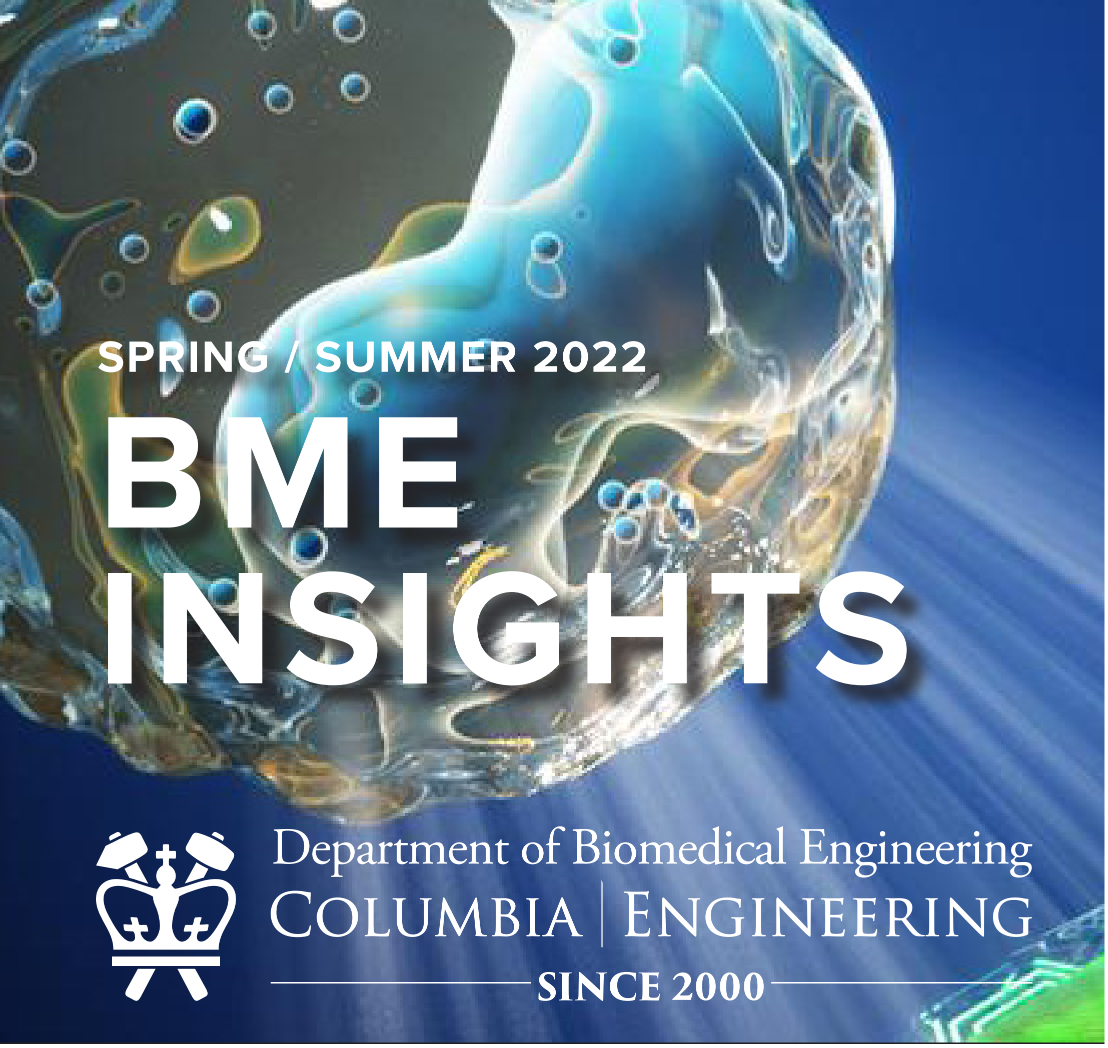
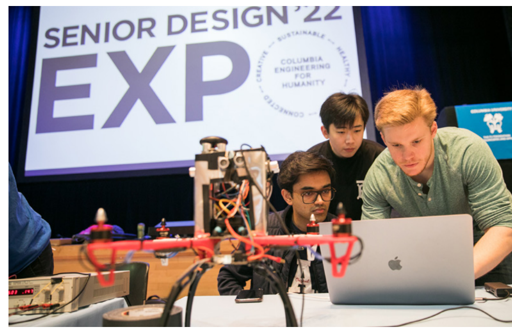
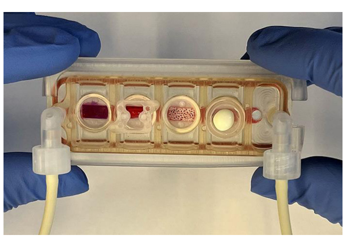
SPRING / SUMMER 2022

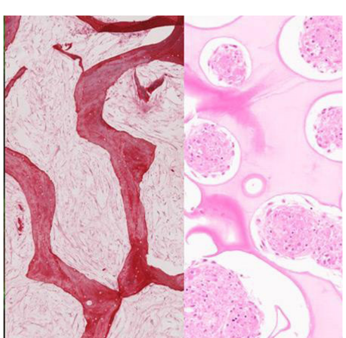
BME INSIGHTS

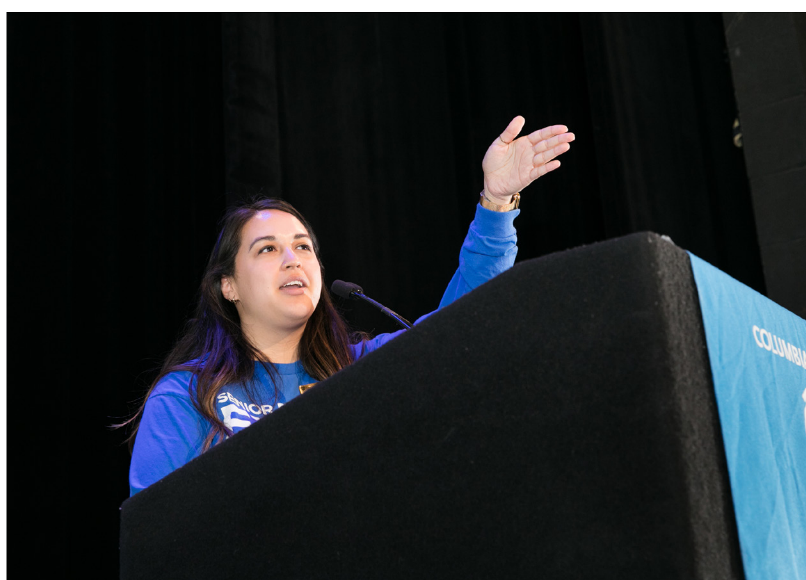
Department of Biomedical Engineering
COLUMBIA | ENGINEERING
SINCE 2000











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Photos on front cover from top left, clockwise.
1) Probiotic bacteria (E. coli Nissle 1917 strain, green) is engineered to controllably evade immune system (macrophage, transparent) using a genetically encoded encapsulation system (capsular polysaccharides with circuit board, shown as transparent coating surrounding the bacterial cells). This system was used to enhance delivery of therapeutic bacteria for cancer therapy. (Ella Marushchenko, Alex Tokarev, Danino Lab/Columbia Engineering) 2) Columbia BME Chair X. Edward Guo at NEBEC 3) Research team at Senior Design Expo 2022 4) Senior Design Project 5) Speaker at Senior Design Expo 2022 6) Tissues cultured in the multi-organ chip (from left to right: skin, heart, bone, liver, and endothelial barrier) maintained their tissue-specific structure and function after being linked by vascular flow. Photo credit: Kacey Ronaldson-Bouchard/Columbia Engineering 7) The new multi-organ chip has the size of a glass microscope slide and allows the culture of up to four human engineered tissues, whose location and number can be tailored to the question being asked. These tissues are connected by vascular flow, but the presence of a selectively permeable endothelial barrier maintains their tissue-specific niche. Photo credit: Kacey Ronaldson-Bouchard/Columbia Engineering 8) Professor Sanja Vickovic 9) Award ribbons at NEBEC 10) Professors Elham Azizi and José McFaline-Figueroa win NSF CAREER awards | *Back cover photo:* Laboratory for Stem Cells & Tissue Engineering | *Portrait Photography:* Eileen Barroso | *NEBEC Photography:* Timothy Lee

Columbia BME in Numbers

1:4
Faculty-to-Undergraduate Student ratio

Over **$26M**
in Annual Faculty Research Expenditures 2021-2022

4
Faculty winners of the ASME Van C. Mow Medal

1
Faculty elected to the National Academy of Sciences

3
Faculty elected to the National Academy of Engineering

6
Faculty elected to the National Academy of Medicine

30
Startups launched by students and faculty since 2014

17
AIMBE Fellows in Faculty

10
Faculty Recipients of NSF CAREER Award

60%
of MS Students Participate in Research

114 Undergraduates
238 Masters Students
162 PhD Students

A Note From the Chair

Dear Colleagues and Friends of Columbia BME,

I am pleased to present to you the 2022 Spring and Summer Edition of Columbia University's Biomedical Engineering Insights. The 2021-2022 Academic year was unexpected and challenging with many twists. The COVID omicron variant certainly dampened our optimistic projections for 2021-2022. We are pleased, though, that we thrived despite spring and summer COVID variants. With the support of our amazing BME faculty, staff, and students, we quickly turned our virtual 48th Northeast Bioengineering Conference (NEBEC) into an in-person event. We are proud that the BME Department hosted a successful NEBEC conference for our northeast faculty and student peers. 500 faculty, researchers, and students from more than 75 institutions came together on the Columbia campus. As the first in-person conference for most attendees since 2019, NEBEC 2022 was memorable and demonstrated a seamless integration of virtual and in-person events that may be the new normal going forward. From keynotes to panels to poster sessions, NEBEC was overflowing with engaging speakers and exciting research.

Despite the challenging year, the BME Department has added four outstanding new members to our growing Department. Professor Sanja Vickovic is one of the pioneers of spatial transcriptomics that enabled researchers to profile intact tissue samples massively. Professor Lauren Heckelman is interested in engineering education, medical imaging, biomechanics, and signal processing. She will be instrumental in further elevating our undergraduate BME program. Professor Treena Livingston Arinzeh, a world-class leader in functional biomaterials for tissue regeneration in orthopedic and neural applications, joins us from the New Jersey Institute of Technology and will further solidify our internationally leading position in mechanobiology and mechanomedicine. Dr. Santiago Correa, one of our 2020 inaugural Rising Stars in Engineering in Health from Stanford, will join us as an assistant professor of biomedical engineering. He is our department's first LGBT+ hire and second Hispanic faculty member. Taking inspiration from nature, Dr. Correa engineers this next-generation technology via supramolecular self-assembly across length scales – first by constructing bioinspired multifunctional nanoparticles that, in turn, self-assemble to produce macroscopic biomaterials imbued with unprecedented immuno-modulatory capabilities.

Our innovative BME design students swept the top three prizes at this year's Columbia Venture Competition, where more than 100 alumni judges from around the world gathered to rank Columbia startups. Our students' winning projects addressed important health-related issues including colorectal cancer, vision/hearing, and vaccination. The Columbia Venture Competition is a partnership between Columbia College, Columbia Engineering, Columbia Entrepreneurship, the School of International and Public Affairs (SIPA), and the Alliance Program that works with French universities Sciences Po, Sorbonne University, and École Polytechnique.

As we move forward into the 2022-2023 academic year, we are hopeful that the world will finally emerge from the cloud of COVID-19. Columbia BME is pleased to work with our colleagues in the Department of Biomedical Engineering at Johns Hopkins University to host the 2022 Rising Stars in Engineering in Health Workshop, this time in Baltimore this time. The application deadline is August 19, 2022. We are excited to visit our colleagues in Baltimore in November!

We wish all our colleagues and friends in BME a great summer and a successful 2022-2023 academic year!

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

Celebrating Faculty Excellence

Honors, Recognition, and Achievement

Elham Azizi
Assistant Professor of Biomedical Engineering; Herbert and Florence Irving Assistant Professor of Cancer Data Research

- National Science Foundation (NSF) CAREER Award

José McFaline-Figueroa
Assistant Professor of Biomedical Engineering

- National Science Foundation (NSF) CAREER Award

Kam Leong
Samuel Y. Sheng Professor of Biomedical Engineering (Systems Biology)

- 2022 Founders Award, Society for Biomaterials (SFB)

X. Edward Guo
Department Chair and Stanley Dicker Professor of Biomedical Engineering; Professor of Medical Sciences (in Medicine)

- 2022 American Society for Bone and Mineral Research (ASBMR) Adele Boskey Award

Promotions

Helen Lu
Percy K. and Vida L.W. Hudson Professor of Biomedical Engineering, named Senior Vice Dean of Faculty Affairs and Advancement

Samuel Sia
Professor of Biomedical Engineering, Faculty Director of SEAS Entrepreneurship; named Vice Provost for the Fourth Purpose and Strategic Impact

Scholarly Leadership

Samuel Sia
Professor of Biomedical Engineering, Faculty Director of SEAS Entrepreneurship, Vice Provost for the Fourth Purpose and Strategic Impact

- Chair (2022-2024) NIH study section Instrumentation and Systems Development (ISD)

Photos at left, from top left, clockwise: Columbia Engineering Commencement, BME 2022 Senior Dinner, BME PhD Interview Weekend, BME 2022 Department Retreat, BME 2022 Pride Ice Cream Social
Photos at right: BME 2022 Faculty Celebratory Dinner by Timothy Lee Photographers

Treena Arinzeh

Treena Livingston Arinzeh, PhD is currently a Professor of Biomedical Engineering at Columbia University. Dr. Arinzeh received her B.S. from Rutgers University in Mechanical Engineering, her M.S.E. in Biomedical Engineering from Johns Hopkins University, and her Ph.D. in Bioengineering from the University of Pennsylvania. She was a project manager at the stem cell technology company, Osiris Therapeutics, Inc. and joined the faculty of the New Jersey Institute of Technology (NJIT) as one of the founding faculty members of the department of biomedical engineering. She served as interim chairperson and graduate director. Dr. Arinzeh has been recognized with numerous awards for her research, including the Presidential Early Career Award for Scientists and Engineers (PECASE). She is a fellow of the American Institute for Medical and Biological Engineering (AIMBE), the Biomedical Engineering Society (BMES) and the National Academy of Inventors. She has also been recognized for her efforts in diversity and inclusion. She is currently the Director of Diversity of the NSF Science and Technology Center for Engineering MechanoBiology, which is a multi-institutional center led by the University of Pennsylvania.

Santiago Correa (Jan. 2023)

Santiago Correa's research operates at the interface of materials science, nanotechnology, and immunology to engineer the immune system and improve human health.

Dr. Correa develops biomaterials composed of nano-scale building blocks, which are used to reprogram the body's immune system to fight cancer, autoimmune disease, and infection.

Taking inspiration from nature, Dr. Correa engineers this next-generation technology via supramolecular self-assembly across length scales – first by constructing bioinspired multifunctional nanoparticles that, in turn, self-assemble to produce macroscopic biomaterials imbued with unprecedented immuno-modulatory capabilities.

Dr. Correa obtained his BS in Biomedical Engineering at Yale prior to completing a PhD in Biological Engineering at MIT. While in the Hammond Lab at MIT, he explored how nanoparticle surface chemistry could be engineered to better target ovarian cancer and to fabricate multifunctional nanomaterials. Afterwards, Dr. Correa completed his postdoctoral training as an NCI F32 Fellow in the Appel Lab at Stanford, where he developed immunomodulatory biomaterials to treat cancer.

Lauren Heckelman

As a Lecturer in the Discipline of Biomedical Engineering, Dr. Lauren Heckelman's primary responsibility is to teach and mentor undergraduate BME students. She aims to guide her students toward the next phase of their educational or professional journey by developing their critical thinking and problem-solving skills via hands-on learning activities and through individualized mentorship.

Dr. Heckelman teaches a two-semester BME laboratory course sequence and a two-semester Senior Design course sequence. The BME laboratory courses are divided into smaller modules covering a wide range of biomedical engineering sub-disciplines including biomechanics, medical imaging, instrumentation, and bioelectricity, among others. Senior Design enables interdisciplinary groups of students to identify a need within the realm of biomedical engineering, brainstorm and assess potential solutions, develop multiple prototypes, and curate a business plan based on their product. The students are in the driver's seat throughout the engineering design process, while also working collaboratively alongside Columbia faculty and staff with expertise related to their projects.

Heckelman is a three-time Duke biomedical engineering graduate. She earned her B.S.E. in 2016, her M.S. in 2017, and her Ph.D. in 2022. She was recently awarded the 2022 Dean's Award for Excellence in Teaching by the Duke Graduate School for her exemplary commitment to educating undergraduate and graduate students.

Sanja Vickovic

Sanja Vicković, PhD, is a Core Faculty Member and Director, Technology Innovation Lab, at the New York Genome Center. She holds joint appointments as an Assistant Professor at the Fu Foundation School of Engineering and Applied Science and the Herbert and Florence Irving Institute for Cancer Dynamics at Columbia University, and as a Wallenberg Academy Fellow of the Royal Swedish Academy of Sciences and the Royal Swedish Academy of Engineering Sciences at Uppsala University.

Dr. Vicković is an experienced and accomplished engineer and an inventor of the spatial transcriptomic technology called "Visium" and now commercialized by 10x Genomics. In addition to being a skilled technologist, Dr. Vicković also has training and experience in mathematics and biological sciences. Prior to joining the NYGC in 2022, Dr. Vicković had already collaborated with the NYGC, playing a crucial role in the first demonstration of the application of spatial transcriptomics to a disease model in collaboration with researchers at the NYGC's Center for Genomics of Neurodegenerative Disease.

Dr. Vicković joined the NYGC from the Broad Institute of MIT and Harvard, where she was a Wallenberg Fellow in Aviv Regev's lab. She obtained her PhD in Gene Technology from the KTH Royal Institute of Technology, Stockholm.

José McFaline-Figueroa Wins NSF CAREER Award

Genomicist focuses on defining the molecular changes induced in aggressive cancer cells after they've been exposed to anti-cancer therapy and how those changes alter response to treatment

By Holly Evarts

José L. McFaline-Figueroa, assistant professor of biomedical engineering, has been recognized with a National Science Foundation (NSF) CAREER Award for his work on defining how cancer cells respond after exposure to anti-cancer therapy, and how that response depends on the genetic background of individual cancer cells. One of the NSF's top honors given to early-career faculty, the three-year, $542,418 award will support his project, "Defining kinase-driven cellular response networks using single-cell genomics."

One of the many difficulties in treating cancer is that tumors are heterogeneous--while a large population of cells will react one way to treatment, individual cells may react in another. It is thus critical to study tumors at the resolution of single cells to learn about mechanisms you might not see when examining a large group of cells.

Thanks to major advancements in the field, researchers can now isolate and characterize molecular components of a single cell within heterogeneous cell groups. McFaline-Figueroa develops and applies multiplex single-cell genomics tools that enable his group to probe the large combinatorial space between genes and exposures. His Chemical Genomics Laboratory then uses the functional atlases of cellular response obtained by their methods to identify more powerful treatment combinations to treat disease, especially cancer.

McFaline-Figueroa's earlier work leveraged the throughput of novel single-cell genomic approaches for the multiplex assessment of the effect of genetic and chemical perturbations on gene expression programs. The NSF CAREER award will support his extending these tools to develop large-scale data-driven prediction of how individual genes contribute to the molecular changes that accompany cellular response.

The team plans to determine how protein kinases, master regulators of the cell, contribute to the dynamic molecular changes that cancer cells undergo in response to cytotoxic and genotoxic stress. The group will apply and broaden their methods for multiplex perturbation screens at single-cell resolution to probe the large interactions space between kinases and cellular stressors. The broader goal is to develop workflows to create functional molecular atlases with broad applications in various scientific fields, including therapeutic development and cellular engineering.

"We expect our methods will enable unprecedented insight into the regulatory networks that drive stress response and can be adapted to determine the genetic dependency of transcriptional phenotypes in a wide variety of experimental systems," said McFaline-Figueroa, who is also an associate member of the Herbert and Florence Irving Institute for Cancer Dynamics and a member of the Herbert Irving Comprehensive Cancer Center. "This NSF CAREER award will support our group's efforts to leverage these functional atlases of cellular response to arrive at novel treatments against cancer, with a particular focus on aggressive tumor types that frequently fail the current standard-of-care."

McFaline-Figueroa also plans, as part of his NSF project, to work with high school students taking part in the NY Bioforce program and, in collaboration with the University of Puerto Rico, to develop a short course for graduate students at external institutions for the analysis of existing single-cell genomic datasets.

Elham Azizi Recognized with NSF CAREER Award

Computational biologist focuses on characterizing various interacting cell types in the tumor microenvironment to advance the development of improved, personalized cancer treatments

By Holly Evarts

Photo Credit: Timothy Lee Photographers

Elham Azizi, Herbert and Florence Irving Assistant Professor of Cancer Data Research in the Irving Institute for Cancer Dynamics and department of biomedical engineering, has won a National Science Foundation (NSF) CAREER award to study interactions between cells inside and around breast cancer tumors to better understand how aggressive tumors evade the body's immune defenses. One of the most prestigious prizes awarded by the NSF to early-career scientists, the five-year, $500,030 grant will support her project, "Integrative modeling of intercellular interactions in the tumor microenvironment."

"Breast cancer is the second leading cause of cancer deaths among women overall and the leading cause of cancer deaths among African American and Hispanic women in the United States," said Azizi, who is also affiliated faculty of Computer Science, and a member of Data Science Institute and the Herbert Irving Comprehensive Cancer Center. "There is a pressing need for principled and scalable computational methods capable of analyzing and integrating measurements from thousands to millions of tumor and immune cells using recent genomic and imaging technologies. The innovative machine learning tools we develop to tackle this problem will be made publicly available to benefit the broader scientific community for use in exploring other biological systems and cancers."

Azizi's Computational Cancer Biology Laboratory uses novel machine-learning techniques together with cutting-edge genomic and imaging technologies to study and model the composition and circuitry of cells in tumors. Azizi's approach involves leveraging genomic profiling at single-cell resolution and developing machine learning and statistical methods to analyze and integrate high-dimensional genomic data. The group characterizes various interacting cell types in the tumor microenvironment to better understand their underlying mechanisms with the goal of developing improved and personalized cancer treatments.

For this project, Azizi's focus is on developing new computational methods to analyze the interactions between immune cells and breast cancer. The deep generative models will enable her group to analyze crosstalk between diverse cell states, in particular between tumor-associated fibroblasts and immune cells.They expect this new framework to reveal how cell organization in breast tumors impacts immune response and will inform approaches for improving anti-tumor immunity.

Champion Hockey Player's Road to Science

Columbia Biomedical Engineering Department, the Irving Institute for Cancer Dynamics, and the New York Genome Center welcome new faculty member, Sanja Vickovic, PhD

By Lorenza Favrot | Edited by Holly C. Evarts, Madisen Grimaldi, and Melanie Farmer

Dr. Sanja Vickovic's path to cancer research was not a traditional one. Born and raised in Croatia, a professional ice hockey career brought her from Zagreb to Stockholm. She was part of the Croatian National Team Women's Ice Hockey from 2005 to 2012. The team became World Champions in 2007 and Swedish Elite Champions in 2011. However, it was a win for science as she joined an experimental genomics lab at the Royal Institute of Technology (Stockholm, Sweden), focusing on technology development. She hasn't looked back since.

Dr. Vickovic obtained a BSc in bioengineering from the University of Zagreb, a MSc in Molecular Biotechnology followed by a PhD in Genetics at the Royal Institute of Technology. Following her graduate work, she joined the Broad Institute of MIT and Harvard as a Wallenberg Fellow. The Wallenberg Fellowship provides recent PhD graduates in Sweden with an opportunity to pursue their independent research to build the foundation of their lab. She joins Columbia University on July 1st as an assistant professor of biomedical engineering (in the Herbert and Florence Irving Institute for Cancer Dynamics). She also will have an appointment at the New York Genome Center (NYGC) as a Core Faculty and the Director of the Technology Innovation Lab.

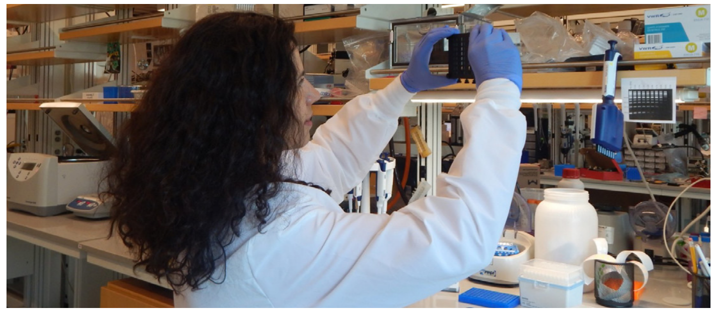
In her lab, she will focus on developing accessible genomic methods for use in clinics. Currently, sporadic causes, progression mechanisms, or the influence of environmental factors responsible for increasing cancer occurrences are poorly understood. While mutational signatures lead to positive selection and growth stimulation during cancer formation, we need to correlate this burden to mechanisms of cancer progression, including chronic inflammation. These aberrant cell programs need to be triggered by complex host-environment interactions. "In my group, I want to bridge the gap in studying these cell-to-cell responses by developing novel genomics, molecular and deep learning tools for characterizing the spatial tissue environment. I strongly believe these approaches will improve our molecular and histological understanding of the inter-and intra-cellular wiring of tissue interactions and the environment needed for signaling during disease progression," Dr. Vickovic explains.

Dr. Vickovic has pioneered novel spatially resolved transcriptomics and genomics methods that enable massive parallel in situ profiling of intact tissue samples. She co-developed a spatial transcriptomic technology called "Visium," which is now commercialized by 10X Genomics, a biotech company specializing in gene sequencing technology. The desire to transform the field of pathology and introduce genomics concepts that directly link tissue histology to gene expression and function is what initially inspired her interest in the spatial genomics field.

Dr. Vickovic was drawn to Columbia University because of its robust biomedical engineering program. "Columbia has developed one of the strongest bioengineering programs in the country and has a fantastic track record of collaborating within and across different NYC institutions. This is an important virtue of any engineering school as we need to be able to translate our methods and machinery into clinical applications fast," says Dr. Vickovic. Additionally, joining the Irving Institute for Cancer Dynamics (IICD) seemed like a natural choice because of her background in mathematics and her research related to cancer. Researchers from IICD are from various departments of the University, facilitating collaboration across multiple fields to carry out interdisciplinary research.

> **"Columbia has developed one of the strongest bioengineering programs in the country and has a fantastic track record of collaborating within and across different NYC institutions. This is an important virtue of any engineering school as we need to be able to translate our methods and machinery into clinical applications fast.**
>
> **—DR. VICKOVIC**

"Being part of IICD allows me to continue focusing on interdisciplinary research and connecting interests in combining novel analysis approaches in real-time as we develop new technologies. Additionally, it is wonderful to be able to easily connect to the large cancer network in the NYC area through IICD. There are always so many opportunities around and having access to patient data we use in our data science program is amazing," Dr. Vickovic explains. "We are delighted to have Dr. Sanja Vickovic joining the Institute. Her expertise in spatial genomics and transcriptomics will be a great addition to our IICD team and our commitment to technology development," says Dr. Simon Tavaré, Professor of Statistics and Biological Sciences, and Director of the Irving Institute for Cancer Dynamics.



Dr. Sanja Vickovic in her lab at the New York Genome Center (Photo Credit: Lorenza Favrot, Photo Credit Page 10: Björn Frändfors)

At NYGC, Dr. Vickovic will direct the Technology Innovation Lab, which explores completely novel concepts in genomics, biophysics, and chemistry to develop tools for characterizing the missing 'biological' measurements and space which cannot be addressed with current methods. "An important aspect we are currently discussing is the concept of causality in biology. We are moving away from only profiling cells to being able to perturb and predict the behavior of complex biological systems," Dr. Vickovic adds. She is no stranger to NYGC, as she has previously worked with NYGC Faculty members Hemali Phatnani and Silas Maniatis. In collaboration with NYU Faculty member Richard Bonneau, they generated the most extensive histo-molecular profile of any neurodegenerative disease to date. "It was such a beautiful scientific collaboration that I had to join NYGC to continue asking the tough biological questions," she explains.

Dr. Vickovic's dedication and drive as an athlete are traits she brings to her career in cancer research. She looks forward to being part of multiple departments and institutions across Columbia University and NYGC, "allowing more exposure to the diversity science has to offer. I trained in three different fields, and I love interacting with students and peers. I also think the departments welcomed me with open arms despite not being the traditional faculty candidate. It says a lot about the opportunities that Columbia University and NYGC have to offer to perform cutting-edge science," she concludes.

University Faculty Team Up Again to Design Tech Innovations for NYC

For second year in a row, faculty win Urban Tech Awards to develop technology innovations to improve urban living in the face of the COVID-19 pandemic, superstorms, and other extreme events

by Allison Chen

Nine Columbia University faculty teams have each won an $85,000 Urban Tech Award for projects to develop technology applications to improve urban living in the face of superstorms like Sandy and Ida and the current COVID-19 pandemic. Each proposal focuses on designing technological solutions to protect from and prevent future pandemics, attacks, and disasters in New York City and other major cities in the world. To encourage impactful collaborations across the University, each team includes at least one Engineering and Applied Sciences faculty member and at least one faculty member from either a different school or a different department.

The award's inaugural round last year, funded by a gift from a generous Columbia Engineering alumni donor, was highly successful, and the same donor is supporting the program's second year.

"The COVID-19 pandemic has certainly exposed weaknesses in the design and infrastructure of modern cities like New York, as have the onslaught of natural disasters over the past few years," said Shih-Fu Chang, Columbia Engineering interim dean. "It's clear we need a broad range of innovations as we emerge from an extraordinarily difficult time, and bringing together the best minds in New York City and at Columbia can only lead to exciting, innovative solutions. We're very grateful to our donor for being so generous in continuing this visionary program."

The themes for this year's round are smart cities and logistics, sustainable building design and sensors, safe work and public spaces, enhanced learning technologies, and improved diagnostics. The proposals came from faculty across the University, including from Columbia University Irving Medical Center (CUIMC), Columbia Climate School, the Dental School, Mailman School of Public Health, and Teachers College. Six of the nine winning teams are renewals for a second year of funding.

These are the [three BME] projects that won awards.

Testing the Efficacy of Far-UVC Light to Safely Inactivate Airborne Viruses at the Columbia University College of Dental Medicine (Renewal)

David J. Brenner, Director, Center for Radiological Research (CUIMC)
Steven Matthew Erde, Assistant Professor, Dental Medicine (CUIMC)
Gordana Vunjak Novakovic, Mikati Foundation Professor, Bioengineering (Engineering)

Far-UVC light is an exciting new modality that has been shown to safely and very efficiently kill airborne viruses in occupied rooms. We plan to install these far-UVC lights at the Columbia College of Dental Medicine, and measure changes in airborne pathogens when the lamps are turned on.

Development and Field-Testing a Mobile App for Tracking Home-Based COVID-19 Rapid Test Results (Renewal)

Samuel Sia, Professor, Biomedical Engineering (Engineering)
Wafaa El-Sadr, Professor, Epidemiology (ICAP)
Jessica Justman, Associate Professor, Epidemiology (CUIMC)
Guangxin Han, Postdoctoral Research Scientist, Electrical Engineering (Engineering)

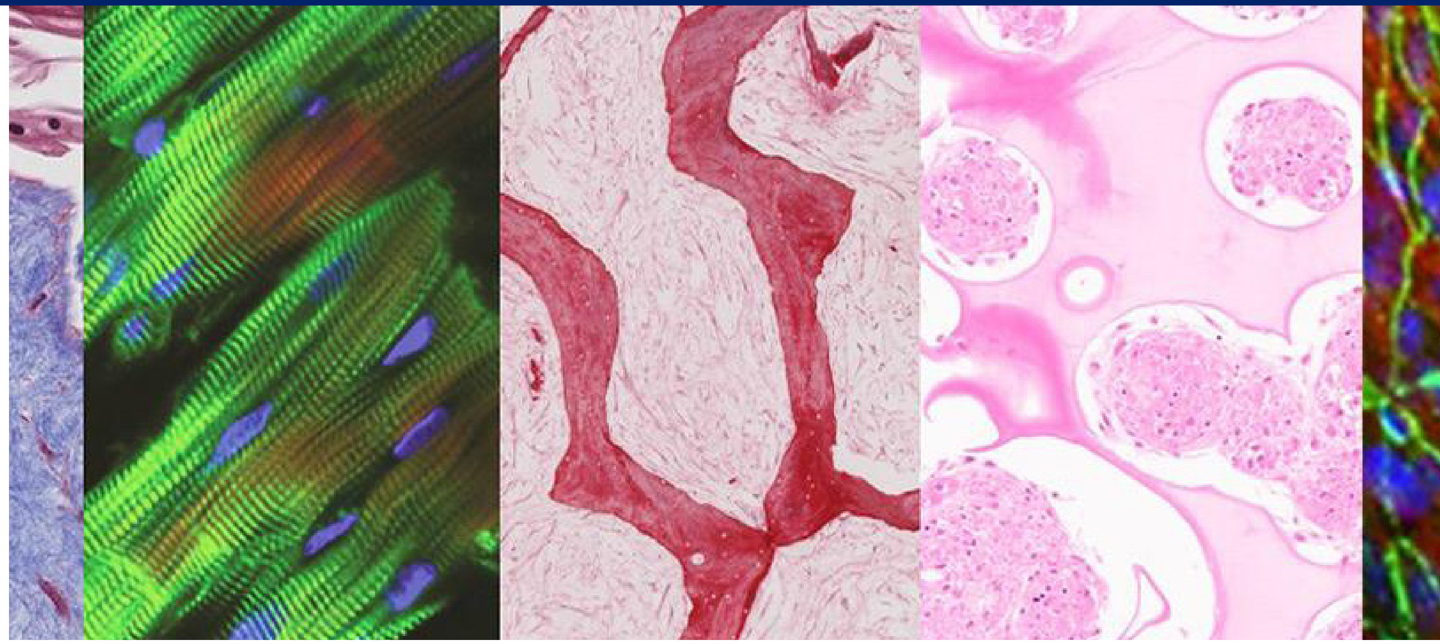
We are conducting a field study in Upper Manhattan to study whether a mobile app can improve the adherence of the public to perform COVID-19 self-testing according to recommended public health guidelines.

Ultra-low Cost UV Sensor for Sterilization and Disinfection Monitoring (Renewal)

Ioannis Kymissis, Professor, Electrical Engineering (Engineering)
Elizabeth Hillman, Professor, Biomedical Engineering (Engineering)

UV sterilization has emerged as a leading strategy for disinfection of spaces, air, and objects in the environment; but advanced sensors are required to measure the dose in a spectrally selective manner to ensure both safety and adequate sterilization. In this project, we will develop a new generation of low cost UV sensors with spectral selectivity for integration with UV sterilization lamps, systems, and monitors.

> **"It's clear we need a broad range of innovations as we emerge from an extraordinarily difficult time, and bringing together the best minds in New York City and at Columbia can only lead to exciting, innovative solutions.** —SHIH-FU CHANG
> INTERIM DEAN, COLUMBIA ENGINEERING



Tissues cultured in the multi-organ chip (from left to right: skin, heart, bone, liver, and endothelial barrier) maintained their tissue-specific structure and function after being linked by vascular flow. Photo credit: Kacey Ronaldson-Bouchard/Columbia Engineering

Plug-and-Play Organ-on-a-Chip Can Be Customized to the Patient

Major advance from Columbia Engineering team demonstrates first multi-organ chip made of engineered human tissues linked by vascular flow for improved modeling of systemic diseases

By Holly Evarts

Engineered tissues have become a critical component for modeling diseases and testing the efficacy and safety of drugs in a human context. A major challenge for researchers has been how to model body functions and systemic diseases with multiple engineered tissues that can physiologically communicate—just like they do in the body. However, it is essential to provide each engineered tissue with its own environment so that the specific tissue phenotypes can be maintained for weeks to months, as required for biological and biomedical studies. Making the challenge even more complex is the necessity of linking the tissue modules together to facilitate their physiological communication, which is required for modeling conditions that involve more than one organ system, without sacrificing the individual engineered tissue environments.

Up to now, no one has been able to meet both conditions. Today, a team of researchers from Columbia Engineering and Columbia University Irving Medical Center reports that they have developed a model of human physiology in the form of a multi-organ chip consisting of engineered human heart, bone, liver, and skin that are linked by vascular flow with circulating immune cells, to allow recapitulation of interdependent organ functions. The researchers have essentially created a plug-and-play multi-organ chip, which is the size of a microscope slide, that can be customized to the patient. Because disease progression and responses to treatment vary greatly from one person to another, such a chip will eventually enable personalized optimization of therapy for each patient. The study is the cover story of the April 2022 issue of Nature Biomedical Engineering.

"This is a huge achievement for us—we've spent ten years running hundreds of experiments, exploring innumerable great ideas, and building many prototypes, and now at last we've developed this platform that successfully captures the biology of organ interactions in the body," said the project leader Gordana Vunjak-Novakovic, University Professor and the Mikati Foundation Professor of Biomedical Engineering, Medical Sciences, and Dental Medicine.

Taking inspiration from how the human body works, the team has built a human tissue-chip system in which they linked matured heart, liver, bone, and skin tissue modules by recirculating vascular flow, allowing for interdependent organs to communicate just as they do in the human body. The researchers chose these tissues because they have distinctly different embryonic origins, structural and functional properties, and are adversely affected by cancer treatment drugs, presenting a rigorous test of the proposed approach.

"Providing communication between tissues while preserving their individual phenotypes has been a major challenge," said Kacey Ronaldson-Bouchard, the study's lead author and an associate research scientist in Vunjak-Novakovic's Laboratory for Stem Cells and Tissue Engineering. "Because we focus on using patient-derived tissue models we must individually mature each tissue so that it functions in a way that mimics responses you would see in the patient, and we don't want to sacrifice this advanced functionality when connecting multiple tissues. In the body, each organ maintains its own environment, while interacting with other organs by vascular flow carrying circulating cells and bioactive factors. So we chose to connect the tissues by vascular circulation, while preserving each individual tissue niche that is necessary to maintain its biological fidelity, mimicking the way that our organs are connected within the body."

> **"This is a huge achievement for us—we've spent ten years running hundreds of experiments, exploring innumerable great ideas**
>
> **—PROFESSOR VUNJAK-NOVAKOVIC**

The group created tissue modules, each within its optimized environment and separated them from the common vascular flow by a selectively permeable endothelial barrier. The individual tissue environments were able to communicate across the endothelial barriers and via vascular circulation. The researchers also introduced into the vascular circulation the monocytes giving rise to macrophages, because of their important roles in directing tissue responses to injury, disease, and therapeutic outcomes.

All tissues were derived from the same line of human induced pluripotent stem cells (iPSC), obtained from a small sample of blood, in order to demonstrate the ability for individualized, patient-specific studies. And, to prove the model can be used for long-term studies, the team maintained the tissues, which had already been grown and matured for four to six weeks, for an additional four weeks, after they were linked by vascular perfusion.

The researchers also wanted to demonstrate how the model could be used for studies of an important systemic condition in a human context and chose to examine the adverse effects of anticancer drugs. They investigated the effects of doxorubicin—a broadly used anticancer drug—on heart, liver, bone, skin, and vasculature. They showed that the measured effects recapitulated those reported from clinical studies of cancer therapy using the same drug.

The team developed in parallel a novel computational model of the multi-organ chip for mathematical simulations of drug's absorption, distribution, metabolism, and secretion. This model correctly predicted doxorubicin's metabolism into doxorubicinol and its diffusion into the chip. The combination of the multi-organ chip with computational methodology in future studies of pharmacokinetics and pharmacodynamics of other drugs provides an improved basis for preclinical to clinical extrapolation, with improvements in the drug development pipeline.

"While doing that, we were also able to identify some early molecular markers of cardiotoxicity, the main side-effect that limits the broad use of the drug. Most notably, the multi-organ chip predicted precisely the cardiotoxicity and cardiomyopathy that often require clinicians to decrease therapeutic dosages of doxorubicin or even to stop the therapy," said Vunjak-Novakovic.

The development of the multi-organ chip began from a platform with the heart, liver, and vasculature, nicknamed the HeLiVa platform. As is always the case with Vunjak-Novakovic's biomedical research, collaborations were critical for completing the work. These include the collective talent of her laboratory, Andrea Califano and his systems biology team (Columbia University), Christopher S. Chen (Boston University) and Karen K. Hirschi (University of Virginia) with their expertise in vascular biology and engineering, Angela M. Christiano and her skin research team (Columbia University), Rajesh K. Soni of the Proteomics Core at Columbia University, and the computational modeling support of the team at CFD Research Corporation.

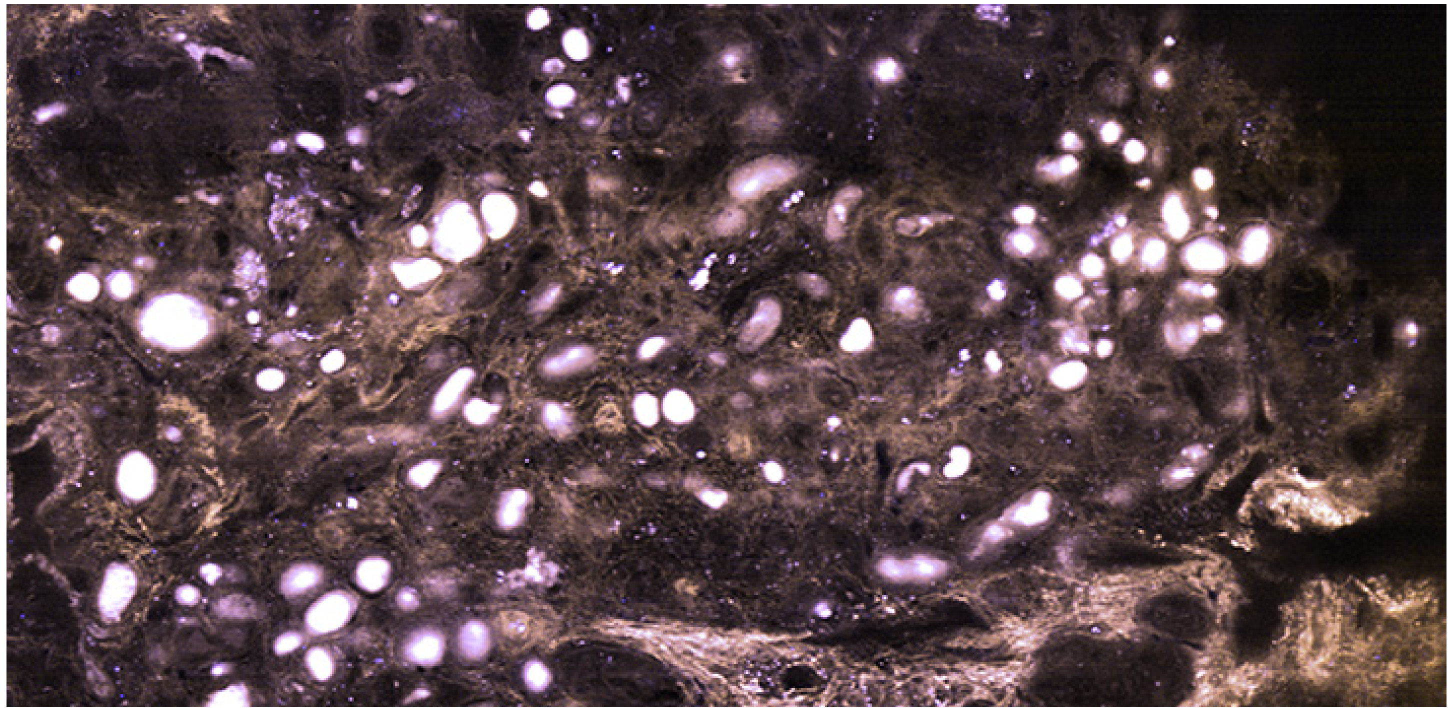
The research team is currently using variations of this chip to study, all in individualized patient-specific contexts: breast cancer metastasis; prostate cancer metastasis; leukemia; effects of radiation on human tissues; the effects of SARS-CoV-2 on heart, lung, and vasculature; the effects of ischemia on the heart and brain; and the safety and effectiveness of drugs. The group is also developing a user-friendly standardized chip for both academic and clinical laboratories, to help utilize its full potential for advancing biological and medical studies.

Vunjak-Novakovic added, "After ten years of research on organs-on-chips, we still find it amazing that we can model a patient's physiology by connecting millimeter-sized tissues—the beating heart muscle, the metabolizing liver, and the functioning skin and bone that are grown from the patient's cells. We are excited about the potential of this approach. It's uniquely designed for studies of systemic conditions associated with injury or disease, and will enable us to maintain the biological properties of engineered human tissues along with their communication. One patient at a time, from inflammation to cancer!"

New Technology Could Make Biopsies a Thing of the Past

MediSCAPE, a high-speed 3D microscope designed by Columbia Engineers, can see real-time cellular detail in living tissues to guide surgery, speed up tissue analyses, and improve treatments.

By Holly Evarts



A Columbia Engineering team has developed a technology that could replace conventional biopsies and histology with real-time imaging within the living body. Described in a new paper published today in Nature Biomedical Engineering, MediSCAPE is a high-speed 3D microscope capable of capturing images of tissue structures that could guide surgeons to navigate tumors and their boundaries without needing to remove tissues and wait for pathology results.

For many medical procedures, particularly cancer surgery and screening, it is common for doctors to take a biopsy, cutting out small pieces of tissue to be able to take a closer look at them with a microscope. "The way that biopsy samples are processed hasn't changed in 100 years, they are cut out, fixed, embedded, sliced, stained with dyes, positioned on a glass slide, and viewed by a pathologist using a simple microscope. This is why it can take days to hear news back about your diagnosis after a biopsy," says Elizabeth Hillman, professor of biomedical engineering and radiology at Columbia University and senior author of the study.

Hillman's group dreamed of a bold alternative, wondering whether they could capture images of the tissue while it is still within the body. "Such a technology could give a doctor real-time feedback about what type of tissue they are looking at without the long wait," she explains. "This instant answer would let them make informed decisions about how best to cut out a tumor and ensure there is none left behind."

Another major benefit of the approach is that cutting tissue out, just to figure out what it is, is a hard decision for doctors, especially for precious tissues such as the brain, spinal cord, nerves, the eye, and areas of the face. This means that doctors can miss important areas of disease. "Because we can image the living tissue, without cutting it out, we hope that MediSCAPE will make those decisions a thing of the past," says Hillman.

Although some microscopes for surgical guidance are already available, they only give doctors an image of a small, single 2D plane, making it difficult to quickly survey larger areas of tissue and interpret results.

These microscopes also generally require a fluorescent dye to be injected into the patient, which takes time and can limit their use for certain patients.

Over the past decade, Hillman, who is also Herbert and Florence Irving Professor at Columbia's Zuckerman Mind Brain Behavior Institute, has been developing new kinds of microscopes for neuroscience research that can capture very fast 3D images of living samples like tiny worms, fish, and flies to see how neurons throughout their brains and bodies fire when they move. The team decided to test whether their technology, termed SCAPE (for Swept Confocally Aligned Planar Excitation microscopy) could see anything useful in tissues from other parts of the body.

"One of the first tissues we looked at was fresh mouse kidney, and we were stunned to see gorgeous structures that looked a lot like what you get with standard histology," says Kripa Patel, a recent PhD graduate from the Hillman lab and lead author of the study. "Most importantly, we didn't add any dyes to the mouse —everything we saw was natural fluorescence in the tissue that is usually too weak to see. Our microscope is so efficient that we could see these weak signals well, even though we were also imaging whole 3D volumes at speeds fast enough to rove around in real time, scanning different areas of the tissue as if we were holding a flashlight."

"Hillman's group dreamed of a bold alternative, wondering whether they could capture images of the tissue while it is still within the body."

As she "roved around," Patel could even stitch together the acquired volumes and turn the data into large 3D representations of the tissue that a pathologist could examine as if it were a full box of histology slides.

"This was something I didn't expect -- that I could actually look at structures in 3D from different angles," says collaborator Dr. Shana Coley, a renal pathologist at Columbia University Medical Center who collaborated closely on the study. "We found many examples where we would not have been able to identify a structure from a 2D section on a histology slide, but in 3D we could clearly see its shape. In renal pathology in particular, where we routinely work with very limited amounts of tissue, the more information we can derive from the sample, the better for delivering more effective patient care."

The team demonstrated the power of MediSCAPE for a wide range of applications, from analysis of pancreatic cancer in a mouse, to Coley's interest in non-destructive, rapid evaluation of human transplant organs such as kidneys. Coley helped the team get fresh samples from human kidneys to prove that MediSCAPE could see telltale signs of kidney disease that matched well to conventional histology images.

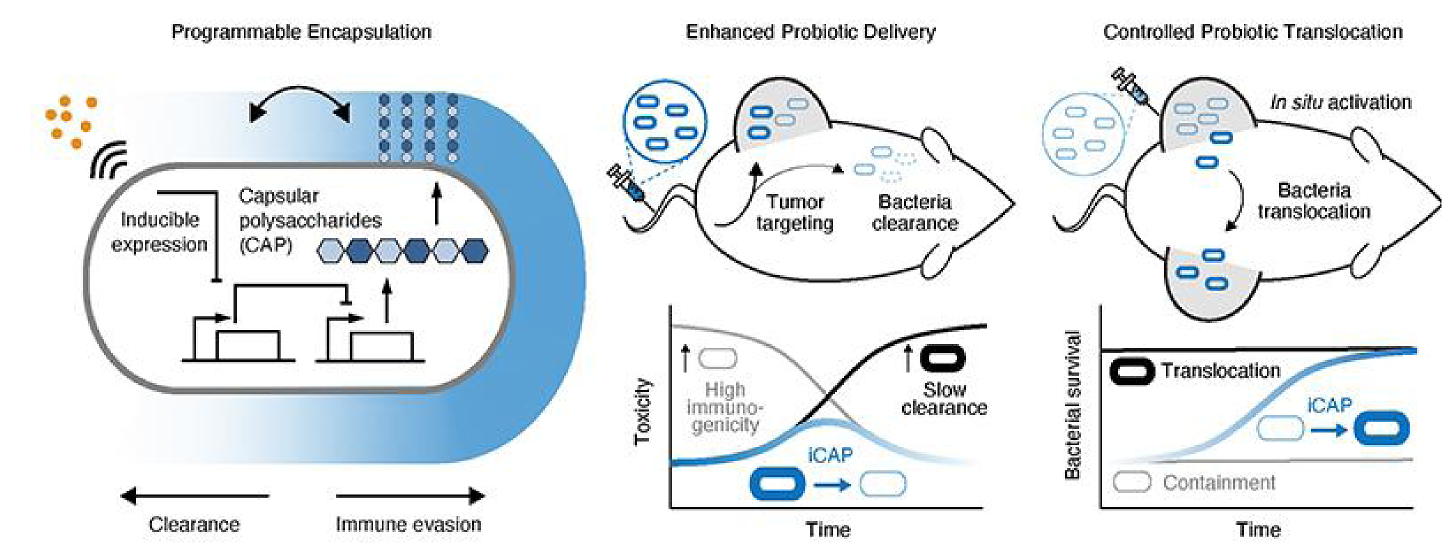
The team also realized that by imaging tissues while they are alive in the body, they could get even more information than from lifeless excised biopsies. They found that they could actually visualize blood flow through tissues, and see the cellular-level effects of ischemia and reperfusion (cutting off the blood supply to the kidney and then letting it flow back in).

"Understanding whether tissues are staying healthy and getting good blood supply during surgical procedures is really important," says Hillman. "We also realized that if we don't have to remove (and kill) tissues to look at them, we can find many more uses for MediSCAPE, even to answer simple questions such as 'what tissue is this?' or to navigate around precious nerves. Both of these applications are really important for robotic and laparoscopic surgeries where surgeons are more limited in their ability to identify and interact with tissues directly."

A critical final step for the team was to reduce the large format of the standard SCAPE microscopes in Hillman's lab to something that would fit into an operating room and could be used by a surgeon in the human body. Post-doctoral fellow Wenxuan Liang worked with the team to develop a smaller version of the system with a better form factor, and a sterile imaging cap. PhD candidate Malte Casper helped to acquire the team's first demonstration of MediSCAPE in a living human, collecting images of a range of tissues in and around the mouth. These results included rapidly imaging while a volunteer literally licked the end of the imaging probe, producing detailed 3D views of the papillae of the tongue.

Eager to take this technology to the next level with a larger clinical trial, the team is currently working on commercialization and FDA approval. Hillman adds, "We are just so amazed to see what MediSCAPE reveals every time we use it on a new tissue, and especially that we barely ever even needed to add dyes or stains to see structures that pathologists can recognize."

Hillman and her team hope that MediSCAPE will make standard histology a thing of the past, putting the power of real-time histology and decision making into the surgeon's hands.



Schematics of the inducible capsular polysaccharides (iCAP) system to control immune evasion and clearance (left). The iCAP system enhances systemic delivery of bacteria by transiently encapsulating bacteria. Non-CAP bacteria (thin gray cells) lead to toxicity by exposing bacterial surface for immune detection, and permanently CAP-expressing bacteria (thick black cells) lead to over-protection. The iCAP (blue cells) system reduces initial inflammation while effectively clearing bacteria over time (middle). The iCAP system controls bacterial translocation between tumors by activating an encapsulation system within one tumor which results in bacteria migration to uncolonized tumors at different locations (right) (Tetsuhiro Harimoto, Jaeseung Hahn, Kam Leong, and Tal Danino/Columbia Engineering)

Engineering an "Invisible Cloak" for Bacteria to Deliver Cancer Drugs

Novel microbial encapsulation system for therapeutic bacteria enables more effective delivery, shown to kill cancer cells in mice

Columbia Engineering researchers report that they have developed a "cloaking" system that temporarily hides therapeutic bacteria from immune systems, enabling them to more effectively deliver drugs to tumors and kill cancer cells in mice. By manipulating the microbes' DNA, they programmed gene circuits that control the bacteria surface, building a molecular "cloak'' that encapsulates the bacteria.

"What's really exciting about this work is that we are able to dynamically control the system," said Tal Danino, associate professor of biomedical engineering, who co-led the study in collaboration with Kam Leong, Samuel H. Sheng Professor of Biomedical Engineering. "We can regulate the time that bacteria survive in human blood, and increase the maximum tolerable dose of bacteria. We also showed our system opens up a new bacteria delivery strategy in which we can inject bacteria to one accessible tumor, and have them controllably migrate to distal tumors such as metastases, cancer cells that spread to other parts of the body."

For the study published today by Nature Biotechnology, the researchers focused on capsular polysaccharides (CAP), sugar polymers that coat bacterial surfaces. In nature, CAP helps many bacteria to protect themselves from attacks including immune systems. "We hijacked the CAP system of a probiotic E. coli strain Nissle 1917," said Tetsuhiro Harimoto, a PhD student in Danino's lab who is the study's co-lead author. "With CAP, these bacteria can temporarily evade immune attack; without CAP, they lose their encapsulation protection and can be cleared out in the body. So we decided to try to build an effective on/off switch."

To do this, the researchers engineered a new CAP system, which they call inducible CAP, or iCAP. They control the iCAP system by giving it an external cue--a small molecule called IPTG--that allows for programmable and dynamic alteration of the E. coli cell surface. Because iCAP alters bacterial interactions with immune systems (such as blood clearance and phagocytosis) in a directed manner, the team found that they could control the time

to which bacteria can survive in human blood, by tuning how much IPTG they give to the iCAP E. coli. In effect, they created an "on/off" switch that controls how the immune system responds to their therapeutic bacteria.

While using bacteria for therapy is a new, alternative approach to treating a broad array of cancers, there are a number of challenges, in particular, their toxicity. Unlike many traditional drugs, these bacteria are alive and can proliferate within the body. They are also detected by the body's immune systems as foreign and dangerous, causing high inflammatory response--too much bacteria means high toxicity due to over-inflammation--or rapid bacteria elimination--too little bacteria means no therapeutic efficacy.

Jaeseung Hahn, a postdoctoral research scientist in Danino and Leong's labs who co-led the project, noted, "In clinical trials, these toxicities have been shown to be the critical problem, limiting the amount we can dose bacteria and compromising efficacy. Some trials had to be terminated due to severe toxicity."

The ideal bacteria should be able to evade the immune system upon entry to the body, and efficiently get to the tumor. And once they are in the tumor, they need to be eliminated in other parts of the body to minimize toxicity. The team used mouse tumor models to demonstrate that, through iCAP, they could increase the maximum tolerable dose of bacteria 10 times. They encapsulated the E. coli strain to enable it to evade the immune system and get to the tumor. Because they did not give IPTG in the body, the E. coli iCAP lost its encapsulation over time, and was easier to be eliminated in other parts of the body, thus minimizing toxicity.

To test efficacy, the researchers then engineered E. coli iCAP to produce an antitumor toxin and were able to shrink tumor growth in colorectal and breast cancer mouse models more so than in the control group without the iCAP system.

The team also demonstrated controllable bacterial migration within the body. Past studies have shown that low levels of bacteria leak out from tumors upon tumor growth. For this new study, the Columbia team used iCAP to show that they can control bacterial leakage from a tumor, as well as their translocation to other tumors. They injected E. coli iCAP into one tumor, fed the mice with water containing IPTG, activated iCAP within a tumor, and saw E. coli iCAP leak out and migrate to uninjected tumors.

The group is exploring a range of research areas. There are more than 80 different types of CAP that exist just for E. coli and even more for other bacteria species that could be engineered using similar approaches. In addition, CAP is not the only molecule that bacteria have on their surface, and other surface molecules could be controlled in a similar fashion. Additionally, while iCAP is controlled by an externally provided IPTG in this example, other control systems such as biosensors could be used to autonomously control surface properties of therapeutic bacteria.

The team, also affiliated with Columbia's Herbert Irving Comprehensive Cancer Center and Data Science Institute, notes that clinical translation is the next major challenge they would like to tackle. "While there is a good deal of laboratory research showing various ways to engineer microbes, it is very difficult to apply these powerful therapies to a complex animal or human body. We've shown proof of concept in mouse models, but given that humans are 250 times more sensitive to bacterial endotoxins than mice, we expect our results may have an even bigger effect on human patients than on mice," said Harimoto.

Leong added, "Bacterial cancer therapy holds unique advantages over conventional drug therapy, such as efficient targeting of the tumor tissue and programmable drug release. Potential toxicity has been limiting its full potential. The cloaking approach presented in this study may address this critical issue."

Probiotic bacteria (E. coli Nissle 1917 strain, green) is engineered to controllably evade immune system (macrophage, transparent) using a genetically encoded encapsulation system (capsular polysaccharides with circuit board, shown as transparent coating surrounding the bacterial cells). This system was used to enhance delivery of therapeutic bacteria for cancer therapy. (Ella Marushchenko, Alex Tokarev, Danino Lab/Columbia Engineering)

Elham Azizi Receives a Provost's Grant

Elham Azizi, Assistant Professor of Biomedical Engineering and Herbert and Florence Irving Assistant Professor of Cancer Data Research, was among the Fall 2021 awardees of the Provost's Grants Program for Junior Faculty who Contribute to the Diversity Goals of the University. The program is designed to support Schools' diversity plans, by advancing the career success of outstanding junior faculty who contribute to the diversity goals of the University by their research, teaching, and mentoring activities. She was awarded a grant for her project titled "Machine Learning for Characterizing Spatial Dynamics in Tumor Tissues."

Profs. Hendon and Lu Awarded Provost Seed Grant: In these Hallowed Halls - Alumni Showcase Project

Christine Hendon, Associate Professor of Electrical Engineering, and Helen Lu, Percy K. and Vida L.W. Hudson Professor of Biomedical Engineering and Senior Vice Dean of Faculty Affairs and Advancement, have been awarded a seed grant for their project "IN THESE HALLOWED HALLS - ALUMNI SHOWCASE PROJECT."

The goal of this work is to highlight the diversity of the Columbia Engineering alumni community. The first is the development of a website designed to showcase the diversity of engineering students that have long been a part of the Columbia Engineering community. This will be a dedicated page that archives the histories of Black and Latino/a identifying alumni through historical and firsthand accounts. The second is a keynote event that brings alumni of color to campus to share their narratives with the current Columbia community in order to bridge relationships and ties through a shared common experience.

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.

Christine Hendon, Electrical Engineering; Helen Lu, Biomedical Engineering

Treena Livingston Arinzeh
Professor, Biomedical Engineering
Tissue engineering and biomaterials. Stem cell biology. Bone engineering.

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

Lauren Heckelman
Senior Lecturer in the Discipline of Biomedical Engineering, Department of Biomedical Engineering
Engineering education. Medical imaging. Orthopaedic biomechanics. Image and signal processing.

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, Director of Master's Studies
Professor of Biomedical Engineering & Orthopaedic 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, Chair of Diversity, Equity & Inclusion *Robert and Margaret Hariri Professor, Biomedical Engineering & Radiology (Physics); Director, Ultrasound Elasticity Imaging Laboratory* | Elasticity imaging. Therapeutic ultrasound. Soft tissue mechanics.

Andrew F. 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, Vice Dean of Faculty Affairs and Advancement
Percy K. and Vida L.W. Hudson Professor, Biomedical Engineering; Director, Biomaterials & Interface Tissue Engineering Laboratory | Interface tissue engineering.

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

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

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.

Paul Sajda, Vice Chair *and Vikram S. Pandit Professor of Biomedical Engineering; Professor of Electrical Engineering and 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).

Sanja Vickovic
Assistant Professor of Biomedical Engineering; Director, Technology Innovation Lab, New York Genome Center
Spatial transcriptomics, computational biology, machine learning, genomics, cancer biology, and aging.

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.

Outstanding BME Students Honored - 2022

by Alexis Newman

On May 16, 2022, Columbia Engineering students, deans, faculty, staff, parents, friends, and alumni gathered in person for Class Day to celebrate the accomplishments of outstanding students. Among the honorees were three undergraduate and four graduate students in Biomedical Engineering. We also honor twenty undergraduate senior designers who placed in the top four teams at Columbia BME's Senior Celebration on May 14, as well as twelve MS student designers who placed in the top two teams at the MS Biomedical Design & Innovation Awards on May 5.

GRADUATE STUDENT CLASS DAY AWARDS

- **Timothy Jacobsen & Meghan Pinezich** Yuen-huo Hung and Chao-chin Huang Award in Biomedical Engineering ("The Grandparents' Award")
- **Kaveri Thakoor** Morton B. Friedman Memorial Prize for Excellence (School level award)
- **Mona Ziaei** Outstanding Achievement Award in Biomedical Engineering Master's Studies

UNDERGRADUATE STUDENT CLASS DAY AWARDS

- **Hannah Ballard** Claire S. and Robert E. Reiss Prize
- **Özgenur Çelik** King's Crown Leadership & Excellence Award: Health & Wellness (University level award)
- **Amy MiHyun Jang** Richard Skalak Memorial Prize

MS BIOMEDICAL DESIGN & INNOVATION AWARDS

- **Team IRLy - SSI detection** - Best Innovation. *Design Team Members: Deema Abdel-Meguid, Albert Go, Samantha Botros, Erica Kreisberg, Justin Freeman, Wendy Shi*
- **Team Neurobis - Stroke detection** - Best Business Strategy. *Design Team Members: Alexandros Drivas, Mickael Elhaik, Tim Lantin, Xuanbao Li, Selma Marrakchi, Lauren Sekiguchi*

SENIOR DESIGN AWARDS

- **Team Cerv** 1st Place, BME 2022 Senior Design Award. *Design Team Members: Kiarra Lavache, Aala Nasir, Emme Pogue, Joyce Liu, Hannah Ballard*
- **Team CAUTIcare** Runner Up, BME 2022 Senior Design Award. *Design Team Members: Özgenur Çelik, Michaela O'Donnell, Neil Kennedy, Emma Glajchen, Prithi Chakrapani*
- **Team Stabilitek** Runner Up, BME 2022 Senior Design Award. *Design Team Members: Shivanni Ramdass, Adi Shastry, Liz Thomas, Micah Woodard, Erik Emsbo*
- **Team Luma** Best Pitch, BME 2022 Senior Design Award. *Design Team Members: Pavin Sethbhakdi, Jui Buamahakul, Justin Saintil, Leanne Pichay, Joanne Wang*

11 Engineering Students Win 2022 NSF Graduate Research Fellowships

by Allison Chen

Top row (L-R): Cole James Allan '21, Christine Ye Shu Blackshaw '21, Sarah Hancock '21, Ayah Hassan '18. Middle row (L-R): Joseph T. Lee '21, Isabella Leite '22, Kaylo Littlejohn '20. Bottom row (L-R): Anushka Murthy '22, Amey Praveen Pasarkar '22, Yongpeng Tang '18, Miranda Wang '22.

Eleven students from all nine departments of the School have won 2022 National Science Foundation (NSF) Graduate Research Fellowships. The fellowships were awarded by the NSF Graduate Research Fellowship Program (NSF GRFP), the oldest graduate fellowship of its kind.

The program recognizes and supports outstanding graduate students in NSF-supported science, technology, engineering, and mathematics disciplines who are pursuing research-based master's and doctoral degrees at accredited United States institutions.

Fellows are awarded a three-year annual stipend of $34,000 and a $12,000 education allowance paid to their chosen institution. Past fellows include many Nobel Prize winners, Google founder Sergey Brin, and Freakonomics co-author, Steven Levitt.

The Engineering cohort includes:

Cole James Allan '21

Cole James Allan received his BS from Columbia in mechanical engineering in 2021. While at Columbia, he performed research on myosin networks and their roles in morphogenesis in Professor Karen Kasza's Living Materials laboratory.

Christine Ye Shu Blackshaw '21

Christine Blackshaw received her BS in civil engineering and a minor in earth and environmental engineering from Columbia in 2021. She worked with civil engineering faculty, including Professor George Deodatis on modeling hurricane induced flooding in NYC's subway system and Professor Marco Giometto on incorporating urban trees into computational fluid dynamics (CFD) simulations. She is currently a first year PhD student at Princeton in the civil and environmental engineering department.

(continued)

Sarah Hancock '21

Sarah Hancock received her BS in computer science from Columbia in 2021. She is currently a PhD student at Harvard University in the atmospheric chemistry modeling group in the Department of Environmental Science and Engineering.

Ayah Hassan '18

Ayah Hassan received a BS degree in chemical engineering with a minor in sustainable engineering from Columbia in 2018. While at Columbia, she performed research in Professor V.Faye McNeill's laboratory, which focuses on research relating to atmospheric chemistry, air quality, and atmospheric aerosols. She is currently a senior air quality consultant for Ramboll.

Joseph T. Lee '21

Joseph T. Lee received his BS degree in applied physics from Columbia in 2021, where he is currently pursuing his PhD in physics.

Isabella Leite '22

Isabella Leite is currently an undergraduate senior studying biomedical engineering and minoring in applied mathematics. While at Columbia, she performed research in the Laboratory of Synthetic Human Organogenesis under Professor Mijo Simunovic.

Kaylo Littlejohn '20

Kaylo Littlejohn received his BS in electrical engineering from Columbia in 2020. While at Columbia, he worked under the direction of Dr. Paul Sajda, where he created virtual reality 3D environments and image processing software for non-invasive brain machine interface experiments. He is currently a PhD student in the electrical engineering and computer sciences at University of California–Berkeley.

Anushka Murthy '22

Anushka Murthy is currently an undergraduate senior studying applied mathematics. Her research focus is in probability theory and its connections with analysis and discrete math. At Columbia, she did an integrable probability research project in the mathematics department with Evgeni Dimitrov, where they studied the one point marginals for the height function of ASEP started from half-flat initial conditions. She will begin her PhD studies in mathematics at Stanford this fall.

Amey Praveen Pasarkar '22

Amey Praveen Pasarkar is currently an undergraduate senior studying operations research. While at Columbia, he worked with Professor Itsik Pe'er in the Department of Computer Science on using machine learning methods to understand the complexities of the microbiome.

Yongpeng Tang '18

Yongpeng Tang received his BS in operations research from Columbia in 2018. He is currently pursuing his PhD in industrial engineering at the University of Southern California. His research interests include optimization and causal inference.

Miranda Wang '22

Miranda Wang is currently an undergraduate senior studying biomedical engineering. Her interests include tissue engineering, biotechnology, and synthetic biology.

STUDENT SPOTLIGHT

9 Columbia BME Teams Participate in 2022 Senior Design Expo

By Alexis Jaya Hutchinson | Professional Photography by Timothy Lee Photographers; Video Stills by Jane Nisselson; Additional Photography by Columbia BME Staff; Graphics by Columbia BME Student Teams

On May 5th, over forty projects completed by teams across the School of Engineering were presented at the 9th Annual Senior Design Expo, an opportunity for students to highlight their innovative and fresh approaches to complex issues through design.

This year, nine teams represented the Department of Biomedical Engineering with their unique and helpful projects spanning from jaw alignment to fall risk detection devices. Here are some highlights of the projects our seniors presented at the expo:

NeuroNotice

Golda Daphna, Luis Muncharaz Duran, Kalsoum Mbacke, Rhea Sablani, Elaine Tan

To create a more affordable and accessible device for testing peripheral neuropathy, this team created NeuroNotice, a device worn on the foot that uses random stimulation to track loss of sensation indicative of peripheral neuropathy.

deSTIgma: A Digital STI Test Recommendation Platform

Susanna Baek, Katharyn Fatehi, Andy Garcia, Vivian Shi, Ruxandra Tonea

Despite our growing knowledge of Sexually Transmitted Infections (STIs), this team notes a lack of accessibility, education, and stigma as one of the reasons for increasing infection rates. The deSTIgma STI Test Recommendation Digital Platform combats this by using comprehensive and relevant patient information to provide test recommendations, clinic maps, and educational resources.

budDLS: Buddy for Daily Living Skills

Kaitlin Abrantes, Amy Jang, Hyunjee Lim, Kelly Pu, Joa Yun

For children with Autism Spectrum Disorder (ASD), learning daily living skills (DLSs) may be accompanied by some difficulties. This team produced the budDLS which uses a multimodal solution to enhance independence for tasks requiring hygienic liquids.

LUMA

Jui Buamahakul, Leanne Pichay, Justin Saintil, Pavin Sethbhakdi, Joanne W. Wang

Due to the use of NaOCl to sterilize the tooth canal following a root canal procedure, NaOCl's cytotoxicity produces limitations that could lead to a reinfection rate of 35%. To combat that, this team created Luma, a device that uses photodynamic therapy to disinfect without adverse effects, providing an elimination of 97% of bacteria that can cause reinfection.

(continued)

CAUTIcare

Özgenur Çelik, Michaela O'Donnell, Neil Kennedy, Prithi Chakrapani, Emma Glajchen

Catheter-associated urinary tract infections (CAUTIs) are expensive and deadly infections that oftentimes do not have proper testing protocols due to time and resource limitations. With CAUTIcare, patients will have access to urine turbidity testing which could prompt the early detection of CAUTIs.

JawLign

Joshua Fuller, Isabella Leite, Joseph Borison, Yeji Cho, Miranda Wang

To limit relapse rates following jaw surgery, this team has created JawLign, a platform which allows for early relapse detection through the personalized tracking of jaw positioning by using dental impression imaging as a guide.

SleepSense

Keni Chen, Eileen Choi, Olimpia Gavaudan, Michelle Kim, Michael White

Excessive Daytime Sleepiness (EDS) can be both fatal and life-altering. This team created SleepSense to track fatigue and uncontrolled sleeping as well as alert the user when fatigue is detected.

CERV

Hannah Ballard, Aala Nasir, Kiarra Lavache, Joyce Liu, Emme Pogue

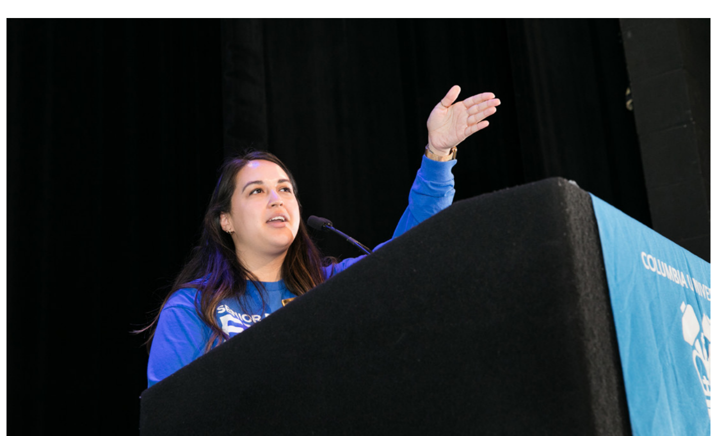
With cervical softening as an indicator for cervical sufficiency, which is a contributing factor in preterm birth rates, CERV is an accessible and affordable biomechanical device which measures cervical stiffness to allow patients to measure their risk for preterm birth.

Stabilitek

Erik Emsbo, Shivanni Ramdass, Adi Shastry, Elizabeth Thomas, Micah Woodard

To lower the rates of injury death by fall for the geriatric population, this team created Stabilitek which measures fall risk using motion sensing insoles.

We are so proud of each team. They were dedicated to this work and produced exceptional projects that we hope to see come to fruition in the near future.



COLUMBIA BME BLAZE

Monthly Blog Highlights Exceptional Columbia BME Students and Alumni

In our monthly spotlight blog, get to know the alumni and students of Columbia's Department of Biomedical Engineering. Read what our BME folks are up to, from our labs' latest research, to our students' plans for the future, to our teams' innovations, start-ups and other career successes.

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

COLUMBIA BME BLAZE

August 2022 - BME Blaze: Bunmi Fariyike

Bunmi Fariyike

Education

- **B.S. Biomedical Engineering, Minor in Hispanic Studies, 2020, Columbia University**
- **Entering MD Class of 2021, Stanford University School of Medicine**

Where are you from?

I was born and raised in the suburbs of Atlanta, GA, but I am a proud Nigerian-American, and I have always considered Nigeria a second home.

What is your current role?

I just finished my first year of medical school at Stanford. This summer, I have the honor and pleasure of spending two months in ColOmbia (yes, many people thought I meant I was coming back to ColUmbia) working in a neurotrauma center to understand how care is delivered in different parts of the world while simultaneously conducting research on neurotrauma devices with the goal of improving access to neurosurgical care in developing nations.

What drew you to the field of Biomedical Engineering?

My interest in engineering began with my incredible AP Physics teacher in high school, Dr. Casey Jones. For the first time, I found myself engaged in math as a tool for first understanding and then improving the world around us. Coming from a Nigerian-American background, my interest in addressing healthcare disparities began at a young age as I grappled with just how different my access to healthcare was from that of my extended family back in Nigeria. In AP Physics, I literally discovered engineering as an academic discipline and, more importantly, as a means for specifically serving communities like mine that are often left on the periphery of innovation. To me, biomedical engineering seemed like the perfect foundation for the career I hope to spend thinking about how we design and redesign healthcare technology for the unique strengths and constraints of developing nations and underserved communities.

Why did you choose Columbia BME?

I was drawn to Columbia BME because I felt that Columbia was an environment where pursuing engineering would not be at the exclusion of my other interests. As a student, I was able to learn more about an art than I thought an engineer could ever learn. I got to take English classes and reawaken my love for writing poetry and short stories. I was able to improve my Spanish in the Dominican Republic conducting sexual health research and in Spain becoming the first BME premed to study abroad (many thanks to Sarah Jane for paving the way). I even became a certified bartender along the way!

Apart from all the opportunities that Columbia offered, being connected to New York City as a young person was a life-changing experience. Never in my life have I felt so independent yet so connected to the world around me. I miss the energy of the city every single day. There is nowhere else quite like it.

What were some of your favorite projects/memories from the program?

One of my favorite projects from the program was having to build our own EKG machine in BME Lab. If only I had known then that, in a few short years, someone would be expecting me to interpret what those little squiggles mean.

Taking a shot with Dr. Kyle at the 20th Anniversary celebration, however, is easily my favorite memory overall. It's so easy for us to forget that our professors are real people too, and I am so happy to have shared that brief moment of freedom and fun with everyone in the program just before the pandemic began.

What was your proudest moment at Columbia?

My proudest moment was somehow pulling together our Senior Design project in time despite being in the midst of a global pandemic. There were many moments in which I was sure that we wouldn't have anything to show for all the hours we spent in the Makerspace and the BME Lab, but we ended up with a final product and presentation that we were all very proud of.

How has your experience with Columbia BME contributed towards your goals?

Columbia BME helped me feel like my vision for the world was not only feasible, but also timely and important. I got into engineering precisely because I wanted to engineer for humanity, and to have that mission underscoring everything at the University was incredibly important for developing my vision for changing the world. At Columbia, I not only became a strong engineer, but I was able to situate my education and work in the context of social justice and global health, an intersection that I hope to explore for the rest of my career and life.

What are your thoughts on the strength of Columbia BME's alumni network and how has that influenced your career path?

Even though I now live all the way across the country from Columbia, I still feel so held by our community. At Stanford Medicine, there are two other Columbia BME graduates who have taken their undergraduate education to go on to do amazing things at Stanford (shoutout Blynn and Samuel). Also, when Dr. Kyle was here visiting some professors at Stanford, he emailed me, and we were able to get dinner together. It was a wonderful surprise. The Columbia network is so vast and varied that it somehow finds you wherever you are. I remember once being on vacation in Venice, Italy during undergrad, and I ended up sharing a hostel room with a fellow Columbian!

Any words of wisdom or tips for prospective BME students?

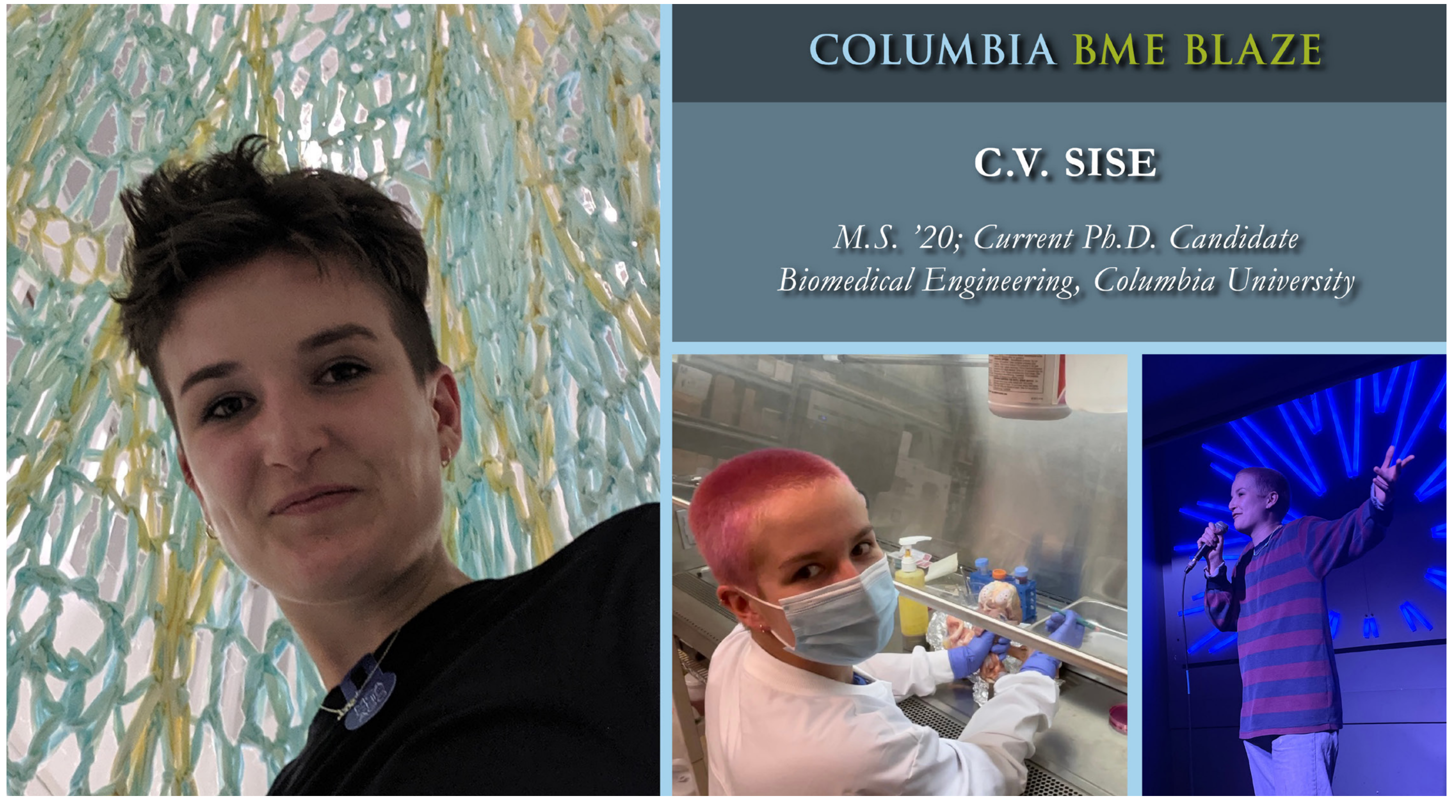
Don't let anyone scare you out of doing BME. It is difficult, and a lot is expected of you. But people who know that BME is for them can feel it, and they don't regret their decision.

What are you excited about?

I am excited about my summer here in Colombia, where I hope to continue to improve on my Spanish fluency while learning from some of the world's leading experts in how to deliver large impact with a small number of resources.

Photos at left, from left to right and top to bottom: Every year, Stanford Medicine hosts Moonlighting, which is affectionately known as "med school prom". This is the Happy Hour before heading downtown for the main event; All of Stanford's Entering MD and PA Classes of 2021 celebrating getting our white coats and stethoscopes; New friends in Colombia; We took advantage of our proximity to Lake Tahoe to go skiing this winter. It was my first and very humbling, to say the least; My younger sister came out to San Francisco to celebrate her graduation from the University of Chicago. We met up in the city and spent the day together; This year, I had the honor of serving as one of Stanford Flu and COVID Crew's Internal Directors. Together, Bel, Mel, and I organized numerous on-campus events in which first-year medical students like us vaccinated over 5,000 members of the Stanford community against the flu; Some of my closest friends and I met up on campus almost a year after virtual graduation to take the graduation photos that we deserved; Stanford's Flu and COVID Crew also does many off-campus events, providing flu and COVID vaccines in areas where vaccine access is low. After spending the day vaccinating farmworkers in the Central Valley, we stopped at Yosemite National Park on the way home.

June 2022 - BME Blaze: C.V. Sise



C.V. Sise

Education

- **Sc.B. – Biomedical Engineering, 2018, Brown University**
- **M.S. – Biomedical Engineering, 2020, Columbia University**
- **M.Phil. – Biomedical Engineering, 2022, Columbia University**
- **Ph.D. Candidate in Biomedical Engineering at Columbia University**

Where are you from?

Upstate New York

What drew you to the field of Biomedical Engineering?

At the beginning of undergrad, I chose to study Biomedical Engineering because I wanted to take a wide variety of science classes across disciplines. What started out as an indecisiveness grew into a love for studying how the body works.

Tell us about your experience at Columbia University.

My experience at Columbia has been largely defined by the people within my department. I've gained many friends and collaborators through my fellow PhD students, and have been grateful to get to know many professors within the department.

Why did you choose Columbia BME?

When choosing among programs, it was important to me to study in a city, so I could find community outside of my workplace. I also do standup comedy in my free time, and NYC has a lot of opportunities for comedians. Most importantly, I work in orthopedics, and Columbia has an impressive presence within the field.

What are some of your favorite projects/memories from the program so far?

My favorite project has also been my main area of research which is working with a femtosecond laser to treat osteoarthritic cartilage. I came to Columbia with no experience in optics or light-tissue interaction, and have been able to take advantage of classes offered by the Physics department to boost my knowledge of the field.

My favorite memories at Columbia have been the late night studying I would do with my friend in my cohort during my first two years. I also have loved the many department events, as it has allowed me to meet professors I would have otherwise not crossed paths with.

What are your proudest moments at Columbia so far?

I feel very proud of my small victories in lab: getting a new experimental protocol to work, getting clear imaging results, finishing up month-long studies. Those little moments (as well as the failures that preceded them) have accumulated and allowed me to grow my confidence as a researcher and scientist.

I'm also proud of my work as a teaching assistant for various classes. Last fall, I stood in for a professor and taught a lecture to 100 students, and it was cool to be on the other side of the lecture podium.

What has been your experience as a member of the LGBTQ+ Community in STEM?

At times, it's very hard to study in a field where so few people are like you, and it can be difficult to navigate presentation and politics in academic settings. I've relied heavily on the support of other LGBTQ+ students, and have been able to network with professors within the community as well.

There are things that need to change at Columbia, and other institutions across the country – people getting my pronouns wrong or making unwanted comments on my appearance, to name a few – but I think there are good people working to make changes here, and I'm hopeful that things will be easier for queer STEM students in the future.

What does Pride Month mean to you?

To me, Pride Month is about spending time with my queer friends who support me throughout the year. It's a time that I reflect and feel grateful for my history and the community I've found in NYC. It's a time I get to celebrate who I am.

Homophobia and transphobia are on the rise globally, and it's scary to see this change happen in real time. For me, Pride is a way to push back against people who tell you to be ashamed of who you are, and a time for allies to be vocal in their support of the LGBTQ+ community.

What advice would you give to others who wish to pursue a degree and/or career in BME?

Make friends who are in your field and collaborate! You can learn so much from people around you, and having a support system within your field is helpful when you're working through the hardest moments. If you're early on in your studies, I would recommend keeping your options open; there are so many beautiful and interesting areas of research within Biomedical Engineering.

Tell us about qSTEM at Columbia.

qSTEM (queer in STEM) is a graduate student organization for LGBTQ+ students and allies. We hold social events, book clubs, and lecture series. Its main goal is to increase community in STEM at Columbia. We're currently looking to boost our visibility and membership, so if you're reading this: please join our mailing list by emailing LGBTQatSEAS@gmail.com.

What are you excited about?

I'm excited about the future! I think there are a great deal of wonderful people who make Columbia a better place and I'm excited to see them thrive.

Photos at left, from left to right: CV at MCA Chicago on a lab trip, CV doing a sterile dissection in lab, CV performing standup comedy

Columbia BME Hosts 48th Northeast Bioengineering Conference (NEBEC) 2022

By Abigail Ayers | Professional Photography by Timothy Lee Photographers; Conference Toolkit Artwork By Abigail Ayers

What happens when you gather 500 faculty, researchers, and students from over 75 institutions, all of whom are passionate about biomedical engineering, and put them together on one campus? A sharing of science, an interchanging of ideas, a convergence of connoisseurs, a networking across niches, or just pure magic– whatever you want to call it, it all happened last weekend at the 48th Annual Northeast Bioengineering Conference hosted by Columbia University. As the first in-person conference for most attendees since 2019, NEBEC 2022 was memorable, and demonstrated a seamless integration of virtual and in-person events that may be the new normal going forward. From keynotes to panels to poster sessions, NEBEC was overflowing with engaging speakers and exciting research.

Keynote, Day I: Xingde Li, PhD

Day 1 started off strong with parallel sessions and the first keynote speaker, Dr. Xingde Li from Johns Hopkins. As a professor of biomedical engineering, electrical and computer engineering, and oncology, Dr. Li represents the epitome of multidisciplinary research with his work in biophotonics imaging technologies. Dr. Li shared his lab's exciting work developing optical coherence tomography (OCT) tools to assist surgeons with operation on brain cancers, as well as a new cutting-edge miniaturized optical imaging tool using two-photon endomicroscopy for subcellular biochemical and neural imaging.

Senior Design Posters

In the afternoon, senior undergraduate students from various universities presented their senior capstone designs. With an impressive lineup of compelling projects and beautiful presentations, the selection of finalists for the senior design award was difficult. Ultimately, a team from Fairfield University took home first place with their project titled "STEM Outreach Through Youth Sports Biomechanics" (Prince Addo, Chizimuzo Chibuko, Aina March Razakamanantsoa, Tobenna Ugwu, Rachel Jacobson, John Minogue, John F. Drazan, PhD), followed by the "Non-Contact Image Analysis of Breathing Rate Using an Unmanned Aerial Vehicle (UAV)" team from University of Maine in second (Jacob Holbrook, Dominic Kugell, Margaret McCarthy, Basel White, Andre Khalil), and "Vacuum Toothbrush for Removal of Oral Aspirates" team from New Jersey Institute of Technology in third (Sahitya Kulkarni, Alexandra Griffith, Christian Rodrigues, Rachelle Cham, Marie Jean, Thomas Dolalas, Domenico Valente, Vivek Kumar).

Future Biomedical Engineers

Day 2 brought special presentations in the Future Biomedical Engineers session from incredible young researchers selected out of over 80 applicants as finalists for the Young Scientist Award. With topics ranging from adhesive mechanisms of cartilage to interpretable deep learning for medical imaging, the presenters had the audience fully engaged and consistently running over time with the Q&As. Kaveri Thakoor from Columbia University, with her talk titled "Interpretable and Portable Deep Learning Systems for Detection of Ophthalmic Diseases", was selected for the graduate student Young Scientist Award, and Dr. Ricardo Cruz-Acuña from Columbia University Irving Medical Center, with his talk titled "Engineered Hydrogel Elucidates Contributions of Matrix Mechanics to Esophageal Adenocarcinoma and Identify Matrix-activated Therapeutic Targets", was selected for the postdoctoral Young Scientist Award. These awards recognize young researchers who have already made outstanding contributions to biomedical engineering and show great promise in becoming leaders in the field.

Keynote, Day II: Deepak Vashishth, PhD

Following the Future Biomedical Engineers presentations was the keynote speaker for Day 2, Dr. Deepak Vashishth from Rensselaer Polytechnic Institute. As a professor of Biomedical Engineering and the Director of the Center for Biotechnology and Interdisciplinary Studies, Dr. Vashishth advocates for research that is interdisciplinary, socially responsible, and technologically innovative. His talk focused on his breakthrough work on bone fragility in diabetes. With 537 million people affected by diabetes worldwide, and growing incidence of early onset type II diabetes, the gap is ever-widening between our knowledge of the disease and the demand to treat it– a gap that researchers, like Dr. Vashishth, are working to close. His group investigates how collagen modifications affect whole bone structure, what this may look like in a diseased condition, and how understanding these properties can lead to better treatment and prevention of bone fragility.

Columbia BME 20th Anniversary Celebration & Department Chair Panel

After lunch on Day 2, conference attendees were honored with the unique opportunity to sit in on a discussion between one NSF program manager and eight BME Department Chairs from leading research and educational institutions across the northeast United States. Opening remarks from Dr. Shi-Fu Chang, Dean of Columbia Engineering, Dr. Zvi Galil, Dean Emeritus of Columbia Engineering, and surprise guest Dr. Michael Crow, current president of Arizona State University and former Executive Vice Provost of Columbia Engineering, highlighted how far the Department of Biomedical Engineering at Columbia has come in its 20 years since creation, and more generally how vital the field of biomedical engineering has become to promoting scientific discovery and tackling healthcare issues globally. In the words of Dr. Crow, the field of biomedical engineering "further enhances the centrality of the role of engineering in all things."

With Dr. Edward Guo, current BME Department Chair at Columbia, as moderator, the star-studded panel included: Vicki Colvin, PhD from Brown University, James Duncan, PhD from Yale University, Andreas Hielscher, PhD from New York University, Kristi Kiick, PhD from University of Delaware, Laurel Kuxhaus, PhD from the National Science Foundation, Michael Miller, PhD from Johns Hopkins University, Mitchell Schaffler, PhD from The City College of New York, and Marjolein van der Meulen, PhD from Cornell University. The panel discussion focused on maintaining and growing BME communities during and post pandemic, with all panelists sharing valuable insights regarding their experiences managing departments during the past years of the COVID-19 pandemic. As leaders within their respective universities, these panelists were faced with many unprecedented challenges, including adapting to online learning, supporting students' mental health, and confronting shortcomings in university infrastructure exposed by the sudden changes.

(continued)

Both Dr. Schaffler and Dr. Duncan commented on the irony that educators had no choice but to be flexible, and were forced to come up with creative teaching strategies–but that it has provided an opportunity to re-think best approaches to student learning. Dr. Colvin and Dr. Hielscher spoke about how the isolation during the pandemic has caused a loss of connection to community and other serious impacts on identity; with this has come a shift in the conversation about mental health, bringing a lot of these topics out of the shadows. Other shifts since the beginning of the pandemic include universities' approaches to diversity, equity, and inclusion; Dr. van der Meulen discussed the responsibility the BME community has to take an active role not only in conversations about it but in implementing real structural changes in the higher education system. Finally, the panelists touched on how COVID-19 has changed the public perception of the field of biomedical engineering; Dr. Miller explained that COVID created a clear mission to work toward something important (a vaccine, treatment, prevention of spread, etc.), which inserted medicine and engineering into widespread conversation and ultimately led to more appreciation from the public; on the other hand, other panelists pointed out that many people still don't attribute these discoveries and medical feats to the engineers responsible for them. Biomedical engineering provides the engine and wheels that keep the healthcare system vehicle moving, but people mostly remember who is in the drivers' seat. As Dr. Colvin noted, the pandemic has highlighted that perhaps engineers and those in the academic community need to learn how to tell a story, focusing on humans and the journeys they've taken, to better communicate their broader impact on the world.

Best Poster Awards

In the afternoon of Day 2, a sea of over 200 posters took over spaces across campus for presenters to share their work with conference attendees. With topics spanning from tissue engineering to imaging to medical devices, intriguing projects could be found around every turn. Three were chosen for the Best Poster Award: Xiaojun Lian from The Pennsylvania State University with the project titled "Robust pancreatic beta cell differentiation from human pluripotent stem cells by small molecules", Ian Sands et al. from University of Connecticut with the poster "Biomimetic Electrically Conductive Coating for Enhanced Brain Microelectrode Interface", and Yasaman Aghil et al. with the work "Electroactive Gelatin Fibrous Scaffolds for Promoting Cell Adhesion, Growth, and Infiltration".

New Innovator Faculty Award

Throughout the parallel sessions spread across the conference, eight finalists for the New Innovator award for Junior Faculty gave talks on their work. The parallel sessions were a huge hit, with fantastic presentations and audience engagement consistent through both days. Out of the finalists, Dr. Xi Ren, with his talk titled "It Takes a Heart to Make the Lung: Recapitulate Human Cardio-pulmonary Co-development Using Stem Cells", was selected for the New Innovator Award. This award recognizes the accomplishments of researchers in the early stages of their independent career.

Acknowledgments

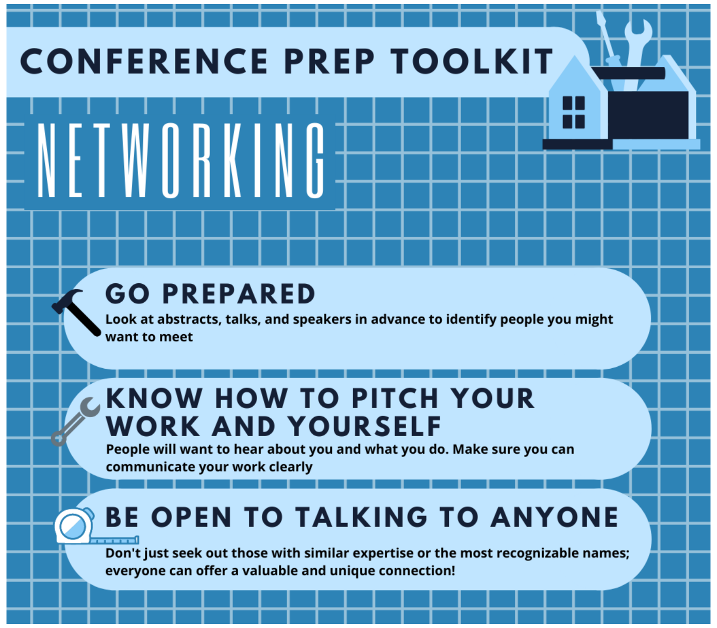
All in all, NEBEC was an action-packed two days full of scientific discussion and building relationships in the biomedical engineering community. Congratulations to all award winners and everyone else who participated! The event would not have been possible without the session chairs, organizing committee, judges, and 34 Columbia BME undergrad and grad student volunteers who kept everything running smoothly. A special thanks goes to platinum sponsors Columbia Department of Biomedical Engineering, NYU Tandon School of Engineering, the National Science Foundation, IEEE EMBS, and Regeneron; gold sponsors Brown Department of Biomedical Engineering and Johns Hopkins Department of Biomedical Engineering; silver sponsors Pitt Department of Bioengineering and University of Delaware; and bronze sponsors CEMB, Drexel University School of Biomedical Engineering, Science, & Health Systems, Cornell University Meinig School of Biomedical Engineering, and Soterix Medical, Inc.

EVENT RECAP: NEBEC

The ability to share a mutual love for science face-to-face was a breath of fresh air (masked, of course), all thanks to the organizers who worked tirelessly to pull off a safe and responsible in-person conference. Many left the conference energized with a new optimism for the future of the biomedical engineering field. I think I speak for us all when I say: it's good to be back!

Conference Prep Toolkits

Are you excited to attend the next conference? Worried about getting back into the swing of things after two years of virtual events, or preparing to attend a conference for the first time? One of the best things about scientific conferences is the opportunity for researchers to come together and share the latest work in their fields. In particular for biomedical engineering, which spans many disciplines to bring together biology, medicine, and engineering, conferences provide a unique space for cross-talk between subfields that can lead to new ideas and collaborations. Therefore, networking is an essential, yet sometimes intimidating, component of events like NEBEC. Similarly, giving a poster presentation or talk is a great way to share your work with others, but it can be nerve-wracking. In general, thinking about how to prepare for a conference in order to make the most of it socially and professionally can seem overwhelming. With this conference preparation toolkit, you'll be on your way to an enjoyable and productive experience at your next conference!



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