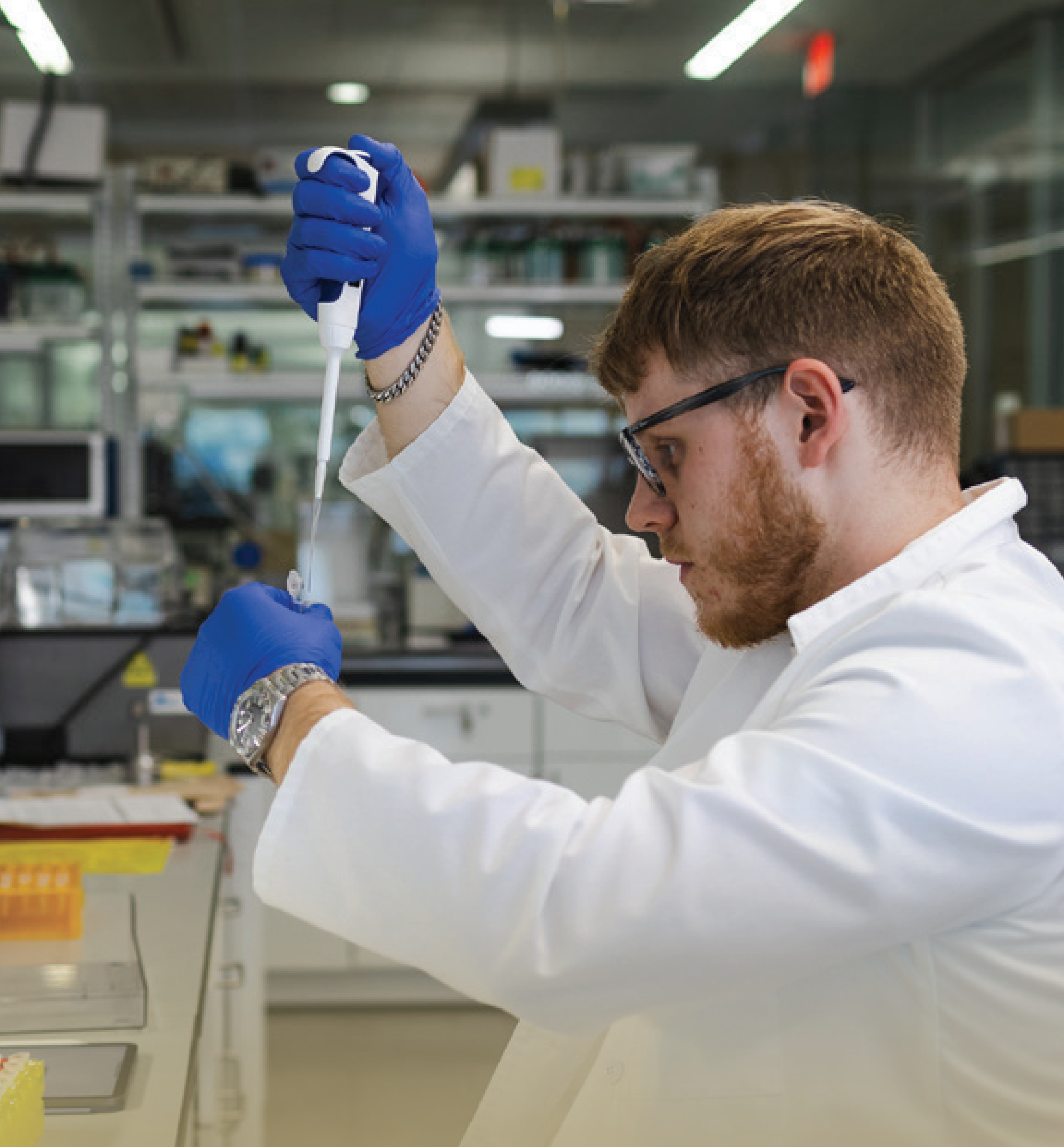


BME in the Center of Washington, D.C.

Department of
Biomedical Engineering

GW | Engineering

Letter from the Department Chair

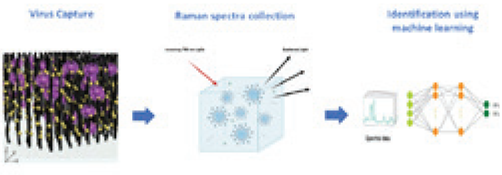
Located in the heart of the Nation's Capital, the Department of Biomedical Engineering at The George Washington University offers unique and exciting opportunities for our students. Our prime location enhances their educational experience by providing unparalleled access to various federal agencies and research labs and well-developed and externally funded biomedical and health-related research programs within our department, complemented by the adjacent GW School of Medicine and Health Science and GW Hospital. Our current research efforts span a broad spectrum of critical topics, including the use of biophotonic tools to advance personalized medicine, new technologies for understanding electrical conduction abnormalities in the heart, developing next-generation biocompatible recording and simulation devices, and engineering novel therapeutic platforms for cancer treatment.

We take pride in offering small classroom sizes, a dedicated core faculty, and a collaborative learning experience. Our nurturing and inclusive environment is critical to our mission of training the next generation of biomedical engineers who are aware of contemporary issues and challenges within the biomedical field and society at large. Students graduate equipped to pursue diverse career paths, from engineers, research scientists, and medical doctors to patent lawyers, regulatory experts, and policy-makers.

While the School of Engineering and Applied Science has hosted BME undergraduate and graduate programs within the Department of Electrical and Computer Engineering since the early 2000s, we are proud to mark the 10-year anniversary of the BME Department! This milestone celebrates our growth as the newest department within GW Engineering and highlights our ongoing commitment to excellence in biomedical engineering education and research.

Vesna Zderic, Ph.D.
Professor and Chair
Department of Biomedical Engineering
School of Engineering and Applied Science
The George Washington University

CLINICAL COLLABORATIONS FOR IMAGE ANALYSIS



Raman spectroscopy and machine learning for virus identification.

Collaborations between engineering and medicine are crucial for improving patient outcomes, with medical imaging a prime example. Through partnerships with clinicians at GW and the NIH, Prof. Murray Loew works to enhance image analysis and explore the intersection of oncology and biomedical engineering.

Alongside GW's School of Medicine and Health Sciences, Loew validated machine learning methods for assessing kidney tumors, detecting and localizing prostate cancer, and predicting head and neck cancer recurrences. With NIH's Clinical Center, Loew images living *ex vivo* liver tumors to register images of intact tissue to biopsy locations. Ultimately, this work will lead to accurate radiology-pathology correlations and a quantitative description of tumor heterogeneity.

As AI becomes integral in image interpretation, Loew focuses on building clinician trust through explainability approaches that clarify the images' clinically relevant components. Simultaneously, he's innovating algorithms for earlier cancer diagnosis and classification, with a particular focus on prostate cancer, where his work on radiation therapy leverages imaging to understand surrounding tissues better. By combining CT and MRI data, these innovations improve treatment targeting precision and boosting techniques.

Each of Loew's advancements relies on his ongoing collaborations to ensure his research aligns with clinical needs. Clinicians, in turn, benefit from access to cutting-edge technology and novel approaches. Through these partnerships, Loew addresses important challenges in medical imaging and improves patient outcomes.

BEHIND ALEC TRIPI'S DECISION TO PURSUE ADVANCED EDUCATION

Hands-on learning, collaboration, and a supportive community are hallmarks of undergraduate education in the BME Department. Many students, like Alec Tripi, B.S. '24, capitalize on the opportunity to extend their exploration of biomedical engineering by pursuing the department's combined five-year Bachelor's/Master's program.

As an undergraduate, Tripi heavily engaged in research through classwork projects, independent ventures, and lab activities. In Prof. Chung Hyuk Park's lab, he began developing a soft robotics gripper with a touch sensor for feedback, allowing for easy grip adjustments. Tripi hopes to integrate this technology into his prosthetics venture, adding complexity and utility to his designs.

Networking opportunities at AIMBE and GW BMES events helped Tripi secure job opportunities, including a fellowship in NIST's Fire Safety Engineering Department and an internship at Infinite Technologies Orthotics and Prosthetics. In collaboration with BMES, the GW Innovation Center, and e-NABLE, his prosthetics venture aims to make these devices more accessible by distributing free 3D-printed prosthetics to local clinics.

Through the combined program, Tripi is able to pursue specialized courses to find his niche. His current interest in integrative orthopedic technology makes his varied experiences in and out of the classroom invaluable. Tripi's journey highlights how leveraging department resources can enhance a student's academic and professional development, preparing him for a unique career in novel biomaterial technologies and manufacturing techniques.

Alec Tripi

Kenise Morris' Journey of Growth and Innovation

Dr. Morris (RIGHT) explains her research to a student at the annual Research and Design Showcase.

The Provost Diversity Fellowship Program at GW fosters a diverse graduate student community across the university. This diversity is vital at GW Engineering as we innovate solutions to global challenges requiring varied perspectives. By supporting individuals like triple alumnus Dr. Kenise Morris, B.S. '16, M.Eng. '18, Ph.D. '24, GW enables leaders from diverse backgrounds to pursue advanced degrees, contribute to vital research, and represent impacted communities.

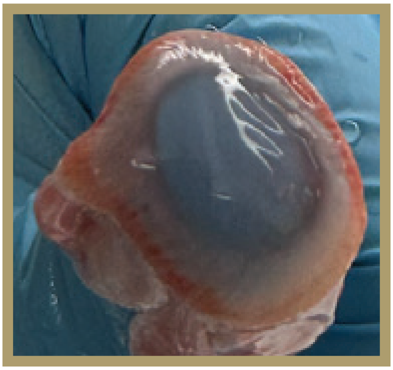
The fellowship's financial support is crucial for improving access to doctoral programs, as the funding is what enabled Morris to pursue her Ph.D. In her doctoral research, Morris and her advisor, Dr. Anne-Laure Papa, investigated the use of platelets for cancer treatment. While platelets are known to stop injuries from bleeding, they also play a major role in cancer metastasis. Under Papa's guidance, Morris investigated the interactions between cancer cells and platelets to leverage them and develop a new diagnostic tool for monitoring disease progression.

While many researchers are exploring liquid biopsy as an alternative to imaging for patient monitoring, Morris and Papa sought to expand platelets' ability to detect a broader profile of cancer cells. Platelets naturally attach to cancer cells and protect them from immune cells in the bloodstream regardless of their phenotype, which changes as they adapt to resist treatment. With the team's platelet-based circulating tumor cell (CTC) capture technology, clinicians have the potential to detect and capture more CTCs over existing diagnostic tools, facilitating personalized therapy plans for patients through detailed drug profiling.

Papa praised Morris for her remarkable progress, from having no prior research experience to successfully defending her dissertation and contributing to other published research. Despite the added challenges of starting her Ph.D. during COVID-19, Morris benefited from Papa's guidance and the strong support network within her lab. The combined experiences of her diverse lab peers not only enriched Morris' research journey but also played a crucial role in her personal and professional growth. As a result, Morris is poised to continue advancing biomedical engineering in her career.

Dr. Anne-Laure Papa (L) and Dr. Kenise Morris (R).

Alumnus Bridges Engineering and Medicine to Optimize Ultrasound Imaging



The GW Nanofabrication and Imaging Center (GWNIC), equipped with the latest light, confocal, and electron microscopes, is an ideal space for BME students like Alessio Denny, M.S. '24, to advance research in ultrasound imaging. With the goal of enhancing students' educational and research opportunities, this state-of-the-art facility supported Denny's study on ultrasound-induced corneal damage–a pressing issue as ultrasound is explored as a treatment for various corneal disorders, including keratoconus, which impacts around one in every 375 people across the U.S.

GWNIC's scanning electron microscopy machine was pivotal for Denny's analysis of corneal lesions induced by ultrasound at varying frequencies and intensities. This machine provided high-resolution images of the corneal samples, which Denny then used to quantify the lesioned surface area with Fiji image processing software. He employed various mathematical tools to uncover the relationship between the frequency, intensity, and lesion size, revealing that a frequency of 600 kHz and an intensity of 1 Wcm-2 cause the greatest damage to the corneal surface. His findings offer insights for optimizing ultrasound procedures while balancing safety and permeability.

"Without exploiting the center's capabilities, I would not have been able to describe the corneal lesion area changes mathematically with respect to ultrasound frequency and intensity," said Denny.

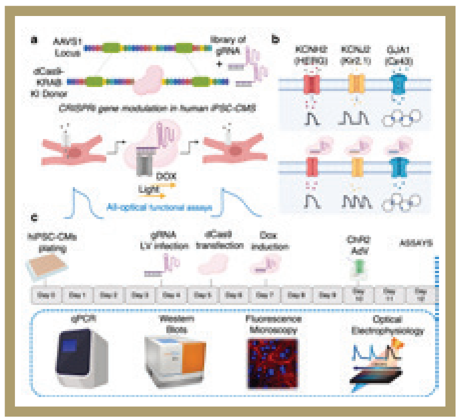
By leveraging the GWNIC's advanced technology and ultrasound machines in her advisor's lab, Prof. Vesna Zderic, Denny elevated his research and extended its impact beyond ophthalmology. The differential equation model he developed to precisely simulate ultrasound propagation into corneal tissue in MATLAB is adaptable to any biological tissue subjected to ultrasound. Anastas Popratiloff, director of the GWNIC, who also guided Denny, noted that this approach not only enriched Denny's research experience but also exemplified the facility's mission.

Having completed his master's degree, Denny emerges with a strong grasp of ultrasound machine functions and laboratory techniques indispensable for his future medical career. He is set to begin a six-year program at the Università Cattolica International Medical School in Rome, Italy, where his interdisciplinary training and exposure to medical problems at GW Engineering will help him further bridge engineering and medicine.

International Collaboration on Subcellular Optogenetic Control of Heart Cells

(LEFT TO RIGHT) **Graduate students and postdocs in the Entcheva Lab, Khady Diagne, Maria Pozo, Weizhen Li, Julie Han, and Yuli Heinson, with Dr. Emilia Entcheva.**

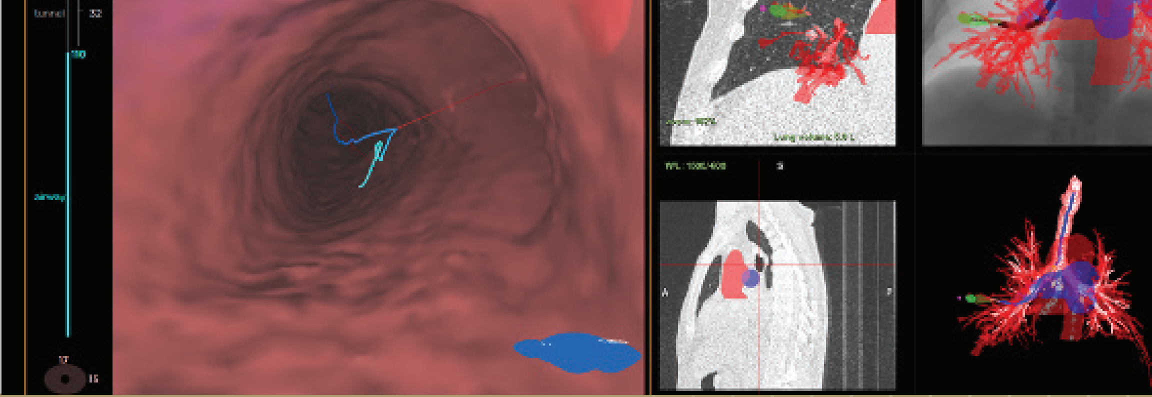
Prof. Emilia Entcheva conducts pioneering research straddling the fields of optics, molecular biology, and electrophysiology. Her work combining all-optical techniques with precise genetic manipulation in human stem-cell-derived cardiomyocytes (iPSC-CMs) in large-scale studies is not only pushing the boundaries of cardiac research but also facilitating collaborations with researchers worldwide.



In recent years, Entcheva's lab has published significant papers in leading journals, such as Communications Biology, showcasing the utility of optogenetics and all-optical techniques in designing new high-throughput systems to understand and manipulate cardiac function. Her innovations include label-free imaging to analyze heart wave dynamics, cost-effective cardiotoxicity screening methods, and all-optical technologies for multimodal characterization of iPSC-CMs. A notable study led by her Ph.D. student Julie Han validated the deployment of CRISPRi gene modulation alongside all-optical electrophysiology in post-differentiated human iPSC-CMs, linking gene manipulation to changes in function.

As a follow-up study, Han successfully expressed light-controlled "magnets," optogenetic tools that manipulate distances at the molecular level, in various organelles in myocytes like mitochondria and lysosomes, which serve as secondary calcium stores alongside the sarcoplasmic reticulum. The "magnets" were used to dynamically and reversibly control calcium stores' proximity and coordination during cardiac electromechanical activity. This data formed the basis for Entcheva's new study funded by the Human Frontier Science Program, a highly competitive initiative supporting innovative, basic research at the frontiers of the life sciences. Her study is the first to examine how secondary calcium stores may shape heart activity in iPSC-CMs, particularly regarding arrhythmias.

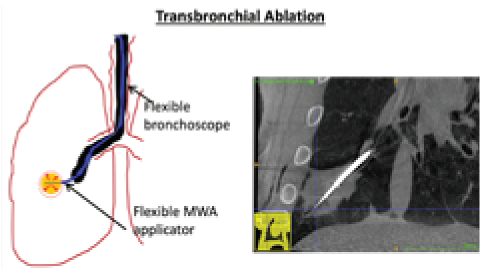
Entcheva's leadership has attracted top international collaborators for this project, including Drs. Moritoshi Sato from Japan and Michael Colman from the U.K. Their combined expertise in optogenetics, molecular tools, and computational models will deepen the understanding and control of cardiac function, simultaneously training graduate students and postdocs in GW Engineering's unique in-house all-optical systems. By expanding knowledge in this area, Entcheva's work paves the way for advancements in personalized medicine while ensuring GW Engineering remains at the forefront of scientific discovery.



Advancing Thermal Ablation Technology for Personalized Cancer Treatment

Wattage, food type, and even container influence the time taken to heat food in a microwave oven. Similarly, treating cancer with energy-based devices raises questions about the optimal settings for effective tumor ablation. Unlike heating food, however, there's no real-time feedback to help clinicians determine if treatment was sufficient and what next steps to take. Alongside external collaborators, Prof. Punit Prakash's research group seeks to address this gap by developing technologies for image-guided thermal ablation. As a new faculty member, he aims to leverage the BME Department's collaborative environment and proximity to the GW Hospital to advance this minimally invasive technique.

Tissue characteristics vary widely across individuals, providing a rationale for the personalized treatment delivery approach Prakash and colleagues are pursuing. They developed needle and catheter-based devices to burn tumors with microwave energy and a device offering directional control of ablation patterns, which may enhance treatment precision. Prakash noted that while imaging and other clinical data can be used to inform therapy decisions, further advancements in devices and predictive modeling are essential to realizing this potential.



For lung cancer, the group developed a flexible ablation catheter that may overcome challenges in accessing tumors in diverse lung sites. They collaborated with industry partners to advance the technology from proof-of-concept to manufacturing and pre-clinical testing in large animals. Now, the group is conducting a clinical study in Australia, where they treated the first patient in March. Their ongoing work aims to develop a computational pipeline that estimates individual disease characteristics, like location, dimensions, and physical properties, from imaging data to predict treatment outcomes.

To broaden the impact of his group's research, Prakash emphasizes the value of proximity to clinicians at the GW Hospital. Regular interactions can foster sustained research efforts, exposure to new ideas, and expand research opportunities. With no medical school at his prior institution, GW Engineering is the ideal place for forming new clinical partnerships. Collaborating with BME colleagues with complementary expertise will also enable his group to tackle broader problems. This collaborative environment is a key strength of the department, offering a dynamic space that informs and advances research.

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