Alma Mater

Far above Cayuga's waters,
With its waves of blue,
Stands our noble alma mater,
Glorious to view.

Lift the chorus, speed it onward,
Loud her praises tell;
Hail to thee, our alma mater!
Hail, all hail, Cornell!

Far above the busy humming
Of the bustling town,
Reared against the arch of heaven,
Looks she proudly down.

Lift the chorus, speed it onward,
Loud her praises tell;
Hail to thee, our alma mater!
Hail, all hail, Cornell!

CornellEngineering
Meinig School of Biomedical Engineering

2022 Commencement

May 28, 2022

PROGRAM

10:45 Welcome
Dr. Marjolein van der Meulen
James M. and Marsha McCormick Director of Biomedical Engineering; Swanson Professor of Biomedical Engineering

Award Recognition

Doctor of Philosophy Degree Recipients
Dr. Peter Doerschuk
Director of Graduate Studies, Professor

Master of Engineering Degree Recipients
Dr. Newton de Faria
Master of Engineering Program Director, Professor of Practice

Bachelor of Science Degree Recipients
Dr. Steven Adie
Associate Director of Biomedical Engineering,
Director of Undergraduate Studies, Associate Professor

Closing Remarks
Dr. Marjolein van der Meulen
James M. and Marsha McCormick Director of Biomedical Engineering; Swanson Professor of Biomedical Engineering

Class Photos

Reception

DOCTOR OF PHILOSOPHY

Steven Ayala
Thesis title: "The effect of combined impact injury and mechanical sliding on cellular damage to articular cartilage from the knee and ankle."
Advisor: Lawrence Bonassar

Monideepa Chatterjee
Thesis title: "Therapeutic utility of the MRL/MPJ regenerative mouse in clinically-relevant tendon injuries."
Advisor: Nelly Andarawis-Puri

Alexandre Pellan Cheng
Thesis title: "Liquid biopsies for infectious and immune diseases."
Advisor: Iwijn De Vlaminck

Carolyn Chlebek
Thesis title: "Identification of novel cellular pathways involved in bone mechanotransduction using transcriptomics."
Advisor: Marjolein van der Meulen

Jacob A. Erstling
Thesis title: "Ultrasmall fluorescent inorganic core - organic ligand shell (core-shell) nanoparticles for optical super-resolution microscopy and oral delivery."
Advisor: Uli B. Wiesner

Christine Harper
Thesis title: "The influence of mechanical stress on components in the bacterial cell envelope."
Advisor: Christopher J. Hernandez

Jongkil Kim
Thesis title: "Enhancing biochemical, structural, and mechanical properties of tissue-engineered menisci and entheses using biochemical and biomechanical stimuli."
Advisor: Lawrence Bonassar

Hania Koziol
Thesis title: "Hydrophobically modified glycopolymers for the treatment of dry eye disease."
Advisor: David Putnam

Nichaluk (Nikki) Leartprapun
Thesis title: "Optical coherence elastographic and tomographic microscopy for resolution-enhanced micromechanical and structural imaging of biological systems."
Advisor: Steven Adie

Marianne Lintz
Thesis title: "Tissue engineered strategies for total disc replacement: structure and mechanical properties of the intervertebral disc."
Advisor: Lawrence Bonassar

Jason (Chang) Marvin
Thesis title: "Leveraging biological insight from the regenerative MRL/MpJ mouse strain for tendon mechanistic discovery and guiding therapeutic development."
Advisor: Nelly Andarawis-Puri

Melanie Maurer
Thesis title: "Uncovering the role of lamin A/C in nuclear mechanics and regulation of gene expression in health and disease."
Advisor: Jan Lammerding

Duncan McCloskey
Thesis title: "Developing devices and techniques for enabling point-of-care molecular diagnosis."
Advisor: David Erickson

Zeinab Mohamed
Thesis title: "Development of a biologically relevant bacterial outer membrane platform for elucidating biomolecular interactions."
Advisor: Susan Daniel

Aaron Mok
Thesis title: "Deep and wide multiphoton imaging in highly scattering biological tissues."
Advisor: Chris Xu

Patrick Muljadi
Thesis title: "The role of glycosaminoglycans in fatigue injured tendon."
Advisor: Nelly Andarawis-Puri

Taylor Oeschger
Thesis title: "Development of low-cost micro-volume antimicrobial resistance assays for pathogenic bacteria."
Advisor: David Erickson

Daniel Rivera
Thesis title: “Observing and manipulating physiological function in the brain and heart of mouse models of neurological and cardiovascular disease with light.”
Advisor: Chris Schaffer

Nancy Ruiz
Thesis title: “Unraveling the molecular and physiological mechanisms leading to vascular dysfunction in Alzheimer’s disease.”
Advisor: Chris Schaffer

Johana Uribe
Thesis title: “Supported biomimetic membranes to study the surface interactions between cancer extracellular vesicles and human primary stem cells.”
Advisor: Susan Daniel

Tibra Wheeler
Thesis title: “T cell immunomodulation in the lymph node for inhibition of load-induced osteoarthritis.”
Advisor: Ankur Singh & Marjolein van der Meulen

Meiqi Wu
Thesis title: “Computational and hardware adaptive optics for biomedical imaging with optical coherence tomography.”
Advisor: Steven Adie

Evan Ma Yu
Thesis title: “Deep learning methods to process and analyze MRI images.”
Advisor: Mert Sabuncu

DOCTOR OF PHILOSOPHY

FACULTY STATEMENTS

Steven Ayala *by Lawrence Bonassar*

Steven received his bachelor's degree in biomedical engineering from the College of New Jersey and came to Cornell in 2017. His thesis research developed new in vitro models for posttraumatic osteoarthritis to understand how cartilage cells are damaged after impact injury and subsequent mechanical loading. He demonstrated that cartilage from the knee and ankle exhibit different sensitivities to cellular damage due to mechanical loading and that these sensitivities were altered by impact injury. This work gives important new mechanistic insights on the reasons for differences in incidence rates of posttraumatic osteoarthritis rates between the knee and the ankle. After graduation, Steven will be seeking a position in industry.

Monideepa Chatterjee *by Nelly Andarawis-Puri*

Monideepa joined the Andarawis-Puri lab after receiving her honors B.Eng. with distinction from the University of Delaware. At Cornell, her research identified the healing capacity of a regenerative mouse model in clinically-relevant tendon injuries of varying severity. Subsequently, she evaluated the use of this healing, regenerative tendon as a therapeutic following tendon overuse. She has two first-author publications, with three others in preparation, and eight research conference abstracts and co-authorships with the undergraduate students that she mentored. She has been recognized for her research achievements with the prestigious National Science Foundation Graduate Research Fellowship and won the Orthopaedic Research Society Tendon Section's best poster award. Outside of the lab, Moni was heavily involved in K-12 STEM outreach as the Cornell BMES Outreach Co-chair. She also worked to ensure equity for underrepresented minority college students through her work in the Diversity Programs of Engineering office and was selected to attend the ELIS residential leadership program in South Korea to advocate for women's equality in the global workplace. Moni has continued her research career and is currently a senior biomedical engineer at Medtronic. Congratulations Moni! You were always an influential leader while managing to be a team player all at the same time.

Alexandre Pellan Cheng *by Iwijn De Vlaminck*

Alex joined the De Vlaminck Lab after graduating from Polytechnique Montreal with honors. Alex's Ph.D. studies led to the development of novel liquid biopsy technologies to monitor infection and immunity from blood and urine, including a urine test to simultaneously detect a large range of viral and bacterial pathogens and the degree of host tissue injury due to infection (PNAS, 2019), a blood test to broadly quantify cell, tissue, and organ specific injury due to COVID-19 (Cell Med, 2021), and a blood test to monitor all major complications of stem cell transplantation (PNAS, 2022). He was recognized with a National Science and Engineering Research Council of Canada award and an excellence in teaching award from the Cornell BME department. After graduating, Alex joined the New York Genome Center for postdoctoral studies.

Carolyn Chlebek *by Marjolein van der Meulen*

Understanding the in vivo response of the skeleton to mechanical loading can identify anabolic processes to harness for therapeutic bone formation in disease. Carolyn joined my group to focus on understanding how in vivo loading drives skeletal gene expression as a function of location and age. She perfected technical methods to extract genetic material from small mouse tissues; set up computational pipelines to analyze large volumes of genetic sequence data; and demonstrated novel biological mechanisms associated with the response to mechanical stimuli with age. Carolyn joined us from RPI after an outstanding undergraduate career, a trajectory she continued at Cornell starting with an NSF Graduate Research Fellowship. She presented her data annually at the meetings of the Orthopaedic Research Society and American Society for Bone & Mineral Research, including an ASBMR Young Investigator Travel Grant. In addition to research experience, Carolyn has an exceptionally strong commitment to diversity, primarily through her involvement with SWE, culminating with a SWE Outstanding Collegiate Member Award in 2019. Locally her contributions were recognized with CUEmpower Outstanding Peer Mentor and Ephrahim Garcia Graduate Student Excellence in Mentoring Awards. I look forward to seeing Carolyn excel as a postdoctoral fellow at the Maine Medical Center.

Jacob A. Erstling *by Uli B. Wiesner*

Jacob joined the Wiesner Lab in the Materials Science and Engineering department in 2017, coming from Florida International University with a B.S. degree in biomedical engineering. He was interested in ultrasmall (diameters below 8 nm) fluorescent silica core - poly(ethylene glycol) shell nanoparticles synthesized in water, referred to as Cornell prime dots (C’Dots) with applications in bioimaging and nanomedicine. He quickly joined a team in the group interested in converting regular fluorescent C’Dots into dots showing optical blinking, enabling optical super-resolution microscopy (OSRM) in the form of stochastic optical reconstruction microscopy (STORM). After co-authoring a first paper on this subject, Jacob made the very important discovery that aluminum inserted into the silica network of the core in the form of four-fold coordinated aluminum induces optical blinking of encapsulated dyes, likely via photo induced redox processes. This mechanism is applicable across a large number of dyes and dye families, and leads to optical blinking with high photon flux per blink and high photostability, resulting in substantially improved resolution in OSRM as compared to parent dyes. Furthermore, the associated aluminosilicate based C Dots, now referred to as C'Dots, enable STORM without the need for a second laser and oxygen scavenging systems, thereby enabling STORM in live-cells, a major advance over the capabilities of regular dyes. These advances have led to a sea change in the ability of C'Dots to interrogate their biological environment, in particular in cancer cells, the main target for which C'Dots have been developed over the last ~15 years. In addition to his work on OSRM, Jacob further established in model cellular systems as well as in vivo animal models that ultrasmall C'Dots are promising candidates for oral delivery, another discovery of major importance for the field. Jacob's work is documented by four published papers, and several more in the pipeline. His outstanding contributions have been recognized through various fellowships, including the Cornell Sloan & Colman Diversity Fellowship and Marcus and Donna Loo Graduate Fellowship. Jacob has been an incredibly supportive force in the group, helping and collaborating with a large number of his peers. He will be thoroughly missed. We wish him all the best for his next career step.

Christine Harper *by Christopher J. Hernandez*

The idea that physical forces can regulate the growth and development of organisms has been recognized for over a century and is seen in the shapes of bird wings, tree limbs and bones. Christine is the first engineer to explore the role of mechanical forces in the physiology of bacteria. Christine used a microfluidic device to "hug" individual bacteria and watch how they responded to mechanical forces. She discovered the first mechanically sensitive regulatory system in bacteria – a way to connect mechanical forces to gene expression. Her work has helped establish the field of bacterial mechanobiology and provides a basis for the emerging field of engineered living materials. Christine joined the Hernandez Research Group after completing her bachelor's degree in biomedical engineering at Rose-Hulman Institute of Technology. Christine has presented her work at the Biophysical Society national meeting and has authored scientific articles in the Proceedings of the National Academy of Sciences, USA and APL Bioengineering. As a graduate student, Christine was awarded a National Science Foundation Graduate Research Fellowship and the Cornell NanoScale Facility (CNF)

Nellie Yeh-Ph Lin Whetten Award. She was also selected by Cold Spring Harbor for their prestigious Advanced Bacterial Genetics course.

Jongkil Kim *by Lawrence Bonassar*

Jongkil received his bachelor's and master's degrees in bioengineering from Hanyang University in South Korea prior to joining Cornell BME in 2016. His thesis research focuses on using bioreactors to impose biochemical and mechanical stimuli to guide the development of tissue engineered meniscus implants. His work has uncovered key ideas in balancing cellular traction forces and extracellular matrix synthesis to achieve more highly organized and mechanically functional meniscus implants. He won multiple prestigious awards including the Kwanjeong Educational Foundation Scholarship and a best presentation award from the Meniscus Section of the Orthopaedic Research Society. After finishing his degree, he will pursue postdoctoral training at Harvard Medical School.

Hania Koziol *by David Putnam*

Hania came to Cornell BME and the Putnam group via Montana State University where she majored in chemical engineering. She first connected with the Putnam group at an entrepreneurship conference in California where she approached me and said, "I'd like to join your group." Sometimes blunt statements like that can be met with equally blunt answers like, "Well, apply and you might get in" or, "Well, good luck with that", but Hania's delivery of the statement was so incredibly sincere that it eventually and thankfully led to her acceptance into our program. Hania's research has focused on ophthalmology, specifically a condition called "dry eye disease", which is caused by an instability of the eye's protective tear film. The film's instability leads to its rupture, followed by direct exposure of the cornea cells to air. The condition is widespread throughout the world and is characterized by severe and continuous eye irritation. Eye drops help, but are poorly effective. Hania's research has led to the design of new polymers that can interact with tears in ways that lead to tear film stability. Imagine a comfortable transparent liquid Band-Aid on your cornea, and you will have imagined Hania's research. Her work will lead to a new way to treat patients with dry eye disease, and it has already led to significant interest from companies that would like to develop her materials into new products.

Nichaluk (Nikki) Leartprapun *by Steven Adie*

Nichaluk Leartprapun joined the Adie Lab after completing her master's degree in bioengineering innovation and design from Johns Hopkins University. Her thesis research led to the development of new approaches to improve the resolution of optical coherence elastography

(OCE) and optical coherence tomography (OCT). Notably, Nikki developed photonic-force optical coherence elastography (PF-OCE) to perform volumetric, time-lapse imaging of micromechanical properties. This technique has been demonstrated for 4D imaging of engineered cell cultures, and has enabled observation of cellular-scale dynamics not accessible with previously-existing technologies. She also developed resolution-enhanced optical coherence tomography (RE-OCT), which is a technique that provides a way to improve upon the resolution of beam-scanned OCT systems beyond the widely-held resolution limit. Nikki's research in the group has led to an impressive eight published papers, plus one paper in review and another in preparation. These include articles in Nature Communications, Scientific Reports, Optics Letters, and Biomedical Optics Express. Although we will miss Nikki's ability to dive deep, understand what is going on, and then efficiently implement solutions, we look forward to hearing about the cool things she gets up to during her postdoc at the Wellman Center for Photomedicine, Massachusetts General Hospital, Harvard Medical School.

Marianne Lintz *by Lawrence Bonassar*

Marianne came to Cornell BME after earning her bachelor's degree in biological engineering from MIT. She began her Cornell career in the laboratory of Prof. Cynthia Reinhart-King before switching to the laboratory of Prof. Lawrence Bonassar. Her thesis focused on understanding metabolic influences on the structure and mechanical function of native and tissue engineered intervertebral discs. Notably, she demonstrated that hypoglycemia had a profound effect on collagen assembly in tissue engineered discs and during development in vivo. Her work gave important new insight on mechanisms of degenerative disc disease in patients with diabetes and for strategies of growing discs for transplantation. She is currently a postdoctoral fellow at Ankasa Regenerative Therapeutics in San Francisco, CA.

Jason (Chang) Marvin *by Nelly Andarawis-Puri*

Jason joined the Andarawis-Puri Lab after earning their B.S. in biomedical engineering from the University of Texas at Dallas. His dissertation research focused on harnessing biological cues from the local environment of regenerative Murphy Roths Large (MRL/MpJ) tendons for mechanistic investigation and therapeutic applications. His dissertation established a paradigm shift in the tendon field, demonstrating that non-healer tendon cells are capable of attaining a regenerative phenotype when exposed to MRL/MpJ-derived structural and soluble proteins. This work has been published as a second-author paper in The FASEB Journal with three first-author papers in preparation. As a graduate student, Jason has been recognized with several awards and accolades, including the NSF GRFP, Cornell

Provost Diversity Fellowship, Ephrahim Garcia Graduate Excellence in Mentoring Award, Zellman Warhaft Graduate Student Commitment to Diversity Award, Center for Teaching Innovation Graduate Fellowship, Orthopaedic Research Society (ORS) Podium Award, and ORS 3-Minute Thesis 1st-Place Prize. Jason has also been a passionate mentor and advocate through his leadership roles as a Cornell Graduate Resident Fellow and committees for national scientific societies. After graduation, Jason will continue his academic training as a postdoctoral research fellow in the Galloway Lab at Harvard Medical School and The Massachusetts General Hospital. Congratulations Jason! Keep paving new paths!

Melanie Maurer *by Jan Lammerding*

Melanie joined Cornell's biomedical engineering Ph.D. program in 2017 after graduating from the University of Texas, Dallas, and spending a year at the Fraunhofer Institute in Stuttgart, Germany, funded by a prestigious Fulbright Fellowship. In the Lammerding Lab, Melanie joined "Team Muscle" to investigate how mutations in the nuclear envelope protein lamin A/C cause muscular dystrophy and heart disease. Using induced pluripotent stem cells (iPSC) derived from patients and healthy controls that she—in a tremendous tour de force—differentiated into cardiac myocytes, Melanie was able to identify that lamins mutations responsible for heart disease result in abnormal nuclear structure and stability, as well as perturbed gene expression. Melanie's outstanding work has already led to two published manuscripts, with two more first-author manuscripts in review. Melanie's tremendous talent has been recognized in several awards, including a National Science Foundation Graduate Research Fellowship and a Predoctoral Fellowship from the American Heart Association. Melanie has served as a wonderful mentor to three undergraduate students and an M.Eng. student, while also organizing numerous outreach efforts at Cornell such as Girl Scout Engineering Day. As an outdoor enthusiast, avid climber, runner and adventures traveler, Melanie loves to explore the world, but it was here in Ithaca that she found Bram, the love of her life and now husband. Melanie recently started her new position as a product scientist at 23andMe, moving across the coast to California with Bram. Congratulations, Melanie. We will miss you!

Duncan McCloskey *by David Erickson*

Duncan McCloskey was born in Long Island, NY in 1995 and joined the Cornell biomedical engineering Ph.D. program in 2017 after his B.S. in nanoscale engineering from the University at Albany. Duncan's research involves the development of point-of-care devices for enabling nucleic acid diagnosis of Kaposi's Sarcoma – with a particular focus on subsaharan Africa. Duncan focused his efforts on developing the simplified sample processing techniques associated with the overall system as well as supporting the deployment of the system now at 11 sites in Uganda, Rwanda, Malawi, Kenya, Tanzania, and Botswana. Following his graduation, Duncan will move to Tennessee and continue working the biomedical industry.

Zeinab Mohamed *by Susan Daniel*

Zeinab Mohamed joined the Daniel Research Team and pioneered new platforms for studying the outer membrane surface of gram-negative bacteria. Gram-negative bacteria are enclosed by a complex outer membrane that protects them against antibiotics and antimicrobial peptides by serving as an impermeable barrier. With the rise in antibiotic resistance, in vitro tools such as bacterial membrane models have become critical for understanding the intrinsic properties of gram-negative outer membrane that impact membrane permeability and their effects on antibiotic efficacy. However, these membrane models often lack the molecular and structural complexity of the native Gram-negative outer membrane. To overcome this, Zeinab developed several Gram-negative outer membrane models that capture key components of the outer membrane as a platform for studying membrane behavior in presence of antibiotics. Zeinab's work has shown the impact of antibiotics on membrane permeability, changes in the membrane barrier properties, and modes of action of these drugs. Zeinab is the first author on two published papers and a contributor to five more. Zeinab was the recipient of the prestigious NSF graduate research fellowship and a Colman fellow. She also spent time as a graduate residence advisor for upperclassmen in the Carl Becker residence hall, helped undergraduates navigate research opportunities by serving as a graduate coordinator for the Louis Stokes Alliance for Minority Participation and Ryan Scholars Program in Diversity Programs in Engineering. For her commitment to service, Zeinab was the recipient of the Robert Mozia Distinguished Service Award and the Zellman Warhaft Commitment to Diversity Award. Zeinab has been an excellent support for younger students and her efforts in helping students fit in and belong at Cornell are commendable. She has been an important part of the Daniel team, worked well on a diverse team including industry partners, and has mentored new students joining her project as they work to further advance the platform she has developed for even greater impact and use. It has been my pleasure as her advisor to foster her growth as a researcher, scientist, mentor, and leader. Zeinab looks forward to conducting research abroad and I wish her all the best in her future endeavors!

Aaron Mok *by Chris Xu*

Aaron joined the Chris Xu optical imaging group in the spring of 2018. Aaron's work focused on multiphoton deep tissue imaging. Over the last four years, he has become an expert in imaging instrument design and setup, particularly for neuroscience applications in both mice and flies. By working on both instrument design/development and their applications in neuroscience, Aaron has developed a comprehensive set of skills to discover the needs in biological sciences, generate ideas and create the tools to address those needs, and then carry out the experiments. In addition to his own work, Aaron worked very well with others on collaborative projects. Aaron does a great job in his presentations, sometimes representing the group. His paper at the 2019 Cornell Biophysics Annual Symposium won the best presentation award. His short video won first prize at the Frontiers in Neurophotonics Highlights contest. He has also won multiple paper awards at Photonic West, one of the premier conferences for biophotonics. Congrats, Aaron!

Patrick Muljadi *by Nelly Andarawis-Puri*

Patrick joined the Andarawis-Puri Lab after receiving his bachelor's degree in mechanical engineering from the University of Colorado Boulder. His research focused on the effect of changes in the extracellular matrix that occur during onset of tendinopathy. His research project tested the hypothesis that the increase in glycosaminoglycans (GAGs) that occurs in response to fatigue injury is a key modulator of the mechanical properties and mechanotransduction of the injured tendons, and is integral to promoting a reparative instead of degenerative response to subsequent exercise. His findings demonstrated a role for post-injury GAGs in directly and indirectly modulating tendon multiscale mechanics and viscoelasticity as well as limiting tenogenic phenotype, suggesting that GAGs may serve as a diagnostic or therapeutic target to enable reparative exercise after tendon fatigue injury. His thesis work will appear in Connective Tissue Research and the Journal of Biomechanics. In addition to his research, Patrick enjoyed mentoring and collaborating with his peers and working as a backpacking instructor for Cornell Outdoor Education. After graduation, he will join Medical Metrics Inc., providing imaging core laboratory services for clinical trials. Congratulations Patrick! The lab will miss your laid-back attitude!

Taylor Oeschger *by David Erickson*

Taylor Oeschger joined the Erickson Lab at Cornell in 2017 after receiving a Bachelor of Science in chemical engineering and a Bachelor of Science in biological engineering from Montana State University in Bozeman, Montana. During her time at Cornell, she focused her efforts on the development of novel diagnostic tests for quantifying antibiotic resistance primarily within Carbapenem-resistant Enterobacterales and Neisseria gonorrhoeae. She made several important contributions to the field including developing a novel paper-based semi-quantitative test and conducting some foundational work on the efficacy of certain indicators as measures of bacterial metabolic activity. She also wrote several review articles during her time on predicting future pandemics and diagnostics for sepsis. Following completion of her degree she plans to move to Seatle, Washington and continue working in the diagnostics area.

Daniel Rivera *by Chris Schaffer*

Linear and nonlinear interactions between light and biological materials, when analyzed and controlled carefully, can provide powerful tools for biomedical research. Daniel's graduate research has focused on developing and using several such tools in the study of neurological and cardiovascular disease in mice. Daniel developed optical techniques to map the blood perfusion and oxygenation in the brain, and used these approaches to screen for drugs that improve brain blood flow in Alzheimer's disease. He has recently adapted these methods to work in the beating heart of mice, enabling measurements of blood flow to the heart in mouse models of heart failure. On the manipulation side, Daniel has advanced the use of tightly-focused, femtosecond-duration laser pulses as a kind of scalpel that can cut inside tissue without damaging overlying structures. He used this laser scalpel to demonstrate a unique laser-based surgical therapy for focal epilepsy that led to a 95% reduction in seizure propagation. Daniel has also been a dedicated educator during his graduate work, recognized by graduate fellowship from the Department of Education and by the praises of his students. He has helped to develop curricular materials, led major components of required courses in the BME undergraduate major, and helped to guide senior design projects.

Nancy Ruiz *by Chris Schaffer*

Reductions in blood flow to the brain are common in neurodegenerative diseases, such as Alzheimer's disease, and likely contribute to the memory and cognitive problems in these conditions. Nancy's graduate research has focused on understanding what causes these brain blood flow reductions through studies that utilize advanced imaging methods to directly visualize blood flow in the brain of mice. Nancy has shown that reactive oxygen species, generated by a particular enzyme in the brain, cause the arrest of white blood cells in brain capillaries that we previously linked to the blood flow reductions. Her work also aims to understand how brain function improves when this blood flow deficit is rescued, where she has shown rapid and substantial improvements in memory function. Nancy's graduate research is supported by a fellowship she received from the American Heart Association. In addition to her research, Nancy is deeply committed to outreach efforts that provide exposure to interesting science topics to schoolchildren that helps them develop awareness of the impact of science in their lives. This has included having students join in analyzing real research data as well as seeing the experiments that generated it.

Johana Uribe

by Susan Daniel

Johana Uribe joined the Daniel team and took on a new project at the time aimed at understanding the molecular-scale interactions between stem cells and extracellular vesicles shed from tumor cells. These cancer-derived extracellular vesicles have been recognized as important modulators of intercellular communication within the tumor microenvironment. These vesicles facilitate the transfer of information between cancer and non-cancer cells, which has been determined to be a major factor contributing to cancer progression. One example is the induction of proangiogenic activity and myofibroblast differentiation in adipose derived stem cells when in the presence of these cancer vesicles. The interactions leading to malignant outcomes induced by these vesicles remain poorly understood. However, they are an important target for cancer research, as blocking these interactions could be a means to stopping cancer progression. One limitation is the lack of platforms available to study the interaction between these vesicles and stem cells. Johana developed new platforms to study these interactions and found that the surface molecules on these vesicles can drive changes in stem cells that promote growth factors that correlate with observed biological outcomes. One microscopy based platform allows optical monitoring of biological changes and a second one is based on an electrical readout that allows monitoring of the mesenchymal to epithelial transition in a label-free manner. Johana's work resulted in two first author papers and several contributions to other published papers. During her time at Cornell, Johana received a prestigious NSF Graduate Research Fellowship and a Sloan graduate fellowship. Johana also dedicated her time to various organizations focused on helping underrepresented students gain a sense of belonging, confidence, and success in academic ventures. Johana serves as a great inspiration, role model, and a good friend to other students. It has been my pleasure as her advisor to foster her growth as a researcher, scientist, mentor, and leader. Johana moves on to a new adventure as a postdoctoral researcher at the King Abdullah University of Science and Technology where she will continue her studies on cell biology and cancer and have many exciting adventures exploring the Middle East, the desert, and culture. I wish for Johana all the best success for her future!

Tibra Wheeler *by Ankur Singh & Marjolein van der Meulen*

Tibra Wheeler joined my lab in 2016 and was co-advised by Prof. van der Meulen. Tibra joined Cornell after excelling at the University of South Carolina (USC). At Cornell, she received the prestigious NSF GRFP and Sloan fellowships and most recently was selected as a 2021 Scholar in the Cornell chapter of the Edward A. Bouchet Graduate Honor Society. Her Ph.D. research created a new collaboration that redefined the contribution of the immune system in osteoarthritis, demonstrating an important role for T cells and lymph nodes. Tibra presented her work at several notable national and international conferences, published in peer-reviewed journals, and was recognized with the Special Interest Group Immunoengineering Poster Award from Society for Biomaterials (2019). In addition to her excellent academic career, Tibra contributed tremendously to the Cornell community through her leadership of the Black Graduate and Professional Students Association and coordination of the Ryan Scholars Program. Tibra received several awards including the Diversity Programs in Engineering Graduate Student Excellence in Leadership Award (2019) and Outstanding Peer Mentor (2018). We are grateful to have worked with Tibra, and confident her talents will make far-reaching impact throughout her career.

Meiqi Wu *by Steven Adie*

Meiqi Wu joined the Adie Lab after completing her B.S. in electrical engineering from the University of Science and Technology, China. Her thesis research focused on new ways to integrate computational and hardware adaptive optics, with the goal of extending the imaging depth of optical coherence tomography (OCT). After investigating the limitations that tissue scattering places on computational adaptive optics for deep imaging in mouse brain, she studied the improvements that can be obtained by combining computational and hardware adaptive optics in an 'unconventional partnership', through experiments as well as theoretical simulations. Meiqi's research in the group has led to four published papers, plus one in preparation. Her strengths with quantitative analysis and computation were recognized by the finance industry, and she was recruited by Wizard Quant, a Chinese private fund company in Shanghai. We wish you all the best for this next stage of your career!

Evan Ma Yu *by Mert Sabuncu*

Our understanding of brain structure and function has advanced greatly thanks to magnetic resonance imaging (MRI). As the technology develops and the amount of data multiplies, it is essential to develop computational methods to effectively and efficiently extract useful information from these data. In his thesis, Evan investigated the use of deep learning models to prepare, process and analyze structural brain MRI scans. For example, in his groundbreaking work, Evan introduced an unsupervised, robust, and interpretable method that aligns brain scans with high accuracy, especially in the context of large displacements. Evan was one of the first Ph.D. students in the Sabuncu research group at Cornell and he helped build up the lab from scratch. He played a critical role in establishing the compute infrastructure and launching the deep-learning based neuroimaging research program. After graduation, Evan is headed to the Boston area to work at an exciting new start-up. I am confident that Evan will have a big and positive impact on the future of healthcare technologies.

MASTER OF SCIENCE

Name: Erin Maloney
Advisor: Dr. Nelly Andarawis-Puri

MASTER OF ENGINEERING

Aarushi Agarwal
Tomiwa Akande
Sasha Anderson
Ethan Blum
Lindsay Browning
Irene Chan
Jason Chen
Stephen Wasyl Chupil
Margaret Cruz
Josiah Davis
Kurt Russell Edlund II
Zheshen (Sandy) Gong
Sanasi Atul Gore
Abigail Grabowski
Rhea Gulati
Audrey Guo
Shivakshi Gupta
Luke Humphrey
Chiemezue Ijomanta
Tharun Janardhanan Iyer
Sneha Jeevan
Ivan Jiran
Rachel Lauren Kelly
Glenn Kim
Girija Krishna Kumar
Anshul Krishnan
Sneha Suresh Kuhikar
Joseph Kulczyk
Abbie Charlotte Lai
Kanyarat Lee
Taehee Lee
Silu Li
Xiaoyi Li
Zoe Yi Chieh Lin
Joyce Liu
Peng'an Liu
Jenna Lowe
Melanie Page Lyons
Bhamini Mahendra Babu
Liam McLane
Shaun Nuzzo
Pari Oggu
Kento Okada
Charby Ortega De Maio
Isabella Posey
Srijit Ray
Shawn Reginauld
Annie Ranchana Roshan
Cyndhia Varshni Sangadala
Wannakorn Sangthongngam
Kirsten Scheller
Rae Stephenson
Reagan Stewart
Paige Stitzel
Edgar Macburney Storm III
Pitsinee Supapol
Nicolas Cruz Tan
Zheng Tang
Shivani Tuli
Shulin Wang
Haoyang Wang
Andrew Wang
Jessica Xiang
Purui Xu
Pushpendra Yadav
Hairong Zhang
Michael Zhang
Ann Zhao
Irfan Zobayed

MASTER OF ENGINEERING 2021-22 PROJECTS

DESIGN PROJECTS

Novel delivery of biologics

Irene Chan, Shivani Tuli, Andrew Wang

With advances in therapies and medical technology, and a shift to at-home care to improve patients quality of life, there has been a need to move away from traditional delivery of biologics. This design team engaged in extensive research on a novel method to deliver biologics and other drug products. Various cutting-edge solutions from pioneers of the field were discovered in the process. The team organized the technology into categories and evaluated the advantages and engineering challenges of each technology as well as the physiological challenges they need to overcome. From the available solutions, the team narrowed down the most promising approach and proposed design criteria for a novel method of delivery of biologics.

Asthma attack management device

Huey Li, Kento Okada, Sneha Jeevan, Zheng Tang

Asthma is a chronic condition affecting over 25 million people in the U.S. annually. Several triggers can induce sudden inflammation of the airways and restrict patient breathing. Current asthma-care devices utilize FeNO biomarkers that are too expensive and technically challenging to be integrated with a home-use device. Our user-friendly, at-home use device for asthma aims to monitor the onset of an asthma attack to improve intervention time, create patient-specific symptom awareness and help patients manage asthma better.

Cerebrospinal fluid computational and mechanical model of therapeutic cerebral drug delivery device

Ethan Blum, Kurt Edlund, Kirsten Scheller, Zheshen Gong, Srijit Ray

Standard of care for drug delivery to any region of the brain is significantly limited by the current technology. Enclear Therapies' mission is to extend the lives of patients with central nervous system related diseases by using cerebrospinal fluid dynamics for controlled and personalized drug delivery to specific regions of the brain. This project has helped further Enclear's mission by exploring the possibilities of how to create a computational model and mechanical model to replace expensive animal models. Our team successfully built a mechanical test bench that emulates the material properties of brain structures and provides live pressure readings, allowing for robust and replicable testing of the cerebral spinal fluid pump.

E. coli and total coliforms detection

Irfan Zobayed, Nicolas Tan, Joseph Kulczyk

Strains of Escherichia coli (E. coli) are found in organismic waste. E. coli detection is the primary indicator of fecal contamination and thereby deemed necessary by the EPA and WHO for determining drinking quality water. Effective methods of testing water for E. coli exist; however, these expensive methods require 12-24 hours to provide reliable results. There is a need to determine coliforms in chlorinated drinking water set for time-effective, high accuracy coliform detection. Our team aims to develop an accurate, reliable method and an accessible, affordable device that provides results in less than the common 8-hour workday.

Functional canine heart teaching model

Melanie Lyons, Abigail Grabowski, Luke Humphrey

The purpose of this project is to develop a canine heart model to be used by veterinary students and educators that evades current model issues. These issues include the lack of physical or dynamic models in the veterinary space, as well an absence of models that demonstrate pathophysiology. Our canine heart model is 3D printed with a flexible filament and aims to mimic the way muscles contract in the heart. The heart is equipped with LEDs to show progression of electrical activity, as well as an EKG display. The system is programmed to actuate in real time, displaying bradycardia, normal sinus rhythm and tachycardia. Together, these features depict the heart in a realistic manner that help veterinary students learn about canine heart function.

Assistance in Motion: Robotic Mobility Device for Toddlers

Aarushi Agarwal, Chiemezue Ijomanta, Tharun Iyer, Reagan Stewart

Toddlers ages one to three explore their environment by crawling and walking. Toddlers need the opportunity to develop gross motor skills and create an environment for themselves that is stimulating and challenging. Currently, there is a gap in the market for pediatric-powered mobility devices that allow toddlers with mobility limitations to develop at the same mental and physical rate as their fully-mobile counterparts. Our team found a way to address the need for powered mobility devices for immobilized toddlers that will assist them in moving independently. From this need, we created Assistance in Motion, a Robotic Mobility Device for Toddlers.

Detection and auto-injector for opioid overdose response

Ann Zhao, Glenn Kim, Sneha Kuhikar, Shaun Nuzzo, Sasha Anderson

The opioid crisis is an epidemic that has led to over 760,000 deaths in America since 1999. The current treatment for opioid overdoses is the use of naloxone through an injection or intranasal spray. The administration of naloxone can prevent or reduce the number of overdose deaths. Regrettably, a majority of overdoses occur when a person is alone and the lifesaving drug cannot be administered in time. Our project aims to provide a solution by creating a device with the ability to detect an overdose through physiological signals and trigger auto-injection of the lifesaving drug naloxone.

Liquid ventilation for treatment of acute respiratory distress syndrome

Biji Akande, Taehee Lee, Jenna Lowe, Bhamini Mahendra Babu, Sanasi Gore

COVID-19 and other diseases can cause Acute Respiratory Distress Syndrome - fluid buildup in lung alveoli preventing oxygen exchange. The resulting hypoxia in patients necessitates mechanical gas ventilation for life support. Gas ventilation, however, sometimes cannot sufficiently restore oxygen levels and can also cause ventilator-induced lung injury (VILI). The desired outcome would be total removal of mucus/debris from the alveoli, minimization of VILI, and restoration of patient's O2 and CO2 to safe levels. The proposed solution is liquid ventilation, a type of mechanical ventilation in which the lungs are cycled with oxygenated perfluorocarbon liquid.

Meniscus repair w/ RF tissue welding

Lindsay Browning, Rachel Kelly, Paige Stitzel, and Jessica Xiang

Approximately one million surgical procedures are performed each year in the U.S. to repair torn meniscus tissue. Unfortunately, in most cases, surgeons will resect damaged tissues rather than attempt to repair them, leading to potential cartilage damage and osteoarthritis. This project aims to develop a tissue fusion system that uses radiofrequency (RF) energy to repair partial tears of the meniscus. Our goal is to provide a minimally invasive and highly effective RF-based treatment for torn meniscus by developing testing protocols and assessing the optimal parameters of RF to maximize the mechanical benefit and minimize cell damage to the meniscus.

Design of an epi-illumination acoustic radiation force-optical coherence elastography (ARF-OCE) system

Jason Chen, Silu Li, Hairong Zhang, Karan Patel, Haoyang Wang

Acoustic radiation force - optical coherence elastography (ARF-OCE) is an imaging technique that combines ultrasound and optical coherence tomography to noninvasively assess the mechanical properties of biological materials. This project aims to develop an epi-illumination ARF-OCE system to quantitatively measure tissue viscoelastic properties. The proposed design uses a 1300 nm near-infrared laser and a 75 MHz high-frequency ultrasound transducer to achieve a resolution of less than 50 μm. The desired outcome of this project is to validate the system on tissue-mimicking phantoms, after which the system could be applied to image biological tissues ex vivo and in vivo.

Preventing droplet evaporation in high-throughput microfluidic devices for live-cell imaging

Charby Ortega De Maio, Edgar Storm

Super-omniphobic patterns allow rapid dispensation of small volumes of liquid on a surface in the shape of droplets. Such droplets can act as bioreactors for tissue culture and other kinds of experiments. Nevertheless, droplets quickly evaporate due to their high surface-area-to-volume ratio, disrupting the concentration of reagents in which experiments run initially. Therefore, evaporation must first be prevented for this technology to be successfully applied in a lab setting. This project aimed to achieve this while preserving the system's ease of use and allowing the visualization of the droplets in real-time.

Pediatric cardiovascular simulator

Ivan Jiran, Stephen Chupil, Liam McLane

Our project aimed to develop a robust and low-cost mock circulatory loop (MCL) to facilitate lab testing of pediatric left ventricular assist devices (LVADs). MCLs physically simulate the movement of blood in the human body, generally through a system of pumps, tubes, chambers, and sensors. Our loop incorporates a variety of sensors with feedback control to allow for real-time monitoring and manipulation of physiological parameters such as blood pressure, heart-pumping efficiency, and blood vessel stiffness. This automation will allow researchers to easily test pediatric LVADs across a wide range of heart failure scenarios before moving on to in vivo testing.

Tracking parent's compliance for baby carriers

Anshul Krishnan, Girija Krishnakumar, Cyndhia Varshini Sangadala, Kuan Cao, Jessica Hastings

Hip dysplasia refers to the condition where the hip socket does not fully cover the ball region of the upper thigh bone. Upon ossification in infants, this causes the femoral neck to become anteverted, leading to osteoarthritis during adolescence. While bracing is the current alternative, usage of baby carriers can enhance early intervention efforts. However, non-compliance of a prescribed baby carrying regimen has been linked to poorer outcomes. We aim to embed a comfortable, safe and accurate sensor system to evaluate this compliance by tracking the baby's presence in a carrier at any given time.

KneeTester device for ACL injury diagnosis

Audrey Guo, Abbie Lai, Zoe Lin, Annie Ranchana Roshan, Wannakorn (Gina) Sangthongngam

The anterior cruciate ligament (ACL) is a tissue that holds the thigh to the shin within the knee, which has a quarter million injuries a year. Diagnosing the injury is done manually; a doctor uses their hands and intuition to identify the damage to the ligament. The KneeTester, developed at Weill Cornell Medicine, is a mechanical device that can quantify measurements of knee laxity (flexibility) with six degrees of freedom. Our project improves the functionality of the device by providing a novel sensor setup to improve accuracy, alongside a brand-new user interface for clinicians that is visually appealing, intuitive, and effective.

Sticky hydrogels for knee cartilage defects

Pari Oggu, Isabella Posey, Rae Stephenson, Pitsinee Supapol, Pushpendra Yadav

Not all cartilage lesions require surgical intervention, however, a large market exists among patients with high grade defects that are best treated with replacement or repair. Current solutions for long-term repair of cartilage defects of the knee provide only limited relief and functionality that declines over time due to interference from the body's natural healing response. These challenges provide opportunities for the development of a sticky, hydrogel-based synthetic cartilage product that can improve the long-term treatment of cartilage defects by immediately providing proper mechanics, staying anchored within the defect, and maintaining functionality as the body ages and heals.

Revolutionized cochlear implant through the use of micromagnetic stimulation

Lynnda Lee

Electrical stimulation has been used widely for neural prosthetic devices, for example, a cochlear implant. However, several side effects include biocompatibility, small selectivity of targeted neurons, and poor sound quality. To solve such issues, we explored the possibility of applying microscale-magnetic stimulation to a cochlear implant. This study involves the micro-magnetic stimulation to understand how a time-varying magnetic field, an induced electric field generated by micro coils, could potentially activate the voltage-gated channels in cochlear nerves. Coil design via the Finite Element Magnetic Method is utilized based on the biological characteristics of the cochlea.

MASTER OF ENGINEERING 2021-22 PROJECTS

RESEARCH PROJECTS

Name: Margaret Cruz
Advisor: Dr. Shaoyi Jiang and Dr. Minglin Ma
Project Title: "Milk-derived extracellular vesicles for refined drug delivery."

Name: Josiah Davis
Advisor: Dr. Anthonay Hay
Project Title: "Characterizing the impact of bacteria on pumped human breast milk."

Name: Shivakshi Gupta
Advisor: Dr. Jonathan Butcher
Project Title: "Studying the role of matrix elasticity and viscosity on neo-vascularization using methacrylated gelatin (GelMA), a mechanically-tunable bioink, to establish a clinical alternative for autologous fat grafts used in post-mastectomy breast reconstruction."

Name: Joyce Liu
Advisor: Dr. Newton de Faria and Dr. Steven Adie
Project Title: "Tethered enzyme-based rapid point-of-care diagnostic testing for brain injury, investigating the effects of multiple scattering in OCT."

Name: Peng'an Liu
Advisor: Dr. Fenghua Hu
Project Title: "Potential cellular functions of PGRN & TMEM106B genes implicated in FTLD/ALS/AD."

Name: Shulin Wang
Advisor: Dr. Jan Lammerding
Project Title: "Understanding factors affecting metastasis."

Name: Purui Xu
Advisor: Dr. Sunghwang Jung
Project Title: "Cleaning surfaces with air bubbles: effect of substrate angle."

BACHELOR OF SCIENCE

Nick Allen
Anna Ashford
Jackson Bauer
Kuan Cao
Maple Chen
Brooke Cohen
Parker Dean
Ria Desai
Michael Eboh
Annette Gleiberman
Jessica Hastings
Brianna Hou
Erin Hudson
Niaa Jenkins-Johnston
Jordan Johnson
Sarah Kenney
Lauren Kret
Hannah Lim
Ketaki Londhe
Nandika Nair
Julia O' Connor
Jonathan Pierre
Tara Sarmiento
Riya Singh
Leah Snyder
Danielle Streever
Ronya Strom
Amy You
Colin Zenge
Emma Zhang

BACHELOR OF SCIENCE 2021-22 PROJECTS

AllerTest

"Action" Jackson Bauer, Kuan Cao, Lauren Kret

Over 85 million Americans are affected by food allergies and 32 million of these cases are life-threatening. As such, we aim to create a portable device that tests for the presence of food allergens and gives patients with allergies total peace of mind that the food they are about to eat will not send them to the hospital. Current rapid allergen tests on the market are costly and are limited in the variety of allergens they can test at once. Thus, our design aims to detect multiple allergens through a lateral flow assay in under five minutes, while maintaining affordability to be accessible to more patients.

Bili-Battlers

Amy You, Nandika Nair, Colin Zenge, Jessica Hastings

Three in five newborns will develop jaundice within the first few days of life, requiring phototherapy for moderate to severe cases. In many cases, jaundice will recur after the child has been discharged from the hospital, requiring additional treatment and leading to the largest cause of neonatal ICU readmission. Our design is an affordable, at-home wearable device that differs from other jaundice treatment options with the integration of both colorimetric detection and treatment to ensure the child receives the perfect amount of phototherapy to bring them back to safe and healthy conditions.

Diabetes Destroyers (pedipanel)

Anna Ashford, Jonathan Pierre, Nicholas Allen, Riya Singh, Michael Eboh

Around 425 million people worldwide currently have diabetes, with an approximation that 35% of those people will develop diabetic neuropathy, or nerve damage associated with diabetes. There are currently no treatments available aside from mitigating symptoms and slowing disease progression, which requires a fast diagnosis. Clinical research has shown that the oxygen saturation recovery time of patients with diabetic neuropathy in their feet is slower than in healthy patients when introduced to a cold stimulus. Therefore, our proposed solution is a scale-like device that incorporates peltier junctions and pulse oximeters to record temperature modulated oxygen saturation recovery times in conjunction with vibrational motors for real-time patient feedback.

Haemonauts (RBClear)

Brooke Cohen, Parker Dean, Ronya Strom

Currently, for those with severe malarial infections, the only therapy is transfusion. Africa accounts for 95% of malaria cases, and the transfusion need exceeds the entire blood supply of the continent. Our proposed solution is a magnetic filtration device to separate malaria-infected red blood cells from healthy red blood cells, reducing the donor blood needed to tranfuse into the patient.

Aquaporin

Kaelyn Gaza, Maple Chen, Ria Desai, Sarah Kenney

Over 785 million people lack access to clean water worldwide, and this problem disproportionately affects lower class communities. Drinking contaminated water can cause diseases including cholera, typhoid, and dysentery. Our product provides a cheap and sustainable way to filter both heavy metals and bacteria from water. It uses chelators to uptake heavy metals, activated carbon to adsorb ions like fluoride and decrease turbidity, and renewable plant xylem to filter bacteria. Based on our preliminary cost analysis, our product will cost only 2.5 cents to provide one person with drinkable water for a month, making it accessible to lower class communities.

Exvaders

Annette Gleiberman, Dani Streever, Erin Hudson, Ketaki Londhe

Glioblastoma multiforme (GBM) is the most aggressive form of brain tumor, with less than a 5% five-year survival rate. Presently, neuro-oncologists have minimal abilities to assess treatment efficacy as current imaging modalities cannot distinguish tumor growth from treatment effect. Additionally, tumor sampling occurs just once for the vast majority of patients, making data on tumor response and mutation overtime extremely limited to non-existent. This lack of temporal data is a roadblock to the approval of new treatments and the improvement of current standards of care. This is why we teamed up with Exvade Bioscience, a company in Atlanta, Georgia that has been working to improve care for patients with GBM. Our device is a permanent implantable pH sensor that works in tandem with an implant previously designed by the company. As the tumor grows, it exhausts nutrients delivered in the blood and cells begin the process of anaerobic respiration, of which lactic acid is a major bioproduct. This process raises the pH of the microenvionment, making acidity a hallmark of growth and disease progression. Along the length of the implant, spaced out micro-pH electrodes detect these small changes and relay them via bluetooth to a monitor. In this way, our device brings relevant temporal and spatial data to clinicians treating GBM to improve both care of patients and research on this difficult and devastating disease.

Spectaculum “Engineers at your cervix”

Emma Zhang, Julia O’Connor, Leah Snyder, Niaa Jenkins-Johnson

The introduction of the Pap smear in the U.S. and Europe caused incidence and mortality due to cervical cancer to decrease by more than 50% (Waxman, 2005). Pap smears, along with other diagnostic tests, are performed via pelvic examination with a speculum. The importance of pelvic exams is clear, yet many women cite negative emotions leading up to them and even preventing them from attending a routine gynecological appointment. This is largely a function of discomfort experienced during Pap smears, such as pressure and pinching from the speculum. Spectaculum aims to implement a uniform expansion to eliminate pinching and reduce pressure on the vaginal walls, while still allowing the clinician access to the cervix.

Patch Peeps (TIDU)

Brianna Hou, Caleb McCurdy, Jordan Johnson, Tara Sarmiento

Conventional insulin delivery methods for the management of diabetes involve intravenous delivery either via shots or an insulin pump. While this allows for quick and convenient systemic delivery, repeated injections lead to the formation of scar tissue at the delivery site which then interferes with the diffusion of insulin. We propose a noninvasive, transdermal method of delivery that uses iontophoresis to promote insulin diffusion through the skin and into the blood stream. Our device will work in conjuction with a continuous glucose monitor to create a feedback loop and will serve as a painless alternative to more invasive diabetes management methods.