FALL / WINTER 2022-2023

BME INSIGHTS

Department of Biomedical Engineering
COLUMBIA | ENGINEERING
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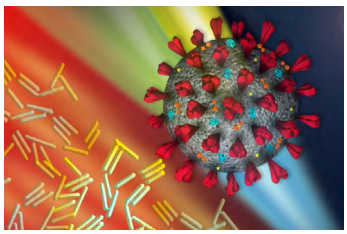

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Photos on front cover from top left, clockwise. 1) Award crystals from the 2022 Rising Stars in Engineering in Health workshop 2) The Class of 2026 raise their beanies, a longstanding Columbia Engineering tradition 3) Graduating Masters students at the Fall 2022 Celebration 4) New Columbia BME Professor Santiago Correa at the 2022 Columbia BME Holiday Party 5) F-35A Lightning II aircraft receive fuel from a KC-10 Extender from Travis Air Force Base, Calif. Credit: U.S. Air Force photo/ Staff Sgt. Madelyn Brown 6) Fatema Lodgher, M.S. '21 7) Columbia BME Chair X. Edward Guo 8) Infrared heating of plasmonic nanoparticles facilitates multiplexed reverse transcriptase quantitative PCR for rapid detection of SARS-CoV-2. Credit: Abigail Ayers/Columbia Engineering, Nicoletta Barolini 9) The small intestine of a 16 day chick embryo. Credit: Morphogenesis and Developmental Biomechanics Lab 10) Aamna Siddiqui 11) Columbia's booth at the 2022 BMES Annual Meeting, Photo by Yang Xiao | *Back cover photo by Yang Xiao*: Ph.D. student Anna-Liisa Sepp speaks with a prospective student at the 2022 BMES Annual Meeting | *Photos on page 4 from top left.* 1) Award crystals from the 2022 Rising Stars in Engineering in Health workshop 2) Students at the 2022 Columbia BME Holiday Party 3) Morphogenesis and Developmental Biomechanics Lab 4) Graduating Masters students at the Fall 2022 Celebration 5) Columbia BME Undergrads skating into 2023, Photo by Helen Cen

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

33
Startups launched by students and faculty since 2014

19
AIMBE Fellows in Faculty

10
Faculty Recipients of NSF CAREER Award

60%
of MS Students Participated in Research in 2022

112 Undergraduates

226 Masters Students

164 PhD Students

A Note From the Chair

Dear Colleagues and Friends of Columbia BME,

We are pleased to present to you the 2022 Fall / Winter edition of Columbia University's Biomedical Engineering Insights. We wish you, Columbia BME faculty, staff, students, alumni, and friends, Happy Holidays and a prosperous New Year.

2022 has been a transformative year for Columbia BME. We are finally emerging from the COVID cloud and have begun to return to normal. We are beginning to see what the post-COVID future is for our department and the BME field in general. We envision a future for BME where higher education and biomedical engineering research will extend beyond the traditional boundaries of institutions. COVID has accelerated the digital and online delivery of BME education and research. We now feel confident that in-person University research and education can be complemented by virtual and online components. Columbia BME has made its Departmental Seminar Series available live on Zoom and on YouTube. These public lectures (with the permission of speakers) are available on the ColumbiaBME YouTube channel. We also started the Columbia BME Faculty in Focus series with cutting-edge research updates from our outstanding faculty.

This November, we held our third annual Rising Stars in Engineering in Health Workshop. This year, the Workshop was hosted at Johns Hopkins University for the first time. Twenty bright young stars in engineering and medicine from across the country were selected from more than 150 applicants. The success of the Rising Stars initiative carries forward with each new cohort. For example, sixteen out of twenty of the inaugural Rising Stars class of 2020 have secured faculty positions at prestigious universities, and close to half of the class of 2021 have already secured faculty positions. We are also very excited that the Meinig School of Biomedical Engineering at Cornell University now joins our initiative and will host the Rising Stars in Engineering in Health Workshop in 2023.

With leadership from Columbia BME, the Northeast Biomedical Engineering League (NE BME) is off to a great start. NE BME, with more than 30 inaugural members, aims to play an influential role in shaping the national and global future of BME research and education. We are excited to work with the league's founding leadership to develop an NE BME vision for the future of the field.

In 2022, we welcomed four new faculty members into our Columbia BME family: Sanja Vickovic, Treena Arinzeh, Lauren Heckelman, and Santiago Correa. These fantastic new faculty members have settled in and have already made a significant impact on Columbia BME research and education. We are excited to expand our Columbia BME faculty further this year with two active searches: one in bioimaging/AI and one in the BME Master's education program. We are also actively pursuing a targeted opportunity for a prominent faculty member in pulmonary/cardiovascular bioengineering.

As we move forward into 2023, we are hopeful for a healthier, more peaceful, and more stable world. It begins with building that future we envision together, right here at Columbia Engineering.

As a first step, we invite you to join our 7th Annual Engineering in Medicine Symposium on Thursday, February 23, 2023, held here at Columbia University.

Wishing you a happy holiday season from all of us at Columbia BME.

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

DEPARTMENT HIGHLIGHTS

Shih-Fu Chang, Elizabeth Hillman, and Jeannette Wing Elected to the NAI

National Academy of Inventors Selects Columbia Engineering Researchers for their "highly prolific spirit of innovation."

By Holly Evarts

Three Columbia Engineering researchers--Shih-Fu Chang, Elizabeth Hillman, and Jeannette Wing--have been elected to the National Academy of Inventors for their "highly prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on the quality of life, economic development, and welfare of society." They join a cohort of 169 distinguished inventors to be NAI Fellows, the highest professional distinction awarded to academic inventors. The 2022 Fellow class hails from 110 research universities, governmental, and non-profit research institutions worldwide. They collectively hold over 5,000 issued U.S. patents.

"This year's class of NAI Fellows represents a truly outstanding caliber of inventors. Each of these individuals have made significant impact through their work and are highly regarded in their respective fields," said Dr. Paul R. Sanberg, FNAI, President of the NAI. "The breadth and scope of their inventions is truly staggering. I am excited to see their creativity continue to define a new era of science and technology in the global innovation ecosystem."

Professor of Biomedical Engineering Elizabeth Hillman

Elizabeth Hillman is a Herbert and Florence Irving Professor at the Zuckerman Institute, and a professor of biomedical engineering and radiology at Columbia University. She came to Columbia Engineering in 2006, where she founded the Laboratory for Functional Optical Imaging. Her research focuses on the development and application of optical imaging and microscopy technologies to capture functional dynamics in the living systems.

With a particular focus on studying the brain, Hillman uses her imaging techniques to explore the interrelation between real-time behavior, neural activity, and blood flow in the brain. Among her major technological contributions are the development of dynamic contrast methods for small animal imaging, the application of in-vivo "wide-field optical mapping" to studying neurovascular coupling, and the recent development of swept, confocally-aligned planar excitation (SCAPE) microscopy, a technique capable of very high-speed 3D-imaging of neural activity in behaving organisms such as adult and larval fruit flies, zebrafish, C. elegans worms, and the rodent brain.

Hillman is a fellow of the Optical Society of America (Optica), the Society of Photo-Optical Instrumentation Engineers (SPIE), and the American Institute for Medical and Biological Engineering (AIMBE). She has received the OSA Adolf Lomb Medal for her contributions to optics at a young age, the SPIE Biophotonics Technology Innovator Award, and the Royal Microscopical Society Mid-Career Scientific Achievement Award, as well as early career awards from the Wallace Coulter Foundation, National Science Foundation, and the Human Frontier Science Program. She holds a BSc and MSc in Physics (1998) and a PhD in Medical Physics and Bioengineering (2002) from University College London.

Prof. Nerurkar Awarded Major $1.9M Embryo Grant

The 4-year grant from the National Institutes of Health (NIH) and the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) will support Prof. Nerurkar's research into the biophysical and biochemical intricacies of how embryos precisely sculpt healthy organs, such as the small intestine, during development.

By Harry Kelso

Professor Nandan Nerurkar has earned a major four-year grant totaling $1.9 million from the National Institutes of Health (NIH) and the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). The grant, entitled "Molecular control of mechanical forces driving buckling morphogenesis of the small intestine" will support his research into the biophysical and biochemical intricacies of how embryos precisely sculpt healthy organs, such as the small intestine, during development.

A member of the department of Biomedical Engineering, Nerurkar investigates how tissues and organs form in developing embryos via interwoven genetic, molecular, and biophysical cues. Utilizing live in vivo imaging of early-stages in a classical embryology model system, the chicken embryo, his Morphogenesis and Developmental Biomechanics Lab explores how developmental signals specify the forces that influence tissue growth and stem cell differentiation, including in birth defects when such processes go awry. Ultimately, he seeks to uncover design principles of embryonic tissue formation for applications in regenerative medicine and tissue engineering.

The grant will support Nerurkar’s work in building highly quantitative perspectives on the many factors affecting embryonic development, particularly in understanding how cell behaviors in the developing small intestine are regulated by molecular cues, and how the resulting mechanical events that shape this organ feed back to control these cell behaviors, ensuring stereotyped morphogenesis of this and other organs in the developing embryo. These studies will provide important insight into the basis of devastating birth defects of the small intestine, and will reveal mechanisms for controlling tissue self-organization that can be repurposed for regenerative medicine and tissue engineering applications.

The small intestine of a 16 day chick embryo. The precise loops are essential for packing the lengthy intestinal tube within the body cavity, and abnormal looping in humans results in devastating birth defects such as volvulus and gastroschisis.

Elham Azizi Receives a CZI Science Diversity Leadership Award

By Lorenza Favrot and Harry Kelso

Elham Azizi - Herbert and Florence Irving Assistant Professor of Cancer Data Research (in the Herbert and Florence Institute for Cancer Dynamics and the Herbert Irving Comprehensive Cancer Center) and Assistant Professor of Biomedical Engineering - has received a Chan Zuckerberg Initiative (CZI) Science Diversity Leadership award for her project titled "Computational Modeling of Regulatory Mechanisms in the Spatial Breast Tumor Microenvironment Purpose." Launched earlier this year in collaboration with the National Academies of Sciences, Engineering, and Medicine (NASEM), the Science Diversity Leadership award recognizes outstanding early- to mid-career researchers in the biomedical sciences who foster diversity, equity, and inclusion in their scientific fields through their outreach, mentoring, teaching and leadership efforts.

The $1.15 million grant will support the Azizi lab for five years to develop novel machine-learning tools to dissect underlying dysregulated mechanisms in the triple-negative breast tumor microenvironment through integrating spatial multi-omics data. Elham Azizi's lab integrates novel machine-learning techniques and cutting-edge genomic and imaging technologies to characterize the complex populations of interacting cell types in the tumor microenvironment and their underlying circuitry to guide improved and personalized cancer therapies.

Photo Credit: Timothy Lee Photographers

"The Science Diversity Leadership program is unique in that it provides generous funding for both research and outreach activities, enabling us to make advances on both fronts," Elham Azizi explains. "The project aims to study gene circuitry underlying dysfunctional immune cells interacting with breast tumor cells in patient specimens. Toward this goal, our group will develop machine-learning techniques for integrating different types of spatially resolved genomic data, including transcriptional, proteomic, and epigenetic data. Our efforts will also include establishing workshops, courses, and internship opportunities for underrepresented high school and undergraduate students and engaging them in impactful research."

However, Azizi sees the broader importance of diversity in science across the globe, especially regarding the ongoing protests in Iran, where she grew up and went to college. "In fostering diversity in our scientific community, it is important to recognize historical and ongoing inequities and how gender, cultural and ethnic identity impacts educational success from early stages of education," says Azizi with regard to the mission of this award. "My personal experience with discrimination against women in Iran has shaped my philosophy in building a broadly inclusive program. I stand with the ongoing women-led uprising in Iran with the beautiful slogan of Women-Life-Freedom ignited by Mahsa Amini's death, though hers certainly not an isolated case and rather an embodiment of decades of systematic oppression of women. I was one of the fortunate ones who managed to immigrate and find extremely supportive mentors who lifted me at critical moments. This movement has unfortunately been confronted with brutal violence including attacks on university campuses such as my alma mater, Sharif University. I ask the scientific community to be the voice of students and women courageously fighting for freedom, and to not leave them in the darkness of internet shutdown."

Azizi added, "I believe creative, collaborative and multidisciplinary scientific research demands talents from diverse backgrounds. I cannot imagine the scientific advances and innovative solutions we would achieve if the protesting and perishing high-schoolers and college students had the same opportunities I had."

AFRL/AFOSR Awards Grant for "Center of Excellence" Focused on the Neuroscience of Decision Making

Team led by neuroengineer Paul Sajda wins $5M from Air Force Research Laboratory and the Air Force Office of Scientific Research to study human decision making in real-world environments

By Holly Evarts

Pilots landing their aircraft on a carrier deck or Wall Street hedge fund traders trying to reduce volatility in their portfolio have to make immediate decisions based on the context and conditions they are under. While researchers have made progress in understanding the neuroscience of decision making for simple decisions in humans and model (animal) systems, there is a huge gap between that and what actually happens in the brain for tasks that require multiple, interdependent decisions made under stress, fatigue, and time constraints.

A team led by Biomedical Engineering Professor Paul Sajda, a leading neuroscience researcher, has won a $5 million five-year grant from the Air Force Research Laboratory (AFRL) and the Air Force Office of Scientific Research to establish an AFRL "center of excellence" (COE) focused on studying human decision making in real-world environments.

The new COE will take a multidisciplinary, multimodal, and multiscale approach to develop a comprehensive understanding of human decision making in real-world environments. Central to this approach is the design, development, and execution of experiments that enable linkage between decision making in animal models with data and tasks performed by humans.

"Our ability to integrate real-world evidence, combine it with our prior knowledge, weigh the costs of our actions, and ultimately generate a decision, is crucial to all aspects of our existence," said Sajda, Vikram S. Pandit Professor of Biomedical Engineering. "Some decisions we make seem simple, like deciding what to eat for breakfast, while others are more complex, such as deciding on a flight plan to fly from Dayton to New York. However, we also know that sometimes we struggle on deciding what to eat for breakfast, in spite of the fact that this seems like it should be an easy decision. Even simple decisions can be made more complex based on internal and external factors that are based on our prior beliefs, our expectations and even our levels of arousal and stress."

Multidisciplinary team includes neural engineers, neuroscientists, biomedical engineers, and computer scientists

The COE brings together an internationally recognized team of neural engineers, neuroscientists, biomedical engineers, and computer scientists to tackle core questions of how our brain makes decisions, learns from its mistakes, and develops expertise. The co-PIs at Columbia include Columbia Engineering Professors Qi Wang (Biomedical Engineering), Steven Feiner (Computer Science), Michael Shadlen and Daniel Wolpert, both professors of neuroscience at the Zuckerman Institute for Mind, Brain, and Behavior.

"We are very excited that Columbia University will house our newest center of excellence," said Gaurav Sharma, chief scientist in AFRL's 711th Human Performance Wing. "Columbia has world-renowned experts in neuroscience, who also have a good deal of experience working with the Department of Defense on military-specific problems."

> **"We will probe human decision making in real-world settings by combining virtual reality (VR) with non-invasive neuroimaging and physiological measurements and neurostimulation. VR technologies allow us to readily change the environment to mimic real-world scenarios and to apply environmental stressors in the tasks.**
>
> **—PAUL SAJDA**
> **PROFESSOR OF BIOMEDICAL ENGINEERING**

Multimodal methods

Critical for understanding the neural basis of decision making requires not just investigating simple decisions under controlled conditions, but also complex decisions in realistic environments. The COE's multimodal approach includes measurements and perturbations ranging from spiking activity and optogenetic stimulation to whole brain simultaneous EEG/fMRI and non-invasive vagal nerve stimulation (VNS).

Paul Sajda, Professor of Biomedical Engineering

Innovative approach from microscale (animals) to macroscale (humans)
The multiscale aspect of the project is particularly innovative in that it uses computational modeling to relate microscale measures from animal studies that provide insight into the mechanistic underpinnings of decision-related neural processing with the macroscale measures from human neuroimaging and neurostimulation studies that inform how humans make complex decisions in naturalistic contexts.

Central to this approach is the design, development, and execution of experiments that enable the team to use data that link decision making in animal models with tasks performed by humans. The researchers will conduct both rodent and human experiments largely focused on rapid decision making, ones that must be made almost instantly. This focus will enable the team to use a variety of experimental and computational methods employed for reaction time tasks both in animals and humans. It will also map well to many real-world decision-making scenarios, including those of interest to the Department of Defense, such as choices made by fighter pilots and ISR (Airborne Intelligence, Surveillance and Reconnaissance) operators.

"We will probe human decision making in real-world settings by combining virtual reality (VR) with non-invasive neuroimaging and physiological measurements and neurostimulation," Sajda explained. "VR technologies allow us to readily change the environment to mimic real-world scenarios and to apply environmental stressors in the tasks."

The CoE brings together leading experts from Columbia Engineering, the Zuckerman Institute, and the Data Science Institute, in a collaboration with the top AFRL researchers on current and future Air Force challenges surrounding decision-making. This new partnership also provides a broad range of opportunities for a new generation of United States scientists and engineers to address USAF and US Space Force research needs.

Welcoming the Class of 2026

A new cohort of students begin their first year at Columbia Engineering

by Allison Elliott

The Class of 2026 raise their beanies, a longstanding Columbia Engineering tradition.

More than 360 students converged on Lerner Hall on Wednesday, August 13, to be welcomed as the newest Columbia engineers and given their traditional first-year beanies.

Dean Shih-Fu Chang greeted the students, relating that, as the newly named dean of engineering, he too felt that he was beginning a new journey. He highlighted the many opportunities open to students to participate in entrepreneurship programming and extracurricular clubs, study and intern abroad, and work with faculty in labs doing cutting-edge research. Dean Chang also stressed the importance of an engineering degree.

"Engineering is now a foundational degree," said Dean Chang. "It is an incredibly wide field with many opportunities, enriched by the Liberal Arts Columbia Core, research and internship opportunities, a very large number of clubs and student activities, and the unique NYC experience that you cannot find in any other place."

Paul Sajda, Vikram S. Pandit Professor of Biomedical Engineering, then shared with students insights from his research in neural engineering. His research involves what happens in the brain when it makes a rapid decision and what brain processes are behind our preferences and choices, especially under time pressure. Such research can lead to advances in cognitive orthotics, the development of tools to help people with cognitive impairment.

Sajda, who is also a professor of electrical engineering and radiology, encouraged students to think of engineering in this human-centered way.

"It's not just about making a cool new tool," he said. "Now more than ever the actual application matters."

> “It's not just about making a cool new tool...now more than ever the actual application matters.
>
> —PAUL SAJDA
> PROFESSOR OF BIOMEDICAL ENGINEERING

He is currently exploring how this area can address psychiatric conditions like PTSD and potentially alleviate symptoms once a trigger is sensed by a mobile brain-computer interface.

“We are solving problems that matter,” he said. “That’s a 21st century engineer.”

Leonard Robinson, an electrical engineering major from the Class of 2013, followed Sajda with some advice for students. Now an engineering team lead at biotech company Cytiva, Robinson counseled students to focus on their health, cherish their friendships, and build wealth – in the broadest sense.

Quoting Warren Buffet, he said, “the biggest investment you can make is in yourself” and urged students to take advantage of the wealth of educational and learning opportunities open to them at Columbia.

Sophomore and Davis Scholar María Valerio Roa rounded out the program with her personal experience as an international student from the Dominican Republic applying to colleges during the pandemic. It was during the Columbia Engineering Experience (CE2) program for prospective students that she “fell in love with Columbia Engineering.”

Roa, admitting to feelings of hopelessness from remote schooling during the pandemic, was particularly inspired by the Art of Engineering talk with Professor David Vallancourt. “Here were professors who were so curious and dedicated,” she said.

She applied to only one college in the United States – Columbia Engineering, early decision. “I joked to friends that I made the decision and chose Columbia before applying,” she said.

Calling it the best decision of her life, Roa recounted how she soon made friends, joining the Columbia Undergraduate Science Journal and Grupo Quisqueyano, a student club representing Dominican students. She also shared that she had interned at a pharmaceutical company back home and co-founded a program to help low-income students from the Dominican Republic apply to competitive schools.

“Columbia allowed me to dream and use the city as my classroom,” she said. “Columbia Engineering taught me that college is for way more than studying; it’s for dreaming and discovering.”

After the talks, Junior Tameem Asif, representing Engineering Student Council Academic Affairs, led the students in the Honor Pledge before Vice Dean of Undergraduate Programs Barclay Morrison closed out the program, encouraging students to enjoy the rest of their orientation before the start of classes after the Labor Day holiday.

> “Engineering is now a foundational degree.
>
> —SHIH-FU CHANG
> DEAN, COLUMBIA ENGINEERING

Romare Antrobus, PhD student and co-lead author of the study, examining a sample of the compostable bioleather made in Schiros' lab at FIT, and characterized at the Lu lab. Credit: John Abbott/Columbia Engineering

Compostable Bioleather Offers Sustainable Solutions for the Clothing Industry and Beyond

Researchers at Columbia Engineering and the Fashion Institute of Technology team up to create a non-toxic bioleather, inspired by the power of microbes and indigenous science.

By Harry Kelso

Since the dawn of the Industrial Revolution, clothing production has been on an unsustainable path. Like most manufacturing, textiles are produced in a linear fashion with a cradle-to-grave model. Fabrics like cotton are farmed, worn, used, then thrown away. The textile industry as a whole is responsible for 10% of global carbon emissions, with leather being especially harmful.

The cattle industry is the single leading driver of deforestation, and the tanning of leather creates a great deal of chemical pollution. These challenges have motivated a search for more sustainable textiles, especially leather alternatives.

A team with a track record of successful collaboration may hold an answer. Biomedical Engineering researchers at Columbia Engineering recently announced they have created a compostable bioleather with superior flame-retardance and low environmental impact. Their microbial nanocellulose (MC) bioleather has a 1,000-times lower carcinogenic impact than cow leather and a significantly smaller carbon footprint than synthetic leather or cotton. Their study was published on July 1, 2022, in Environmental Science: Advances.

The team, led by Theanne Schiros and Helen Lu, together with Ph.D. candidate Romare Antrobus, has been working together for several years in Columbia's Materials Research Science and Engineering Center (MRSEC) to develop materials for a broad range of applications from biomedicine to energy, electronics, and textiles laid the foundation for inventing this versatile new material.

"Our bioleather represents a breakthrough not only for textiles but shows other industries how to explore a sustainable manufacturing process to engineer regenerative materials," said Lu, Percy K. and Vida L.W. Professor of Biomedical Engineering and Senior Vice Dean of Faculty Affairs and Advancement at Columbia Engineering.

To make high-performance biotextiles, the team harnessed microbial biosynthesis of nanocellulose, drawing inspiration from pre-industrial and indigenous science. Schiros hypothesized that a main component of mammalian brain used for millennia to tan hides into leather--lecithin phosphatidylcholine-- would stabilize the interaction of cellulose with both water and lipids in a tanning emulsion, and modify the material properties of MC through its hydrophilic groups to make it suitable for use as a bioleather. When the researchers used traditional brain and smoke tanning processes, they noted an increase in tensile strength and ductility of MC, which encouraged this line of investigation. Their discovery led to the development of an eco-friendly, plant-based lecithin "tanning" process for nanocellulose that created a

strong, compostable bioleather.

This new process will not only transform future textile development but also cultural heritage research. While civilizations around the world have been creating sustainable and durable textiles since antiquity, most of these ancient techniques have been lost.

“Our team is now collaborating with scientists at the Metropolitan Museum of Art to develop a conservation studies database for artifacts in their cultural heritage collections and to understand the mechanism behind historic brain and organ tanning,” said Schiros, associate professor of materials science at the Fashion Institute of Technology and adjunct associate research scientist in Columbia’s MRSEC.

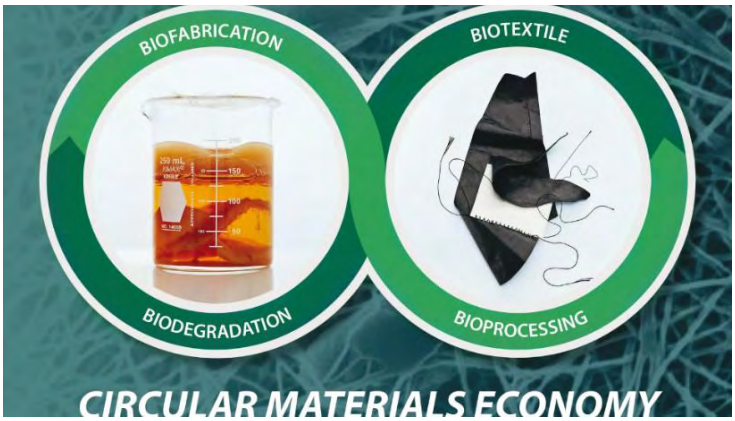
Coming full circle to modern-day design, the researchers created a pair of naturally dyed, microbial bioleather sneakers in a collaboration with Public School NY. The sneakers are part of an exhibition, Towards a Circular Society: Learning from Nature, currently on view at the University of Bern’s Wyss Academy for Nature. They will also be on view in a separate exhibition at the Montreal Museum of Fine Arts.

> **“Our bioleather represents a breakthrough not only for textiles but shows other industries how to explore a sustainable manufacturing process to engineer regenerative materials.**
>
> **—PROFESSOR HELEN LU**
> **PROFESSOR OF BIOMEDICAL ENGINEERING AND SENIOR VICE DEAN OF FACULTY AFFAIRS AND ADVANCEMENT AT COLUMBIA ENGINEERING**

This new study builds off the researchers’ successful rethinking of manufacturing through the lens of biomaterials and the circular economy, including two startups spun out of their labs, Algiknit, which makes kelp-based biofibers, and Werewool, which has created a platform for high-performance regenerative textile fibers with DNA-programmed color and function, such as stretch or waterproofing, provided by engineered proteins.

With their accomplishments in harnessing the power of microbes and developing paleo-inspired green processing techniques, Lu and Schiros expect biofabrication to play a critical role in facilitating a transition to a more sustainable economy. MC offers a modular engineering platform for high-performance regenerative materials with various applications, from tissue engineering to batteries, electronics, biosensors, and pollution remediation, which the researchers are continuing to explore.

Schiros believes the broad applicability of their research may only be a matter of time. She added, “The biofabrication approach developed here can incentivize and accelerate a paradigm shift to a circular materials economy, critical to global climate goals and sustainable development.”



Microbial biofabrication and green processing inspired by cultural heritage offer a path to a circular material economy.
Credit: Theanne Schiros/Columbia Engineering and FIT

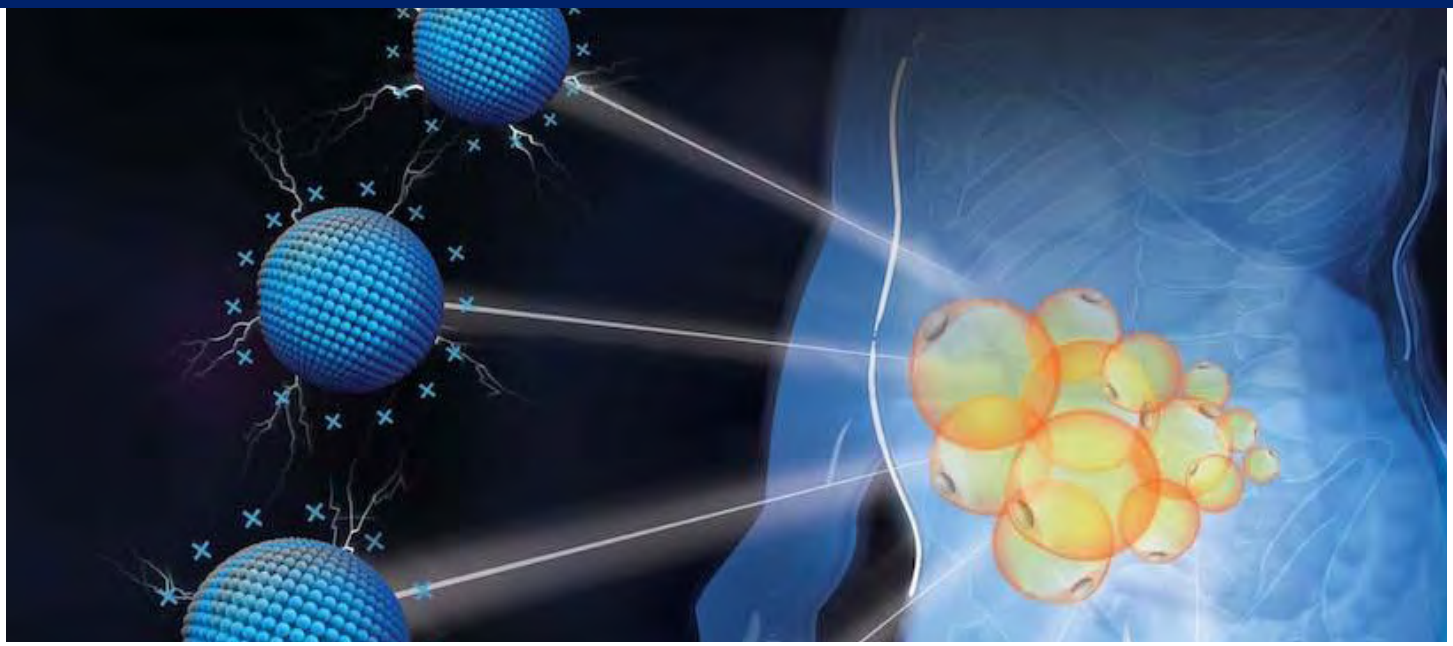


Illustration of depot-specific targeting of fat by cationic nanomaterials
Credit: Nicoletta Barolini/Columbia University

Positively Charged Nanomaterials Treat Obesity Anywhere You Want

Columbia researchers discover that the cationic charged P-G3 reduces fat at targeted locations by inhibiting the unhealthy lipid storage of enlarged fat cells

By Holly Evarts

Researchers have long been working on how to treat obesity, a serious condition that can lead to hypertension, diabetes, chronic inflammation, and cardiovascular diseases. Studies have also revealed a strong correlation of obesity and cancer--recent data show that smoking, drinking alcohol, and obesity are the biggest contributors to cancer worldwide.

The development of fat cells, which are produced from a tiny fibroblast-like progenitor, not only activates the fat cells' specific genes but also grows them by storing more lipids (adipocytes and adipose tissue). In fact, lipid storage is the defining function of a fat cell. But the storage of too much lipid can make fat cells unhealthy and lead to obesity.

Challenges in targeting fat cells

The ability to target fat cells and safely uncouple unhealthy fat formation from healthy fat metabolism would be the answer to many peoples' prayers. A major challenge in obesity treatment is that fat tissue, which is not continuous in the body but is found piece by piece in "depots," has been difficult to target in a depot-specific manner, pinpointed at the exact location.

There are two main kinds of fat: visceral fat, internal tissues that surround the stomach, liver, and intestines, and subcutaneous fat, found under the skin anywhere in the body. Visceral fat produces potbellies; subcutaneous fat can create chin jowls, arm fat, etc. To date, there has been no way to specifically treat visceral adipose tissue. And current treatments for subcutaneous fat like liposuction are invasive and destructive.

New studies use cationic nanonmaterials to target fat

Two new studies from researchers at Columbia Engineering and Columbia University Irving Medical Center (CUIMC) may have the answer to targeting fat cells depot-specifically and healthily. The papers demonstrate a new method to treat obesity by using cationic nanomaterials that can target specific areas of fat and inhibit the unhealthy storage of enlarged fat cells. The materials remodel fat rather than destroying it, as, for example, liposuction does.

The first paper, published today by Nature Nanotechnology, focuses on visceral adiposity, or belly fat. The second paper, published online November 28 by Biomaterials, focuses on fat underneath the skin as well as chronic inflammation associated with obesity.

The team of researchers, led by Li Qiang, associate professor of pathology and cell biology at CUIMC, and Kam Leong, Samuel

Y. Sheng Professor of Biomedical Engineering and of systems biology at CUIMC, recognized that adipose tissue contains large amounts of negatively charged extracellular matrix (ECM) to hold fat cells. They thought that this negatively charged ECM network might provide a highway system of sorts for positively charged molecules. So they took a positively charged nanomaterial, PAMAM generation 3 (P-G3), and injected it into obese mice. The P-G3 quickly spread throughout the tissue and the team was excited that their method to specifically target visceral fat worked.

Unexpected results

And then something intriguing happened: P-G3 shut off the lipid storage program in fat cells and the mice lost weight. This was totally unexpected, given the well-established function of P-G3 in neutralizing negatively charged pathogens, such as DNA/RNA cell debris, to alleviate inflammation.

"Our approach is unique--It departs from the pharmacological or surgical approaches," says Qiang, who specializes in obesity and adipocyte biology. "We used cationic charge to rejuvenate healthy fat cells, a technique no one has ever used to treat obesity. I think this novel strategy will open the door to healthier and safer reduction of fat."

> "With P-G3, fat cells can still be fat cells, but they can't grow up.
>
> —KAM LEONG
> SAMUEL Y. SHENG PROFESSOR OF BIOMEDICAL ENGINEERING AND OF SYSTEMS BIOLOGY AT CUIMC

P-G3 helps new fat cell formation and also inhibits the unhealthy lipid storage of enlarged fat cells

In these two studies, the researchers discovered that the cationic material, P-G3, could do an intriguing thing to fat cells--while it helped new fat cell formation, it also uncoupled lipid storage from the housekeeping functions of fat cells. And because it inhibits the unhealthy lipid storage of enlarged fat cells, the mice had more metabolically healthy, young, small fat cells like those found in newborns and athletes. The researchers found that this uncoupling function of P-G3 also holds true in human fat biopsies, signifying the potential of translation in humans.

"With P-G3, fat cells can still be fat cells, but they can't grow up," said Leong, a pioneer in using polycation to scavenge pathogens. "Our studies highlight an unexpected strategy to treat visceral adiposity and suggest a new direction of exploring cationic nanomaterials for treating metabolic diseases."

New applications for drug delivery, gene therapy, and aesthetics

Now that they can selectively target visceral fat, Leong and Qiang envision several applications. The Biomaterials study demonstrates a simple approach that could be used for aesthetic purposes; like Botox, P-G3 can be locally injected into a specific, subcutaneous fat depot. The investigators, who have patents pending, are now engineering P-G3 into various derivatives to improve the efficacy, safety, and depot specificity.

What the researchers are particularly excited about is developing P-G3 into a platform that can deliver drugs and gene therapies specifically to a given fat depot. This may repurpose many drugs from systemic safety concerns, such as Thiazolidinediones (TZDs), a potent but unsafe drug that is a strong modulator of fat and used to treat type 2 diabetes—but it has been linked to heart failure and banned in several countries.

"We're very excited to discover that cationic charge is the secret to targeting adipose tissue," Qiang said. "Now we can shrink fat in a depot-specific manner--anywhere we want--and in a safe way without destroying fat cells. This is a major advance in treating obesity."

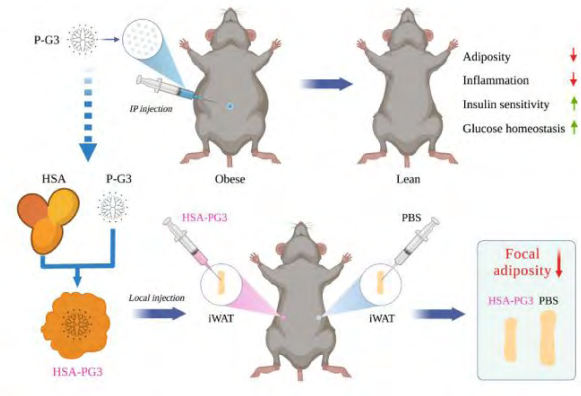


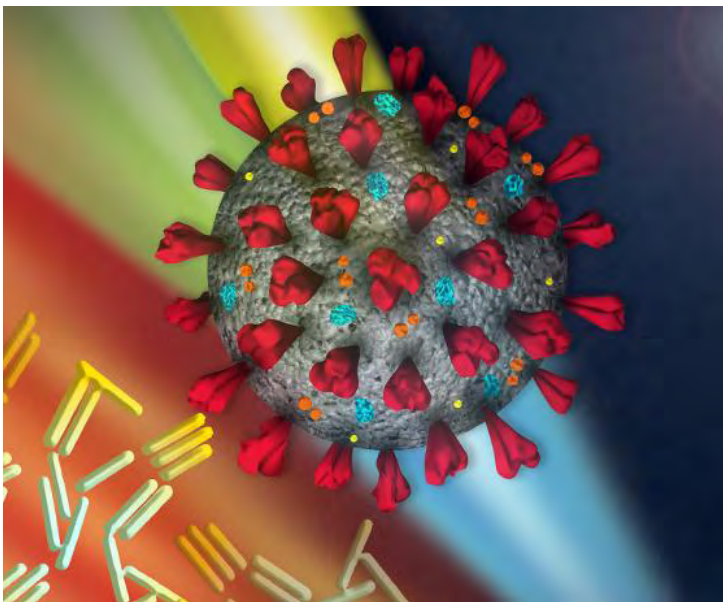
Illustration showing how cationic nanomaterials target depot-specific fat cells.
Credit: Qianfen Wan/CUIMC and Baoding Huang/Columbia Engineering

The study is titled "Selective targeting of visceral adiposity by polycation nanomedicine." Authors are: Wan Q, Huang B, Li T, Xiao Y, He Y, Du W, Wang BZ, Dakin GF, Rosenbaum M, Goncalves MD, Chen S, Leong KW, Qiang L. Selective targeting of visceral adiposity by polycation nanomedicine. Nature Nanotechnology, Online ahead of print, DOI:10.1038/s41565-022-01249-3 (2022)

New COVID-19 Rapid-test Technology Performs PCR Faster than Similar Tests on the Market

Researchers at Columbia Engineering and Rover Diagnostics team up to develop a low-cost, portable platform that gives RT-PCR results in 23 minutes that match laboratory-based tests

By Holly Evarts



Infrared heating of plasmonic nanoparticles facilitates multiplexed reverse transcriptase quantitative PCR for rapid detection of SARS-CoV-2. Credit: Abigail Ayers/Columbia Engineering, Nicoletta Barolini

For more than 30 years, polymerase chain reaction (PCR) has been the gold standard in molecular diagnostic testing, detecting genetic material, such as those from a virus or from human DNA. But PCR, including reverse transcription polymerase chain reaction (RT-PCR), is mostly done at large, centralized laboratories, not in point-of-care (POC) settings, because its instrumentation is bulky, expensive, takes a long time for results, and requires trained technicians to run it. These limitations have led to a shortage of accurate POC diagnostics as well as bottlenecks in test results, particularly during the COVID-19 pandemic.

Researchers at Columbia Engineering and Rover Diagnostics announced today that they have built an RT-PCR platform that gives results in 23 minutes that match the longer laboratory-based tests—faster than other PCR tests on the market. It can be adapted to test for a broad range of infectious diseases including not just COVID-19 but also flu, strep, and other viruses that require fast diagnosis. Its targeted sensitivity is higher than other types of tests such as isothermal, antigen, and CRISPR. And, at just two pounds, the Rover PCR is easy to carry around and can be used by anyone.

"Our aim was to create a platform that can be used in locations where rapid turnaround results are critical, at pharmacies, transportation hubs, public events, and at companies screening employees coming back to work," said Sam Sia, professor of biomedical engineering and Vice Provost for the Fourth Purpose and Strategic Impact at Columbia.

The system was co-developed with Rover Diagnostics, a biotech start-up co-founded in 2018 by Sia and serial tech entrepreneur Mark Fasciano, Rover's CEO. The platform uses sample preparation techniques developed at Sia's lab, combined with a new approach to thermal cycling, bypassing the standard approach of Peltier device—which heats the sample from outside the vial. Instead, Rover's system uses a photothermal process—plasmonic hermocycling—that relies on nanoparticles irradiated by light to rapidly generate heat from inside.

The team successfully performed reverse-transcriptase quantitative PCR (RT-qPCR) in a reaction vessel containing all the PCR reagents. qPCR is the current gold-standard laboratory technique for identifying COVID infection. The technique provides quantification of infectious units, but it also poses a number of hurdles for point-of-care (POC) miniaturization.

In the study published today in Nature Nanotechnology, the researchers addressed these challenges by leveraging plasmonic nanoparticles—discrete metallic particles that respond to infrared light by releasing heat—to achieve real-time and multiplexed RT-qPCR on clinical specimens.

"This should really move the needle on delivering rapid and accurate molecular clinical diagnostics in decentralized settings," said Fasciano, a computer scientist turned software and biotech entrepreneur. "Thermal cycling, so critical to DNA and RNA testing, can now be sped up and clinicians and patients alike won't have to wait so long for results."

The Rover team is moving forward with a commercial product that can detect COVID-19, its variants, and other infectious diseases.

First of its kind PhD program combines engineering and dental medicine

Columbia's new dual degree in dentistry and engineering will train next generation of dental scientists

By Allison Elliott

Credit: College of Dental Medicine, Columbia University

Despite significant advances made in biomedical research over the past decades, the field of dentistry has suffered from a shortage of dental scientists who can readily translate these advances to improve patient care.

To meet this growing demand and train up the next generation of leaders in dental science, Columbia University has launched a new dual degree program at the intersection of engineering and dentistry. Set to welcome its first cohort in the Fall of 2023, the Doctor of Dental Surgery/Doctor of Philosophy in Biomedical Engineering (DDS/PhD) dual degree program is the first of its kind and will be offered by Columbia Engineering and the College of Dental Medicine at Columbia University.

With the support of the faculty from the Department of Biomedical Engineering, Helen Lu, Percy K. and Vida L.W. Hudson Professor of Biomedical Engineering and Professor of Dental and Craniofacial engineering, helped to develop the program with leadership from the Columbia University College of Dental Medicine, including Dean Christian S. Stohler and Sunil Wadhwa, Leuman M. Waugh DDS Associate Professor of Orthodontics.

Wadhwa sees the offering as a logical step toward addressing current challenges in dental care. "The negative impact of oral health diseases has not improved in the past 30 years," said Wadhwa. "We need more dental scientists who can adapt and translate basic science findings into dental health care applications."

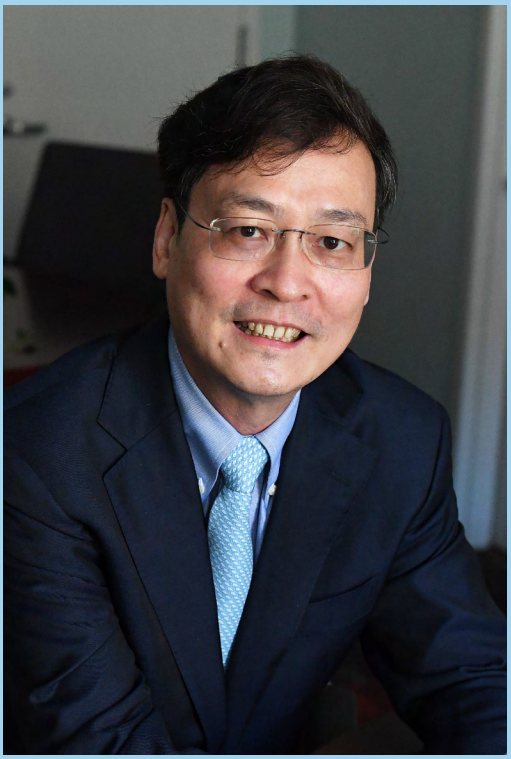
Combining engineering and dentistry has already led to significant innovations. Digital dentistry such as intra-oral scanning, CAD-CAM, and 3D printing, has almost replaced dental impressions sent to dental laboratories for the construction of dental appliances and restorations, and AI and Big Data have begun to show promise in the diagnosis and prognosis of oral diseases.

Lu, who is also senior vice dean for faculty affairs and advancement at Columbia Engineering, believes the program will help practitioners make the most of the synergies between dentistry and engineering and enable novel approaches for treating and understanding oral diseases. The program was conceived to advance the current training of dental students with world-class training in biomedical engineering research at the graduate-level.

"With a program such as this, we are meeting a real need for education and research that can lead to breakthroughs in the practice of dentistry," said Lu. "An education program that combines the latest technologies and scientific findings will equip the next generation of practitioners to be true pioneers in dental medicine."

Open to a select group of Columbia dental students, candidates for the program will have an undergraduate degree in engineering and the necessary prerequisites to enter the DDS program. Similar to the long-standing and highly successful MD/PhD program at Columbia, these dual degree trainees will earn both a DDS and PhD, entering the Biomedical Engineering PhD program as a doctoral student.

"This partnership signals the next exciting phase of collaboration between engineering, the dental school, and the medical field," said Columbia Engineering Dean Shih-Fu Chang. "We look forward to seeing new talent and transformative breakthroughs made possible by this unique program."



X. Edward Guo Receives 2022 Adele L. Boskey Award

On September 2, The American Society for Bone and Mineral Research (ASBMR) announced Dr. X. Edward Guo would receive the 2022 Adele L Boskey Esteemed Award for Bone and Mineral Research. The award recognizes an ASBMR member for outstanding and major scientific contributions, leadership, and mentorship in the area of bone and mineral research, especially in the areas of mechanisms of mineralization, bone mineral, bone quality, and mechanobiology. Guo received the award during the ASBMR 2022 Annual Meeting at the Austin Convention Center in Austin, Texas.

Professor Guo is the Chair and Stanley Dicker Professor of Biomedical Engineering and Professor of Medical Sciences (in Medicine) at Columbia University. As director of Columbia's Bone Bioengineering Laboratory, he and his team have two major research thrusts. The first is developing innovative three-dimensional imaging and modeling techniques for bone microstructure and the second is the mechanobiology of the skeleton. His research has been recognized nationally and internationally, having over 200 peer-reviewed papers and seven book and book chapters in the musculoskeletal research areas.

Two Columbia Teams Win Cancer-Engineering Seed Grants

Two Columbia University research teams have been awarded seed grants from the Herbert Irving Comprehensive Cancer Center (HICCC) and Columbia Engineering. The winning projects, jointly funded by the two divisions, underscore cutting-edge, innovative research that combine diverse expertise in engineering and oncology.

The multidisciplinary teams each receive a one-year, $80,000 award. The partnership between Columbia Engineering and the HICCC is flourishing and includes educational initiatives and additional funding opportunities that aim to spur out-of-the-box ideas and solutions to address cancer.

From Biomedical Engineering

Christoph Juchem, PhD, associate professor of biomedical engineering

Elham Azizi, PhD, assistant professor of biomedical engineering, member of POSB

Award winners (from left to right): Brent R. Stockwell, PhD; Elham Azizi, PhD; Kenneth Olive, PhD; and Christoph Juchem, PhD.

CORE FACULTY DIRECTORY

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
Machine learning in single cell analysis and cancer.

Santiago Correa
Assistant Professor, Biomedical Engineering
Drug delivery. Nanotechnology. Nanomedicine. Gene delivery. Biomimetic materials. Supramolecular chemistry. Immune modulation. Biomaterials.

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, Senior 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
Vikram S. Pandit Professor of Biomedical Engineering; Professor of Electrical Engineering and Radiology; Director, Laboratory for Intelligent Imaging & Neural Computing | Neuroimaging. Computational neural modeling.

Samuel K. Sia, Vice Provost for the Fourth Purpose and Strategic Impact
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.

3rd Annual Rising Stars in Engineering in Health Workshop

Photography by Harry Kelso and Alexis Newman

A tradition started by Columbia Uviversity's Department of Biomedical Engineering lived on in its third iteration, but for the first time it was not hosted by Columbia.

On November 18th and 19th, 2022, prominent researchers across the United States and Canada convened on the campus of Johns Hopkins University for the 2022 Rising Stars in Engineering in Health Workshop. The workshop selects a couple dozen of the best and brightest young researchers working at the intersection of engineering and biomedicine. Those selected for the Rising Stars cohort are typically one to two years away from applying for a faculty position, hoping to gain valuable insight on the journey of a prospective new faculty researcher through the two-day interactive workshop.

This year, the workshop was a joint venture between Columbia Engineering, Columbia Medicine, and Johns Hopkins Biomedical Engineering. Each institution pursues excellence in engineering in health and has prioritized doing so in an environment that embraces diversity, equity, and inclusion. This workshop represents the collaboration between Columbia and Johns Hopkins as they work side-by-side to innovate at the intersection of engineering and health science and educate the next generation of scientists.

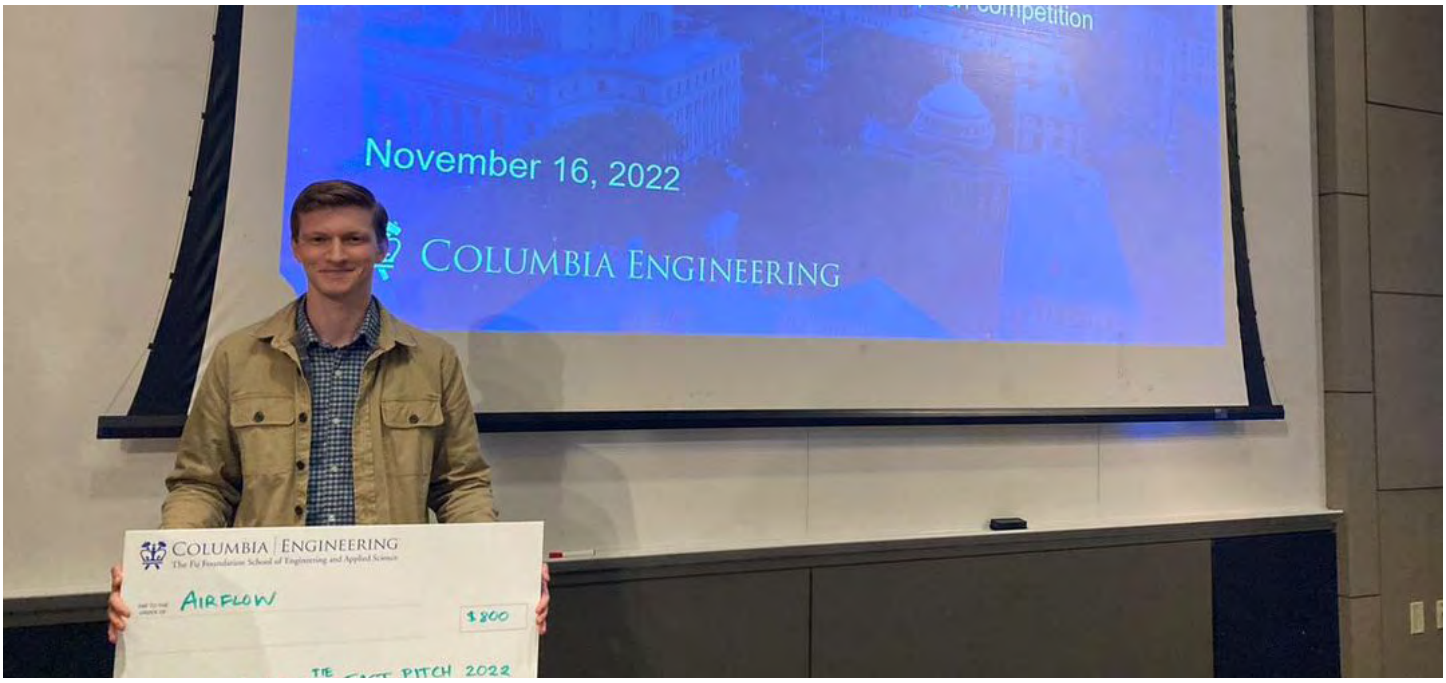
This year, the Rising Stars honed their interview and communication skills by presenting 5 minute lightning talks in an overview of their research. They met with junior and senior faculty to gain more insight into the world of academia. And in a new twist, this year the Rising Stars even practiced improv to improve their confidence and interview skills when seeking faculty positions.

However, this year also saw a surprise in the welcoming of the Meinig School of Biomedical Engineering at Cornell University as a new institutional partner for the Rising Stars in Engineering in Health Workshop. Starting in 2023, the workshop will be supported by all three universities, with the location changing campus every year. 2023's Rising Stars in Engineering in Health Workshop is expected to be hosted by Cornell University in Ithaca, New York.

Be sure to follow Columbia BME (@ColumbiaBME) Cornell BME (@CornellBME) and Johns Hopkins BME (@JHUBME) on social media for updates about the next call for applications!

Cooper Shifrin Wins 2nd Place at Fast Pitch Graduate Competition

By Harry Kelso



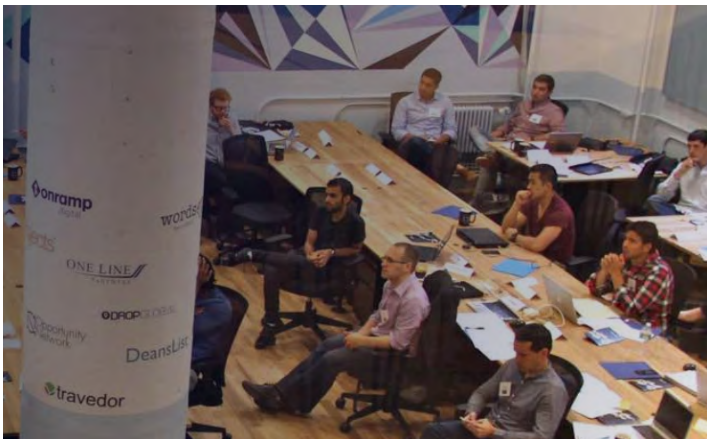
A few years ago, Cooper Shifrin's father became a quadriplegic after a bicycle accident. This came with many challenges, but one of the largest was preventing the development of bed sores. The condition required caretakers and family members to reposition him every few hours. Shifrin (M.S. '2023) then started working on a medical mattress idea as a result of these needs witnessed in his own home.

On Wednesday, November 16th, 2022, Shifrin's idea won him a second-place prize among graduate students at the annual Columbia University Fast Pitch Competition. Fast Pitch is Columbia Engineering's campus-wide annual elevator pitch competition where students win money to support their ideas. Teams have 60 seconds to sell their business ideas to a panel of judges to win up to $5,000. Fast Pitch is Columbia's longest-running pitch competition on campus.

Fast Pitch acknowledged Shifrin's extensive research. Medical professionals typically recommend repositioning patients with limited mobility every two hours, and there is currently no mattress or device that eliminates this need. After researching this topic, Shifrin learned that bed sores form at a specific time and pressure threshold (typically 2 hours and 32mmHg applied to any area of the skin) and that no mattress on the market used pressure sensing.

Shifrin's goal is to develop a medical mattress that uses sensory-guided pressure redistribution to eliminate the need for caretakers to reposition patients with limited mobility. This is an ambitious goal, but it will be an important advancement for those at risk for bed sores.

Today, Shifrin continues to prototype and will have the first section of the mattress developed by the end of January.



Aamna Siddiqui Awarded Best Poster at SURE Symposium

Aamna Siddiqui completes the Columbia University-Amazon Summer Undergraduate Research Experience (SURE) Program. As a SURE fellow, Aamna completed 10 weeks of research under the advisement of Dr. Clark Hung and graduate student Matthew Pellicore.

Aamna joined CEL from Virginia Commonwealth University. She is a rising senior majoring in Biomedical Engineering with a minor in Political Science. This summer, Aamna's project involved investigating the effects of fluid shear on fibroblast-like synoviocytes, and how changes in primary cilia length and incidence may be involved. Her final poster, titled "Assessing Changes in Mechanosensitivity and Primary Cilia Incidence and Length in Fibroblast-like Synoviocytes in response to siRNA-mediated IFT88 knockdown", was presented at the SURE 2022 Summer Symposium on August 3, 2022. Aamna's project was awarded "Best Poster" for Poster Session A.

SURE is an initiative that began in 2021 with generous support from Amazon. The program aims to provide a unique summer research experience for a cohort of students from historically underrepresented backgrounds in STEM. In addition to the completion of a research project, fellows attended programming, lectures, and workshops focused on career, professional, and research skills development. The summer 2022 cohort included 50 fellows.

Congratulations Aamna on your hard work this summer!

2022 Columbia BioMedX Awards Announced

We are very excited to announce our 2022 - 2023 Columbia Biomedical Engineering Technology Accelerator awardees. This year was highly competitive, with a record number of participants in our Lab-to-Market bootcamp and a very exciting pitch competition! These teams are among the Columbia faculty members awarded a Columbia Life Science Accelerator grant to bolster advanced biomedical research.

Funds are awarded to perform a "killer experiment", that is, an experiment that will substantially remove risk and leave no doubt that the product will be an improvement over the status quo. The goal is to help translate these scientific innovations into clinically effective products.

CONGRATULATIONS TO THE FOLLOWING TEAMS

NeuroFlex: Wireless, High-Resolution Neural Interface for Drug-Resistant Epilepsy (Co-funded by TRx)

Brett Youngerman, MD, MS (Neurosurgery) and Kenneth Shepard, PhD (Electrical and Biomedical Engineering)

Patients with epilepsy suffer from seizures, cognitive decline, and decreased life expectancy. Approximately one third of patients with epilepsy are drug-resistant and face uncontrolled seizures. While surgical intervention can mitigate symptoms and improve quality of life, surgical treatment of epilepsy is largely underutilized due to its invasiveness, multi-step complexity, and high cost. To address the need for a lower-cost, single-step intervention to treat drug resistant epilepsy, the team of Drs. Youngerman and Shepard developed a flexible, wireless, high-resolution neural interface for diagnostic seizure monitoring and therapeutic neuromodulation. Following placement, this device improves real-time neural mapping accuracy and supports therapeutic efficacy without the need for additional surgeries.

(continued)

UltraNav: Novel Focused Ultrasound Device for Drug-Free Treatment of Alzheimer's Disease (Co-funded by TRx)

Elisa Konofagou, PhD (Biomedical Engineering and Radiology) and Lawrence S. Honig, MD, PhD (Neurology)

Alzheimer's disease affects over 6 million people in the United States alone, with devastating economic and healthcare consequences. Abnormal aggregation of beta-amyloid and tau protein is a hallmark feature of Alzheimer's disease, and clearance of protein aggregates remains a major focus for Alzheimer's therapies. The team of Drs. Konofagou and Honig developed UltraNav (ultrasound + navigation) which transiently opens the blood brain barrier in a focused region and stimulates an immune response to clear beta-amyloid plaque and tau. Clinical safety and preliminary efficacy have been demonstrated in pre-clinical and early-stage clinical studies. Funding from BiomedX and TRx will enable investigation of tau pathology in patients receiving treatment with UltraNav.

Artificial Intelligence-Powered Dental Disease Detection

Helen H. Lu, PhD (Biomedical Engineering), Sunil Wadhwa, DDS (Orthodontic Dental Medicine), and Michael T. Yin, MD (Medicine, Infectious Diseases)

Periodontal disease, characterized by progressive bone loss, and caries (cavities) are the two most common dental conditions, impacting nearly 50% of U.S. adults. Diagnosis and monitoring of periodontal disease and caries currently rely on qualitative assessment of dental radiographs. The team of Drs. Lu, Wadhwa, and Yin developed an artificial intelligence (AI) algorithm for rapid and accurate assessment of dental radiographs for detection and monitoring of bone loss. This innovative approach to radiographic assessment could improve diagnostic accuracy and throughput, enable longitudinal tracking of disease state, and inform treatment strategies in patients with periodontal disease and caries.

Bio-Microbur for Oral Delivery of Biologics (Funded by TRx, Co-funded by ACT and BiomedX)

Kam Leong, PhD (Biomedical Engineering)

Most patients prefer to take oral medications over injections, which are more burdensome and expensive. However, many therapies, such as insulin, must be delivered via injection because if taken orally they get degraded by the digestive system and are not well absorbed. To address these problems, Dr. Leong and team have developed a tiny swallowable device, a "bio-microbur," inspired by sticky fruit burs that adhere to animal furs and clothing. The bio-microbur will protect labile drugs, prolong their retention, and enhance their absorption by the digestive system. After the bio-microbur sticks to the intestinal wall, the nanospikes and the coatings will biodegrade and release drugs or nanoparticles that carry drugs across intestine walls for safe and efficient delivery of critical therapies. The team will test a proof-of-concept for the device to ultimately establish a new platform technology for the efficient oral delivery of biologics.

SHPE is a Place for Latinx Engineers

Columbia's chapter of the Society of Hispanic Professional Engineers offers members professional development, networking, and a 'familia' on campus

When Eva Soler Cruz, Nathan Ocampo, and Jordhy Gonzalez joined Columbia's chapter of the Society of Hispanic Professional Engineers (SHPE), they were looking for a community to help navigate life as engineering students and advance their careers as young professionals.

SHPE provided that — and a lot more.

This year, these three Columbia Engineering students are members of the group's executive board, and they're excited for a year of events and opportunities for the group's members.

Soler Cruz (BME '24), the chapter's secretary, says she "highly recommends students to join SHPE because it is not only an amazing opportunity to network and grow as a young professional but to also become part of a community of like-minded individuals that you could eventually call your 'familia.'"

What is SHPE?

The Society of Hispanic Professional Engineers is a national organization that aims to provide support and role models in the Hispanic community. Columbia's chapter — one of more than 200 at colleges across the country — organizes social events, workshops, outreach to local high schools, and an annual trip to the SHPE national conference.

"SHPE really is a community. It's the one I was searching for, and I'm really glad I found it," says Jordhy Gonzalez (CS '23), the chapter's vice president internal. "It also serves as a source of general personal development," he says.

What does SHPE do throughout the academic year?

A highlight of the year is the group's annual trip to the organization's national conference. Chapter president Nathan Ocampo (BME '23) says it's "the best opportunity to network with companies and obtain internships or full-time jobs."

"The National Conference is the biggest conference for Hispanics in the United States. More than 200 companies attend the career fair looking for Hispanic talent. These companies also support different competitions like the Extreme Engineering Competition that consists of a non-stop 24 hours competition to design a specific machine," he says.

Throughout the year, SHPE partners with companies and units at Columbia to offer professional development, career planning, and networking opportunities. The membership also gets together early in the semester and during finals to share their collective knowledge.

(continued)

"It helped me here at Columbia with my class choices and getting into certain clubs. Older members kind of serve as mentors to the younger members, telling them 'oh, maybe you should start working on your resume, start applying to these research positions, or start take these courses,'" Gonzalez says.

How is SHPE involved in the New York City community?

Community outreach is another important part of SHPE's annual calendar. Each year, the membership chooses a local high school to host the Noche De Ciencias (Night of Science) for what Ocampo describes as "an inspirational night of science to remember."

"This year we will visit groups of students, parents, and educators to share with them some inspirational words, provocative thinking, and most importantly share our struggles and suggestions with the students. The parents will be given a separate workshop to learn more about where to get money for college, how to help their kids stay motivated at school, and let them know that there is a group of engineers in their community they can always reach out to," he says."

Columbia SHPE also sponsors junior SHPE chapters at several local high schools. "We had this program for the junior chapter where they were able to learn computer science languages as part of the program, for people to get an early start," Gonzalez says. As a result, one of the junior chapters has started hosting an annual hackathon.

What should students who want to join expect from SHPE?

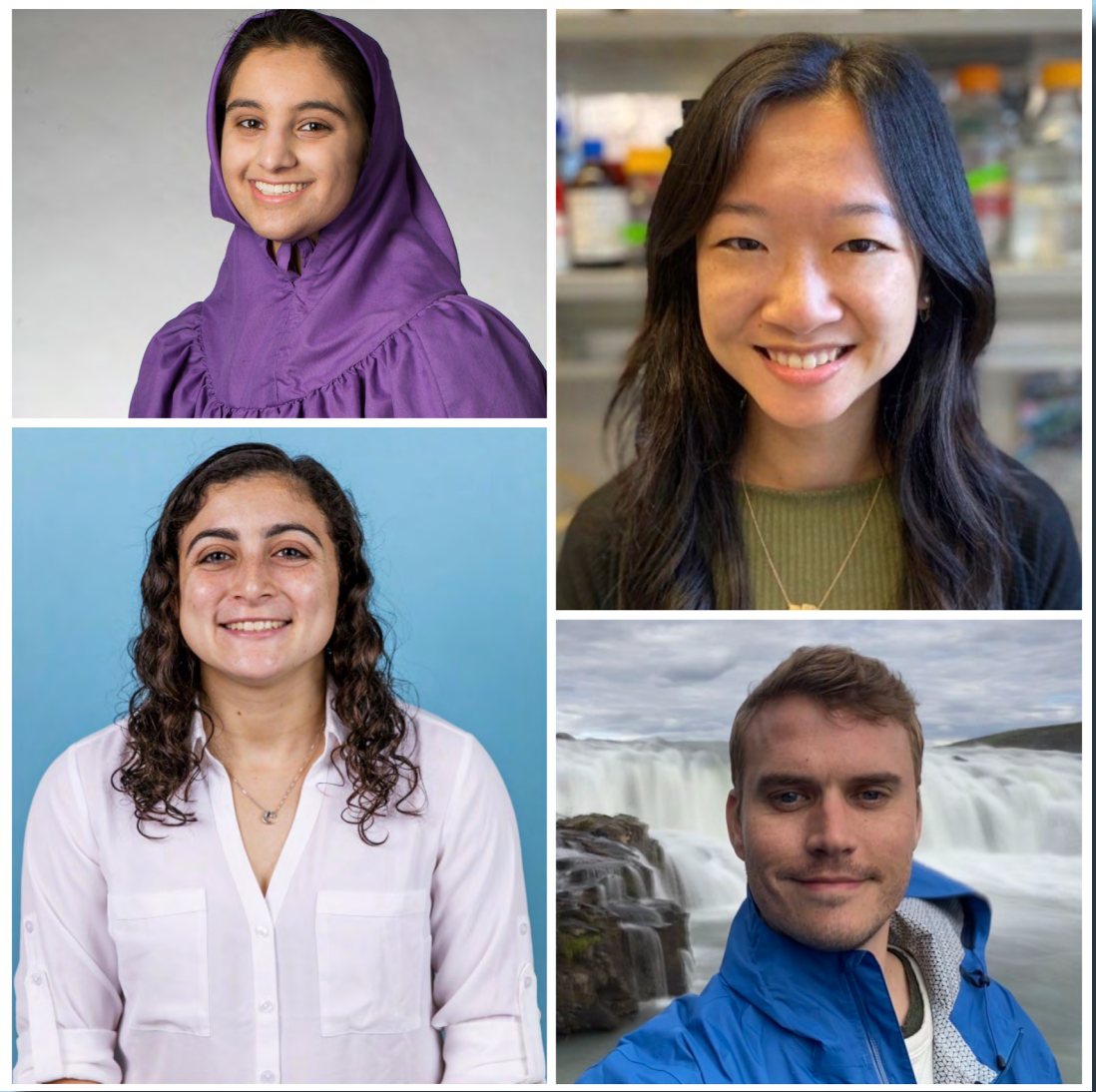
SHPE is actively seeking new Columbia Engineering students to join. "We are always excited to have new members join our organization," Ocampo says. Anyone who's interested can send an email to shpe@columbia.edu or sign up for the mailing list.

"It's really easy to join," Gonzalez says "We don't really reject anyone. Just tell us you're interested, and we are open to accepting anyone."

Soler Cruz, a rising junior, says she's glad to have joined the group her first year.

"Being a member of SHPE has empowered me to take risks with any professional opportunities presented and take action through them to further decrease the gap between the Hispanic community and the professional world."

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."

September 2022 - BME Blaze: Fatema Lodgher

Fatema Lodgher

Education

- **B.S. Biomedical Engineering, 2016, University of Houston**
- **M.S. Biomedical Engineering, 2021, Columbia University**
- **Ph.D. Biomedical Engineering, Columbia University, (in progress – fingers crossed!)**

Where are you from?

That's flummoxing; I was born in West Virginia, grew up in Houston, and moved to New York from San Antonio. So, I'm a West Virginian, Texan, Houstonian, and now, a New Yorker.

What is your current role?

I am working on a Ph.D. under the mentorship of Dr. Hillman in the Laboratory for Functional Optical Imaging. My work in the lab involves studying neural activity and blood flow on the mouse cortex to better understand brain states and movement.

What drew you to the field of Biomedical Engineering?

One of my biggest influences was my dad. Growing up, my dad was a big do-er, as in come the weekend, he'd always be working on some sort of project. I, unfailingly, was his faithful assistant. Those weekends making things with him were some of the best of childhood. It's really no wonder I became an engineer!

I chose Biomedical Engineering because the human body is fascinating. Humans have had human bodies for as long as humanity has been around, and we are only just starting to meaningfully unravel its secrets and figure out what makes the body work.

Plus, in what other field would I be able to help so many people at once, the ones today and the ones to come? The things we make and things we discover (with the tools that we made) contribute to new scientific discoveries and help make yesterday's dream therapies into tomorrow's patient realities.

Why did you choose Columbia BME?

I came into my Master's degree as a pathway to an industry job. With that in mind, I chose Columbia because I would be academically challenged, be able to establish an incredible professional network, and be fairly close and well connected to multiple BME job markets. And, it fulfilled a life-long dream of living in New York City!

As part of my course load, I did research for a semester in the Hillman Lab. I enjoyed the research and felt like this lab was somewhere I could grow. So, I came back, and Dr. Hillman was nice enough to take me back.

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

Easily, they are almost all of hanging out with the friends I've made in and out of the lab! I have gotten to meet so many wonderful people and made lifelong friends.

What was your proudest moment at Columbia?

Graduating- I finished my Master's degree during the pandemic. So, definitely graduating. And, I look forward to graduating again (fingers crossed!)

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

In terms of professional career moves, only time will tell. But, in terms of my human goals, I've taken much of what I've learned in graduate school (like questioning basic assumptions) and applied them to other facets of my life. I've noticed a decrease in the problems I've made for myself. It's been nice.

I think another thing I am slowly learning (or possibly relearning, I'm not sure) from the people around me is the ability to take small risks and just go for it. That's the really wonderful thing about Columbia BME and New York City– as long as you're being responsible, no one really cares what you do. There is a profound amount of freedom in that.

Any words of wisdom or tips for prospective BME students?

Self-care is super important. Remember to sleep well, eat properly, drink water, and have fun.

What are you excited about?

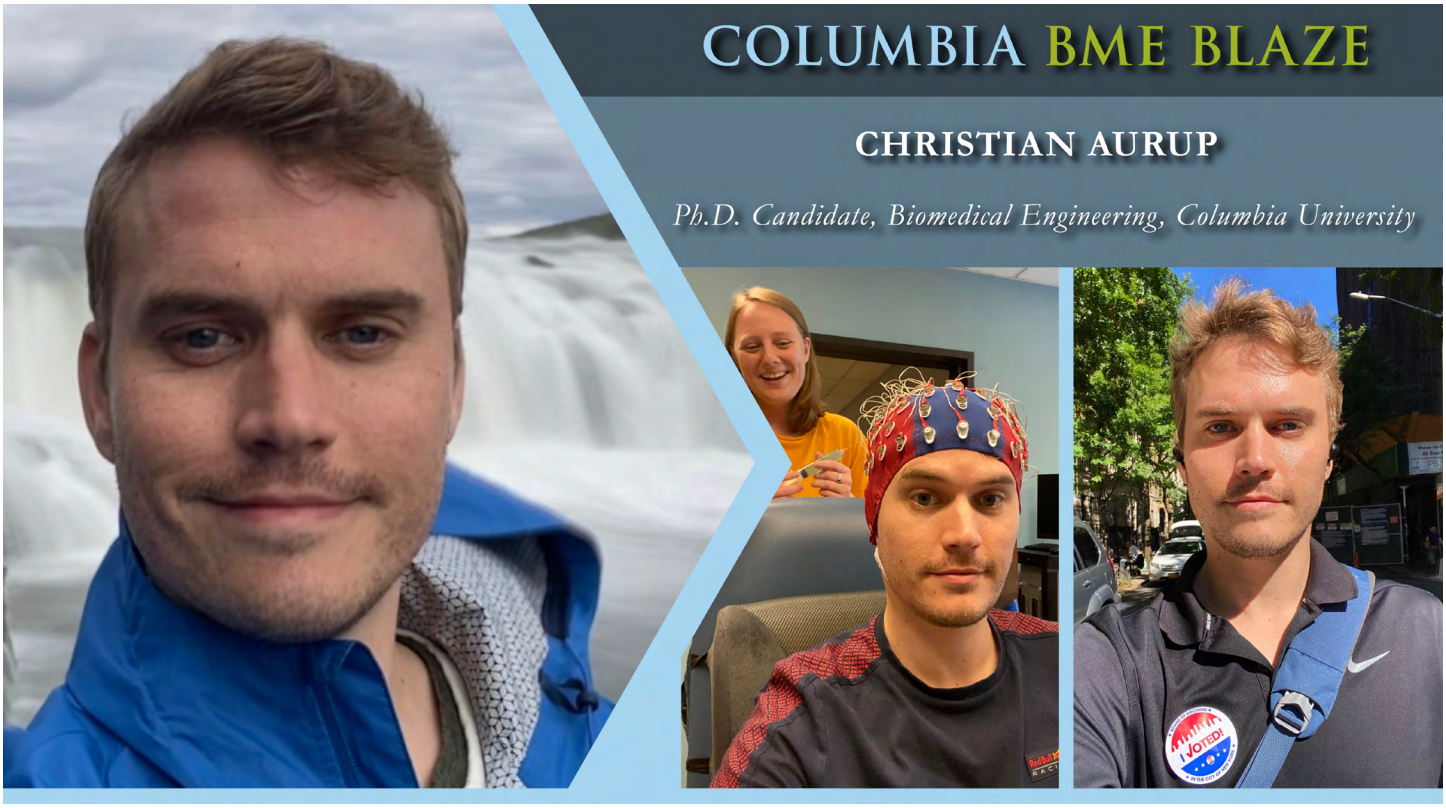
In general? Ice cream, llamas, plants, and brains.

> **"The things we make and things we discover (with the tools that we made) contribute to new scientific discoveries and help make yesterday's dream therapies into tomorrow's patient realities.**

—FATEMA LODGHER
M.S. ALUMNA AND CURRENT PH.D. STUDENT IN THE HILLMAN LAB, ZUCKERMAN INSTITUTE, BIOMEDICAL ENGINEERING DEPARTMENT, COLUMBIA UNIVERSITY

Photos at left, clockwise: The Larger Version of the Headshot: Professional photo through portrait sessions set up through EGSC. Definitely, something to take full advantage of; The One in Jackets: The Hillman Lab celebrating Lantern Festival on the roof of the Zuckerman Institute; The One with the Graduates: My friends and I as we graduated with our MS degrees from the BME department!

October 2022 - BME Blaze: Christian Aurup



Christian Aurup

Education

- **B.S. Biomedical Engineering, 2014, University of Delaware**
- **M.S. Biomedical Engineering, 2015, Columbia University**
- **M.Phil. Biomedical Engineering, 2019, Columbia University**
- **Ph.D. Biomedical Engineering, 2022, Columbia University**

Where are you from?

I was born in Denmark but moved to the U.K. at 18 months old and then to New Jersey at 6 years old.

What is your current role?

I am currently writing my dissertation and preparing to defend my Ph.D. thesis work in less than a month. I have spearheaded my lab's research into using focused ultrasound as a noninvasive means of modulation of the central nervous system. We have also further developed an ultrasound-based technique for noninvasive functional imaging of hemodynamic responses in the brain to focused ultrasound neuromodulation. I began experiments with mice near the start of my research career but have graduated to working with nonhuman primates, a link in the chain towards conducting research on human subjects where we hope to treat neurological disorders like Parkinson's disease.

What drew you to the field of Biomedical Engineering?

My starting major as an undergraduate student was Quantitative Biology but it was mostly theoretical and not very hands-on. My older brother was a Biomedical Engineer and it was exactly the hands-on application of mathematics and biology that I enjoyed learning.

Why did you choose Columbia BME?

Two major factors led me to Columbia BME: the school's great reputation and its fantastic location right here in New York City. Being associated with a hospital, Columbia BME also has great resources for interdisciplinary research and no shortage of funding opportunities.

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

My favorite memories from the program involve attending and presenting at conferences around the world. I have been fortunate to share my research in many countries across multiple continents. By far my favorite such trip was to Kobe, Japan. I look forward to visiting again soon.

What was your proudest moment at Columbia?

My proudest moment at Columbia is getting the green light to schedule my defense date. I look forward to wrapping up my research and moving forward with the next undetermined phase of my life.

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

Working at the UEIL has given me a great set of tools I can use in many different professions. I appreciate the most the wide range of opportunities that I have ahead of me.

Any words of wisdom or tips for prospective BME students?

Pursuing a Ph.D. will test the limits of your tenacity. It is typically a path full of failure and disappointment but that is the nature of living on the frontier of science. You go through waves of motivation so you should take advantage of every highly motivated period you have. Lastly, planning your dissertation should inform every step you take in your research. Taking on projects tangential to your primary goals can end up delaying your degree a great deal.

What are you excited about?

I am excited about finishing my degree and exploring all the options available to me regarding what comes next in life professionally. I am excited to sit at a different desk looking at a different screen with a different job title and have more disposable income.

“ Working at the UEIL has given me a great set of tools I can use in many different professions. I appreciate the most the wide range of opportunities that I have ahead of me.

—CHRISTIAN AURUP
PH.D. GRADUATE*, BIOMEDICAL ENGINEERING DEPARTMENT, COLUMBIA UNIVERSITY
***UPDATE SINCE FIRST PUBLISHED**

Photos at left, from left to right: Me in Iceland recently with a waterfall in the background; My colleague Erica Mccune testing a new EEG cap for her study; Me walking out of a polling place. I've voted in every primary and general election since becoming a citizen in 2016.

November 2022 - BME Blaze: Carly Rivera

Carly Rivera

Education

- **B.S. Biomedical Engineering, Expected 2023, Columbia University**

Where are you from?

Arlington, VA

What is your current role?

I am currently going into my senior year at Columbia and I am also a member of the women's basketball team. I work as an undergrad at The Greene Lab at CUIMC.

What drew you to the field of Biomedical Engineering?

My sister is a chemical engineer. I always found engineering to be very interesting, but I am also very interested in medicine. This major allowed me to get the best of both worlds.

Why did you choose Columbia BME?

I chose Columbia BME because I know it is one of the top programs in the country and will prepare me for life after college. The BME faculty are also amazing and are very supportive in helping you learn as much as possible and also provide fun opportunities outside of the classroom to feel immersed in the program. Between the rigorous education and the connections, I have made in the program, I know that I made the right choice.

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

Some of my favorite memories have been working on lab reports with my lab group. We would just spend time in a classroom and work on the reports throughout the weekend. It really helped me get out of my shell and meet new people, while also getting a deeper understanding of the work we were doing in the classroom.

What was your proudest moment at Columbia?

Making Dean's List and Academic All-Ivy in my first semester in SEAS as a BME. I was nervous about coming back to school after the pandemic and playing basketball while trying to be an engineer. I worked very hard in my first semester and was able to not only make Dean's List but also make Academic-All Ivy for Ivy League Women's Basketball.

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

I want to attend medical school after college so studying BME has given me a completely different experience than just the regular pre-med track. I feel like I have a greater knowledge of areas outside of the track that I know will prove useful going forward in the next few years when applying to medical schools. I have also gotten to meet people on the same path as me who I have been able to connect with and get advice from.

Any words of wisdom or tips for prospective BME students?

My biggest tip is to definitely get to know your classmates and your teachers. I have made so many good friends who have helped me and understand how difficult it can be to be a BME at Columbia. The faculty is also amazing and really wants to help us succeed while making sure we are grasping the concepts we will need in the future. Being a BME is the best, no matter how hard it is. I would not change it for the world.

What are you excited about?

I am looking forward to senior design. I got a chance to attend the Expo this year and it made me really excited to start designing a project of my own. I am not sure what I want to work on yet, but I can't wait to get started.

> "I chose Columbia BME because I know it is one of the top programs in the country and will prepare me for life after college. The BME faculty are also amazing and are very supportive in helping you learn as much as possible and also provide fun opportunities outside of the classroom to feel immersed in the program.

—CARLY RIVERA
BS '23, SENIOR YEAR UNDERGRADUATE STUDENT, BIOMEDICAL ENGINEERING DEPARTMENT, COLUMBIA UNIVERSITY

Uniformed basketball photo at left: "I was Academic All-Ivy for Ivy League Women's Basketball this year."

December 2022 - BME Blaze: Josephine Wu

Josephine Wu

Education

- **B.S. Bioengineering, 2017, University of California, Berkeley**
- **M.S. Biomedical Engineering, 2019, Columbia University**
- **M.Phil. Biomedical Engineering, 2020, Columbia University**
- **Ph.D. Biomedical Engineering, 2022, Columbia University**

Where are you from?

Having moved cross-country four times and spent nearly equal parts of my life on the East and West Coasts, I would describe myself as bicoastal. I was born not far from here in Ridgefield, CT but soon after that we moved to San Diego. I then attended middle and high school in the suburbs of Boston, undergrad in the San Francisco Bay Area, and grad school in New York.

What drew you to the field of Biomedical Engineering?

In an introductory bioengineering course in my sophomore year of college, we were shown an image of the infamous Vacanti mouse with a human ear-like structure on its back. Many of my classmates were disturbed at the sight, but there was nothing more thrilling to me than the idea that we could figure out how to grow body parts in the lab.

What is your current role?

Until very recently, I was a Ph.D. candidate in Professor Gordana Vunjak-Novakovic's Laboratory for Stem Cells and Tissue Engineering, where I worked on cartilage and bone tissue engineering spanning the macro scale for regenerative medicine to the micro-scale for in vitro modeling. My dissertation, which I successfully defended in June, was entitled "Engineering spatiotemporal cues for directed cartilage formation." Now I'm staying on in the lab for a few more months to wrap things up, before starting as a postdoc in Professor Daniel Kelly's lab at Trinity College Dublin this fall.

Why did you choose Columbia BME?

As I began thinking about pursuing a Ph.D. in biomedical engineering, specifically tissue engineering, I reached out to one of my earliest research mentors (and the first bioengineer I'd ever met) for advice. Claire steered me in Gordana's direction on account of her pioneering work in the field and, more importantly, her reputation for being a really kind person. Initially, I was nervous about making a 5-year decision essentially based on a 30-minute interaction, but ultimately, I just went with a gut feeling that this was the right place for me. I also took it as a sign that I had Elvis' song, "Can't Help Falling in Love," stuck in my head on the morning of my interview and for days afterward. The interview weekend boat cruise around Manhattan at night definitely didn't hurt, either.

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

I met some of my favorite people through the program, and some of my fondest memories with them include dressing up for EGSC boat cruises (turns out the interview weekend boat cruise was just the first of many), taking the ferry to Governor's Island for the BME department retreat, watching sunsets from the Frying Pan with blueberry mango sangrias in hand – and for a non-boat-related memory, flying to Paris for a long weekend after passing our qualifying exams.

What was your proudest moment at Columbia?

Seeing our work and my name in the New York Times was absolutely surreal! And in a close second, seeing the same histology used for the Engineering in Medicine Symposium this year, with all the PIs setting their Zoom backgrounds to that image.

Any words of wisdom or tips for prospective BME students?

Definitely take advantage of all the opportunities available to you at Columbia, but balance that with experiencing New York outside of the Columbia bubble. As a grad student, having a full life outside the lab made me a far better (happier and more efficient) scientist in the lab – and having an advisor who shared the same philosophy made all the difference.

What are you excited about?

To move to Dublin, Ireland, and start my postdoc this fall!

"As a grad student, having a full life outside the lab made me a far better (happier and more efficient) scientist in the lab – and having an advisor who shared the same philosophy made all the difference.

—JOSEPHINE WU
PH.D. '22; POSTDOCTORAL RESEARCH SCIENTIST AT TRINITY COLLEGE DUBLIN

Photos at left, clockwise from top left: Headshot; Some of my labmates came to see me play violin; GVN lab outing to Kafana, a Serbian restaurant in the East Village; Gordana and I, after my defense; Pottery was the pandemic hobby that stuck; Post-defense celebration with friends

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