on tumors and then, due to reduced immune surveillance of the tumor cores, and selectively begin to grow inside the tumors.

“This is an exciting time for our work on bacteria therapies,” says Danino. “Immunotherapy is now poised to overcome several current limitations for successful interventions against treatment-resistant and metastasized cancers. And the microbiome and synthetic biology fields are pointing towards microbes are modulators of the immune system for cancer therapy.”

Danino’s group leverages modern approaches from synthetic biology to engineer safe and effective bacterial immunotherapies for cancer. Collaborating closely with Nicholas Arpaia's lab at the Columbia University Irving Medical Center (CUIMC) for their immunology expertise, Danino’s team is focused on using synthetic biology approaches to engineer a range of bacterial candidates, and then analyze their interactions with immune cells in tumors to determine the optimal strains for eliciting anti-cancer immune activity.

Columbia Engineering would like to acknowledge support for the PSSCRA grant from CUIMC’s Herbert Irving Comprehensive Cancer Center (HICCC), directed by Dr. Anil Rustgi.

Danino’s overarching goal is that his engineered probiotic and bacterial systems will lead to transformative improvements in cancer therapies, ultimately improving patient outcomes. He notes, “These grants give us the freedom to develop creative and innovative bacteria-based therapies that have real potential to advance current immunotherapeutic delivery approaches for cancer. I’m honored that our work has been recognized by these awards and am excited about where this generous funding will take us.”

Elham Azizi
Assistant Professor, Biomedical Engineering; Herbert and Florence Irving Assistant Professor, Cancer Data Research (in the Herbert and Florence Irving Institute for Cancer Dynamics and in the Herbert Irving Comprehensive Cancer Center)
Machine learning in single cell analysis and cancer.

Tal Danino
Associate Professor, Biomedical Engineering; Director, Synthetic Biological Systems Laboratory
Synthetic biology. Engineering gene circuits in microbes.

X. Edward Guo, Chair
Stanely Dicker Professor, Biomedical Engineering; Professor, Medical Sciences (in Medicine); Director, Bone Bioengineering Laboratory | Image-based microstructural and finite element analyses of skeletons.

Henry Hess, Chair of Graduate Studies
Professor, Biomedical Engineering; Director, Laboratory for Nanobiotechnology & Synthetic Biology
Molecular scale engineering. Nanosystems of biomolecular motors.

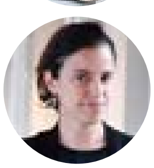
Elizabeth M.C. Hillman
Professor, Biomedical Engineering & Radiology (Physics) and Herbert and Florence Irving Professor at the Zuckerman Institute; Director, Laboratory for Functional Optical Imaging | Optical imaging of brain function.

Clark T. Hung
Professor, Biomedical Engineering & Orthopedic Sciences (in Orthopedic Surgery); Director, Cellular Engineering Laboratory
Cellular and tissue engineering of musculoskeletal cells.

Joshua Jacobs
Associate Professor, Biomedical Engineering; Director, Memory and Navigation Laboratory
Electrophysiology of navigation and memory. Brain stimulation.

Christoph Juchem
Associate Professor, Biomedical Engineering; Director, Magnetic Resonance Scientific Engineering for Clinical Excellence Laboratory (MR SCIENCE Lab) | Brain chemistry/metabolism. Magnetic resonance imaging.

Lance Kam, Chair of Undergraduate Studies
Professor, Biomedical Engineering; Professor, Medical Sciences (in Medicine); Director, Microscale Biocomplexity Laboratory | Micro- and nano-scale fabrication of biological systems.



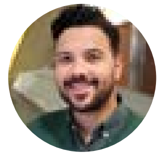
Elisa E. Konofagou
Robert and Margaret Hariri Professor, Biomedical Engineering & Radiology (Physics); Director, Ultrasound Elasticity Imaging Laboratory | Elasticity imaging. Therapeutic ultrasound. Soft tissue mechanics.

Aaron Matthew Kyle
Senior Lecturer, Biomedical Engineering Design; Director, Hk Maker Lab; Director, Undergraduate Studies in Biomedical Engineering
Engineering education and laboratory development.

Andrew Laine
Percy K. and Vida L. W. Hudson Professor, Biomedical Engineering & Radiology (Physics); Director, Heffner Biomedical Imaging Lab
Quantative image analysis. Imaging informatics

Kam W. Leong
Samuel Y. Sheng Professor, Biomedical Engineering (Systems Biology); Director, Nanotherapeutics and Stem Cell Engineering Laboratory | Regenerative medicine through direct cellular reprogramming.

Helen H. Lu
Percy K. and Vida L.W. Hudson Professor, Biomedical Engineering; Director, Biomaterials & Interface Tissue Engineering Laboratory
Interface tissue engineering.



José McFaline-Figueroa (Starting January 2021)
Assistant Professor, Biomedical Engineering; Director, The Chemical Genomics Laboratory
Single-cell genomics, multiplex molecular screens, genome engineering, cancer biology.

Barclay Morrison
Professor, Biomedical Engineering; Director, Neurotrauma and Repair Laboratory
Mechanical injury of the central nervous system.

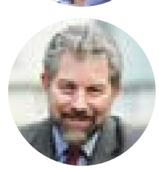
Van C. Mow
Professor Emeritus, Biomedical Engineering
Soft tissue biomechanics. Cell-matrix interactions.

Nandan Nerurkar
Assistant Professor, Biomedical Engineering; Director, Morphogenesis & Development Biomechanics Laboratory | Mechanobiology of embryonic development and organ formation. Birth defects of the central nervous and gastrointestinal systems.

Katherine Reuther
Senior Lecturer, Design Innovation and Entrepreneurship, Department of Biomedical Engineering; Director, Master's Studies in Biomedical Engineering
Engineering education. Soft tissue biomechanics.

Paul Sajda, Vice Chair
Professor, Biomedical/Electrical Engineering & Radiology; Director, Laboratory for Intelligent Imaging & Neural Computing | Neuroimaging. Computational neural modeling. Machine learning.

Samuel K. Sia
Professor, Biomedical Engineering; Director, Microfluidics For Point-Of-Care Diagnostics And Therapeutics Laboratory | Point-of-care diagnostics. 3D tissue engineering. Implantable devices.



J. Thomas "Tommy" Vaughan, Jr.
Professor, Biomedical Engineering, Zuckerman Institute; Director, Columbia University Magnetic Resonance Research Initiative | Magnetic resonance imaging (MRI) spectroscopy (MRS).

Gordana Vunjak-Novakovic
University Professor and Mikati Foundation Professor, Biomedical Engineering & Medical Sciences; Director, Laboratory for Stem Cells and Tissue Engineering
Tissue engineering. Stem cells. Regenerative medicine.

Qi Wang
Associate Professor, Biomedical Engineering; Director, Raymond and Beverly Sackler Laboratory for Neural Engineering and Control
Brain-machine interfaces.

Shining Brightly in Dark Times

This past year, our exceptional students blew us away with their determination, creativity, and resilience when faced with so many unprecedented challenges. Here are just some of their shining moments:

- Innovation Summer: BME student Min Tsou ’23 rises to the challenge of improving vaccine access in moments of extreme demand with her team's innovative VaxFlask.
- BME volunteers Pamela Graney, Jaeseung Hahn, Kay Igwe, Kacey Ronaldson-Bouchard, Chirag Sachar, Sebastian Theilenberg join Columbia Researchers Against COVID19 (CRAC Teams) in the fight against the virus.
- BME senior design team, Neurotrak, wins DEBUT 2020 Venture Prize for their innovative, wireless, wearable device designed to consistently collect electroencephalography (EEG) data in real time to monitor Focal with Impaired Awareness (FIA) seizures. It can increase the accuracy of seizure information over self-reported data and can help doctors make more informed treatment decisions.
- BME '20 graduates Bunmi Fariyike and Michael Kirschner earn Fulbright Scholarships.
- PhD student Carolyn Kim wins NDSEG Fellowship Award.
- 22 Columbia engineers were named NSF Graduate Research Fellows, including BME PhD student Ethan Bendau. (Honorable Mentions: McKenzie Sup & Lianna Gangi)

Fulbright Recipient Bunmi Fariyike ’20 to Conduct Research in Madrid

Graduating biomedical engineer Bunmi Fariyike ’20 has received a prestigious Fulbright Scholarship to conduct genetic engineering research in Spain.

Fariyike will spend nine months at Madrid’s Centro Nacional de Biotecnología (National Center for Biotechnology) developing a platform for modeling bacterial development of antibiotic resistance in vitro, in order to more accurately predict how and why bacteria develop the ability to withstand treatments. It’s a priceless opportunity to link his passions for medicine and public health, he says.

> **“ I don’t think I would have become who I am today without Professor Kyle. It’s been indispensable having a professor who always demanded the best out of us and then a little bit more."**

“I expect that my experience outside of the lab will be just as critical as my time in it,” said the Egleston Scholar, who is also minoring in Hispanic Studies. “I’m excited to expand my knowledge through Spanish language, history, traditions, and especially cuisine. I’m also excited for more opportunities to practice the cultural competence and flexibility that will be critical for a doctor focused on global health.”

Already a global traveler during his Columbia Engineering experience, Fariyike previously spent a semester abroad studying in Madrid, and won a global health research fellowship through ICAP at the Mailman School of Health to conduct research in the Dominican Republic. As program manager for the Columbia chapter of Engineers Without Borders’ Ghana program, he also traveled twice to west Africa to co-lead a team increasing a small village’s access to potable water.

On campus, in addition to his extensive coursework, he spent over two years conducting synthetic biology research with Professor Virginia Cornish of the Department of Chemistry. Over the course of his undergrad career, he found working with Aaron Kyle, senior lecturer in the discipline of biomedical engineering, to be a formative experience.

“I don’t think I would have become who I am today without Professor Kyle,” he said. “It’s been indispensable having a professor who always demanded the best out of us and then a little bit more.”

Now back home in suburban Atlanta due to the COVID-19 lockdown, he is collaborating with teammates to bring their senior design project to fruition—a device designed to provide access to medical-grade oxygen in low-resource settings.

“Seeing just how needed biomedical engineers are in the midst of this pandemic has definitely gotten my gears turning,” he said. “Our senior design project is just the kind of device many countries could be looking for in the near future, which is why our team has poured so much effort—even from home—into making it a reality.”

Looking ahead, Fariyike hopes that his work can bring life-saving care to as broad a swathe of humanity as possible.

“At the core of my interest in both engineering and medicine is an intrinsic desire to use my education to empower communities around the world through healthcare,” he said. “Ultimately, my goal is to become a surgeon engaged in similar types of research or design projects that address the unique challenges faced in developing nations to ensure equitable access to the best of medical technology.”

COLUMBIA BME BLAZE

Monthly Blog Highlights Exceptional Columbia BME Students and Alumni

In December of last year, we launched BME Blaze. In this monthly spotlight, get to know the alumni and students of Columbia's Department of Biomedical Engineering.

To read their amazing stories, follow us on social media for the latest interview or visit bme.columbia.edu and search for "BME Blaze."

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