THE UNIVERSITY OF BRITISH COLUMBIA
School of Biomedical Engineering
Faculties of Applied Science and Medicine

# Engineering Healthcare

**UBC is a Top 40 global research university where bold thinking, curiosity and initiative are changing the world. Discover the researchers at the School of Biomedical Engineering who are transforming healthcare through unconstrained research at the convergence of engineering, medicine and biology.**

CELLULAR & MOLECULAR ENGINEERING

ASSOCIATE MEMBER

CELLULAR & MOLECULAR ENGINEERING

# AMANI HARIRI

## ASSISTANT PROFESSOR

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**We will develop improved nanoscale devices with the capability to execute complex functions, such as targeted drug delivery vehicles and highly sensitive molecular sensors.**

DNA Nanotechnology | Optical Biosensors | Single Molecule Imaging | Targeted Delivery | Neurochemistry | Precision Diagnostics | Aptamer Switches

## Nanoscale Tools for Precision Diagnostics and Therapy

Early detection remains the most effective strategy for improving patient prognosis for many diseases such as Cancer or Alzheimer's. A major requirement for early-stage diagnosis is the provision of assays that can be at the same time sensitive and specific for individual biomarker, and in most cases capable of quantifying multiple biomarkers at the same time. The Hariri Lab engineers functional DNA nanomachines that can sense their environment, reconfigure their structure, and execute task-specific functions. By employing advanced high-resolution imaging, we quantify the biological dynamics of DNA nanoswitches under physiological conditions, ensuring they perform robustly in complex biological settings. Our work decodes exactly how such nanodevices bind to targets, ranging from small molecules to proteins, and function within the cellular environment. We translate this fundamental understanding into powerful applications, integrating our nanomachines into miniaturized devices for the highly sensitive and spatial detection of neurotransmitters in ex vivo settings and the living brain.

The Hariri Lab: https://www.hariri-lab.com/

## RESEARCH EXCELLENCE

We are a multidisciplinary research group leveraging the programmability of DNA to engineer next-generation tools for precision medicine. Some examples include: Developing "smart" DNA nanomachines that reconfigure to execute specific biological tasks; utilizing high-resolution imaging to validate sensor dynamics under physiological conditions; and engineering miniaturized diagnostic platforms for the precise, spatial detection of biomarkers in complex environments like the brain.

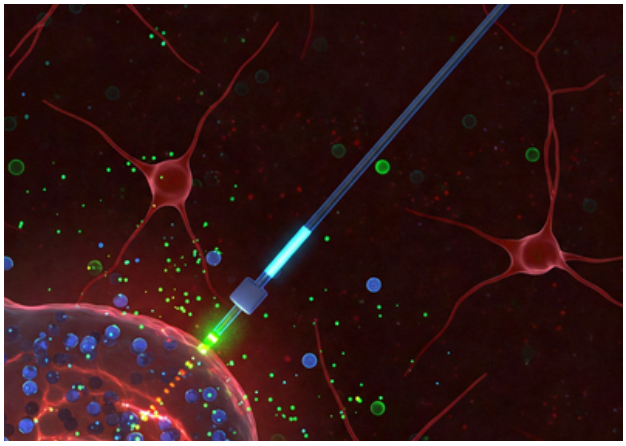
## Our Training Program

The Hariri Lab provides an interdisciplinary environment at the convergence of chemistry, biophysics, and biomedical engineering. We are committed to training the next generation of scientists with a diverse skillset ranging from DNA synthesis, selection and modification to single-molecule diagnostics. Our team fosters a culture of collaboration, where students are encouraged to think creatively to build smart molecular tools that solve complex clinical challenges in cancer and neurodegeneration.

## Integrated DNA Sensors for Brain Studies

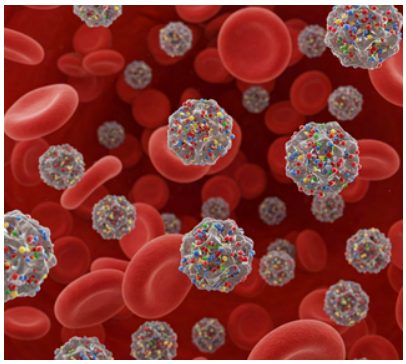
Effective therapies for brain disorders depend on our ability to monitor brain neurochemicals. My lab will be developing integrated aptamer-based optical biosensors that enable quantitative, high-resolution mapping of neurotransmitters across biological scales.

Using this platform, we could obtain an accurate "movie" of how any given circuit in any given brain area is influenced by multiple different NMs simultaneously. This platform will enable us to generate, for the first time, much more meaningful models of neural circuit modulation and computation; more meaningful insights into the effects of drugs on brain function and a better understanding of the pathophysiology of prominent brain disorders leading to innovative platforms for the development of novel therapeutic agents.



## Smart Nanocapsules for Targeted Delivery

Using Aptamer switches, my group will build sophisticated nano-devices capable of executing complex functions, including drug delivery vehicles for the targeted and controlled release of therapeutics with specific mechanistic responses to biochemical triggers with specific temporal/spatial control. Our ultimate goal is to achieve novel assembly mechanisms to address the need for high selectivity, sensitivity, and precise control over the hold and release of molecules in response to specific molecular stimuli. In the long-term, these will enable future applications in biosensing and targeted therapy.



## IP & KNOWLEDGE TRANSLATION

Our ultimate goal is to translate fundamental discoveries in DNA nanotechnology into deployable clinical solutions. We actively pursue the development of point-of-care diagnostic devices and targeted therapeutic platforms. By validating our DNA nanomachines in physiological environments, we aim to bridge the gap between bench-side molecular engineering and real-world medical applications for disease monitoring and treatment.

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CORE MEMBER

# ANNA BLAKNEY

## ASSISTANT PROFESSOR

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**We design new RNA and nanoparticle formulations that enable vaccines, protein replacement therapies, gene editing, etc. These innovations will enable the next generation of RNA medicines.**

self-amplifying RNA | lipid nanoparticles | polyplexes | genetic medicines | immunoengineering | drug delivery

## Developing the Next-Generation of RNA Vaccines & Therapies

RNA medicines have revolutionized healthcare with five siRNA drugs and two mRNA vaccines approved recently, including those against COVID-19. These successes validate RNA technology's scalability, affordability, and rapid development potential. The Blakney Lab is advancing RNA medicine, aiming to create safer, more potent drugs for diverse applications.

A key challenge is the short-lived nature of messenger RNA. We are pioneering an innovative technology called self-amplifying RNA (saRNA), which is a type of mRNA that is derived from a virus, and can make copies of itself upon delivery into a patient's cells. saRNA results in a higher magnitude and duration of protein expression compared to mRNA, which enables the use of a lower dose, fewer side effects and less frequent administration for patients. New applications include new vaccines with unmet clinical need, launching antibodies for the treatment of cancer, and reprogramming astrocytes to combat neurodegenerative disorders.

The Blakney Lab: https://blakneylab.msl.ubc.ca/

## RESEARCH EXCELLENCE

Our team spans chemical engineering to immunology and focuses on clinically translational RNA medicines. We contributed to the first self-amplifying RNA vaccine (Nature Communications 2020) and developed saRNA vaccines with interferon inhibiting proteins for enhanced protein expression and immune responses (Molecular Therapy 2021). We've also devised a method to quantify saRNA copies in samples (Scientific Reports 2023).

## Our Training Program

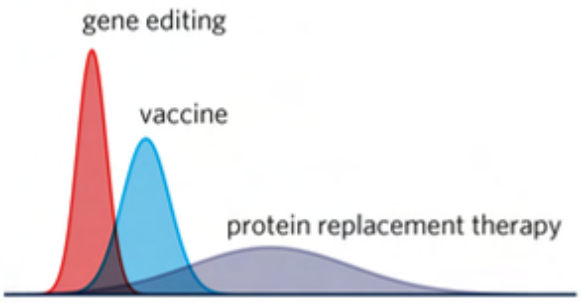
We seek team players passionate about all aspects of the design and development of RNA medicines. We celebrate diversity in all aspects of our group, including backgrounds (we hail from five continents!). Our group offers valuable experience for careers in academia and industry, embodying values of Excellence, Curiosity, Authenticity, Integrity, Ambition, and Collaboration to impact human health positively.

## The Frontier of RNA Design

We are developing novel saRNA designs, using high-throughput RNA and peptide sequencing tools and synthetic biology approaches. This is an exciting frontier as we anticipate that there will be optimal RNA designs for different applications, including vaccines, protein replacement therapeutics, and gene editing. We are characterizing our new designs for: (1) replication, or how long the RNA lasts in vivo, (2) protein expression, or how much protein results from a specific dose of RNA and (3) immunogenicity, or how much inflammation the RNA design causes. Understanding how the design of RNA impacts these three axes will enable us to create a guidebook for RNA design for a variety of applications. We envision that this new library of saRNA designs will enable new RNA medicine for patients, that are safer and more effective than the state-of-the-art. We work closely with industrial collaborators so that we can translate this technology to the clinic and maximize our impact.

## Nanoparticles of the Future

RNA relies on nanoparticles for stability in the body, but even advanced nanoparticles only deliver a small fraction of RNA into cells, possibly due to inefficient targeting. Understanding how cells sense nanoparticles is crucial for optimizing vaccine and therapy effectiveness. We investigate RNA-nanoparticle-immune system interactions to inform new formulation designs, aiming to enhance delivery efficiency and biodistribution in the body. Our approach employs cutting-edge techniques like single-cell RNA sequencing and in vivo imaging for comprehensive characterization.




## IP & KNOWLEDGE TRANSLATION

- New saRNA designs
- Synthetic biology toolkits for RNA expression and tropism
- Barcoding technology to simultaneously detect RNA replication and expression
- Novel nanoparticle formulations
- Modeling of RNA structure/function relationships

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CORE MEMBER

# CARL DE BOER

## ASSISTANT PROFESSOR

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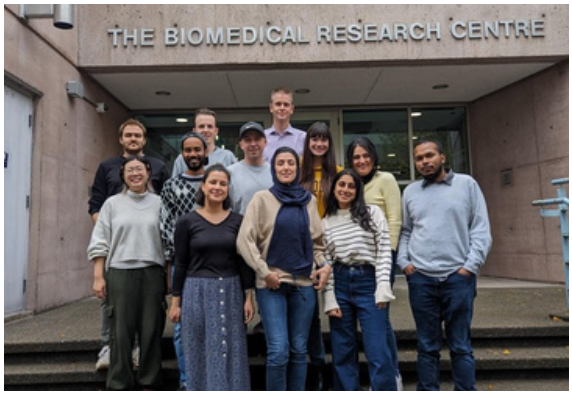



**Our research spans many disciplines and themes but is united by our desire to understand and treat disease**

precision medicine | genomics | synthetic biology | computational biology | machine learning | gene regulation | genetics | complex diseases | evolution

## Deciphering Genome Regulation to Understand and Treat Disease

The goal of my lab's research is to create a pathway from genetic mutation to personalized treatment. Many common complex inherited diseases, like autoimmunity and heart disease, are caused primarily by genetic differences (e.g. mutations) that occur in the DNA surrounding genes. These genetic differences cause disease by changing the cell types and circumstances in which the genes are activated, for instance turning a gene off where it is needed or on where it is not. However, the gene regulatory code is so complex that machine learning and Big Data must be used to learn it. I aim to develop a detailed understanding of gene regulation for personalized treatments, encompassing molecular tool development, statistics, machine learning, evolutionary simulations, and developing drugs or gene therapies that treat diseases (e.g. cancer). While much of our work is important in essentially all diseases, our primary disease foci are heart diseases (e.g. atrial fibrillation), autoimmunity (e.g. lupus, rheumatoid arthritis), and cancer.

The Boer Lab: https://deboer.bme.ubc.ca/

## RESEARCH EXCELLENCE

The Boer lab pioneers the integration of synthetic genomics and machine learning to unravel genome regulation complexities. Understanding genome regulation is now feasible with their innovative methods. They show that studying random DNA reveals how genomes function, as cells use the same mechanisms to interpret it similarly. The lab shows this potential by generating datasets exceeding genome size, providing deep insights into genome regulation.

## Our Training Program

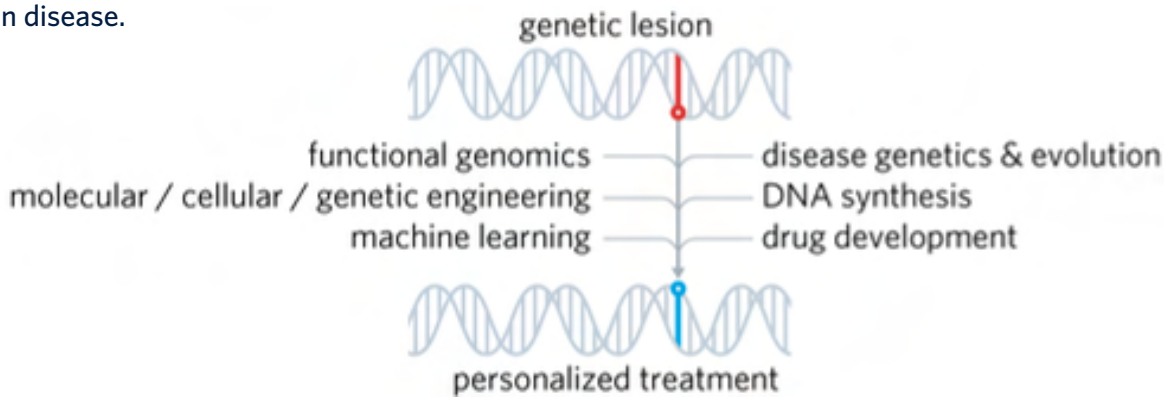
Diversity in knowledge and expertise, and collaboration are needed to make the greatest impact. Lab members will learn cutting-edge experimental and computational techniques from each other and have the knowledge and experiences that are in demand in their future careers. They have opportunities to write proposals and publications, supervise junior trainees, manage projects, and present their work at international conferences. The lab is a welcoming, friendly, and collaborative environment so that members will look forward to their time in the lab.

## Making Better AI Models

Much of the current AI revolution was driven by standardized benchmark datasets that have enabled continual improvement in the computer models. Because of the critical role genomics models play in interpreting disease-associated changes to the DNA, we need more standardized genomics datasets for model benchmarking. We created a genomics "Big Data" benchmark and hosted a global machine learning competition to produce top-performing genomics models. Competitors surpassed the previous state-of-the-art on these data. Combining the best model features resulted in even better models. Now, we apply these superior models to reveal why certain DNA changes result in disease.

## Understanding the Evolution of our Genome

Understanding genome processes is vital for comprehending how DNA changes affect disease. We demonstrated that the biochemical activities associated with gene regulation often occur by chance. Similar to how the brightness of TVs defaults to a comfortable level for most but can easily be customized, cells have evolved a default activity that satisfies most genes, and then evolution can optimize individual genes further to suit the organism's needs. This adds to the growing body of evidence by us and others suggesting that evolving a new regulatory activity is relatively easy, indicating that many disease-associated mutations may create novel activities that did not exist before it.




## IP & KNOWLEDGE TRANSLATION

- DNA synthesis technologies
- Personalized small molecule therapeutics
- Designer regulatory DNA sequences for gene therapies
- Accessible molecular, cellular, computational biology, and machine learning tools

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# CAROLINA TROPINI

## ASSISTANT PROFESSOR

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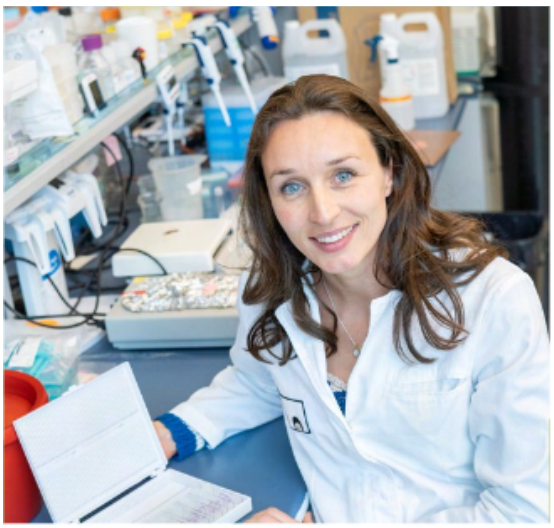


**We develop new technologies to study the gut microbiota and create novel therapeutics.**

precision medicine | phage therapy | microbiota and bacterial engineering | chronic diseases | inflammatory bowel disease | computational biology

## The Microbiota as a Tool for Precision Medicine

Human health is deeply linked to trillions of symbiotic bacteria, fungi, and viruses inhabiting our bodies. This unique microbiota continuously evolves and impacts digestion, immunity, and neurodegeneration by producing compounds absorbed into our blood. The adaptable gut microbiota presents an appealing target for precision medicine. Over 20 million Canadians annually suffer from gut microbiota-linked digestive disorders, underscoring the urgency of translating lab discoveries into clinical treatments.

We are investigating how a disrupted gut environment in diseases such as inflammatory bowel disease affect the microbiota and host at a multi-scale level. We are a cross-disciplinary group that incorporates techniques from microbiology, bioengineering, biophysics and more to create highly parallel assays and study how bacteria and communities function, with the goal of translating the knowledge we gain to improve human health.

The Tropini Lab: http://tropini.microbiology.ubc.ca/

## RESEARCH EXCELLENCE

The Tropini lab integrates bioengineering, microbiology, and biophysics to study gut microbiota's health impact. We investigate changes due to over-the-counter drugs (Cell, 2018) and develop precision health solutions. Recent work includes microbial survival studies (mBio, 2023) and new detection technologies (Sens. Actuators B Chem, 2023).

## Our Training Program

Our lab culture is built on inclusivity and collaboration. We welcome scientists from all backgrounds, both scientifically and culturally. Our students have the opportunity to develop unique skills – from engineering bacteria for drug delivery, to creating precision tools for measuring microbiota-produced metabolites. We prioritize the growth and development of our members, ensuring that everyone gains specialized expertise integral to our lab's innovative research endeavours.

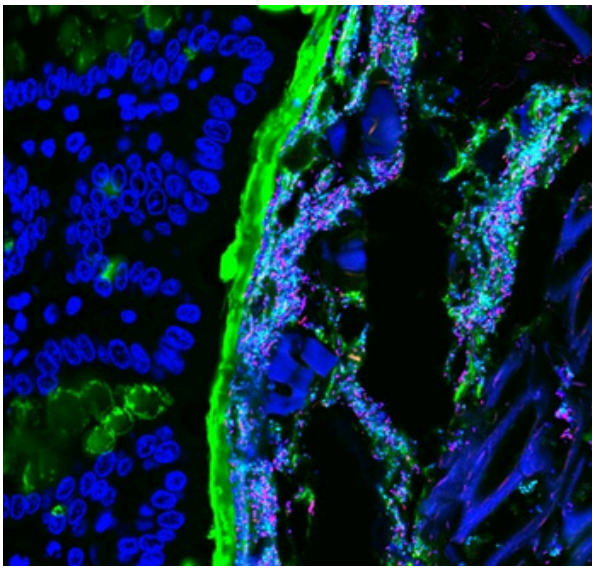
## Engineering Microbiota Sensors of Disease

Our research program is dedicated to developing microbiota sensors that detect changes in the gut environment to indicate human diseases. Diseases like intestinal cancers, IBD, and malabsorption disrupt the gut's equilibrium, altering pH, osmolality, oxygen tension, and temperature. Current diagnostic methods like endoscopy are limited, prompting our pursuit of innovative, specific, and non-invasive technology. We engineer live biotherapeutics to express stable protein reporters and DNA sequences, detectable in patient stool, for diagnosing conditions such as malabsorption, Crohn's disease, intestinal cancers, and inflammation. Our initial focus is on creating an osmolality sensor, vital for understanding diseases like IBD and celiac disease, where gut osmolality varies significantly. Using bacterial genes responsive to osmolality changes, we have developed markers for stool detection. This technology paves the way for smart live biotherapeutics that deliver targeted therapies, revolutionizing diagnosis and personalized medicine in gut health.

## Optimizing Microbiota Therapy Outcomes

In the Tropini Lab, we employ a blend of rigorous in vitro and in vivo experimentation alongside advanced computational techniques to enhance microbiota therapy outcomes. We examine the growth responses of hundreds of bacterial species across tens of families under diseased gut conditions like IBD and cancer, leveraging high-throughput growth measurements and machine learning for comparative genomics.

This method reveals microbial survival under disease-like conditions and predicts bacterial behavior accurately in complex in vivo settings, informing microbiota therapy development.



## IP & KNOWLEDGE TRANSLATION

- Customizable live biotherapeutics
- Microbiota Synthetic Biology toolkits to develop sensors and actuators
- Non-Invasive Diagnostic Technologies
- Educational Outreach and Workshops
- Development of Personalized Medicine Protocols

# CHRISTOPHER MORAES

## ASSOCIATE PROFESSOR

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**Our research and technical expertise lie at the interface between microfabricated cell culture systems, biomaterials design, advanced imaging technologies, and computational modelling; we are particularly curious about the role microenvironmental biomechanical forces play in driving disease and development.**

Mechanobiology | Microfluidics | Biomaterials | 3D Cell Culture

Human-on-a-Chip | Disease Modelling | Therapeutic Screening

## Microenvironmental Regulation of Cell Function

The process by which we grow from embryos into precisely-sculpted functional tissues and organs is a manufacturing marvel. Biophysical signals, such as forces, must play a central role in tissue formation during development, and in tissue disruption during disease; but the tools to measure, manipulate, and recreate biophysical stimuli have lagged far behind the explosive growth of reductionist molecular biology techniques. We leverage microfabrication, materials design, and stem cell tissue engineering to 'watch' the co-evolution of forces and biology as tissues develop and decay; and then use these insights to address healthcare challenges, in drug screening, biotherapeutic manufacturing, and regenerative medicine. This design cycle provides creative and unusual strategies for healthcare, at a time when conventional discovery pipelines are producing fewer, less effective, and more expensive solutions than ever before. Bridging these gaps requires us to integrate expertise in biomedical, mechanical, chemical, and materials engineering with emerging tools in stem cell biology, organoids, and tissue engineering, as we reconstruct biological systems in new and exciting ways.

The Moraes Lab: https://moraeslab.com/cmed/

## RESEARCH EXCELLENCE

The Moraes Lab develops microtechnologies and engineered microenvironments that reveal how physical and chemical cues regulate cell behaviour, enabling more predictive tissue models and next-generation therapeutic discovery systems.

## Our Training Program

We teach people to be curious, inventive, playful, and purposeful; to fearlessly tackle challenging science that needs an engineering mindset. By driving projects from conception to impact, trainees obtain hands-on skills in tissue engineering, constructing microtechnologies, 3D culture systems, and quantitative analyses to study complex biological behaviours. These high-level skills prepare them for careers in academia, biotechnology, medical devices, therapeutic development, and entrepreneurship.

## Mechanical Forces in Biological Systems

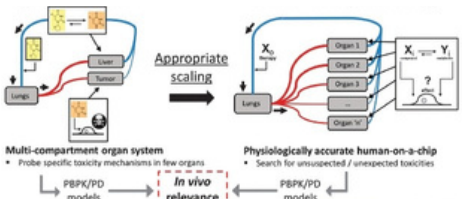
Cells are highly dynamic mechanical entities that sense, generate, and respond to physical forces. These forces regulate tissue development, influence pathological transitions, and shape tissues responses to treatment. To study these interactions, we create microtechnologies capable of applying controlled cyclic mechanical loading in high-throughput formats, and tools for measuring dynamic mechanical forces within three-dimensional developing tissues. These platforms provide new insight into how mechanical cues drive matrix remodelling, cell behaviour, and disease progression in cardiovascular and cancer systems.

## Microengineered Biomaterials

Engineering biomaterials with microscale precision enables the controlled recreation of complex cellular environments. The Moraes Lab designs biomaterials at the interface between nano- and microscale structures, allowing for precise manipulation of 3D hydrogel architectures and fibrous tissue-like matrices. Their work includes methods for controlling single-cell microenvironments, creating microscale tissues that mitigate nutrient transport limitations, and engineering dynamic "smart" biomaterials capable of presenting cells with evolving cues. These systems serve as versatile platforms for studying fundamental biological processes and advancing regenerative medicine.

## Next-Generation Drug Discovery Systems

A major focus of the lab is developing microphysiological systems that better predict human therapeutic responses. The long-term goal is to create interconnected, miniaturized representations of human physiology—a "human-on-a-chip" platform integrating multiple tissue types with real-time analytics. By establishing engineering design rules for these systems, the lab aims to improve the realism and scale of early-stage drug screening, reduce reliance on animal models, and accelerate the development of safer, more effective therapies.




## IP & KNOWLEDGE TRANSLATION

- Dynamic and "smart" biomaterial systems
- Microengineered hydrogel architectures with tunable 3D matrix properties
- Precision-engineered tissue culture systems
- Integrated microphysiological and human-on-a-chip systems
- Analytical tools for real-time assessment of tissue mechanics and cell–matrix interactions

# DENA SHAHRIARI

## ASSISTANT PROFESSOR

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**We are expanding the optogenetics toolkit to study the neural circuitry beyond the brain.**

biomaterials | bioelectronics | neural interfaces | neuromodulation | spinal cord injury | tissue engineeering | organ function augmentation

## Problem-Driven, Technology-Empowered Strategies for Healthcare

The BioAugmentative Interfaces Laboratory specializes in biomaterials and bioelectronics, and is dedicated to pioneering research at the crossroads of materials science, electronic devices, and medicine. We aim to design and develop cutting-edge neuroelectronic devices, advanced sensors, and smart biomaterials. Our innovations seamlessly interface with biological tissues, advancing the study of nerve repair mechanisms and enhancing organ function recovery in individuals affected by traumatic injuries.

We collaborate closely with ICORD, a leading community in spinal cord injury research, based in Vancouver, known for its connection to Rick Hansen's Man-in-Motion tour and accessibility advocacy. ICORD offers state-of-the-art facilities. In our lab, mentorship is central, fostering a culture of curiosity. Students and trainees play vital roles, contributing to groundbreaking discoveries in nerve repair research.

The BioAumentative Interfaces Lab: https://bioauglab.med.ubc.ca/

## RESEARCH EXCELLENCE

At the BioAug lab, research topics undergo rigorous discussion with clinicians and stakeholders for feasibility and clinical impact. We prioritize IP protection for ongoing technologies to enable future entrepreneurship and clinical translation. Alongside scientific publications, we file IPs and ongoing applications. In addition to innovation, we emphasize discovery, recognizing uncertain clinical impacts from scientific findings.

## Our Training Program

We're a diverse, multidisciplinary team united by a passion for innovation and discovery. We are engineers, scientists, clinicians, and entrepreneurs. Competitive and motivated postdoctoral scholars, graduate students and undergraduate students interested in our mission and technologies are encouraged to learn more about our work and consider joining our dynamic and collaborative team.

## Tissue Engineering and Smart Biomaterials

As part of a Canadian government research fund, the New Frontiers in Research Fund - Transformation, we are part of an international effort to develop a holistic tissue engineering approach to regenerate damaged axons after spinal cord injury and to improve function after paralysis. Combining biomaterials and bioelectronics, our latest efforts have also included developing implantable smart biomaterials for a user-controlled device for bladder management. Furthermore, we are developing neural interfaces with embedded electrodes for neural recording and stimulation to establish a bi-directional communication between a prosthesis and its user.

## Expanding the Optogenetics Toolbox

Optogenetics, enabling the study of neural circuitry through genetically targeted optical stimulation, has significantly advanced brain research since its 2005 inception. However, its application to the spinal cord and peripheral nerves remains limited due to the challenges of delivering light to these mobile tissues, which requires flexible probes. With CIHR funding, we have developed a self-sufficient device featuring flexible neural probes with embedded LEDs and fully implantable, pre-programmed electronics. This system allows for autonomous, chronic light delivery. Our fabrication technique is designed for easy adoption, providing the neuroscience community with tools to extend optical stimulation beyond the brain, facilitating the study of spinal cord and peripheral nerve circuitry.

## IP & KNOWLEDGE TRANSLATION

- A neural modulation device
- Scalable fabrication of guidance scaffolds for muscle and nerve regeneration
- High-open volume of axon guidance scaffolds

CELLULAR & MOLECULAR ENGINEERING

CORE MEMBER

# FABIO ROSSI

PROFESSOR

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**We seek to increase our understanding of how tissues regenerate to improve damage repair and reduce fibrosis.**

tissue regeneration | adult stem cells | inflammation | multiomics | regenerative medicine | skeletal and cardiac muscle | stroma and mural cells

## Cellular Systems in Regeneration and Degeneration

Our lab investigates the mechanisms behind tissue regeneration and scarring, aiming to enhance regeneration and reduce scarring. Effective regeneration requires coordinated action among various cell types, including stem cells, stromal progenitors, and inflammatory cells. Using animal models, we study their communication and collaboration. We use multiomics approaches, including single-cell sequencing, high-content imaging, and positional transcriptomics, to analyze human tissues in high detail and compare findings across species.

We focus on skeletal muscle regeneration and degeneration. Muscle efficiently repairs damage, but chronic damage, like in muscular dystrophy, leads to fibrofatty tissue replacement. Mesenchymal stromal progenitors produce this scar tissue but are also crucial for regeneration. We study the signals that direct these cells' fate, aiming to develop therapies to combat fibrosis, a major issue in our aging society.

The Rossi Lab: http://www.rossilab.ca

## RESEARCH EXCELLENCE

We pioneered the discovery that microglia, CNS's resident macrophages, self-renew independently of haematopoietic stem cells, igniting research on tissue resident macrophages. Additionally, we first delineated mesenchymal fibro/adipogenic progenitors' (FAP) role in muscle regeneration and revealed mechanisms for preventing fibrosis post-regeneration. Furthermore, we uncovered FAP's pathogenic role in cardiac issues.

## Our Training Program

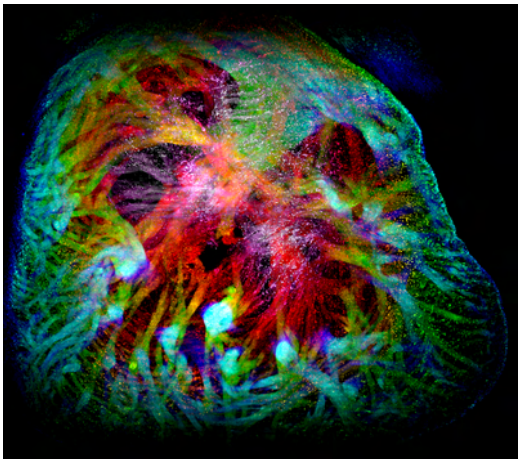
We're an inclusive team of global scientists. Our lab utilizes various animal models and human samples, employing multi-omics and advanced imaging techniques. Learning computational analysis is vital for professional growth. Trainees receive support from our technical team and are expected to be self-driven. They'll gain skills in paper reviews, manuscript writing, grant applications, and global collaborations. Opportunities include supervising juniors, presenting work locally and internationally.

## Mesenchymal Progenitors: the Organism's Factotums

Mesenchymal cells carry out a large number of positive roles spanning from generating the extracellular matrix that provides structural support to most organs, producing trophic factors that sustain the maintenance of tissues, coordinating the inflammatory response to damage and supporting the stem cells that repair it. Tissue maintenance and regeneration relies on the coordinated action of a number of cell types, each performing their function at the right time like instruments in an orchestra. In this analogy, mesenchymal cells are the conductor, engaging in a complex web of interactions to tell each cell type when and where they are needed. We endeavour to understand how these cells sense different type of damage and integrate this information to direct an appropriate response. Our goal is to exploit this understanding to improve regeneration, reduce ageing related damage and avoid scarring.

## Rebuilding Muscle and Avoiding Fibrosis: from Stem Cells to Translation

The loss of large of skeletal muscle is a significant problem brought about by a variety of conditions ranging from congenital diseases to traumatic events to "flesh eating" bacterial infections. We take a variety of translational approaches to address this problem. We generate muscle stem cells from human pluripotent stem cells engineered to express anti-fibrotic molecules, such as single chain antibodies. We combine transplantation of these cells with innovative biomaterials to "fill" volumetric muscle defects. We identify and target, in cooperation with local biotech, signalling pathways that can improve muscle regeneration and reduce fibrosis in diseases such as muscular dystrophy, spinal cord damage and cancer cachexia.



## IP & KNOWLEDGE TRANSLATION

- Deeper understanding of cellular networks in regeneration and degeneration
- Biologics and compounds to reduce fibrosis and increase regeneration
- New combination therapies for congenital muscle diseases
- Creating a community of regenerative medicine researchers and trainees

# FRANCIS LYNN

## ASSOCIATE PROFESSOR

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**We aim to engineer the next generation cell therapy for type 1 diabetes.**

genome editing | stem cell engineering and differentiation | multi-omics | developmental biology | islet biology | disease modelling | diabetes | cell therapy

## Refining Cell-Based Therapies for Diabetes

Diabetes mellitus stems from pancreatic ß-cell dysfunction, housed in islets of Langerhans, producing insulin and glucagon in response to blood glucose changes. Restoring, regenerating, or replacing ß-cells is crucial for diabetes treatment. While islet and pancreas transplantation show promise for ß-cell replacement, limited transplantable tissue restricts their widespread use in curing diabetes.

We study the mechanisms governing islet ß-cell formation from pancreatic stem cells during organ development, focusing on gene regulatory networks in progenitors. We investigate how these networks evolve during differentiation into mature endocrine cells and in long-term ß-cell maintenance. We believe that a greater understanding of these genetic mechanisms and pathways will refine cell-based approaches for preventing and reversing the ß-cell deterioration and loss that occur with diabetes.

The Lynn Lab: https://lynnlab.com/francislynntheun.html

## RESEARCH EXCELLENCE

We value a diverse, team-based approach to answering these questions and enjoy sharing our expertise to facilitate others' research goals. We use a wide variety of approaches in the lab including: genome editing, reprogramming, stem cell differentiation, single cell omics, mouse genetics, cell physiology, organismal physiology, cell transplantation, live cell and intravital imaging, in silico and imaged based screening.

## Our Training Program

Positions open for grad students, postdocs, and research associates to explore β-cell development/function regulation and hypothalamic food intake control. Please email me a cover letter outlining your interests, why you would like to join my lab, and your vita. Experience in islet biology, developmental biology, molecular biology, neuro or stem cell biology is preferred. More important are curiosity and passion about curing disease, and a talent for independent research, supported by a strong publication record.

## Beta Cell Replacement

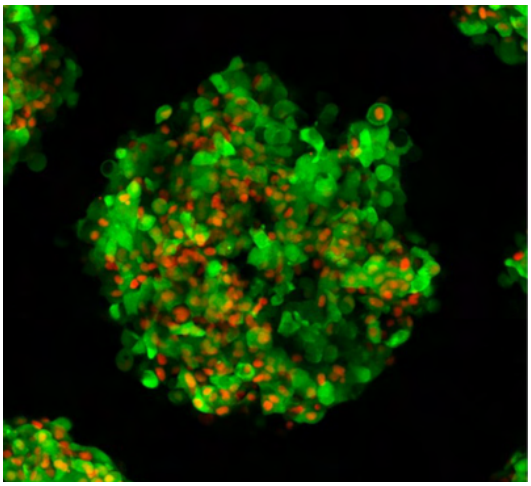
Our research program focuses on engineering advanced pluripotent stem cell (PSC)-derived pancreatic islets for diabetes treatment. We aim to:

- Improve the robustness of the stem cell product so it can better withstand transplantation
- Alter the immunogenicity of the cell product so that systemic immunosuppression can be avoided
- Improve the function of the cell product for rapid control of blood glucose following transplantation

## Beta Cell Biology

Another focus of our research program is understanding the transcriptional control of pancreatic beta cell development, function and growth. Here we aim to:

- Understand how electrical activity of beta cells influences their fate and function
- Define how transcriptional co-activators alter islet cell development and function
- Understand how cell growth is regulated in islets and how cycling impacts differentiation



**Pluripotent stem cell derived insulin (green) and glucagon (red) producing cells**

## Disease Modelling

Leveraging our expertise in islet biology and genome editing of PSCs, we aim to create human models elucidating genetic and environmental diabetes risk factors, including:

- Understanding how disease risk alleles alter beta cell development
- Defining how the fetal environment impacts beta cell development and diabetes risk
- Defining how genetics impact immune cell: beta cell interactions and the development of type 1 diabetes

## IP & KNOWLEDGE TRANSLATION

- Improved cell therapies for type 1 diabetes
- Better understanding of islet cell biology
- New drug targets for the treatment of the major forms of diabetes

# GOVIND KAIGALA

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**We develop new biodevices, assays and workflows for quantitative analysis applied to Cancer research.**

compartmentalization | microfluidics | bio-analytical methods | tumour modelling | tumour profiling | heterogeneity indices

## Developing Microtechnologies for Quantitative Biomedicine

Life is fundamentally characterized by order, with an orchestra of biochemical reactions running in compartments, within, on, and between cells. Disease states, such as Cancer, have this order disturbed and present seemingly random yet complex spatio-temporal interactions. Our lab works on creating new technologies to quantify these interactions in biological systems at varying length and time-scales.

We combine multidisciplinary approaches, such as microfabrication and 3D (bio)printing, chemistry, molecular and cellular biology to engineer new devices and assays, allowing for creative application into clinically translatable workflows.

We also dive into fun physio-chemical phenomena to build an understanding and to translate them into analytical methods.

Microtechnologies for Quantitative Biomedicine Lab (uQB): www.micro-qb.org

## RESEARCH EXCELLENCE

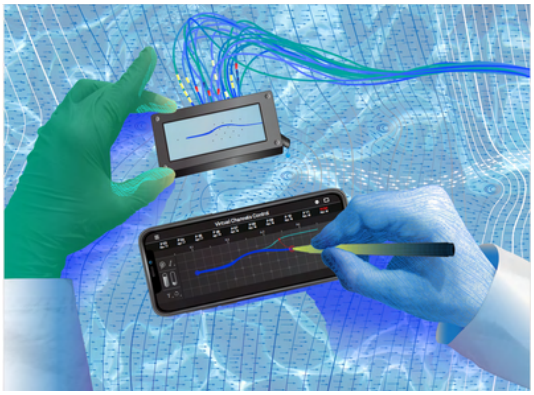
With a decade of industry experience, we identify healthcare technology gaps, advancing bench-to-bedside innovation through industry and health systems collaboration. Our focus is developing micro-total-analysis systems (biodevices) to enhance existing life science and diagnostic workflows. Currently, we study tumour profiling in clinical samples and models, utilizing our bioanalytical expertise to advance oncological research and diagnostics.

## Our Training Program

We strive to have an inclusive culture in our team that is welcoming, supportive, respectful and ensures all team members are heard. We welcome members from all backgrounds - scientifically and culturally. Overall, our mantra is recruit motivated individuals, provide them a good scientific environment (culture), engender curiosity and the outcomes are great!

## Implementing "Wall-Less" Microfluidics

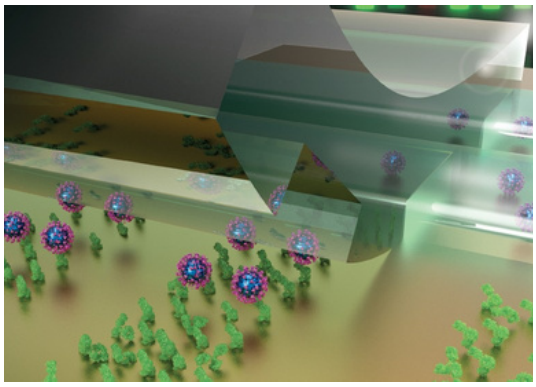
Open-space microfluidics offer new ways to handle, analyze, and interact with biological samples without closed microchannels, reducing the need for liquid containment. This is achieved by creating well-defined chemical environments on a surface using specific liquid-confinement strategies. We also envision fully reconfigurable microfluidic devices that can change shape and function dynamically, enabling researchers to directly manipulate microscale experiments and make real-time decisions.



**Virtual microfluidic channels formed through hydrodynamic focusing within a 2D flow cell.**

## Advancing Bioanalytical Assays

Spatio-temporal interrogation of biological samples faces challenges like low analyte concentrations and difficulty tracking transient biomolecular changes due to slow sampling. Our precision bioanalytics work aims to develop surface-based ultra-sensitive biomolecular assays, focusing on (i) characterizing heterogeneous reactions for life science applications, and (ii) electrokinetics-based sample preparation for low-volume multi-omic assays and ultra-sensitive diagnostics.



**Precision patterning of biomolecules on surfaces open new avenues sensing and profiling.**

uQB research labs are located at the SBME building, Life Science Institute, and the Vancouver Prostate Centre (Vancouver General Hospital campus).

## IP & KNOWLEDGE TRANSLATION

- Ultra sensitive and low volume molecular assays
- Spatial multi-omic workflows
- Biopatterning on surfaces and high-efficiency surface reactions
- Micro and Nanofabrication of Biodevices for research and diagnostic applications
- Tumour-on-a-chip models

# HONGSHEN MA

PROFESSOR
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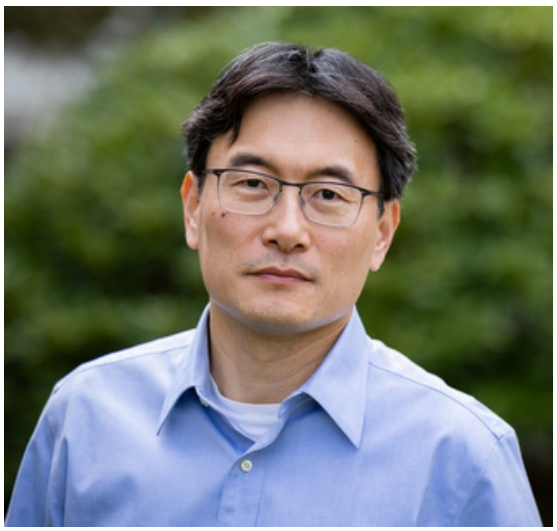
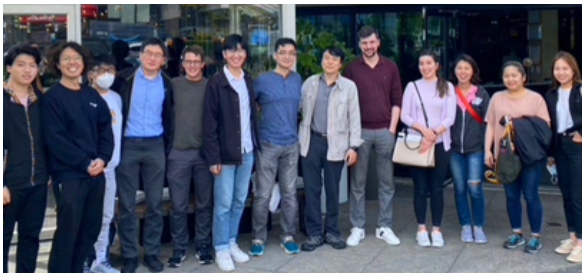




**We develop full-stack bioanalysis tools that transform complex biological experiments into scalable, automated workflows by integrating advances in chemistry, materials, microfabrication, robotics, and AI.**

Microfluidics | Nanotechnology | Robotics | Artificial Intelligence | Cell Sorting | 3D Cell Culture | Single Cell Analysis | Laboratory Automation

## Robotic Automation for 3D Cell Culture

Drug discovery relies heavily on biological models to evaluate effectiveness before testing in patients. Traditional models based on 2D cell culture, where cells grow as flat layers, often poorly predict drug efficacy, contributing to high failure rates in drug development. 3D cell culture addresses these limitations by growing cells in three-dimensional multi-cellular assemblies, such as spheroids or organoids, that more closely replicate cell-cell interactions, mechanical cues, and biochemical gradients. Despite these advantages, 3D cell culture remains technically challenging, labour-intensive, difficult to reproduce, and difficult to scale-up. We are developing new experimental methods and software pipelines to automate and scale-up 3D cell culture. By combining engineered culture substrates, robotics, high-throughput microscopy, and AI-powered data analysis, we aim to dramatically improve throughput and reproducibility to enable scale-up drug testing using physiologically relevant 3D tissue models.

The Multi-Scale Design Laboratory: https://blogs.ubc.ca/hongma/

## RESEARCH EXCELLENCE

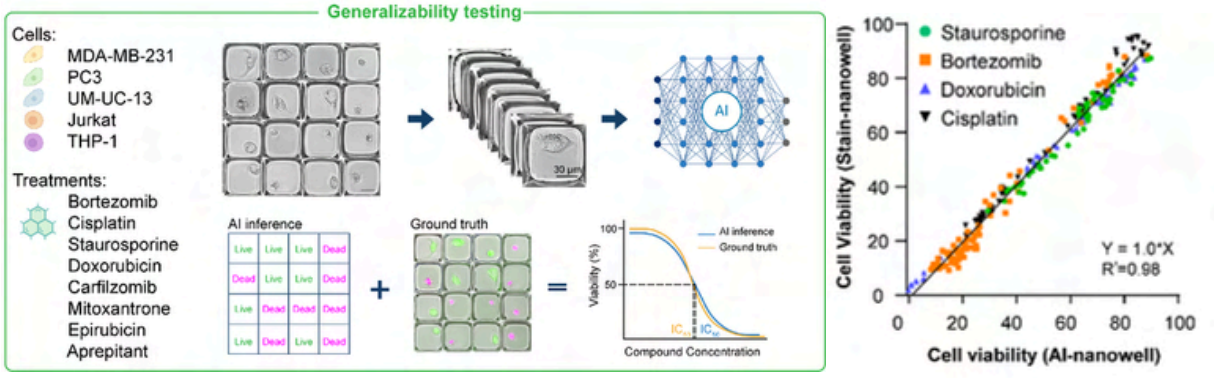
We develop full-stack bioanalysis tools that transform complex biological experiments from fragile, manual processes into scalable, automated workflows. We focus on replacing challenging assays with robust, high-throughput bioanalysis systems that provide richer data and greater biological insights for biomedical research, drug development, and clinical medicine.

## Our Training Program

We are a dynamic, multi-disciplinary research team that brings together ideas from chemistry, materials science, microfabrication, robotics, and AI to invent the next-generation bioanalytical technologies. We recruit students from engineering and biomedical disciplines who are motivated by ambitious and goal-oriented research and enjoy working across traditional disciplinary boundaries. Trainees are encouraged to think ambitiously and creatively, and to continuously develop new skills along the way.

## AI-powered Drug Screening

Advances in artificial intelligence are transforming how biological information can be extracted from microscopy images. Modern AI tools can extract subtle cellular features and phenotypic patterns far beyond what is possible using human cognition. Recently, we developed a method, called "regularized imaging" to train AI models to identify cellular features that are generalizable across cell types and preparation methods. We are using this framework to develop next-generation drug screening to dramatically increase screening throughput and providing more informative drug response profiles.




## Image Cytometry and Microscopy-based Cell Separation

The ability to separate specific cells to analyze them in isolation is a fundamentally important capability in bioanalysis. For the past ~50 years, flow cytometry has been the dominant cell separation technology. While powerful, flow cytometry has several important limitations, including (1) shear stress that can damage sensitive cells; (2) significant cell loss during processing; (3) difficulty handling non-spherical cells, fragile cells, and cell clusters; and (4) an inability to separate cells based on morphology or sub-cellular structure. Many of these limitations can be addressed using microscopy-based approaches, but existing microscopy-guided methods are very low throughput, limiting their practicality for many downstream analytical workflows. We are developing microscopy-based cell separation technologies to expand the toolbox for cell separation and downstream analysis.

## IP & KNOWLEDGE TRANSLATION

We develop bioanalytical technologies to accelerate biomedical research and improve patient outcomes. We translate our innovations through patenting, licensing, and commercialization, with multiple technologies advancing beyond the lab. We work with clinicians to evaluate our technologies in clinical healthcare settings, and we partner with academic researchers and industry to deploy our tools in research and development workflows.

# IVAN ROBERT NABI

PROFESSOR

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**We apply AI to super-resolution microscopy to determine high-resolution architecture of subcellular organelles in order to selectively target proteins that regulate organelle function in health and disease.**

super-resolution microscopy | cellular organelles | membrane contact sites | caveolin | Gp78 | mitophagy | machine learning | cancer

## Applying AI to Super-Resolution Microscopy

Super-resolution microscopy (SRM), Nobel Prize-awarded in 2014, uses fluorescent-based tools to study subcellular structures at the nanoscale in intact cells, offering detailed views. Advancing beyond higher resolution requires quantitative analysis paradigms. AI and machine learning analysis of SRM data hold significant potential for discovering unknown biology lacking ground truth.

Collaborating with the Hamarneh group (SBME, SFU), we develop AI-based SRM analyses to explore the molecular architecture of subcellular structures. Our software, SuperResNET, defines caveolae structures and identifies new scaffold domains. MCS-DETECT detects sub-pixel mitochondria-ER contacts (MERCs). Applying these AI tools to SRM enhances our understanding of subcellular domains, organelles, and their roles in cancer progression.

The Nabi Lab: https://bme.ubc.ca/?directory=ivan-robert-nabi

## RESEARCH EXCELLENCE

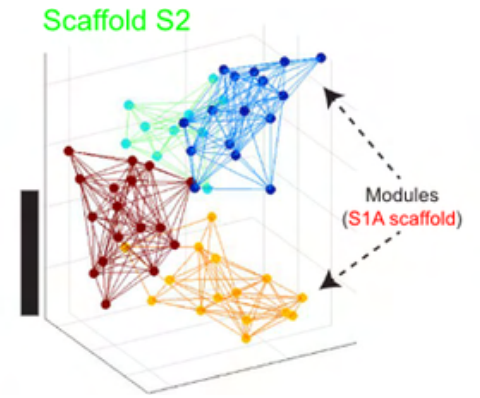
Our research uses super-resolution microscopy to study cellular organelles smaller than the 200-250 nm diffraction limit of visible light. We've pioneered AI-based analyses for biological discovery, exploring caveolae protein caveolin-1's role in tumour cell migration, defining non-caveolar scaffold domains, and identifying Gp78 E3 ubiquitin ligase's tumour suppressor roles through mitophagy and ROS regulation.

## Our Training Program

We seek lab members interested in advancing their skills in cell biology and cellular imaging. Our lab promotes trainee development and collaboration, aiming to build diverse capabilities in cellular imaging and subcellular biology. Trainees will gain unique skills in super-resolution microscopy and in machine learning-based image analysis. We offer an inclusive, safe, and respectful environment to promote scientific excellence.

## Caveolin-1: Function of Non-Caveolar Scaffold Domains

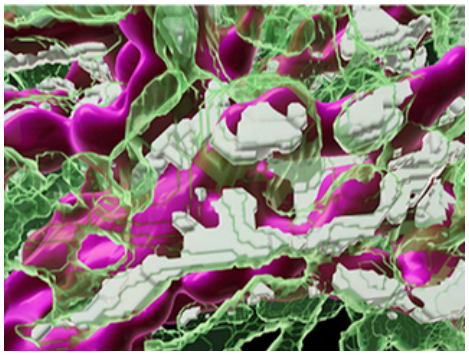
Caveolin-1 (CAV1), the coat protein for caveolae, is a poor prognostic marker for cancers like triple-negative breast cancer and prostate cancer. Caveolae flattening functions as a membrane buffer in response to mechanical stress; non-caveolar scaffold domains function as signaling regulators both inhibiting receptor signaling and promoting focal adhesion signaling and tumour cell migration. CAV1 forms stable 11-mer oligomers; we have shown using single molecule super-resolution microscopy that these oligomers combine to form larger intermediate scaffold structures and caveolae. We aim to define scaffold domains' role in CAV1 signaling to focal adhesions and endocytosis under mechanical stress.




**High-resolution definition of subcellular functionalities will enable selective targeting of specific cellular roles of target proteins**

## Gp78 Tumour Suppressor Function: Mitophagy, Mitochondria-Endoplasmic Reticulum Contacts (MERCs) and ROS

Gp78 is a key E3 ubiquitin ligase in ER-associated degradation involved in protein quality control. It regulates basal mitophagy of cancer cells, promoting mitochondrial health and reducing ROS production, which is associated with cancer progression. We have shown that Gp78 promotes the formation of a distinct class of convoluted tubular ribosome-studded MERCs (riboMERCs) and are interested in better understanding the role of riboMERCs in mitophagy.



## IP & KNOWLEDGE TRANSLATION

- Developing AI-based image analysis software for super-resolution microscopy and making it available for the imaging community
- Defining high resolution functionalities for CAV1 and Gp78 that can be targeted for cancer therapy

# JANE HILL

## ASSOCIATE PROFESSOR

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**"Do or do not. There is no try"**
**-- Yoda**

breath analysis | transcriptomics | respiratory infections | metabolomics | biotechnology | chemical analysis | volatile organic compounds | chromatography

## Advancing Respiratory Diagnostics: Breath and Biofluid Analysis

Breath offers us a non-invasive window into our health. It is a complex matrix consisting of thousands of volatile and semi-volatile molecules as well as aerosols. Exhaled breath contains biomarkers from metabolism, microbiomes, and disease-specific processes, serving as unique chemical signatures for various diseases, including liver and kidney disorders, some cancers, and respiratory diseases. Breath science has gained significant traction in recent decades, emerging as a promising alternative to conventional health diagnostics.

The Hill lab uses advanced analytical tools to explore the applications and limits of 'omics, focusing on breath analysis and transcriptomics in global collaborations. In our basic science work, we are keen to understand the origins and consequences of the volatile molecules we find in breath and the transcripts in blood. We focus on respiratory infections – viral, bacterial, and fungal – however, we are also interested in other human and animal diseases.

The Hill Lab: https://hilllab.chbe.ubc.ca

## RESEARCH EXCELLENCE

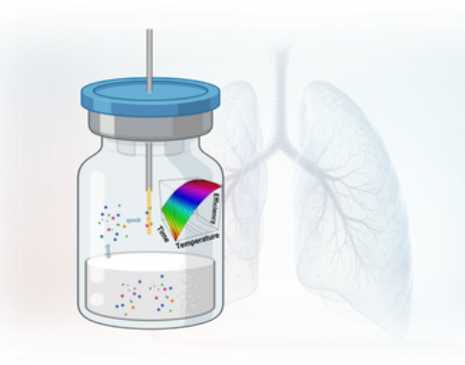
We are dedicated to revolutionizing disease diagnosis and molecular analysis using human breath and biological matrices like sputum, blood, and urine. Employing advanced tools like GC×GC-ToF-MS, we explore the potential of breath analysis and investigate the origins of volatile molecules. Integrating diverse techniques and insights, we link metabolic and disease processes through breath VOC profiles, redefining scientific boundaries.

## Our Training Program

We are a dynamic and multidisciplinary team where chemists, data scientists, mathematicians and more seamlessly collaborate, continually learning from each other. Our strength lies in the ongoing exchange of ideas and knowledge, where our diverse perspectives and insights contribute to our collective success. We provide team members valuable opportunities to enhance their technical and analytical skills through hands-on experience and development.

## Disease Diagnosis and Discovery

We employ some of the most sophisticated analytical tools available to determine the applications and limits of 'omics for diagnosing respiratory diseases such as cystic fibrosis, tuberculosis, and non-tuberculous mycobacterial diseases. Collaborating globally, we analyze breath, sputum, bronchoalveolar lavage, and blood to detect volatile molecules indicating lung infections and treatment responses. Our primary focus is developing sensitive, specific, non-invasive breath-based diagnostics for tracking lung infections. We also study the origins and consequences of these volatile molecules and blood transcripts, emphasizing respiratory infections but also other diseases. Our recent work shows great promise, especially for bacterial infections.



**Optimization of Headspace Solid Phase Micro-extraction for Human Samples.**

## Advancing Next-Gen Technologies

We are also developing a time machine-like technology that enables observing cells' behaviors back in time. In this idea, cells of a population are first uniquely tagged with "DNA barcodes." The barcoded population is then propagated, and its subpopulation is subjected to a given assay. After identifying a barcode linked to cell clones with a desired phenotype, we isolate the same or closely related clone using barcode-based sorting from the initial cell population. This technology enables the isolation of cell clones conferring a target cell state post-differentiation from human pluripotent stem cells. Our collaborative group is currently employing this method to obtain "fate-mapped" clones predisposed to differentiating into various cell types, including naïve cells.

## IP & KNOWLEDGE TRANSLATION

- Development of cutting-edge breath collection tools and technologies
- Human volatilome, animal volatilome, microorganism volatilome
- Biobank of breath VOCs from healthy and diseased people
- Database of breath biomarkers for particular respiratory infections and pathogens
- Database of microbial data across various infections

CELLULAR & MOLECULAR ENGINEERING

# JOEL FINBLOOM

## ASSISTANT PROFESSOR

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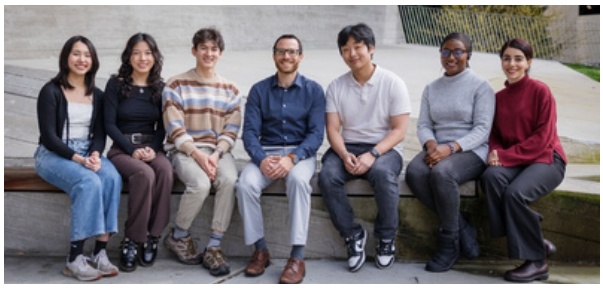


**We leverage bioinspired design principles to direct microbe-material interactions and advance human health.**

nanomedicine | biomaterials | drug delivery | bacterial biofilms | probiotics | antimicrobials | chemical biology | biointerfaces

## Bioinspired Design at the Microbe-Material Biointerface

Bacteria play an important and complex role in human health and disease. Pathogenic bacteria can cause antibiotic resistant infections, which are projected to result in over 10 million deaths per year by 2050. On the other hand, therapeutic microbes such as probiotics have the potential to address microbiome dysbiosis and combat diseases such as inflammatory bowel diseases, but suffer from poor delivery outcomes posed by the harsh conditions of the gastrointestinal tract.

Our research program takes inspiration from dynamic biological systems to develop nanomaterials that interface with bacterial communities and overcome critical biological barriers to both antibiotic and probiotic delivery.

The Finbloom Lab: https://www.finbloomlab.com/

## RESEARCH EXCELLENCE

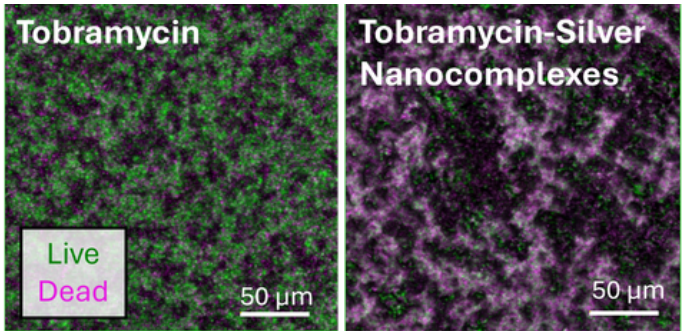
The Finbloom lab designs bioinspired nanomaterials that interface with microbial communities to advance human health. By working at the intersection of chemical biology, nanotechnology, and bioengineering, we tackle critical challenges in the pharmaceutical sciences - treating antibiotic resistant bacterial infections and improving the oral delivery of probiotics.

## Our Training Program

We cultivate an open and respectful environment, where trainees engage in active dialogue and ask critical questions, diving deeper into their research while maintaining a constructive critical tone. We emphasize a growth mindset throughout our research, believing that both positive and negative results advance our research and scientific training, and raise important questions to further our research goals.

## Advancing Antimicrobial Delivery to Treat Resistant Infections

Bacterial biofilm infections are dynamic and heterogeneous bacterial communities, containing a dense extracellular network of polysaccharides, DNA, and proteins. These biofilms are estimated to occur in over 80% of infections and limit antibiotic penetration, leading to 1000x drug resistance. We are designing nanoparticles loaded with antibiotics that interface with bacterial biofilms to direct nanoparticle navigation through the biofilm environment and improve antibiotic delivery efficacies. In a separate project, we are engineering bioinspired antimicrobial nanofibers to trap and kill bacterial pathogens. These approaches will aid in our understanding of biofilm microenvironments and develop next generation nanotherapeutics for the targeted treatment of chronic bacterial infections.




**Bacterial biofilms treated with antimicrobial nanoparticles containing silver and tobramycin. This approach improved treatment outcomes over traditional antibiotic administration. Live bacteria (green), dead bacteria (magenta).**

## Improving the Oral Delivery of Bacterial Therapeutics

Bacterial therapeutics (e.g. probiotics) offer immense promise the treatment of a variety of diseases, including bacterial infections, autoimmune disorders, and inflammatory bowel diseases. However, the oral delivery of living biotherapeutics such as probiotics is hampered by the biological barriers posed by the GI system, such as stomach acid and competition from the native microbiome. We are taking inspiration from natural bacterial communities to design nanostructured microgels with microbe-interfacing functional handles that are capable of encapsulating probiotics to improve their viability, GI retention, and biomedical function.

## IP & KNOWLEDGE TRANSLATION

- Next generation drug delivery vehicles
- Novel combination antimicrobial delivery to overcome resistance
- Nanostructured hydrogels and microgels
- Bioinspired microbe-interfacing nanomaterials

# KELLY MCNAGNY

PROFESSOR
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**Detailed immune phenotyping allows us to identify cells at play in disease. These include the exquisitely specific adult T and B cells but also the more recently discovered long lived lymphocytes that develop and colonize tissues at birth.**

immunology | immunotherapy | immune sculpting | airway disease | stem cells | chronic inflammatory disease | allergy | cancer | innate lymphoid cells | microbiome

## Stem Cells and Immune Response as Modulators of all Disease

The greatest breakthroughs in improving human health result from understanding how immunity and immune response protects us from infectious disease. This has been truly transformative in allowing us to live longer and healthier lives. Yet we are only scratching the surface in understanding the mechanisms that regulate immune cell development, or the role of immune response in non-infectious disease and maintaining normal healthy tissues. Immune cells also play a vital role in maintaining healthy tissues, but can also be the bad actors in driving chronic disease and inflammation when dysregulated.

My lab's view is that ALL disease outcome is linked to immune and inflammatory responses. A key inroad to ameliorating any specific disease is simply a matter of deciphering and understanding the specific immune components at play and then modifying them in way that improves or cures disease and allows normal tissue function to return.

The McNagny Lab: https://bme.ubc.ca/?directory=kelly-mcnagny

## RESEARCH EXCELLENCE

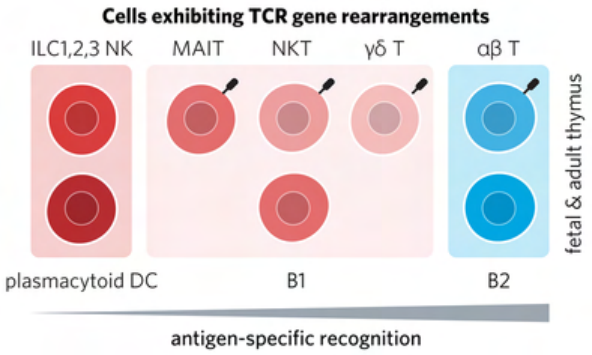
We employ two strategies to understand disease and improve treatment. High-throughput immunophenotyping identifies disease-related immune cells, aiding therapy target identification and providing valuable biomarkers for patient response tracking. Accurate animal models verify disease-driving cells and test treatment strategies, facilitating the development of new therapies translatable to human disease.

## Our Training Program

We seek team members passionate about using immune response to decode diseases. Our motto, "Powered by science and strengthened by diversity," applies to both our research methods and our team. Science thrives on diverse teams and cutting-edge technologies, presenting immense discovery opportunities. Innovative ideas and well-designed experiments positively impacts our understanding the complexity of biology.

## Innate Lymphoid Cells (ILC) in Disease

Despite decades of study, immune response regulation in disease remains poorly understood. Innate Lymphoid Cells (ILCs), a newly discovered immune branch, act as crucial early tissue responders. They ensure appropriate responses to environmental insults, but dysfunction can drive diseases like allergy and inflammatory bowel disease. Early-life environmental exposures program ILC behavior, influencing individual disease responses long-term. Our focus is on understanding this programming, leveraging it for therapy, and harnessing ILC properties to enhance disease outcomes.




## Targeting Tumour Stem Cells in Cancer

Many years ago my lab discovered a family of stem cell proteins called the, CD34 family. We showed that this family is expressed by various stem cell populations during development and that they play key roles in regulating cell polarity, adhesion, chemotaxis and migration and, thus, make normal cells more mobile and invasive. Interestingly, we found that one family member, PODXL, is frequently upregulated by a variety of tumours and always correlates with poor outcome. Strikingly, we showed that inactivating the PODXL gene cripples the ability of tumours to metastasize in preclinical models. Buoyed by this result, we generated a series of monoclonal antibodies to PODXL as potential immunotherapeutics to treat a range of human cancers. Two of these show a striking ability to block tumour metastases or, selectively kill tumours when coupled to toxins and used in preclinical models. We are now exploiting these as both, early diagnostics and therapeutic approaches for cancer treatment.

## IP & KNOWLEDGE TRANSLATION

- Biomarkers of disease and response to therapy
- Actionable immunotherapeutic targets for specific disease
- Novel approaches to immunotherapy
- Robust preclinical animal models for disease
- Detailed mechanistic understanding of disease

CELLULAR & MOLECULAR ENGINEERING

ASSOCIATE MEMBER

CELLULAR & MOLECULAR ENGINEERING

# MARK CEMBROWSKI

## ASSISTANT PROFESSOR

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brain | learning & memory | post-traumatic stress disorder | Alzheimer's disease | epilepsy | autism spectrum disorder | traumatic brain injury

## Learning and Memory in the Brain, in Health and Disorder

We aim to understand how the brain forms, stores, and retrieves memories.

To do this, we take a multidisciplinary, multiscale approach. We combine cutting-edge experimental techniques with computation, engineering, and mathematics to study memory across the spatial scales of the nervous system: molecules, cells, circuits, and behaviour. With this combination, we aim to generate a comprehensive understanding of the neurobiological rules of memory in both health and disorder. Some examples of our funded projects include study of fear memory, recognition memory, traumatic brain injury, autism spectrum disorder, epilepsy, and schizophrenia.

The Cembrowski Lab: http://www.cembrowskilab.com

## RESEARCH EXCELLENCE

Mark Cembrowski is an early-career researcher with a hybrid skill-set in Applied Mathematics and multiscale experimental neuroscience. His lab combines these approaches to identify brain cell types, publishing in prestigious journals like Cell, Neuron, Nature Neuroscience, Cell Reports, and eLife. He was named a 2018 Allen Institute "Next Generation Leader" and won the worldwide 2020 Cajal Club "Krieg Cortical Explorer" early-career researcher award.

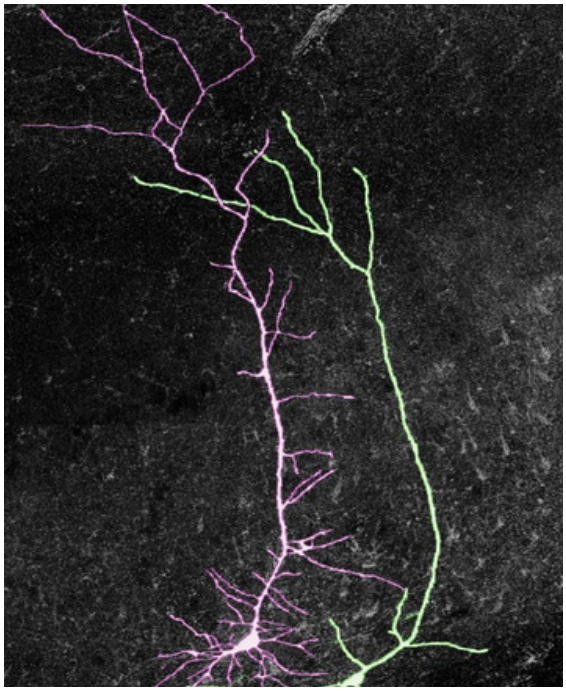
## Our Training Program

Our lab is a safe, inclusive, and supportive space committed to understanding the neuroscience of memory. Emphasizing a "people first" atmosphere, we achieve this through rigorous experiments, honest work, collaboration, and active mentorship. Our multidisciplinary team spans neuroscience, mathematics, computer science, physics, and bioinformatics, fostering a high-energy, team-based approach to research.

## Understanding Learning and Memory in the Brain

In the Cembrowski Lab, we conduct high-throughput cellular and molecular experiments to identify new brain cells and molecules that may be involved in distinct forms of memory. Motivated from these discovered cells and molecules, we then employ a combination of brain circuit mapping and manipulation to understand how these molecules, cells, and circuits can causally influence learning and memory.

This approach has led to the discovery of new organizational principles of the brain, as well as the identification of a wholly new form of cellular memory. These results have broadened our knowledge of the foundational operation of the brain, and are currently being used to understand memory-related impairments occurring in Alzheimer's disease, PTSD, and epilepsy.



## Working Directly with the Living Human Brain

It is exceptionally challenging to understand the molecules and cells that guide memory in the human brain. In a highly specialized collaboration with local brain surgeons and neuropathologists, we have designed a research program that is capable of directly studying the living human brain from informed, consenting participants undergoing brain surgery. We are one of the few groups in the world capable of doing this type of research, and in combination with our state-of-the-art technologies and machine learning approaches, are deriving wholly new approaches to understanding learning and memory directly in the human brain. We aim to identify new drug targets and test them in live human brain experiments, hoping to advance understanding and treatment of memory-related brain disorders.

## IP & KNOWLEDGE TRANSLATION

- New fluid biomarkers for early diagnosis of brain disease
- Druggable targets and drug repurposing for brain disease
- Development of personalized understanding of disorders of learning and memory

# MEGAN LEVINGS

PROFESSOR
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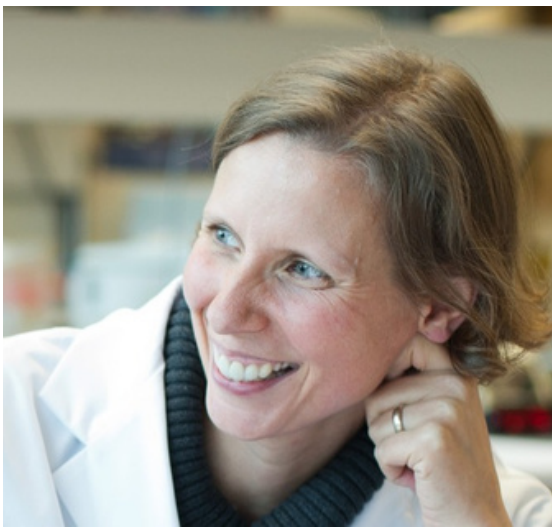


**We aim to combine the immunoregulatory properties of regulatory T cells with cell engineering to create bespoke therapies with the potential to cure autoimmunity and prevent transplant rejection**

immunology | cell engineering therapy | transplantation | autoimmunity | regenerative medicine | chimeric antigen receptors | human immunology

## Engineering Immune Cells to Regulate Immunity

Our immune system is actively regulated so that, while it is fighting off foreign/dangerous substances, it does not react to our own cells or harmless materials. This balancing act of attack versus ignore is called immune tolerance. Lack of immune tolerance causes many conditions, such as autoimmune disease and transplant rejection. Currently, treatment for immune-mediated diseases involves lifelong immunosuppressive drugs, which increase infection and cancer risks. My research centres on T regulatory cells (Tregs), pivotal for immune tolerance and potential therapeutics. To harness Tregs' natural tolerance induction and develop effective therapies for immune-mediated diseases, we need to define how, when and where Tregs function in the body. My research program aims to understand Treg biology and apply that knowledge to develop new Treg-based therapies to manipulate immune tolerance.

The Levings Lab: https://www.bcchr.ca/levingslab
Check out this video about our lab: https://www.youtube.com/watch?v=q9Csr5fKN-I

## RESEARCH EXCELLENCE

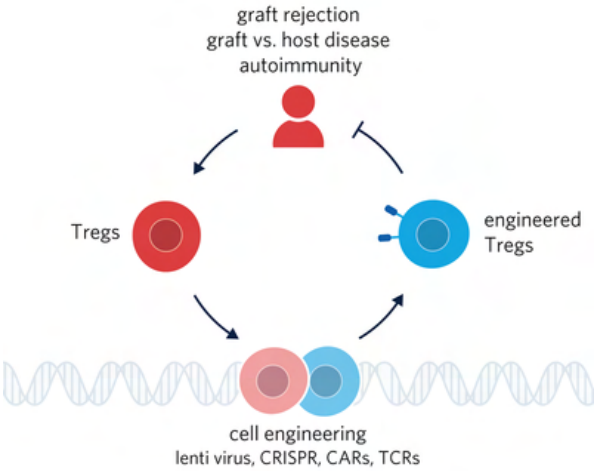
Tregs are living pharmaceutical factories, responding to local environments to resolve immune responses, prevent autoimmunity and repair tissues. We use cell and molecular engineering approaches to harness these properties to create new therapies for transplantation and autoimmunity. Our work has already created new types of Treg therapies currently in clinical testing with a pipeline of exciting new strategies under development.

## Our Training Program

We're a vibrant team of over 20 global researchers studying Tregs for human health. Our work spans various systems, from manipulation and analysis of immune cells, to testing cell therapy approaches, to using synthetic biology to manipulate Treg specificity and function. Trainees love the collaborative environment and exposure to translational immunology. Join the team at BC Children's Hospital Research Institute: https://www.bcchr.ca/about-us/training-opportunities

## CAR Treg Therapy

Transplantation, the primary treatment for end-stage organ failure, requires immunosuppressive drugs, increasing infection and cancer risks. My lab explores using Tregs' immunosuppressive abilities to reduce reliance on conventional treatments. We've pioneered CAR-engineered Tregs for transplantation therapy, now in clinical trials. Yet, significant knowledge gaps remain. Our project employs mouse models to test if CAR-Tregs can synergize with non-toxicimmunosuppression for transplantation tolerance induction. This research aims to enhance understanding and develop effective cellular therapies, improving patient outcomes in transplantation.




## Allogeneic Treg Therapy

Regulatory T cells (Tregs) are immune cells that suppress inflammation and promote tissue healing. Clinical trials of adoptive Treg therapy yield promising results for inflammatory diseases. Yet, the high cost and logistical challenges in patient-specific Treg manufacturing hinder widespread use. An allogeneic (i.e., not patient-specific) therapy is an ideal solution and we have developed a method to make abundant allogeneic Tregs from human thymus, a Treg-rich tissue that is routinely discarded after pediatric heart surgery. We plan to trial thymic Tregs to prevent graft versus host disease, and we're working on a good manufacturing procedure (GMP)-compliant method to isolate, expand, and preserve these cells. We aim to test new bioreactor based strategies for scale up, test optimized media combinations and develop ways to make unlimited allogeneic Tregs from stem cells.

## IP & KNOWLEDGE TRANSLATION

- New chimeric antigen receptors for use in Tregs
- Strategies to make "off the shelf" Tregs for therapy
- Knowledge of Treg therapy mechanisms of action
- Proof-of concept data for Treg applications in transplantation and autoimmunity
- Bespoke combination therapies enabling Treg applications in current clinical practice

# MICHAEL UNDERHILL

PROFESSOR
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**We use state-of-the-art lineage tracing and genetically engineered models coupled with multi-omics approaches to better understand the fate and function of mesenchymal stromal cells in health and disease.**

stem cells | tissue regeneration | cancer | fibrosis | aging | genetic mouse models | omics | lineage tracing | computational biology and therapeutics

## Mesenchymal Stromal Cells in Health and Disease

Adult stem and progenitor cells are pivotal for maintaining tissue homeostasis, renewal, and regeneration. Dysfunction in these cells underpins various diseases such as cancer, fibrosis, and degenerative disorders. Our research focuses on mesenchymal stromal cells (MSCs) and their involvement in these pathological processes. Our interest stemmed from prior investigations into MSCs during limb development and the discovery of quiescent MSCs in adult muscle. Utilizing transcriptomics and functional assays, we identified the Hypermethylated in Cancer 1 (Hic1) gene, which governs fundamental aspects of MSC behavior. By generating novel mouse lines with modified Hic1 alleles, we can meticulously explore the fate and function of MSCs, thereby advancing our understanding of their role in disease pathology and potential therapeutic interventions. In short, MSCs play critical roles in health and disease, with implications for treating aging, cancer, fibrosis, and promoting tissue regeneration.

The Mesintel Therapeutics Lab: https://mesintel.com/

## RESEARCH EXCELLENCE

We use advanced mouse models and single-cell omics methods to explore MSC biology. Our research is funded by CIHR, Terry Fox Research Institute, Stem Cell Network, and NIH. I direct the SBME sequencing facility, facilitating diverse sample sequencing and driving spatial transcriptomics efforts. I co-founded Mesentech Inc., focusing on bone formation stimulation, and Mesintel Therapeutics Inc., developing therapeutics for cancer and fibrosis treatment.

## Our Training Program

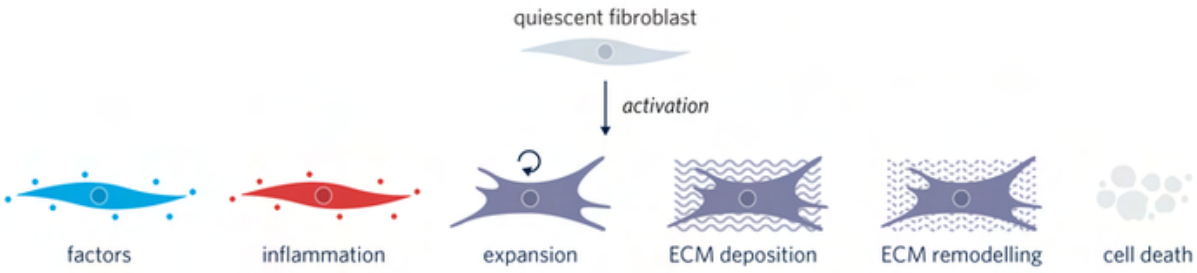
Successful trainees embody engagement, passion, integrity, and a commitment to scientific rigor. We cultivate these traits in a supportive, inclusive, and stimulating environment, where they gain expertise in both wet and dry lab techniques. With this skill set, trainees in my group have gone onto successful and rewarding careers in academia and industry.

## MSCs in Aging (CIHR)

The capacity for tissue regeneration decreases as we age, culminating in a gradual decline in function. Hutchinson Gilford Progeria Syndrome (HGPS) patients die of age-related degenerative diseases at ~ 13 years old. HGPS is caused by a mutation in LMNA which leads to the aberrant intracellular accumulation of a protein termed progerin. Experimental evidence suggests that defective MSCs play a key pathogenic role in HGPS. We hypothesize that MSC dysfunction leads to decreased tissue regeneration, contributing to age-related pathologies. This is being tested in a new mouse model mirroring HGPS phenotypes. The goal is to better define how MSCs impact aging, with subsequent development of strategies to extend the healthy lifespan.

## MSCs in Tissue Regeneration and Fibrosis (CIHR and SCN)

In many diseases, MSCs transition to an "activated" myofibroblast-like state in response to injury (or other signals). Under these conditions, they produce a transient microenvironment to support tissue regeneration, whereas in repair, they persist and directly contribute to tissue scarring and fibrosis. Fibrosis underlies ~45% of chronic diseases and is a major contributor to end-stage organ failure. In some instances, removal of the injurious agent is accompanied by significant disease regression. A series of novel genetic models will be used to explore the contribution of MSCs to fibrosis, with a specific emphasis on the development of therapeutic approaches to modify MSC activity to reduce fibrosis.




## IP & KNOWLEDGE TRANSLATION

- New genetic tools to study MSC biology
- Human-informed genetic mouse models to study disease
- Novel platforms for discovery and validation of therapeutic targets
- Development of new computation tools for analysis of single cell omics datasets

# NIKA SHAKIBA

ASSISTANT PROFESSOR
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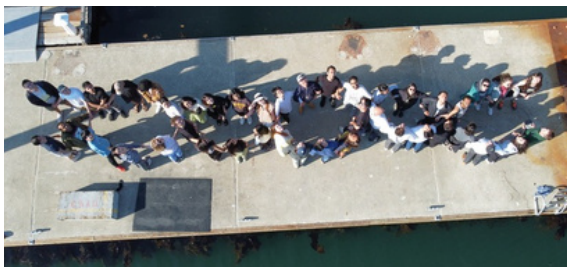


**We explore how competitive and cooperative interactions between stem cells impact their growth and differentiation. Leveraging computational and genetic tools, we will engineer multicellular stem cell societies for therapies.**

cellular engineering | stem cells | synthetic biology | pluripotency | cell competition | computational biology | stem cell differentiation | embryonic development | cell therapy

## Engineering Stem Cells for Cell Therapies

Cell therapies involve the transplantation of living cells into the body and are a new pillar in medicine, opening the door to treating degenerative and otherwise intractable diseases. Pluripotent stem cells (PSCs) hold promise for off-the-shelf therapies, but understanding their decision-making process is crucial for widespread accessibility and efficient manufacturing. My research team believes that the key to robust PSC engineering lies in viewing cells as simple autonomous machines.

Like computer circuitry, the DNA-based "processor" in cells, comprising around 20,000 genes, regulates cellular behaviour. Our team merges systems and synthetic biology to understand how this processor guides decisions in pluripotent stem cells (PSCs) and their collective behaviour. We aim to predict PSC fate through simulations, revolutionizing cell therapy manufacturing.

The Shakiba Lab: https://shakiba.bme.ubc.ca/

## RESEARCH EXCELLENCE

Our interdisciplinary lab merges engineering and life sciences to advance stem cell research and therapy development. In 2019, we found that cell competition influences cell growth in culture and developed genetic tools to control stem cell behavior. We're now investigating how to use cell competition to enhance stem cell purity, yield, and survival, both in manufacturing and transplantation, exploring its role in embryonic development.

## Our Training Program

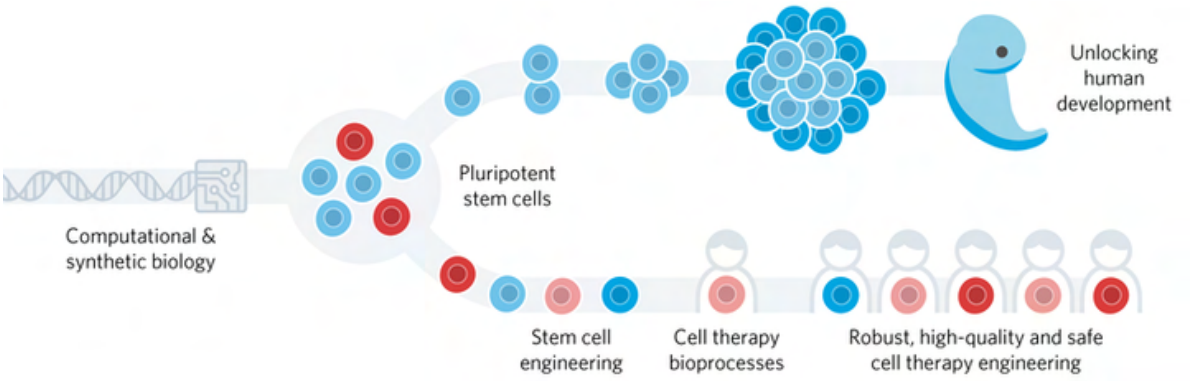
Our team's scientific philosophy is rooted in the belief that intersecting diverse ways of thinking seeds innovation. As a team at the intersection of biomedical engineering, we foster interdisciplinary collaboration and seek members eager to advance our knowledge of stem cells and their societies. We're passionate about using engineering to program cells for regenerative medicine and offer high-quality, open-access mentorship through our co-founded initiative, Advice to a Scientist.

## Competition in Stem Cell Society

Like all human cells, PSCs live in multicellular societies and rely on interactions with one another to make decisions. We're investigating how interactions among PSCs affect their survival, multiplication, and differentiation. Specifically, we're exploring how these interactions impact the quality, efficiency, and yield of PSC-derived cell therapies like insulin-producing beta cells and blood vessel organoids. We're using DNA-based technologies to track single-cell transcriptomes and map their growth in culture. Collaborating with other teams, we're developing computational models to predict competition in PSC growth and differentiation.

## Building a Simulator of PSC Differentiation

While gene regulatory network (GRN) models of PSCs have been devised, they lack biological time and cannot capture dynamic cell state transitions. We're collaborating to integrate the cell cycle into gene regulatory network (GRN) models of PSCs to understand how gene expression drives differentiation. Using single-cell transcriptome and cell cycle tracking technologies, we're validating model predictions of PSC differentiation. This will optimize manufacturing pipelines for deriving specialized cell types from PSCs, identifying key genetic nodes to improve efficiency and reproducibility in cell therapy production.




## IP & KNOWLEDGE TRANSLATION

- New tools to improve the efficiency and robustness of cell therapy manufacturing
- New technologies to preserve the safety of stem cells in manufacturing pipelines
- Genetic engineering tools to augment the differentiation potential of stem cells
- A virtual simulator of human cells

CELLULAR & MOLECULAR ENGINEERING
CORE MEMBER

# NOZOMU YACHIE

PROFESSOR
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**We will retrieve high-content maps of animal developmental processes. The maps will explain the development of complex human and other animal bodies and become backbone resources for next-generation biology.**

genome editing | cell engineering | high-performance computing | computational biology | DNA event recording | stem cell differentiation | development

## Developing a Video Camera and a Time Machine for the Cell

Human development starts with a single fertilized egg, from which cells multiply and transform to build our organs and systems. Activating specific genes in response to internal signals, cells not only establish their function but also communicate with nearby cells. These interactions, regulated by the genome, guide cell differentiation and self-organization, shaping the body's intricate structure.

Modern biology faces a significant hurdle: the inability to directly observe dynamic cellular events. Current molecular profiling methods require sample destruction, offering only static snapshots. To overcome this, our team combines genome, cell, and animal engineering with high-throughput measurements and computing power. We aim to develop two groundbreaking technologies: miniature cell-installed video cameras and time machine-like systems for isolating cells with predetermined destinies.

The Yachie Lab: https://yachie-lab.org/

## RESEARCH EXCELLENCE

Our research group pioneers platform technologies for biology, including cutting-edge genome editing tools (Science 2016, Science 2018, Nature Biotechnology 2020, Cell 2023). We advance cells and animal models with enhanced functions (Science 2022), deepening our understanding of the human body and addressing disorders. Additionally, we're active in laboratory automation to expedite life science research and biotechnology development.

## Our Training Program

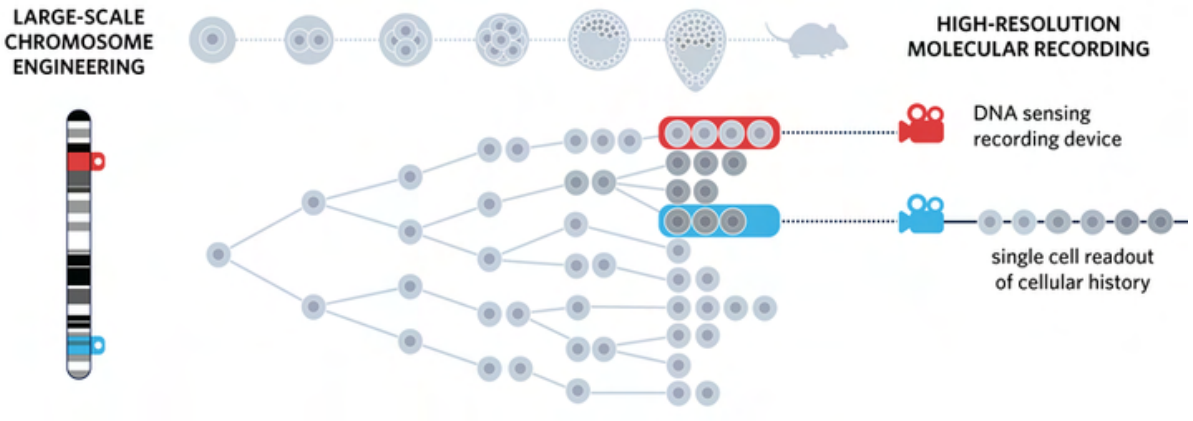
We're seeking lab members keen on advancing skills in mammalian synthetic biology, spanning genome and animal engineering to computer science. Together, we tackle biology's pressing challenges, nurturing unique expertise within our team. Our lab fosters collaboration, maximizing each member's impact on scientific progress while supporting their personal development.

## DNA Event Recording

We're creating cell video camera systems, capturing high-resolution molecular and cellular data of individual cells in a multicellular organism. This data is stored in synthetic "DNA tapes," enabling historical molecular profiles to be read out using high-throughput single-cell sequencing. Similar to a video camera, we've identified four key system modules for DNA event recording and are developing crucial components: (1) high-capacity DNA "memory" modules in chromosomes; (2) highly sensitive "sensor"

## Retrospective Clone Isolation

We're developing a time machine-like technology to observe cells' past behaviours. Cells in a population are tagged with unique "DNA barcodes" and propagated. Subpopulations are then subjected to assays, and barcodes associated with desired phenotypes are identified. These clones or relatives are then isolated from the initial population. Using this, we've isolated clones from human pluripotent stem cells, demonstrating their potential in cell differentiation. We're currently leveraging this technology, in collaboration with others, to obtain fate-mapped clones for various cell types.




## IP & KNOWLEDGE TRANSLATION

- New genome editing tools
- Synthetic Biology toolkits to develop functionally augmented cells
- Elite human cells that have efficient target functionalities or differentiation fates
- High-performance computing platforms
- A virtual human cell simulator

# PAMELA HOODLESS

PROFESSOR
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**My laboratory explores regulatory mechanisms in organ development, in particular the liver, and the relationship of these mechanisms to liver cancer progression.**

cell identity | gene expression | transcriptional networks | differentiation | development | cancer biology | single cell genomics

## How Does a Liver Form?

The liver regulates various bodily processes, including detoxification, glucose metabolism, and lipid synthesis. While it has a remarkable ability to regenerate, chronic liver disease is increasing, and can cause permanent liver damage and scarring that will progress to cirrhosis, poor liver function and can advance to cancer. Liver transplants are the primary treatment, but demand exceeds supply. Understanding liver development can improve disease treatment and provide alternative sources for transplantation.

We use genomic technologies to shed new light on gene networks driving hepatic differentiation in mouse embryos and human pluripotent stem cells by using whole tissue and single cell analyses of gene expression, transcription factor function and epigenetic mechanisms. Since, hepatocellular carcinoma is a liver cancer which commonly re-expresses embryonic genes, we are also exploring if embryonic regulatory mechanisms are reactivated to help drive cancer and if they can be modulated.

The Hoodless Lab: https://www.bccrc.ca/dept/tfl/labs/hoodless-lab

## RESEARCH EXCELLENCE

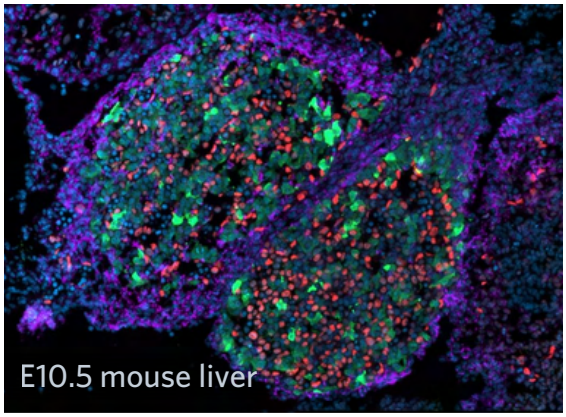
We integrate bench work and computation to study transcriptional networks controlling cell identity. We investigate gene expression mechanisms driving differentiation to study hepatic organoids and liver cancer progression. We study cell diversity and plasticity in embryonic differentiation, focusing on transcription factor and epigenetic regulator interactions. Greater insight into transcriptional regulation enables new intervention opportunities.

## Our Training Program

Our lab members engage in both bench work and computational analysis, aiming for a balanced understanding of biology and computational concepts. Regardless of primary focus, everyone learns experiment design and execution. We foster independence and collaboration, valuing diverse ideas and contributions for discovery.

## Hepatic Cell Identity

The regulated transcription of genes is essential for proper cell identity. We investigate how transcriptional and epigenetic factors drive differentiation in mouse and human pluripotent stem cells. Using single-cell genomics, we study cell diversity in the embryonic mouse liver. By mapping transcription and epigenetic factors in the genome, we explore gene expression regulation during differentiation. Our research extends to liver organoids from human pluripotent stem cells, facilitating mouse-human developmental comparisons. Interestingly, some embryonic liver genes are aberrantly upregulated in liver cancer. We are using our expertise in gene regulation to examine the different cell types in tumours and to explore how the embryonic transcriptional networks contribute to liver cancer progression.




**The image illustrates various cell types within the developing embryonic mouse liver. Blue indicates the nuclei of all cell, purple marks mesodermal cells around and within the liver bud, red marks endothelial cells forming blood vessels, and green denotes emerging hepatoblasts.**

## Cell Relationships in the Liver

The liver has an elegant architecture which is essential for normal functions. It liver contains various cell types, including hepatocytes, cholangiocytes, hepatic stellate cells, and sinusoidal endothelial cells. We're investigating cell relationships and developmental history using genome editing-based lineage tracing with fluorescent markers. Collaborating, we're developing DNA event recording techniques in human pluripotent stem cell-derived organoids, using CRISPR-Cas9 to track cell history during differentiation.
The goal is to compare mouse and human development which may lead to better hepatic organoids for functional applications.

## IP & KNOWLEDGE TRANSLATION

- Maps of regulatory networks in liver differentiation
- Defined mechanisms of liver differentiation and morphology in organoids
- Insights into the relationships of development and cancer
- Identification of potential targets for cancer interventions
- Improved understanding of cell-cell relationships in the liver

# PETER ZANDSTRA

PROFESSOR
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**Our mission is to generate functional tissue from stem cells to uncover the rules of organ formation. We focus on developing the human blood-forming and immune systems to create new, cost-effective immunotherapies.**

blood and lymphoid cell development | computational modelling | stem cell engineering | pluripotent stem cells | systems biology | synthetic biology | Immunoengineering

## From Stem Cells to Functional Tissues

Pluripotency, the extraordinary ability of certain stem cells to develop into any cell type in the body, offers insights into human development and disease. Human pluripotent stem cells (hPSCs) are an exciting resource for addressing for manufacturing hurdles in cell and gene therapies. Through synthetic biology, they can be engineered and selected, making them an attractive, renewable source for therapeutics and drug discovery.

At the Zandstra Lab, we integrate biological engineering, computational modeling, and stem cell biology to study cell fate control mechanisms. Our focus is on developing accessible therapeutic strategies, leveraging blood-forming and immune system cells to treat cancer and autoimmune disorders. A fundamental goal of our research is to unravel how molecular changes within cells and their environments impact development over time and space.

The Zandstra Lab: https://www.stemcellbioengineering.ca/

## RESEARCH EXCELLENCE

We pioneer innovative technologies for Immuno-Engineering, including synthetic biology, bioprocess engineering, and computational strategies. We develop scalable systems for generating immune cells from stem cells, enhancing developmental biology and regenerative medicine. We lead in developing new cellular therapies and biomanufacturing.

## Our Training Program

In our lab, we're at the cutting edge of Stem Cell Engineering, merging engineering principles with stem cell research for therapeutic and foundational purposes. We seek interdisciplinary team members ready to tackle fundamental and translational challenges using computational and wet lab techniques. Our diverse team spans immunology, stem cell biology, biophysics, engineering, computational biology, machine learning, and synthetic biology, fostering collaboration. Beyond research, we value diverse perspectives and experiences, aiming for breakthroughs in medicine.

## Mathematical and Computational Modelling of Human Tissue Morphogenesis

Understanding blood development requires connecting stem cell regulatory networks to blood-forming multi-cellular niches and functional blood cells. We lead the stem cell field in developing mathematical models of internal regulatory networks that control stem cell behavior, and connecting these decision-making networks to natural or engineered cell environments.

## Synthetic Control of Cell Fate and Function

Current directed stem cell differentiation protocols use cytokine and small molecule supplementation to mimic in vivo environments and developmental events. We are working on engineering synthetic circuit-enabled stem cell lines to detect, select, and control functional tissue development. This strategy focuses on the problem of pluripotent stem cell differentiation into definitive blood progenitor cells and subsequent lymphoid cell development.

## Cell Niche Engineering

We have pioneered the use of synthetic stem cell niche engineering strategies to impose strict control of extracellular signaling, spatial organization and cell interactions on stem cell fate and development. Established capabilities include micro-patterning to study gastrulation-like events and developmental organoid cell niche engineering to promote environments capable of de novo blood development.

## Cellular Therapeutics

Our translational focus is in understanding how to grow blood stem cells from somatic and pluripotent sources, and in how to engineer, in a cost effective and efficient manner, the production of desired compositions of blood cells, such as T-cells and natural killer cells, as therapeutics for malignant and non-malignant blood diseases

## IP & KNOWLEDGE TRANSLATION

- Robust in vitro production platforms for blood lineages
- 2D and 3D in vitro differentiation systems for early embryogenesis
- Computational tools to simulate gene regulatory networks and to predict cell fate and function upon perturbation
- Scalable biomanufacturing of pluripotent stem cells, blood stem cells and immune cells

# SABRINA LESLIE

## ASSOCIATE PROFESSOR

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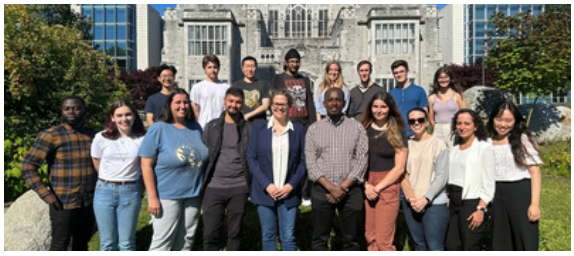


**I aim to use 'bottom-up' microscopy to study the biophysics of biomolecule interactions, combining our single-molecule and single-cell readouts with tissue, organoid, and clinical trial data to advance medicines and bioproducts.**

single-molecule imaging in cell-like conditions | CLiC imaging platform | single-cell imaging | micro/nano fabrication and fluidics | DNA, RNA, protein biophysics

## Seeing is Believing

Everything you experience, from the effectiveness of your vaccine to the sensation of your sunscreen, comes from the interactions of single molecules. Directly observing molecular behaviors and interactions is key to understanding, developing, and therefore optimizing the properties of next-generation medicines and materials.

We use advanced imaging to visualize biomolecules and study their properties and interactions in solution conditions and within human cells and tissues. Our visualization and analysis of biomolecules and drug delivery systems support the design of next-generation medicines for the prevention and treatment of a range of diseases. We characterize lipid-nanoparticle delivery vehicles in live cells, revealing key insights into uptake, endosomal escape, and interactions with DNA, RNA, proteins, and lipid macromolecules as well as other components of the intricate cellular environment.

The Leslie Lab: https://leslielab.msl.ubc.ca/research/

## RESEARCH EXCELLENCE

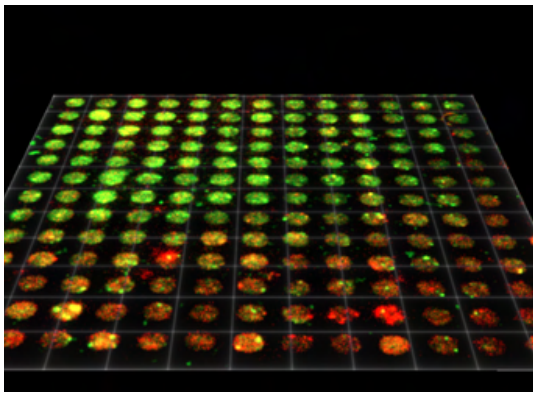
Our interdisciplinary team developed the CLiC imaging platform to study single-molecule and single-cell behaviour, with applications in nanomedicines and bioproducts. We've explored supercoiled DNA, RNA, protein behaviour, and lipid nanoparticle properties. We're pioneering label-free CLiC imaging to study nanoparticle interactions and track them in live cells, aiming to enhance the efficiency and potency of next-generation medicines and bioproducts.

## Our Training Program

The Leslie lab seeks talented, motivated scientists with strong quantitative skills, a team-player attitude, and a growth mindset. We tackle complex problems, such as the biophysics of nucleic acid hybridization, developing single-molecule imaging tools for RNA therapies, and quantifying single-particle behavior in live cells. Our work aims to make impactful contributions to biology, medicine, and new bioproducts.

## Single-Molecule Imaging

One example of our research is the detailed examination of lipid nanoparticles (LNPs), crucial for mRNA-based COVID-19 vaccines. Using our advanced CLiC single-molecule imaging platform, we analyze the distribution of LNP size, mRNA payload, and stability. This single-particle approach, unlike ensemble measurements, enhances the characterization and optimization of pharmaceutical formulations at the level of the individual analyte. This fills a gap in the scientific community, offering new tools to advance nanomedicines at the single-molecule level. Additionally, we are working to understand how the lipid nanoparticle and mRNA components of vaccines interact with each other and with human cells. Our inspiration is to assist vaccine and drug developers design improved formulations that are safe, more effective, and easier to store and distribute equitably to address global health needs.



**Single-particle size, loading, and dynamics are directly imaged and quantified in microwells using the CLiC imaging platform. These measurements guide the design of genetic medicines and vaccines comprising LNPs and mRNA.**

## Unravelling Molecular Interaction in Live Cells

We collaborate with academic and biotechnology partners, leveraging our imaging techniques to overcome clinical development hurdles for LNPs, RNA vaccines, and genetic medicines. For instance, we are collaborating with developers to investigate and optimize antisense oligonucleotides to target and silence disease-causing genes. In our group, we pursue diverseprojects like nucleic acid biophysics, protein interactions, and single- molecule behavior in live cells, offering significant contributions to biology and medicine as well as bioproducts over the long term.

## IP & KNOWLEDGE TRANSLATION

- Convex Lens-induced Confinement (CLiC) imaging platform
- Single-molecule imaging
- Live cell imaging
- Label-free imaging

# SARAH HEDTRICH

## ASSOCIATE PROFESSOR

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**We strive to understand & tackle inflammatory and genetic diseases of human epithelia with a current focus on the skin, lungs, and intestine.**

Bioengineering | organ-on-chip | human-based models | epithelia | skin | lungs | drug delivery | genome editing | gene therapy

## Overview

The overall vision of our lab's research program is to develop and employ complex bioengineered human (disease) models to significantly advance our understanding of the manifestation, progression, and treatment of inflammatory and genetic diseases of human epithelia.

We firmly believe that human-based models are critical to closing the current translational gap in biomedical research. Hence, my lab's research relies on complex human-based organ- and organ-on-chip (OoC) models. We harness these models (1) to unravel pathological mechanisms and (2) to develop and test next-generation therapies with a focus on genetic engineering. Our interdisciplinary research requires close intersectional collaborations with clinicians, engineers, and other life sciences disciplines as well as globally-leading industry partners.

The Hedtrich Lab: https://hedtrichlab.sbme.ubc.ca/

## RESEARCH EXCELLENCE

We develop and utilize complex human-based models to bridge the current gap in translational research from bench-to-bedside and to facilitate the development of safe and effective treatment options for people suffering from debilitating diseases affecting human epithelia such as the skin and the lungs.

## Our Training Program

The training value of my research program derives from its novelty and impact of the proposed research. My lab members are engaged in and drive the development of human-based organ models, which trains them in an interdisciplinary setting using cutting-edge technologies. Our goal for them is to become ambassadors and experts in their use, which will distinguish them from their peers and provide them an advantage in the academic and industrial marketplace.

## Complex bioengineered human (disease) models

Animal models, particularly rodents, are still the gold standard in basic and preclinical research. However, biomedical research is currently undergoing a paradigm shift towards human-derived disease model approaches. This shift has been driven by the notoriously high failure rates of the current drug development process. Although investments increased at unprecedented rates over the past decade, the drug attrition rate hit an all-time high of 95% in 2021. Most drugs fail in clinical stages despite proven efficacy and safety in animal models. Different reasons account for this translational gap, one of them being that the decision on a drug candidate's entry into clinical trials relies almost exclusively on animal-derived data. Poorly characterized animal models, a lack of experimental rigor and quality control, but also distinct interspecies-related differences between animals and humans, contribute to the high failure rate in clinical trials. Therefore, my research's overarching theme and vision is to bioengineer human-derived (disease) models of high clinical biomimicry to bridge the current translational gaps and to verify their predictive value for the human in vivo situation

## Human (Disease) Models for Developing and Testing of Next-Generation Therapies

Gene therapies are powerful tools to prevent, treat, and cure a plethora of human diseases. The fast-paced advances of CRISPR-Cas9 significantly accelerated the genome editing field. However, the main obstacle hampering the clinical translation of gene therapies is the lack of safe and efficient delivery strategies. However, assessing the delivery and therapeutic efficacy in animal models often poorly predicts the human situation due to distinct inter-species related anatomical and (patho)physiological differences.
We aim to close this gap by using human (disease) models that much better recapitulate human biological barriers and, hence, more reliably predict the performance of the delivery systems in vivo. With this, we aim to develop and test novel therapies that can restore the biological resilience in patients affected by genetic diseases and facilitate the clinical translation of our findings.

## IP & KNOWLEDGE TRANSLATION

- Complex, human-based tissue models for preclinical research
- Novel therapeutic strategies for genetic and inflammatory diseases
- Tissue-specific drug & gene delivery vehicles
- Platform approach for in situ gene editing of human epithelia
- Tissue-specific RNA designs

# TIMOTHY KIEFFER

PROFESSOR
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**We developed a multiwell-based 3D stem cell culture method to enable future studies seeking to disease model, conduct small scale screening, and to optimize differentiation protocols.**

diabetes | obesity | stem cell differentiation | cell therapy | islet biology | gene therapy | cell engineering | GI hormones | physiology

## Developing Gene and Cell Therapies for Diabetes

Over 500 million people suffer from diabetes, relying on daily insulin injections or gut-derived hormone injections (GIP and GLP-1) to control blood sugar and manage complications. Our goal is to eliminate the need for chronic drug use and improve patient outcomes through gene and cell therapy. We collaborate with biotech companies to utilize viral and non-viral vectors for innovative hormone delivery strategies.

Cell transplant is proving effective for type 1 diabetes, with success shown in transplanting insulin-producing cells. Human pluripotent stem cells offer a limitless supply, and we've developed protocols to convert them into regulated insulin-producing cells. Genetic engineering enables these cells to evade the host's immune system. UBC, in collaboration with industry, initiated the first clinical testing, highlighting the curative potential of gene and cell therapies for diabetes.

The Kieffer Lab: https://kiefferlab.com

## RESEARCH EXCELLENCE

Our research aims to develop new diabetes therapies by repurposing healthy cells to produce insulin or GLP-1 and differentiating human pluripotent stem cells into insulin-producing cells for disease modeling, drug screening, and cell therapy. We collaborate with industry for clinical testing of stem cell-derived products and develop novel tools, such as biomarkers to monitor cell death and viral vectors for cell-specific gene targeting.

## Our Training Program

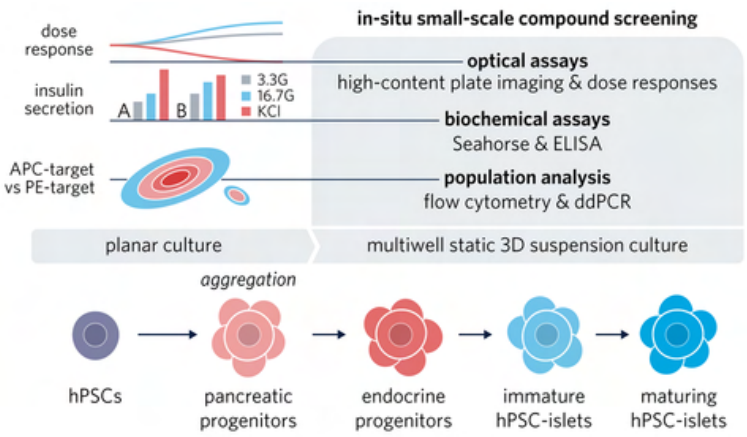
The Kieffer lab seeks motivated researchers to explore mechanisms underlying diabetes and obesity development, informing innovative therapies. Techniques include molecular biology, CRISPR-based cell engineering, stem cell differentiation, viral vector use, microscopy, and in vitro/in vivo evaluations. Trainees gain from local and international collaborations, including industry partnerships.

## Multiwell-Based 3D Culture Platform

Differentiated human pluripotent stem cells represent an exciting opportunity to probe disease mechanisms, variability in function and responses to drugs between individuals, and to test new therapeutic strategies. Building upon our prior efforts to generate functional insulin-producing pancreatic islets from stem cells using scalable methods (Nature Biotechnology 2014), we developed a static 3D culture method for differentiating human stem cells into uniformly sized islet-like aggregates with high reproducibility and consistency in multiwell plates (Cell Reports Methods, 2023). This suspension culture method reduces cell loss and improves differentiation efficiencies. By using reporter stem cell lines with fluorescent protein labels, we can track cell fate in real-time. Additionally, multiwell plates in static 3D cultures allow for protocol optimization, in situ assays, and organoid-based drug screening.

## Translation: Bench to Clinic

We seek to translate our research into new therapies for diabetes and obesity. Kieffer's graduate work at UBC contributed to new classes of drugs to control blood sugar and body weight – DP4 inhibitors and analogs of the incretin hormones GIP and GLP-1. The lab's work on converting stem cells into insulin producing cells supported the path to clinical trials in patients with type 1 diabetes, including with the biotechnology company ViaCyte, where Kieffer served as CSO. Kieffer also served as CSO at Fractyl Health, which is developing a gene therapy for diabetes and obesity using GLP-1 receptor agonists, first reported by his lab in 2010.




## IP & KNOWLEDGE TRANSLATION

- Engineering stem cells with designer features
- Stem cell differentiation to functional islet cells
- Micro- and Macro-encapsulation to contain cells
- In vivo assessment of cell therapy performance
- Gene therapy using viral and non-viral vectors

# YANPU HE

ASSISTANT PROFESSOR
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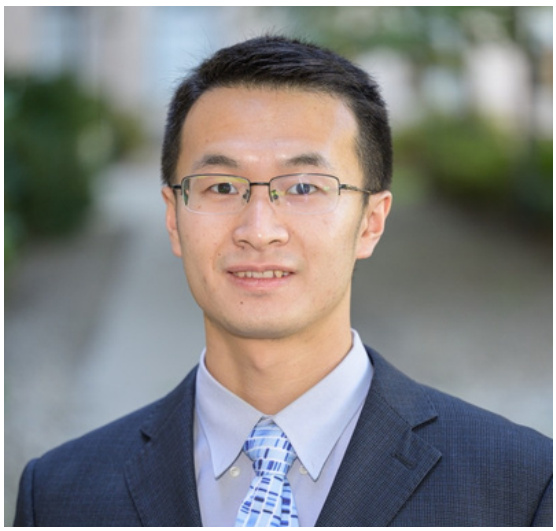
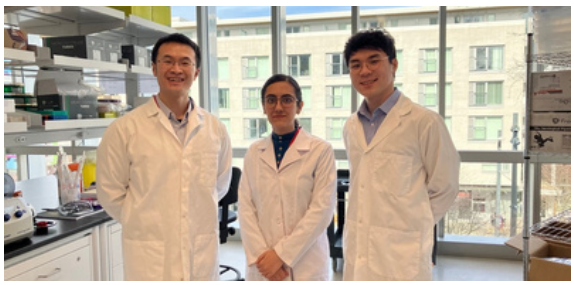




**We leverage protein and cellular engineering to design bio-inspired immunotherapies for cancer, infectious disease, and neurodegenerative disorders.**

immunology | protein engineering | genome editing | animal disease model | biomaterials | molecular biology

## Cell Therapies Targeting Cancer Heterogeneity

Treating cancer is like trying to eradicate an ever-evolving species. While many current strategies are designed to target specific cancer traits, they inevitably exert a selective pressure that when combined with the cancer's inherent genetic instability, fosters the development of acquired resistance. To this end, efforts to develop combination therapies have sought to counter cancer's adaptability by targeting multiple pathways simultaneously to delay or prevent resistance. However, acquired resistance can still eventually emerge even with these strategies. Addressing the problem at its root remains a significant challenge.

We are developing a platform to characterize the heterogeneous surface features of cancer cells from debulking surgery and generate a collection of protein binders to engineer immune cells, equipping them to target the full spectrum of heterogeneous cancer cells and eliminate cancer's adaptability.

The He Lab: https://helabimmunoeng.sbme.ubc.ca/

## RESEARCH EXCELLENCE

Our research bridges immunology, drug delivery, and biomaterial engineering. We have uncovered non-canonical immune signaling pathways (Science Advances, 2020), developed protein-based therapeutics for solid tumours (Advanced Healthcare Materials, 2023), and engineered microneedle-based transdermal vaccination platforms (ACS Nano, 2018).

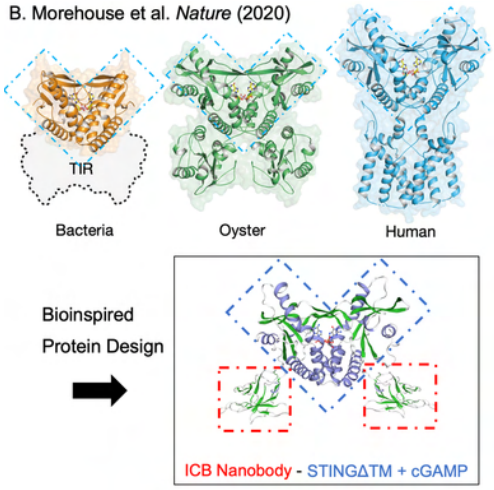
## Our Training Program

Our lab fosters a diverse, collaborative, and interdisciplinary environment. We equip our members with expertise at the intersection of immunology and bioengineering, emphasizing both fundamental discovery and translational impact. We contribute to advancing next-generation immunotherapies, collaborating with synthetic biologists, microbiologists, neuroscientists, and oncologists to ensure alignment with clinical needs.

## Vaccines Overcoming Host Immunodeficiencies

Approximately 3% of the population in North America and Europe are immunocompromised due to congenital conditions, illnesses, or medications that suppress immune function. These individuals face increased susceptibility to vaccine-preventable infections. Under-immunization poses a significant risk of serious illness and death, yet the inappropriate use of live attenuated vaccines can result in severe adverse events due to uncontrolled replication of the vaccine virus or bacterium.

To address host immune deficiencies, which are often caused by a single missing or mis-functioning signaling protein, we leverage protein and cellular engineering to develop bio-inspired vaccine components that restore the damaged signaling pathway, offering a transformative opportunity to make immunotherapies more broadly available to human patients.




**Bio-inspired design of a STING protein-based in situ cancer vaccine: based on a structural core of a V-shape homodimer binding a cyclic dinucleotide which has been evolutionarily conserved within metazoans for over 600 million years.**

## Inducing Antigen-Specific Tolerance to Treat Autoimmunity

Autoimmune diseases such as multiple sclerosis remain challenging to treat, as current therapies, such as B cell depletion, alleviate symptoms but often leave patients immunocompromised and vulnerable to infections. Therapies that can selectively target autoreactive lymphocytes while preserving other protective immune cells remain an unmet need. Among potential therapeutic targets, the gut stands out as an unique immune organ evolved to tolerate an immense diversity of microbiota and dietary antigens. We are developing a strategy that combines gut microbiota modulation with tolerogenic immune cell implantation to induce antigen-specific immune tolerance.

## IP & KNOWLEDGE TRANSLATION

- Identification of alternative or non-canonical immune signaling pathways
- Recombinant protein-based signaling complexes that restores host immune deficiency
- Immune cell-based therapy targeting cancer heterogeneity or inducing immune tolerance
- Bacteriophage-based genome-editing platforms

# ALI BASHASHATI

## ASSOCIATE PROFESSOR

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**We build AI models to derive biological and clinical insights from biomedical data. These findings are utilized for drug development, diagnostics, and precision medicine in cancer.**

artificial intelligence | multi-modal machine learning | computational pathology | computational cancer biology | genomics | stem cell differentiation | molecular biology

## Artificial Intelligence in Medicine (AIM)

In modern biomedicine, understanding how molecular processes shape cellular, tissue, and organ functions is crucial. To do so, research is generating vast data across different scales, aiding insights into disease mechanisms and speeding up developments in diagnostics, biomarkers, and drug discovery. As research produces extensive datasets, the importance of data analysis for extracting insights grows ever more pronounced.

In recent years, significant progress has been made in utilizing AI and machine learning across various fields like text and image analysis. Medical and biological research stand to gain substantially from this surge in AI. Our team focuses on developing AI methodologies to integrate large-scale data, including tissue slide images and omics data, for a deeper understanding of cancer. Our projects cover a wide spectrum of cancer research, from basic science to translational studies.

AI in Medicine (AIM) Lab: https://aimlab.ca/

## RESEARCH EXCELLENCE

In collaboration with biologists and clinicians, our group develops AI models to analyze histopathology images and omics data. These projects enhance cancer biology insights, improve diagnosis, and identify therapy response biomarkers. For instance, our AI models applied to giga-pixel pathology images identified a new subtype of endometrial cancer with poorer survival rates, suggesting referral to tertiary cancer centres.

## Our Training Program

We're seeking lab members keen on advancing skills in mammalian synthetic biology, spanning genome and animal engineering to computer science. Together, we tackle biology's pressing challenges, nurturing unique expertise within our team. Our lab fosters collaboration, maximizing each member's impact on scientific progress while supporting their personal development.



## AI-Driven Precision Medicine

We're using deep learning to analyze histopathology images and omics data from thousands of patients to improve cancer diagnosis and management. In endometrial cancer, our model identified a previously unrecognized high-risk subgroup who are otherwise considered low-risk by current clinical guidelines, and which are crucial for tertiary cancer centre referral (Nature Communications 2024). We're validating and deploying this model internationally, especially in underserved areas. Additionally, we're developing AI for therapeutic target discovery (through AI-based systems biology) and drug development (through AI-based compound screening) in this subtype and 10 other cancers, aiming to improve patient outcomes. Our goal is to enhance cancer treatment through comprehensive AI approaches.

## AI Model Development for Biomedical Data

We're developing a time machine-like technology to observe cells' past behaviours. Cells in a population are tagged with unique "DNA barcodes" and propagated. Subpopulations are then subjected to assays, and barcodes associated with desired phenotypes are identified. These clones or relatives are then isolated from the initial population. Using this, we've isolated clones from human pluripotent stem cells, demonstrating their potential in cell differentiation. We're currently leveraging this technology, in collaboration with others, to obtain fate-mapped clones for various cell types.


## IP & KNOWLEDGE TRANSLATION

- Clinical deployment of AI-based diagnostic systems
- Clinical deployment of AI-driven precision oncology strategies
- Deployment of AI strategies in clinical trials
- Open-source machine learning models for broader oncology community

# CHRISTOPHER NGUAN

## ASSOCIATE PROFESSOR

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**We investigate new clinical translational areas in regenerative medicine impacting end stage organ disease patients in the context of applied science, planetary health, clinical AI in improving outcomes.**

kidney | transplant | regeneration | reperfusion | preservation | planetary health | clinical AI | ML surgery

## Clinical Transplantation and Regenerative Sciences

One in eight Canadians suffer from some degree of chronic kidney disease, with incident numbers increasing up to 10% year over year. This represents combined direct and indirect costs to the healthcare system of approximately 30 billion dollars annually. Application of machine learning facilitated optimization of care at each point of the chain of custody of a donor organ through implantation and maintenance has proven beneficial in this uniquely complicated analyses combining two body integration of the donor and recipient biology, ex vivo injury incurred through logistics and organ storage, and application of vasoactive and immune regulating medications in the acute and long term management of the allograft.

Our research centres on examining preservation strategies to preserve cell, tissue and organ integrity from donation to implantation through to long term survival leveraging advances in machine learning and AI along the clinical pipeline within a planetary health context.

The Nguan Lab: https://www.bctransplant.ca

## RESEARCH EXCELLENCE

We study the biological basis of cell, tissue and organ injury in the context of regenerative, restorative medicine and transplantation, leveraging machine learning methods to optimize clinical management pipelines at each stage of organ transplantation. We put forward these concepts in the context of integrated patient centred and planetary health care.

## Our Training Program

We intake and supervise a diverse group of highly qualified trainees from undergraduates in all areas of study, to undergraduate and postgraduate clinical trainees and clinical - academic specialist fellows. We collaborate throughout the UBC campus and beyond with faculties as diverse as Applied, Computer Science, Population Health, Environmental Sciences and more. We are always interested in fostering students' studies who are interested in the intersection of diverse domains of study and Clinical Transplantation.

## Machine Learning in Goal Directed Anesthesia for Transplantation

An increasing proportion of kidney transplants are sourced from deceased donors in an effort to mitigate organ shortage. However, deceased donor transplants have a higher risk of delayed graft function (DGF), which increases morbidity and mortality in kidney transplant recipients. We hypothesized that the complex interactions between various donor and recipient factors with anesthetic variables in the perioperative period, including hemodynamic management, fluid strategies, and vasopressor use, can impact perfusion to the newly transplanted kidney and subsequently result in DGF. The full potential of deep learning strategies to evaluate and explain these interactions remains underexploited.

We are building deep learning models on multimodal data from anesthesia time-courses including hemodynamics, medications, and fluids combined with preoperative donor and recipient features. We show that time-series focused models apply special salience to the post-anastomosis period in predicting DGF. We demonstrate the models' capability to generate both global and personalized hemodynamic, fluid, and vasopressor targets, and suggest that DGF incidence may be reduced by 28.5% in donation after cardiac death recipients and 18.2% in neurologically determined death recipients via these targets. Our work demonstrate new methods to analyze the complex perioperative transplant concourse, identifying at-risk patients and providing suggestions on levers of intraoperative anesthetic management to prevent DGF.

## Environmental Impacts of Kidney Replacement Therapies

Management of the growing global population living with kidney failure presents a significant challenge for health care systems. KRTs are resource-intensive, and estimation of their environmental impacts is still in its infancy. We are the leaders in examining in head to head to head fashion the comparative environmental impacts via Life Cycle Analysis between Kidney Transplantation, Hemodialysis, and Peritoneal Dialysis. Through our work, we are furthering the understanding of KRTs as prototypic examples of Medicine's outsized environmental impacts and offering opportunities to reexamine and refine new strategies along the kidney care continuum, from manufacturing and procurement, to operations to infrastructure deployment and policymaking to more deeply embed planetary health as a priority within the discussion of optimal clinical care of populations.



## IP & KNOWLEDGE TRANSLATION

- Machine learning in realtime optimization of clinical transplantation procedures
- Ex vivo strategies in organ rehabilitation and modification
- Novel preservation strategies to maintain cell, tissue and organ viability
- Integration of planetary health in the context of clinical transplantation

IMAGING & COMPUTATIONAL BIOLOGY

# DAVID LIU

## ASSOCIATE PROFESSOR

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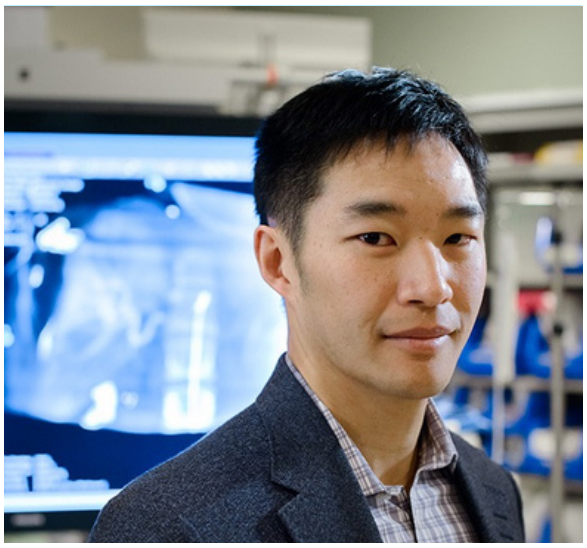
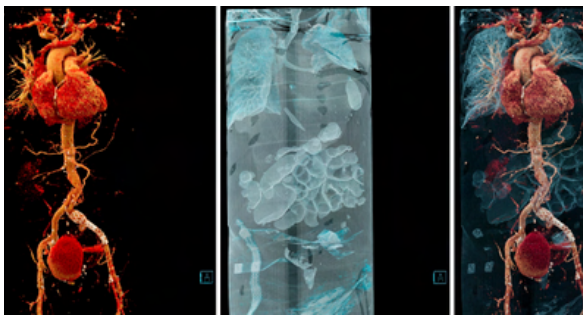
IMAGING & COMPUTATIONAL BIOLOGY

CORE MEMBER





**We will use what we know to innovate, extend and collaborate widely in order to have the largest impact on human health and wellbeing.**

oncology | osteoarthritis | clinical research | interventional radiology | medical devices | radiology | image analysis | artificial intelligence | computer science

## Sophisticated Tools with Immediate Focus on Treatment and Diagnosis

The Minimally Invasive Image-guided Procedures (MIIPs) lab is focused on complementing and supporting my clinical work as an Interventional Radiologist at Vancouver General Hospital. Delivering therapeutics directly to sites of pathology through selective cannulation, catheterization or specialized access is my expertise. The MIIPs lab born out of a desire to engage more specifically with academia as a complement to my existing network of physicians, physician trainees and commercial collaborations. Using this knowledge, we aim to improve outcomes in knee osteoarthritis with a diverse group of physicians, scientists, and knowledge translation specialists making up the Genicular Osteoarthritis Therapy (GOAT) Group. Developing machine learning approaches for image processing to identify features, segmentation, radiomics, improve signal processing, and provide real time decision analysis are also active areas of our research program.

The Creative Destruction Lab: https://creativedestructionlab.com/mentors/david-liu/

## RESEARCH EXCELLENCE

Patient outcomes has always been the measure I value as a reflection of my work. On the materials side, I have developed lower cost nanoparticles for drug delivery, characterized doses and elution properties of microspheres, and optimized embolic and isotope combinations. For the MIIPs lab, in spite of all of the technologies and modern equipment is rooted in the concept that income should never equate outcome.

## Our Training Program

We are building a group founded in cooperation and sincere respect, where diverse perspectives and experiences are brought together to help everyone be the best they can be, while sharing in the mission of advancing IR and imaging to better health outcomes broadly. We aspire for you to leave with excellent research skills, independence, and a sense of satisfaction through contributions made to a positive and strong culture.

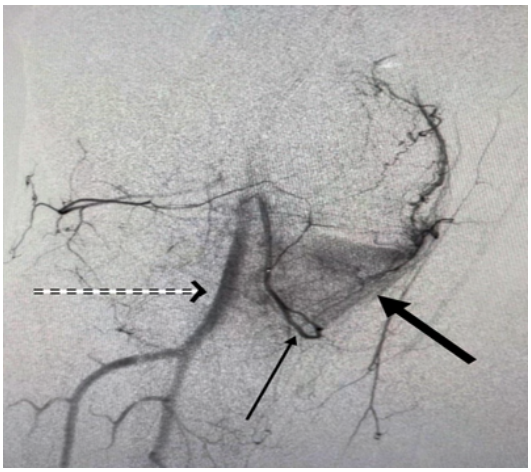


## GAE in Knee Osteoarthritis

Osteoarthritis (OA) of the knee is particularly common as people age, with a lifetime risk of ~45% for sympomatic OA. A nascent IR technique called Geniculate Artery Embolization (GAE) shows great promise along many vectors. We are beginning a prospective study to determine the efficacy of this procedure, complemented with two studies conducted in the MIIPs computer lab. The mechanism of action for GAE is hypothesized to be through decreasing inflammation of the synovium. Synovitis (inflammation of the synovium) is correspondingly considered a leading hypothesis as the driver of pain and degradation of the articular cartilage. Hence, we are undertaking a retrospective study to determine prevalence of synovial inflammation in collections of existing X-ray and MRI image sets. Another project is to develop diagnostic tests optimised to quantify and diagnose synovitis. This will focus on point-of-care ultrasound, since it has major advantages in accessibility and time-to-diagnosis, and optimisation will leverage AI to facilitate segmentation of images to identify synovium and quantify inflammation thereof. Pending the results of these three studies, we expect future studies investigating the molecular cell biology aspects of OA pathogenesis.

## Engineering Tissue Regeneration in the Liver

While damage to healthy tissues adjacent to tumours treated by IR procedures is minimized, healing from the damage caused by a tumour can be extensive. We are developing applications for novel polymer glues, embolics and therapies that facilitating tissue regeneration in the liver.



## IP & KNOWLEDGE TRANSLATION

- New embolic tools and conjugates
- Automated feature detection in medical imaging
- Wearable medical devices for home monitoring
- Disseminating knowledge/techniques within medicine and the community
- Developing tools with commercial partners for a medical market

# DAVID WILSON

PROFESSOR

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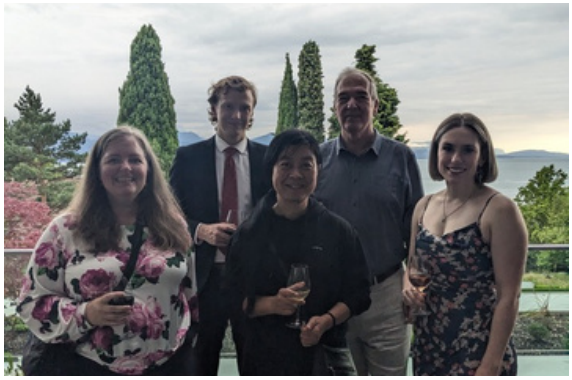


**We use imaging to understand joint mechanics and their connection to joint injuries and diseases.**

osteoarthritis | biomechanics | magnetic resonance imaging | orthopaedics | hip | knee | spine | joint restoration

## Measuring Mechanics With Imaging to Improve Joint Health

Our lab develops new methods for measuring joint mechanics and applies these methods to a) identify specific mechanical causes of osteoarthritis and other musculoskeletal conditions and b) quantify the effects of clinical treatments on mechanics.

Selected current projects:

- Evaluation of the link between the mechanical changes produced by high tibial osteotomy and cartilage health
- Development of new methods for measuring cartilage strain in the loaded hip joint using the Canada Light Source synchrotron
- Application of open MRI to visualize impingement between the femur and acetabulum in patients with femoroacetabular impingement (FAI)
- Exploration of links between bone architecture, joint mechanics, and cartilage degeneration

The Wilson Biomechanics Lab: wilsonbiomechanicslab.com

## RESEARCH EXCELLENCE

We are known for our development and application of mechanical measurements using Upright Open MRI, and our application of these methods to study joint injuries and diseases, as well as treatments. We link these measures to quantitative MRI measures of cartilage health.

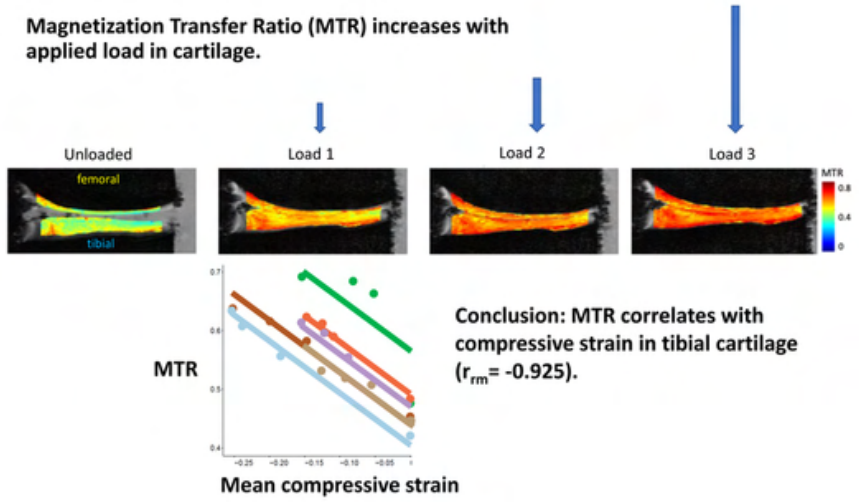
## Our Training Program

The Osteoarthritis Mechanics team is a diverse group of researchers with interests in orthopaedics, biomechanics, and medical imaging. The team includes engineers, graduate and undergraduate students, surgeons and surgical residents and fellows. We collaborate actively with radiologists, physical therapists, epidemiologists, rheumatologists and computer scientists.

## Open MRI for Assessing Joint Biomechanics

Many cases of hip osteoarthritis may be caused by bony deformities that change joint mechanics. It is not clear, though, what size a deformity has to be to cause problems at the hip. In this project we are looking for relationships between mechanical measurements at the hip and clinical symptoms and evidence of hip degeneration.

We are assessing which activities cause mechanical problems in the hip, and how these mechanical problems are affected by deformity size. The results will help doctors to determine which patients with these hip deformities will need early activity modification to prevent or delay the onset and progression of OA and which patients might be candidates for surgical intervention.




## Effect of Osteotomy on Knee Mechanics

This project aims to a) develop new methods for measuring how knees move and transmit load, b) develop new methods for measuring early degeneration in cartilage and, and c) assess how the changes in joint movement and load transmission produced by an operation performed for early osteoarthritis are linked to degeneration of cartilage.

## IP & KNOWLEDGE TRANSLATION

- New tools for studying joint biomechanics
- Insight into the mechanical causes of osteoarthritis
- Assessment of surgical interventions

# ILKER HACIHALILOGLU

ASSOCIATE PROFESSOR
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**We will develop AI systems to improve how point-of-care ultrasound data is collected, accessed, and analyzed, leading to new methods for diagnosing chronic diseases at their earliest stages.**

artificial intelligence | deep learning | ultrasound | point of care ultrasound | brain health | lung health | chronic diseases | neurosurgery | image guided surgery

## Decentralized, Accessible Healthcare

Noncommunicable diseases (NCDs) are usually of long duration and result from a combination of genetic, physiological, environmental, and behavioural factors. Accounting for 71% of all deaths worldwide, they claim nearly 41M people each year. Health inequities arising from geographic, racial/ethnic, and economic factors further restrict access to critical healthcare services. Decentralized, cost-effective, and accessible healthcare has great potential to identify NCDs before they progress to a deadly stage; reverse the progression of the disease; prevent complications; and reduce hospitalizations. Such a decentralized healthcare system could further help address social determinants of health and strengthen disparities. Our research focuses on personalized community-level screening for high-risk individuals to prevent diseases, improve early detection, monitor diseases, and promote patient-specific treatments. This approach aims to reduce complications from non-communicable diseases, significantly enhancing the health and quality of life for Canadians.

Ultrasound Technology and AI for Healthcare(UltrAi) Lab: https://ultrai.med.ubc.ca

## RESEARCH EXCELLENCE

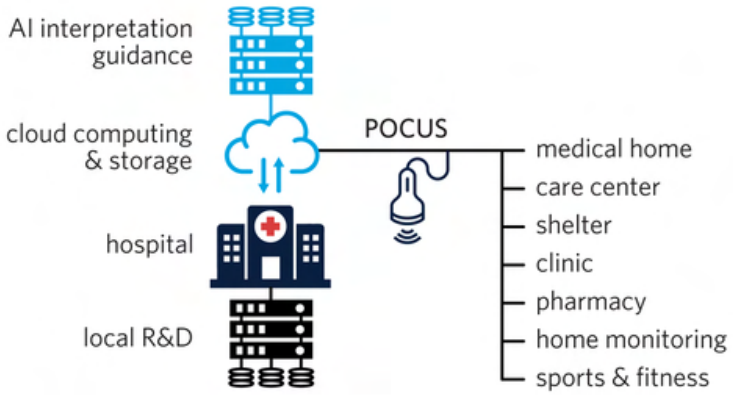
The ULTRAi research lab is focused on developing innovative AI systems for neurosurgery, liver disease, orthopedic surgery, musculoskeletal disorders, brain health, and interventional radiology. We work with clinicians to bridge engineering and clinical research, advancing technologies from bench-to-bedside. We are especially interested AI-enabled point-of-care ultrasound (POCUS) imaging for affordable, accessible healthcare in out-of-hospital settings.

## Our Training Program

Our research program trains skilled biomedical scientists and engineers in a cutting-edge environment, equipping them to develop new AI platforms for healthcare. Trainees develop AI methods for ultrasound and healthcare, gaining highly sought skills for the competitive healthcare software industry. They collaborate with clinicians, surgeons, engineers, and scientists across disciplines, essential for healthcare technology development.

## Point-of-care Ultrasound (POCUS) for Decentralized Healthcare

The research project aims to revolutionize pediatric healthcare by developing novel AI tools tailored for the enhanced management of brain and lung health in pediatric populations through the utilization of point-of-care ultrasound (POCUS). By harnessing the capabilities of artificial intelligence, the project seeks to address current challenges in diagnosis and monitoring, especially in the context of pediatrics, where traditional methods may be less adaptable. The integration of AI with POCUS is anticipated to provide real-time, accurate assessments, enabling more proactive and personalized care for pediatric patients. This innovative approach holds the potential to significantly improve diagnostic precision and treatment strategies for brain and lung health in the pediatric demographic, ultimately contributing to better outcomes and quality of life.




## Improved Management of Musculoskeletal Disease

The annual economic burden of musculoskeletal disease accounted for $213 billion and $ 22 billion in the United States and Canada respectively. We are developing computational methods for improved management of musculoskeletal diseases by incorporating information extracted from ultrasound data. Our specific focus for this project is on arthritis, spine disorders, and traumatic injuries.

IMAGING & COMPUTATIONAL BIOLOGY
CORE MEMBER

## IP & KNOWLEDGE TRANSLATION

- Computer vision systems and methods for real-time needle detection, enhancement and localization in ultrasound
- Computer vision systems and methods for real-time localization of needles in ultrasound images
- Computational ultrasound for improved liver and kidney cancer diagnosis

# KURT HAAS

PROFESSOR

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**Our in vivo imaging of single brain neuron structural and functional plasticity will reveal how neurons process and encode information, and how developing brain circuits self-organize to optimize function.**

imaging of brain neuronal growth | information processing | computational microscopy | machine learning | two-photon microscopes | genetic variant impact | protein function

## Understanding Development of Functional Brain Circuits

The Haas lab investigates how functional brain circuit formation occurs by taking a highly innovative approach combining imaging, computational and genetic technologies. We develop techniques to label individual growing neurons in the developing brain, design and construct ultra-fast 3D-scanning two-photon fluorescent microscopes, and build machine learning-based computational approaches for analyzing complex 4D data sets.

Experiments investigate how sensory experience influences brain circuit development; findings suggest that incoming information directs self-organization for optimized neural networks.The Haas lab is also interested in how circuit formation goes awry, leading to common neurodevelopmental disorders, including Autism Spectrum Disorders and Epilepsy. For this, they investigate how rare genetic variants disrupt protein function, interfering with normal growth and information processing.

The Haas Lab: https://bmiai.ubc.ca/people/kurt-haas

## RESEARCH EXCELLENCE

The Haas lab merges engineering, imaging, computation, molecular biology, and genetics for innovative scientific discovery. We pioneered in vivo single cell transfection, ultrafast 3D scanning two-photon microscopy, and computational approaches to brain neuronal growth analysis. Our research reveals how sensory experience shapes brain circuits and links genetic mutations to Autism Spectrum Disorder (Nature Communications 2020, AJHG 2021).

## Our Training Program

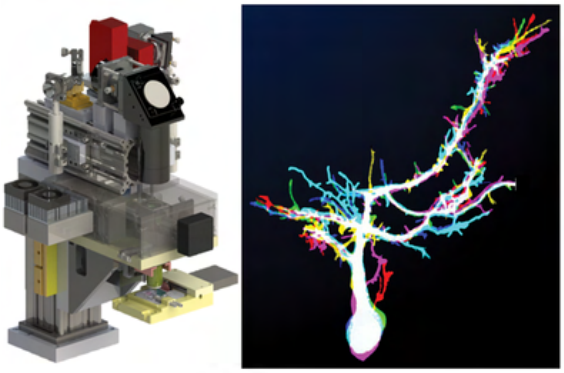
We seek lab members passionate about advancing in mammalian synthetic biology. Our team fosters diverse skills, spanning genome and animal engineering to computer science, tackling biology's pressing challenges collaboratively. Our lab is designed not only to support trainee development but also to foster collaboration among members, ensuring everyone can maximize their contributions to the scientific community.

## Microscopy of Neural Encoding

We are developing ultra-fast 3D scanning two-photon microscopes capable of tracking fluorescent biosensors of neural activity throughout individual neurons within the intact and awake brain of developing animals. This work involves 1) design and construction of microscope optics and components, 2) machine learning-based computational approaches for acquiring and analyzing complex 4D neural activity and morphological plasticity data sets, 3) signal processing and event detection for segmenting and analyzing neural activity, 4) development of methods for delivering DNA encoding fluorescent biosensors in single brain neurons, and 5) development of sensory stimulus paradigms for probing neural encoding and inducing experience-driven plasticity. These innovations form a platform to study how individual brain neurons process information and how sensory experiences influence neural structural plasticity and synaptic connectivity to enhance information encoding.

## Gene Mutation Impact on Protein Function

We develop human cell line-based assays to determine how disease-associated rare single-nucleotide missense mutations inducing single amino acid variants impact protein function. Such missense variants are common, yet little is known of how single amino acid variants contribute to produce pathophysiology, disease expression, and response to treatment. We favor a 'deep phenotypic profiling' approach by developing platforms of multiple assays probing many functions of individual proteins, and multiple mechanisms of molecular dysfunction. This work sheds light on the origins of neurodevelopmental disorders like Autism and lays the groundwork for personalized medicine.



IMAGING & COMPUTATIONAL BIOLOGY CORE MEMBER

## IP & KNOWLEDGE TRANSLATION

- Novel ultra-fast 3D scanning fluorescent microscopy
- Machine learning-based computational microscopy
- Neural activity signal processing and event detection
- Software development for analyzing large 4D structural and activity data sets
- Human cell line assays for probing impact of gene mutations on protein function

# NANCY FORD

## ASSOCIATE PROFESSOR

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**We engage in interdisciplinary and collaborative research using x-ray and CT imaging to understand models of disease with the aim of having a positive impact on human health.**

micro-computed tomography | physiological gating | pre-clinical imaging | x-ray imaging | dental radiology | image quality | contrast-enhanced imaging

## Image-based characterization of respiratory disease and/or lung injury

Micro-computed tomography (micro-CT) is a 3D x-ray imaging technique for producing high-resolution images of rodent anatomy. Dr. Ford has developed techniques for synchronizing the imaging acquisition protocol to the respiratory and cardiac rates of rodents. Synchronizing the imaging protocol allows us to produce images of a specific phase in the respiratory or cardiac cycle, and can produce a series of images throughout the cycle. These images can be analyzed to quantitatively study the anatomy and function of the rodents' heart or lungs.

Currently, we are interested in studying lung injuries caused by e-cigarettes and vaping. We are using an inhalation exposure model in mice to identify any changes to respiratory function and lung tissue following 6 months of exposure to nicotine-containing vaping fluids. We will measure lung structure and function in vivo, assess nasal passageways and bone, and perform histology of lung and oral tissues.

The Ford Lab: https://www.dentistry.ubc.ca/faculty-profiles/f-j/Nancy-Ford/

## RESEARCH EXCELLENCE

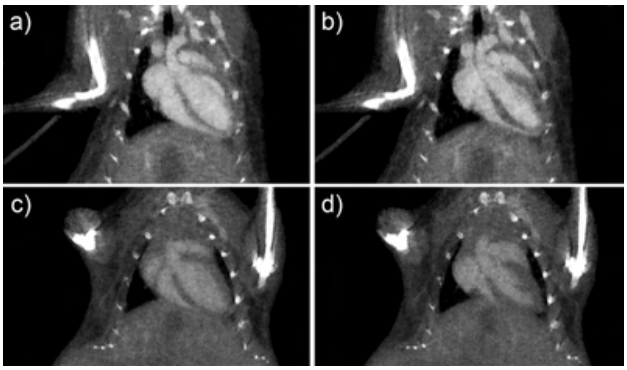
Dr. Ford is a leader in respiratory-gated and cardiac-gated micro-CT imaging and in contrast-enhanced micro-CT. She was the first researcher worldwide to perform respiratory-gated micro-CT imaging on free-breathing animals. She has performed respiratory-gated imaging of lung injury in rats at the Canadian Light Source synchrotron facility, and FLASH radiation therapy treatment to the lung in mice at the TRIUMF particle accelerator.

## Our Training Program

The Ford lab is interdisciplinary, with a broad research agenda that includes fundamental and applied research. The Ford lab accepts students at the MSc, PhD or Postdoctoral level. Dr. Ford also supervises graduate students in the Craniofacial Science program (Faculty of Dentistry), Experimental Medicine program (Faculty of Medicine), and the CAMPEP-accredited Medical Physics program (Faculty of Science). The Ford lab also accepts strong undergraduate students for 4th year thesis projects, directed studies projects or paid positions (Work-Learn, Co-op, summer students).

## Contrast-enhanced micro-computed tomography

X-ray imaging of soft tissue is often challenging due to the similarity in composition between blood, muscle, and organs. Introducing a contrast agent to selectively increase the x-ray absorption can assist in imaging soft tissues and the vasculature. We are testing novel contrast agents for micro-CT imaging to determine the contrast enhancement produced, the organs targeted, and the time course for clearance. We are working towards targeted contrast agents that will bind to receptors on cancer cells.




**Cardiac-gated images in (a) diastole and (b) systole of a mouse given gold nanoparticles (MVivo Au). Similar images from a mouse given an iodinated contrast agent (Fenestra VC) representing (c) diastole and (d) systole.**

**Samir El Ketara and Nancy Lee Ford 2020 Biomed. Phys. Eng. Express 6 035025 https://doi.org/10.1088/2057-1976/ab8741**

## Improvements to image quality

Improving image quality in x-ray and CT imaging will allow for improved diagnostic accuracy. One way the Ford lab is tackling this problem is through the use of machine learning to augment the projection data collected during a CT scan without increasing the radiation dose to the patient. The augmented projection data can be accurately reconstructed, and provide images with reduced noise and artifacts.

In dental imaging, the image quality can be very poor around metallic restorations. We are characterizing the impact of metal restorations on the images to provide clinical guidelines for getting the best images in difficult to image areas. We are also looking at ways to provide better images for the clinicians by retrofitting specialized filters to dental conebeam CT devices to improve penetration of the x-ray beam through metallic structures.

## IP & KNOWLEDGE TRANSLATION

- Developing non-invasive, image-based measurements of respiratory function to monitor rodent models of respiratory disease and/or lung injury
- Developing novel contrast agents to improve detection of cardiovascular disease and cancer
- Developing improved imaging protocols for dental imaging in the presence of metal restorations

# RACHEL EDDY

## ASSISTANT PROFESSOR

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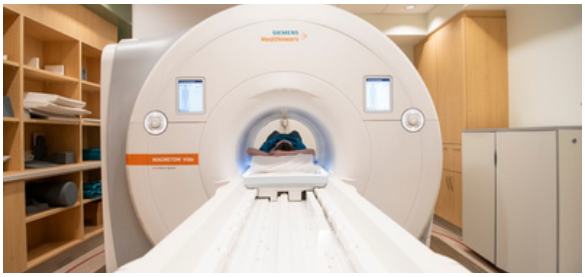


**We develop pulmonary imaging tools to deeply characterize lung health and disease across the lifespan.**

medical imaging | MRI | hyperpolarized 129Xe | CT | lung health | lung structure-function | respiratory disease | data science | image analysis

## Pulmonary Imaging for Lung Health Across the Lifespan

The lungs are highly heterogeneous in health and disease, both regionally within an individual person's lungs and between different people. Pulmonary imaging methods, including computed tomography (CT) and hyperpolarized gas magnetic resonance imaging (MRI), provide new ways to non-invasively see and measure heterogeneous lung structure and function in vivo. MRI using hyperpolarized 129Xe gas in particular enables imaging of regional lung function unlike any other modality.

We pair the development of novel pulmonary imaging methods and measurements, with translational studies to deeply characterize lung health and disease in children and adults, providing imaging biomarkers for early disease detection, phenotyping, image-guided interventions, and therapeutic assessment.

## RESEARCH EXCELLENCE

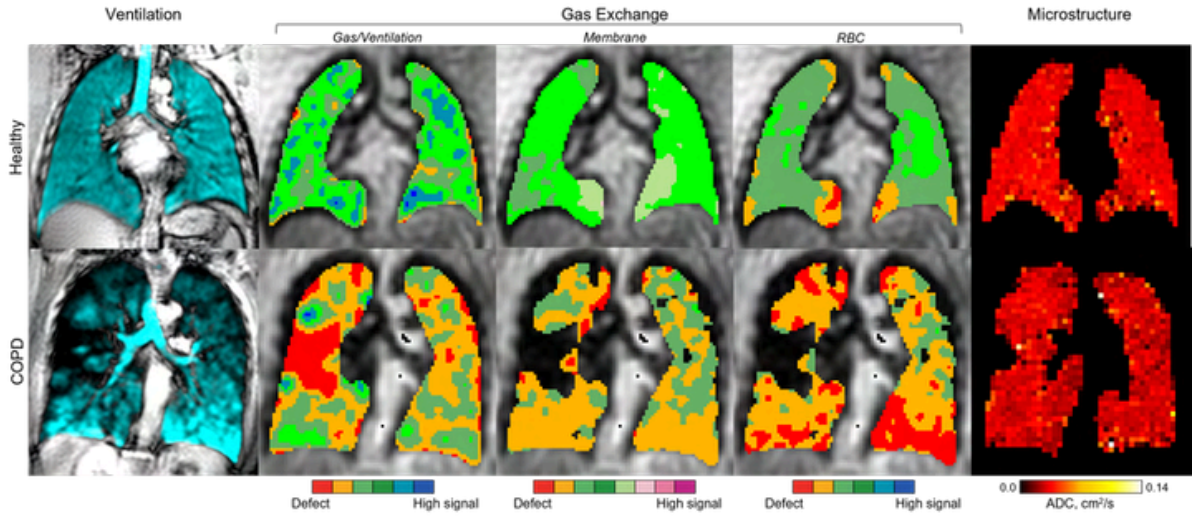
In an era where our lungs are constantly subject to different exposures, we develop and implement novel pulmonary imaging methods to better understand lung health and disease in children and adults. We integrate multi-modal imaging to characterize how lung function follows form. We are one of the only places in the world with dedicated pediatric and adult 129Xe MRI facilities to conduct translational pulmonary imaging studies across the lifespan.

## Our Training Program

We welcome trainees with diverse engineering and physics backgrounds interested in developing pulmonary imaging tools. We collaborate closely with clinicians to enable clinical translation of developed methods, to answer clinically relevant questions. We focus on explicit skill development, especially critical thinking and problem solving, in combination with collaborative research to maximize personal and scientific impact.

## Novel Imaging Methods

As engineers and imaging scientists, we are driven by quantitative imaging methods. Our long-term vision is to push the boundaries of pulmonary imaging to accelerate image acquisition, reconstruction, and analysis. This includes rapid MRI sequences, automated image analysis methods, and multi-modal analysis pipelines.




**Hyperpolarized 129Xe MRI enables visualization and measurement of pulmonary gas distribution (or ventilation), gas exchange as 129Xe dissolved in the alveolar membrane and pulmonary capillary red blood cells (RBC), and alveolar microstructure as the apparent diffusion coefficient (ADC).**

## Characterizing Lung Structure-function

We apply our imaging methods to measure and characterize lung structure-function and their relationships with patient outcomes across a range of chronic lung diseases and inhalational exposures in children and adults. Example recent or ongoing projects include chronic obstructive pulmonary disease (COPD; shown above), long COVID, vaping, cannabis smoking, and cystic fibrosis.

## IP & KNOWLEDGE TRANSLATION

- Accelerated pulmonary imaging acquisition and analysis
- Robust pulmonary imaging biomarkers
- Novel lung disease phenotypes grounded in pathophysiology
- Multi-modal pulmonary imaging pipelines

# ROBERT ROHLING

PROFESSOR

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**Today medical imaging provides life-saving diagnostics, but two-thirds of the world's population lacks access to imaging. We are re-imaging ultrasound imaging to improve access and capabilities.**

ultrasound | medical imaging | robotics | elastography | stillbirth | surgical guidance | spinal cord injury | microfabrication | transducers | quantitative analysis

## Re-Imagining Ultrasound for the 21st Century

My lab focuses on ultrasound imaging research, addressing medical problems through both hardware and software solutions. On the hardware side, we collaborate with microfabrication researchers to create new ultrasound transducers tailored to specific clinical needs. On the software side, we work with signal processing and AI researchers to develop algorithms that analyze ultrasound signals to assess organ health. Our multidisciplinary team spans biomedical, electrical, computer, and mechanical engineering, as well as physics and medicine. For example, we design ultra-high-bandwidth transducers and AI-based analyses to prevent stillbirth by detecting placental issues early. We diagnose liver disease by measuring fat and fibrosis in ultrasound signals and repair spinal cords using ultrasound-guided injections of gels with micro-scaffolds to aid nerve regeneration. In summary, our research integrates diverse tools and collaborations to develop impactful patient care solutions.

The Robtics and Control Lab: https://rcl.ece.ubc.ca

## RESEARCH EXCELLENCE

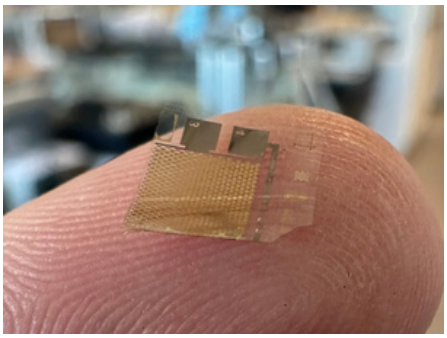
We are revolutionizing ultrasound transducer prototyping by replacing traditional piezoelectric transducers with custom-made micromachined transducers. Notably, in 2018 we developed a high-performance polymer-based CMUT (polyCMUT). This led to flexible transducers for conformal imaging and highly sensitive acoustic emission sensors for non-destructive testing, both winning best paper prizes at the 2022 IEEE Ultrasonics Symposium.

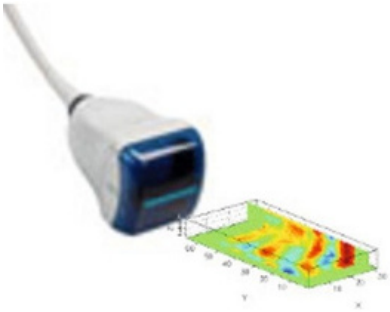
## Our Training Program

My lab is unique because all students have medical co-supervisors to ensure research relevance and impact. We are sponsored by multiple industry collaborators, including two start-ups I co-founded. Sonic Incytes, co-founded with Dr. Salcudean, produces Velacur, an FDA-approved device for measuring liver fat and fibrosis. Sonus Microsystems, co-founded with Drs. Cretu and Gerardo, manufactures polyCMUT transducers for various applications.

## Polymer-Based Ultrasound Transducers

My lab has access to several unique technologies. On the hardware side, I am co-inventor of the polyCMUT (polymer-based capacitive micromachined ultrasound transducers) technology that allow us to custom make our own ultrasound transducers at UBC in a wide range of custom shapes, sizes and capabilities. What other labs can create in 6-12 months, we can create in 1 week using polyCMUT technology and have a wider range of possible designs.





**Our flexible permanent acoustic emissions sticker (above) has a sensing range from 40kHz to 3 MHz to unobtrusively detect the release of ultrasonic stress waves when a stressed material is about to fail. Liver elasticity map from a 3D transducer (left)**

## Elastography for Assessing Liver Health

On the software side, I am co-inventor of the S-WAVE (shear wave absolute vibro-elastography) technology that allows us to measure and quantify the properties of tissue. What other labs can do with single-point measurements, we can do with full 3D volumetric measurements of large portions of an organ to get a more complete and accurate understanding of tissue health. We have used S-WAVE to research detection of prostate and breast cancer, fatty liver disease, chronic kidney disease and placenta-mediated problems with pregnancy. We use the above unique hardware and software technologies plus make advances to the state-of-the-art in AI and robotics to solve medical problems.

## IP & KNOWLEDGE TRANSLATION

- Algorithms for measuring tissue stiffness (11 patents licensed to Sonic Incytes)
- Microfabrication of transducers (6 patent families licensed to Sonus Microsystems)
- Ultrasound guidance of epidural needles (1 patent licensed to Ultrasonix)
- Methods for improving visibility of needles in ultrasound (used across industry)

# ROGER TAM

## ASSOCIATE PROFESSOR

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**Machine learning vision frameworks allow clinicians to identify people with irreversible disease earlier and help reduce further damage.**

medical imaging | image analysis | computer vision | machine learning | data science | clinical prediction | artificial intelligence

## Advanced Algorithms for Biomedical Signal Analysis

Our research program focuses on the development and application of machine learning methods for the analysis of multi-modal biomedical data. We push the boundaries of what machine learning can discover from biomedical signals. I have a particular interest in computer vision techniques for image analysis and discovery of patterns that can screen for undiagnosed diseases and predict patient outcomes. My students have worked on projects that span the spectrum from fundamental discovery to practical deployment.

We focus on cardiology (detecting heart damage with electrocardiograms), respirology (identifying chronic obstructive pulmonary disease with CT scans), and neurodegenerative diseases (diagnosing early multiple sclerosis with MRI scans and predicting dementia risk with actigraphy data). Our lab is highly collaborative, and we work directly with many clinical specialist to ensure our research is relevant to real-world applications.

The Tam Lab: https://blogs.ubc.ca/rogertam/

## RESEARCH EXCELLENCE

My students have published first-author papers in prestigious journals and conferences like MICCAI, MIDL, Lancet Digital Health, and Frontiers in Neurology. We led the field of deep learning of MRIs for diagnosis and prediction in multiple sclerosis. We are particularly proud of producing practical tools used in clinical studies and trials while being novel enough to be published in top technical journals and conferences.

## Our Training Program

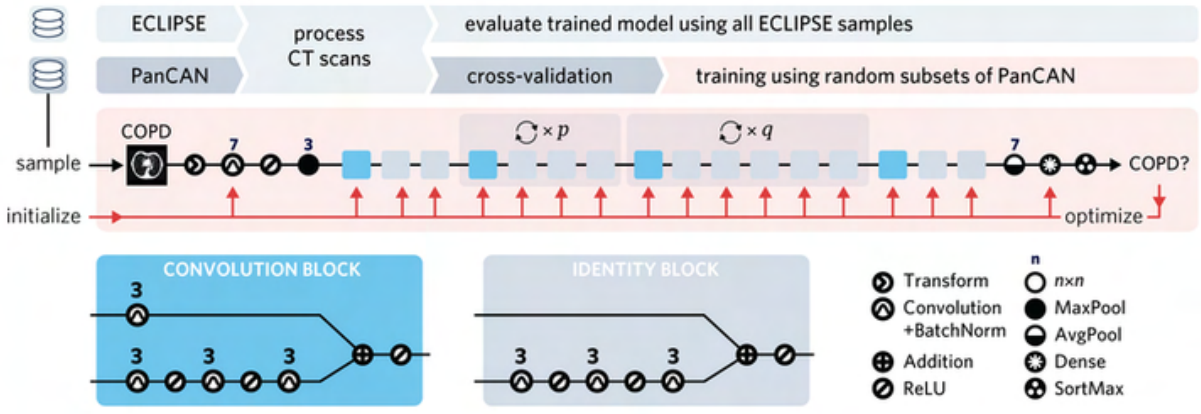
We seek students proficient in computer programming, machine learning, and biomedical signal analysis for applied/translational science projects, with a focus on foundational algorithmic development. My teaching philosophy prioritizes student support and empowerment, cultivating independent learning, problem-solving, and leadership skills. Former students have successful careers as machine learning scientists in companies like Philips Healthcare, Siemens Healthineers, AMD, and Google.

## Beyond Just Pixels

Current machine learning algorithms in clinical prediction often extract only intensity-based features, lacking explicit capture of shape information. Recent studies suggest that incorporating geometric features directly improves shape representation and predictive accuracy. Our ongoing projects focus on extracting 3D meshes from medical images and utilizing geometric features for clinical tasks like visualization and prediction. For instance, we've successfully reconstructed detailed 3D heart surfaces from CT and MRI scans and are extending this to model various brain structures.

## Algorithms that See What We Can't

Many diseases, like chronic obstructive pulmonary disease (COPD) and multiple sclerosis (MS), often manifest with significant damage before obvious symptoms emerge, hindering early detection and proactive treatment. Traditional imaging methods target visible signs, but subtle features remain undetected. Leveraging machine learning, particularly deep learning, we aim to automatically identify these subtle features from non-invasive imaging like CTs and MRIs. Collaborating closely with clinical specialists, our focus includes case-finding in COPD, clinical progression prediction in MS, and other impactful diseases such as dementia and heart failure.




## IP & KNOWLEDGE TRANSLATION

- Novel computational algorithms for analyzing multi-modal biomedical data
- Validated machine learning/computer vision pipelines to detect early disease
- Novel features in biomedical data for personalized clinical prediction
- Methods to improve the usability of machine learning methods on real-world data

IMAGING & COMPUTATIONAL BIOLOGY
CORE MEMBER

# TIM LEE

## PROFESSOR

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BC CANCER RESEARCH
Provincial Health Services Authority

**We create population health-focused solutions in skin cancer detection, from medical devices to artificial intelligence systems.**

Population Health | Dermatology | Skin Cancer | Epidemiology | Medical Imaging | Optical Imaging | Artificial Intelligence

## The Skin Cancer Imaging and Population Health Innovation Lab (SCIPHI)

Our lab studies every aspect of early skin cancer care, including epidemiology, optical technologies, and medical image analysis. We identify problems from a population perspective and engineer solutions to solve them for maximum impact on public health. Our engineering focus is shared between the development of hardware and software: New imaging devices with corresponding novel optical signals, and new image analysis methods including applications of artificial intelligence.

Our work includes:

- Epidemiological studies on skin cancer incidence rates, risk factors, and prognosis.
- Development of non-invasive and accessible optical imaging technologies
- Advanced computer vision techniques using machine learning and deep learning AI across the wide breadth of skin conditions and imaging modalities

Webpage: https://www.bccrc.ca/dept/ccr/people/tim-lee

## RESEARCH EXCELLENCE

Our population health-based research focuses on public impact as a sign of success. This has attracted several industry collaborations to commercialize the IP we develop. Our work on image database infrastructure has been adopted by the International League of Dermatological Societies. Our students' publications and presentations have won many local and international awards, including those from NSERC, SPIE, the International Society for Biophysics and Imaging of Skin, and the World Congress of Dermatology.

## Our Training Program

Trainees in our lab work in a highly multidisciplinary environment at the BC Cancer Research Centre, based out of the Population Health Sciences department. We work in close collaboration with dermatologists Dr. Harvey Lui and Dr. Sunil Kalia of the nearby UBC Dermatology Skin Care Centre for clinical resources. We also collaborate with the UBC Advanced Research Computing team for computational resources. Our team consists of engineers, physicists, dermatologists, statisticians, and computer scientists.

## Optical polarization-based skin cancer detection

This project explores optical polarization, also known as the orientation of light waves, to detect subsurface skin properties based on their scattering behaviour. By shining a laser on the skin and measuring the returning light, we can measure what kind of scrambling occurs within, which can give a new "thermometer-like" measure to help separate cancerous and healthy skin tissue. This technology is aimed at non-dermatologist healthcare providers, improving their diagnostic accuracy and reducing wait times to see specialists. Future iterations of this technology may be able to put this detection ability in the hands of the general public.

**This "thermometer-like" probe measures optical signals from laser light scattered from skin tissue. The differences in microstructure between cancerous and noncancerous skin lesions cause different patterns of scattering, allowing for a device that can make snapshot measurements, built from accessible materials.**

## Automated Skin Cancer Detection Systems

This project aims to help interpret complex and multimodal skin image data with the ultimate goal of distributing techniques to non-dermatologist healthcare providers and, potentially, patients and the general public. Advanced imaging techniques such as dermoscopy, polarization imaging, and optical coherence tomography require special training to interpret, even for experienced dermatologists, limiting scalability and equitable access. To address this gap, we develop computer-aided detection and decision-support approaches that integrate computer vision, deep learning, and medical image analysis to better capture clinically meaningful patterns across modalities. Our goal is to improve the reliability, interpretability, and accessibility of melanoma and other skin malignancy detection, enabling earlier risk stratification and more informed clinical decision-making across diverse care contexts.



## IP & KNOWLEDGE TRANSLATION

- Automatic skin feature extraction, skin lesion segmentation, and skin cancer classification using machine learning and deep learning frameworks
- Applications of generative AI to improve processing of novel skin imaging modalities
- Optical polarimetry technologies for rapid non-invasive skin cancer detection
- Non-contact skin roughness measurement via polarization speckle technology

# BABAK SHADGAN

ASSISTANT PROFESSOR
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**We develop novel biosensing techniques and clinical interventions for early diagnosis of organ dysfunction and targeted treatment delivery.**

sensor | biosensing | wearable | implantable | clinical biophotonics | medical devices | physiological monitoring | sports and exercise medicine

HUMAN INTERFACING DEVICES
ASSOCIATE MEMBER

## We Can Manage Medical Conditions that We Can Monitor

At the Implantable Biosensing Laboratory, our focus is on advanced biosensing techniques and sciences. We specialize in designing, developing, and examining novel implantable and wearable biosensors for clinical applications and health monitoring. The increasing need for continuous monitoring of organ physiology, metabolism, and function, particularly after therapeutic and surgical interventions, has driven significant innovation in biosensing technologies over the past two decades. As a result, external and internal implantable biosensors have become integral components of modern healthcare.

Recent advances in microelectronics, optics, power supplies, and wireless tech have spurred novel biosensor development. Biomaterial progress allows long-term implantation near tissues. With portable computers and intelligent algorithms, biosensors monitor diseases, biomarkers, and tissue function. Data can prompt bedside or remote actions, with automated responses based on real-time readings.

The Implantable Biosensing Lab: https://biosensing.med.ubc.ca

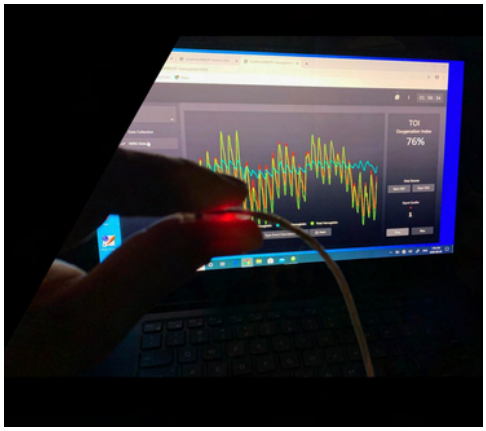
## RESEARCH EXCELLENCE

Implantable biosensors hold promise for enhancing patient care in trauma, organ transplants, chronic diseases, and tissue regeneration. Under artificial intelligence, when paired with a continuous treatment or drug delivery, an implantable biosensor can establish an intelligent closed-loop system to overcome an unsolved clinical challenge, e.g., artificial pancreas in diabetic patients, improving outcomes while reducing complexity and cost.

## Our Training Program

We welcome graduate students and postdoctoral fellows with a keen interest in advanced biosensing techniques and sciences. Our focus is on the design and development of implantable and wearable sensors and medical devices for targeted treatment delivery and their applications in medical disciplines, healthcare, and exercise sciences.

## Implantable Spinal Cord NIRS Sensors



Acute spinal cord injury (SCI) is a devastating neurological condition resulting in permanent morbidity and impaired quality of life. Optimizing hemodynamic management to maintain blood supply and oxygenation of the injured spinal cord tissue is crucial for improving neurological outcomes. However, monitoring spinal cord blood flow, oxygenation, and hydrostatic pressure in real-time remains limited and challenging for clinicians. This research aims to enhance hemodynamic management and neurological outcomes in acute SCI patients. We're introducing a novel technique with an implantable optical sensor for noninvasive intraoperative and post-operative monitoring of spinal cord hemodynamics and oxygenation. This method provides critical information for clinicians to optimize spinal cord hemodynamics, thereby improving neurological outcomes in acute SCI patients.

## Monitoring of Surgical Flap Viability


We have developed a real-time, accurate, and non-invasive technology to monitor the viability and function of surgical reconstructive flaps at the bedside. Our approach utilizes a unique configuration of near-infrared spectroscopy (NIRS) technology to monitor free flap tissue oxygenation, perfusion, and vital signs. With our implantable and miniaturized sensor, we can monitor the perfusion and oxygenation level of surgical flaps transplanted in any external or internal body region. This critical information will enhance surgical outcomes and flap survival rates by enabling earlier and more precise detection of vascular compromise

HUMAN INTERFACING DEVICES
ASSOCIATE MEMBER

## IP & KNOWLEDGE TRANSLATION

- Developing advanced implantable sensors to monitor organ hemodynamics
- Developing novel multi-modal sensors to monitor organ function
- Design and development of the new generation of wearable sports monitors
- Establish implantable medical devices that improve organ repair and function

# CALVIN KUO

ASSISTANT PROFESSOR
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**We make predictions combining wearable sensing with modeling techniques. We utilize kinematics measured from an instrumented mouthguard to predict muscle contributions to head stabilization.**

wearable sensing | remote healthcare | musculoskeletal modeling | biomechanics

HUMAN INTERFACING DEVICES
CORE MEMBER

## Augmenting Healthcare with Continuous Wearable Monitoring

Wearable devices like Fitbit, Garmin, and Oura rings have surged in popularity, integrating health monitoring into everyday wear. Despite their widespread use for tracking health metrics, such data is rarely utilized in clinical settings. While wearable devices hold potential in remote healthcare, supplementing clinical visits with continuous health data, and aiding medical interventions, challenges in sensor accuracy and data interpretation hinder their clinical adoption.

To address these challenges, the Human Motion Biomechanics Laboratory deals with the end-to-end development, validation, and implementation of wearable devices. We use Bayesian inference and confidence maximization to develop algorithms that enhance measurement robustness and improve health state predictions from multi-modal data. Working with partners at the Vancouver General Hospital and BC Children's Hospital, we put these tools to practice in patient populations ranging from athletes recovering from musculoskeletal injuries to children suffering from sleep disturbances.

The Human Motion Biomechanics Lab: https://humbl.bme.ubc.ca

## RESEARCH EXCELLENCE

Our multidisciplinary lab specializes in the full cycle of wearable sensor development and deployment for healthcare. We addressed soft tissue artifacts with innovations like instrumented mouthguards and error-correcting algorithms. We use tailored algorithms to extract clinical metrics, like neck muscle models, supporting interventions. Additionally, we've set international standards for sports data via rigorous real-world validation.

## Our Training Program

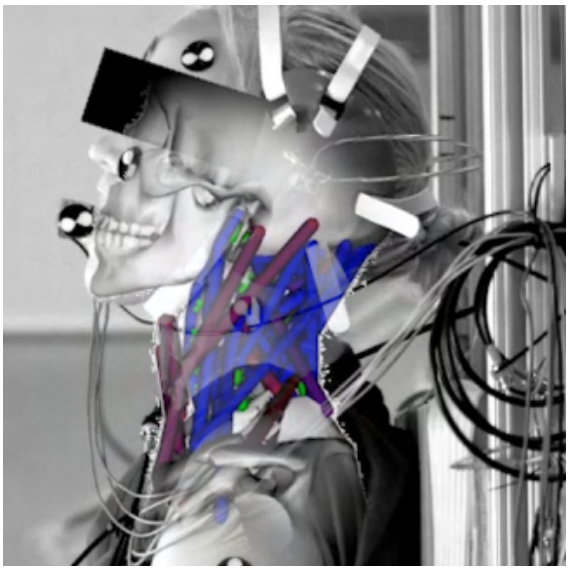
We are looking for lab members who are interested in applying engineering tools for remote healthcare. With diverse backgrounds spanning health sciences to electrical engineering, we offer unique end-to-end capabilities in wearable sensing. Calvin Kuo also oversees specialized graduate programs at SBME (Care Anywhere), focusing on advanced healthcare technology training.

## Sport Injuries

One of our hallmark projects is in the area of sport injury prevention. Previously, we developed and validated instrumented mouthguards for the measurement of head impacts that lead to mild traumatic brain injuries, or concussions. This involved lab validation of the instrumented mouthguard to measure head kinematics and estimated brain strains in finite element simulations, as well as field validation to ensure accurate identification of head impact events. This work can be found in commercial instrumented mouthguard devices (notably Prevent Biometrics) that are used by thousands of athletes worldwide, and has recently been adopted as a concussion protocol standard by World Rugby. We take lessons learned from wearable sensing in concussions and apply similar tools and methodologies to address lower limb musculoskeletal injuries in contact sports, most notably anterior cruciate ligament tears in soccer. Our interest here stems from longitudinal factors on injury risk, which require difficult, but truly unique data collection paradigms and analyses.

## High-Rate Movement Sensing

To facilitate our movement sensing research, we rely on a custom high-sample rate wearable device. Before field deployment, ensuring measurement accuracy is crucial. We target errors encountered outside the lab, like soft tissue movement effects or sensor misplacement by non-experts. We characterize these errors in real-world conditions and develop algorithms (sensor fusion) or methodologies (robust machine learning) to enhance accuracy. Characterizing errors, such as soft tissue artifacts, informs us, aiding in determining dynamic material properties.



HUMAN INTERFACING DEVICES
CORE MEMBER

## IP & KNOWLEDGE TRANSLATION

- Algorithms for more robust wearable sensor measurements
- Methods to validate wearable sensors from the benchtop to the real world
- Maximizing confidence with multiple wearable sensors
- Addressing clinical needs in wearable sensor predictions
- Tools for the collection and interpretation of longitudinal data

# KAREN CHEUNG

PROFESSOR

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**We take advantage of microscale phenomena to develop new technologies, enabling scientific discoveries.**

HUMAN INTERFACING DEVICES

CORE MEMBER

microfluidics | tissue engineering | organ-on-chip | biosensors | implantable neural devices | inkjet | bioprinting

## Organ-on-Chip for Physiology and Development of New Therapies

Organ-on-chip platforms are technologies that can mimic in vivo physiology, allowing a more in-depth understanding of disease progression and permitting evaluation of novel therapeutics. Our team is developing a microfluidic model of the small airway that incorporates airway-specific cells supported by 3D extracellular matrix hydrogels to control the architecture in the microtissue. Our model permits perfusion to expose cells to environmental factors such as wood smoke from forest fires.

We cultivate small tissue constructs with multiple cell types in a 3D environment, offering superior drug screening compared to 2D cultures. Our novel thin-film, on-chip optical O2 sensors monitor oxygen levels in microfluidic organ-on-chip systems, enabling dynamic oxygen microscopy under varying conditions. To improve imaging through dense 3D models, we've developed tissue clearing techniques, enhancing their utility in high-content drug screening and other assays.

The Bio-Medical Micro Devices Lab: https://biomems.ece.ubc.ca/

## RESEARCH EXCELLENCE

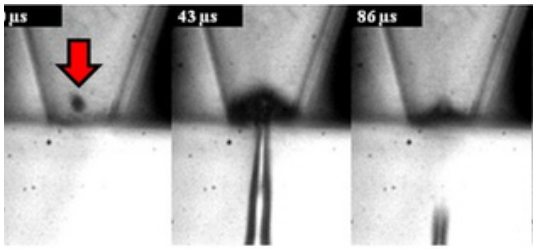
Our research group uses nano- and microfabrication techniques to develop technologies for life sciences and medicine. We take advantage of phenomena at the microscale that allow us to control the microenvironment around microtissues, and create representative models of organs on chips.

## Our Training Program

We are looking for lab members who are interested in developing skills and expertise in biomedical microdevices and microscale technologies. Team members with diverse backgrounds including molecular biology, engineering physics, electrical engineering, biomedical engineering, and chemistry work together to develop new solutions to unmet needs. Alumni from our group are now leaders in industry, medicine, and academia.

## Biomaterials Treatment for Spinal Cord Injury

Mend the Gap is an interdisciplinary project aiming to develop a treatment for spinal cord injuries (SCI) by using injectable biomaterials to support axonal growth across lesions. Our team contributes in three main areas: testing injectable biomaterial bridges with in vitro platforms, developing a controllable electromagnet to align magnetic structures within hydrogels for directing axonal growth, and creating flexible implantable microelectrodes to stimulate neuronal activity alongside the biomaterials bridge. We've designed an SCI chip to examine 3D neurite growth, and a configurable magnetic field generator to align magnetic microstructures across various scales, from in vitro models to large animals.




**Our picolitre-volume inkjet-based platform integrates high-resolution imaging and neural network-based object recognition to enable high-capture, high-throughput single cell dispensing for single cell sequencing.**

## Silicon Photonic Biosensors

Our team is also developing compact, low cost biosensor technologies that will offer significant improvements in both size and cost compared to comparable commercial systems. The silicon photonic biosensors can be fabricated with high-volume, low-cost, scalable semiconductor fabrication processes. These evanescent field sensors detect binding events at the waveguide surface. Our current focus is on the bio-functionalization of the sensor surface that will give sensitive, specific, and multiplex detection. With our collaborators, who are using electronic-photonic integration to incorporate the laser and detectors onto the chip itself, we are developing these silicon photonic biosensors to be used in point-of-need and remote settings, as well as for real-time monitoring of biomanufacturing processes.



## IP & KNOWLEDGE TRANSLATION

- Inkjet-based single cell isolation system for single-cell sequencing
- Silicon photonic biosensors
- Tissue clearing reagents for improved three-dimensional imaging

# MANU MADHAV

ASSISTANT PROFESSOR
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**We design 'closed-loop' experiments in which animals make decisions under controlled sensory conditions and rules, while we peer into the activity of neurons.**

HUMAN INTERFACING DEVICES
CORE MEMBER

neuroscience | electrophysiology | navigation | robotics | signals and systems | sensory integration | Alzheimer's Disease

## Neural Circuits for Computation, Cognition and Control

How do populations of connected neurons perform computations and generate movements and behaviour? How do we integrate information from our surroundings to navigate the world? Our lab (NC4) investigates neural navigation in humans and rodents using custom engineering techniques.

We explore how the brain forms cognitive maps through neural activity recordings in rats navigating virtual reality (VR). We investigate the role of environmental knowledge in action planning, assess the contribution of young neurons to sensory pattern recognition, and quantify age-related navigational decline in normal aging and Alzheimer's disease progression. Collaborating with computer scientists, we develop machine learning techniques for neural data analysis and test algorithms on robots. Additionally, we design and share low-cost animal behavioral apparatuses to promote open methods in neuroscience.

The NC4 Lab: https://www.nc4.sbme.ubc.ca

## RESEARCH EXCELLENCE

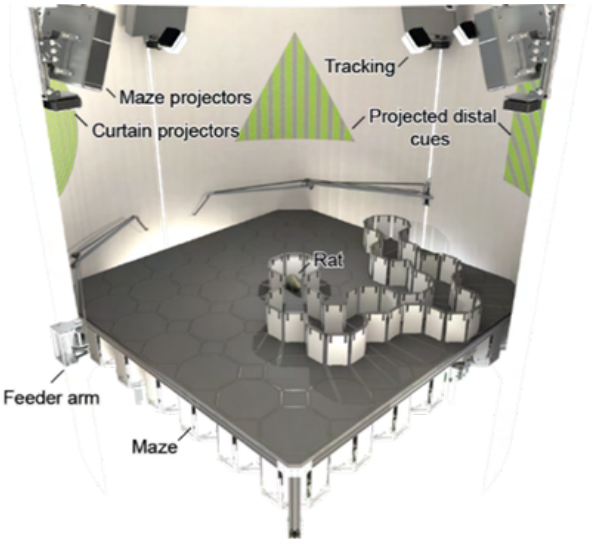
We create innovative apparatuses to record neural activity during free behavior in animals while controlling sensory cues. Our contributions include the virtual reality rodent Dome and optical tracking methods. We're developing a Maze apparatus with dynamic control over routes and stimuli. Using machine learning, we analyze neural data structure to decode the nervous system, embracing naturalistic behaviour complexity.

## Our Training Program

We are unique in our from-scratch development and application of custom engineering techniques and analyses in fundamental neuroscience. Our students gain diverse skills in software (C++/Python, machine learning, image processing), hardware (electronics design, machining, 3D printing, laser cutting), and systems neuroscience (behavioural training, stereotaxic surgery, electrophysiology, neural data analysis). Joining our lab offers skill development tailored to your project and interests.

## High-Fidelity Behavioural and Neural Recordings

Spatial navigation and decision making are crucial for survival, guided by sensory cues and learned context. We built the Omniroute maze to selectively control every aspect of this computation. We can control the visual and auditory cues experienced by a navigating rat, and shape its behaviour through automated rewards and route geometries. We use silicon probes to record the activity of tens to hundreds of neurons in brain regions such as the hippocampus, entorhinal cortex and prefrontal cortex. By correlating these recordings to high-speed 3D behavioural measurements, we can decipher how neural circuits in these regions interact to support navigation, memory and decision making.




## A Behavioural Biomarker for Dementia

In 2021, an estimated 688,000 Canadians, including over 60,000 British Columbians, lived with Alzheimer's Disease (AD) and other dementias. AD causes progressive neural tissue death, but early diagnosis and interventions like diet, exercise, and cognitive training can slow cognitive decline. Early AD affects brain regions crucial for navigation, yet its impact on navigational abilities is not well understood. We developed a virtual reality assessment to measure how participants navigate and track their location relative to the environment and landmarks. Supported by Michael Smith Health Research BC and the CLEAR foundation, this project aims to create a noninvasive tool to help clinicians and caregivers detect and monitor early AD.

HUMAN INTERFACING DEVICES
CORE MEMBER

## IP & KNOWLEDGE TRANSLATION

- New behavioural apparatuses
- Behavioural Biomarkers for Alzheimer's Disease and other dementias
- Algorithms for robotic sensor fusion and control

HUMAN INTERFACING DEVICES

# MATTHIAS GÖRGES

## ASSOCIATE PROFESSOR

mgoerges@bcchr.ubc.ca

**We will apply participatory research methods to identifying risk factors, patient-reported experience and outcome measures, and data capture tools for an individualized pain prediction tool in pediatrics**

digital health | predictive analytics | pediatric anesthesia | data integration | human factors engineering | clinical informatics | usability evaluation



## Digital Health Innovation

The introduction of information technology in medicine has enabled a transformational change, and the ongoing coronavirus pandemic further accelerated the application of virtual health solutions. My primary focus is using technology to enhance patient outcomes through design, implementation, and evaluation. Understanding the clinical context is crucial, so I collaborate with a diverse team, including medical experts, engineers, data scientists, and patients, to address real-world challenges.

Based at BC Children's Hospital Research Institute, my team conducts innovative research blending technology and patient care. We engage in trans-disciplinary collaboration with engineers, computer scientists, and healthcare professionals, primarily in pediatric anesthesia and related specialties. Our current focus is on digital health platform development and predictive analytics applications, with past work including data displays for clinical decision support, vital signs collection infrastructure, and closed-loop anesthesia control.

Research: https://bcchr.ca/mgorges

## RESEARCH EXCELLENCE

Our research, read by clinicians, scientists, and engineers, drives innovation in computer science, statistics, and engineering. For instance, we improved alarm performance in medical intensive care units, developed a pediatric risk score for sepsis mortality, designed an intelligent monitoring device for ICU safety, identified key components for total intravenous anesthesia, and provided guidance on managing missing data in clinical registry analyses.

## Our Training Program

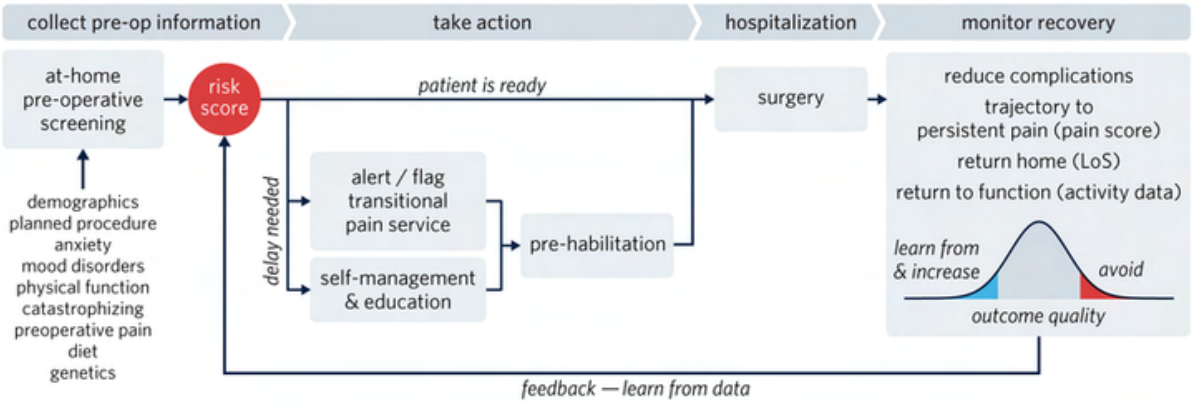
In my research, I appreciate the dual role of needing to develop new tools, methods, applications, etc., while training the next generation of scientists - I do so by enabling their direct access and hands-on experience in the clinical environments at BC Children's Hospital and in other healthcare locations I collaborate with, enabling them to collaborate with industry partners and mentor them in skills relevant for work in- and outside academia.

## Pediatric Pain Risk Prediction

We're using smartphones and AI to enhance pain management for children undergoing surgery, aiming to address persistent post-surgical pain and its impact on daily life. By analyzing factors like biological sex, anxiety, chronic pain, and planned procedures, we aim to predict which children may experience significant pain post-surgery and intervene early. Collaborating with families and children, we'll develop a pain risk score for personalized care, testing it initially on dental, otorhinolaryngology, general, ophthalmology, orthopedic, plastic, and urology surgery cases. Our goal is to improve individualized care, leading to quicker recovery, reduced hospital stays, and lower risk of long-term opioid use.

## Data-Sharing Platform for Researchers and Citizen Science

We're developing a mobile app and database system to facilitate secure health data sharing between research participants and clinical researchers. Users can understand and selectively share their data with scientists, who can then analyze it and return results. Our approach prioritizes user-centric design, providing visualization tools for data understanding and ensuring informed consent for data donation. We'll implement secure data donation techniques, including data collection from various devices, secure transfer, and anonymization while preserving data integrity. Our prototype will undergo testing with both public and research users.




## IP & KNOWLEDGE TRANSLATION

- Digital health platform design, implementation, and evaluation
- Applications for predictive analytics
- Clinical decision support systems
- Risk communication tools
- Data displays and personalized feedback dashboards

# MYEONG JIN JU

ASSISTANT PROFESSOR

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**We acquire an ultra-wide field-of-view retinal image of patients with multi-contrast formation algorithm for identifying pathological characteristics of retinal degenerative diseases.**

HUMAN INTERFACING DEVICES

CORE MEMBER

functional optical imaging | multi-contrast optical imaging | optical signal processing | molecular contrast imaging | computational optics | retinal imaging

## Innovation of Optical Imaging Systems for Advancing Eye Care

At the Computational Ophthalmic Imaging Lab (COIL), we are driven by a singular mission: to delve deeply into the understanding of retinal and neurodegenerative diseases using cutting-edge, non-invasive, in vivo imaging technologies. Our expertise lies in pioneering advancements in biophotonics and computational technology tailored specifically for ophthalmic imaging. Our primary focus involves crafting interactive software and hardware solutions dedicated to enhancing retinal optical coherence tomography imaging.

COIL is committed to pushing the boundaries of optical imaging systems and refining post-processing algorithms. Our focus includes age-related macular degeneration, choroidal melanoma, and retinitis pigmentosa, all potentially causing irreversible vision loss. Additionally, we're delving into neurodegenerative diseases like Alzheimer's and Parkinson's, using retinal imaging insights to gain fresh perspectives and tackle these complex challenges.

The COIL Lab: https://med-fom-coil.sites.olt.ubc.ca/

## RESEARCH EXCELLENCE

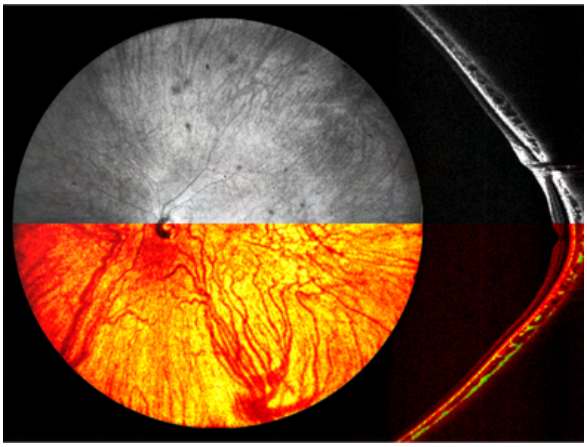
Our dedication of developing functional retinal imaging systems, novel methods of imaging system calibration, and pathological feature extraction algorithms have been making significant progress. Collaborating across disciplines, we're making strides in clinical trials with multi-contrast imaging. Our goal is to enhance the visualization and understanding of retinal and neurodegenerative diseases using cutting-edge imaging technology.

## Our Training Program

At COIL, we are looking for trainees passionate about learning and exploring the field of optical imaging and signal processing. Situated at Vancouver General Hospital, we offer a rich, multi-disciplinary research setting. Our wide range of collaboration with clinicians and vision scientists provides our trainees with unparalleled access to resources, knowledge, and mentorship, ensuring your time here is marked by exceptional growth and success.

## Panoramic Multi-contrast Clinical Retinal Imaging

We are at the forefront of advanced retinal research, spearheading the development of an innovative retinal imaging system meticulously crafted to reveal the intricate details of the retina—the delicate posterior segment of the human eye. We've developed a cutting-edge panoramic polarization-sensitive OCT imaging system. This technology not only offers a detailed view of the retina but also enhances tissue visibility by measuring light polarization, enabling precise quantification of tissue changes. Our research at VGH's Eye Care Centre has made strides in studying various retinal diseases, including tumours, retinitis pigmentosa, age-related macular degeneration, glaucoma, and vascular abnormalities.



## Pathological Models of Small Animal Retinal Imaging

Our commitment to advancing retinal research extends to preclinical studies employing pathological models of small animals. We are actively engaged in the development of a specialized multi-modal functional retinal imaging system designed for small animals, enabling the visualization of high-resolution images with multiple contrasts. Additionally, a central aspect of our research involves the development of signal processing algorithms geared towards extracting disease-specific features from the data acquired through our imaging system. By focusing on the study of the small animal retina, we are dedicated to uncovering the fundamental causes and pathological characteristics essential for the early detection of retinal diseases and neurodegenerative conditions.



## IP & KNOWLEDGE TRANSLATION

- Clinical-grade functional in vivo human retinal imaging system development
- Multi-modal in vivo small animal retinal imaging system development
- AI-based retinal layer segmentation and pathological feature extraction platform
- State-of-the-art optical microscopy system development for functional tissue imaging
- Portable ocular imaging system development for telemedicine

# PETER CRIPTON

PROFESSOR

peter.cripton@ubc.ca


**We will develop and commercialize safety equipment to provide new means to prevent catastrophic injuries such as spinal cord injuries, brain injuries, hip fractures and fetal loss in automobile collisions involving pregnant occupants**

injury biomechanics | injury prevention | spinal cord injury | sex differences in injury | helmet testing | hip fracture | spine injury | seat belt efficacy | traumatic brain injury

HUMAN INTERFACING DEVICES

CORE MEMBER

## Reducing the Burden of Unintentional Injury

In the UBC Orthopaedic and Injury Biomechanics Group, we are dedicated to reducing the impact of human injury and through high quality, high impact and highly ethical research, and to fostering a world-class graduate research and educational environment.

Our research themes include:

- Injury prevention in the areas of brain, spine, and hip fractures
- Improving seat belt efficacy for non-pregnant and pregnant women
- Prevention of spinal injuries in automotive rollovers
- Neurotrauma to the spinal cord and Brain and prevention of these catastrophic injuries
- Basic science of bone fracture
- Helmet design including design of a helmet to prevent cervical spine fractures in headfirst impacts

The Orthopaedic and Injury Biomechanics Group (OIBG): https://injury.mech.ubc.ca/

## RESEARCH EXCELLENCE

Notable OIBG projects include our work with the US Army on vibrations sustained during medical evacuation of spinal cord injury cases, and the safety evaluation of the Whistler Sliding Centre after a fatal injury leading up to the 2010 Olympic Games. OIBG's innovation led to the Pivot helmet, preventing neck injuries during head-first impacts, and the CHIMERA device for evaluating concussion therapeutics, with over 20 sold worldwide.

## Our Training Program

We seek passionate individuals dedicated to impactful research in neurotrauma, orthopaedic injury, and injury biomechanics. Our goal is to positively impact global health through innovative research and foster a supportive, diverse, and challenging educational environment. Join us to help prevent injuries and enhance patient outcomes through groundbreaking work.

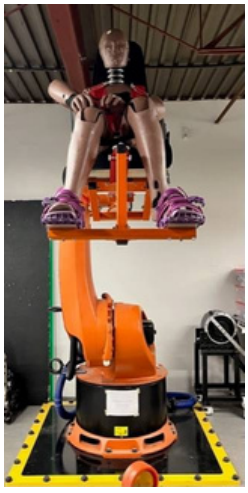
## Preventing Hip Fractures

Using a one-of-a-kind sideways fall simulator, we are increasing our collective understanding of hip fractures, while evaluating existing technologies for their efficacy at reducing hip fracture likelihood. In collaboration with ETH Zürich, a finite element computer model matched to each experiment can be used to predict hip fracture and impact force on a subject-specific basis. This tool guides the design of orthopaedic implants to prevent hip fractures. We've integrated a custom high-speed X-ray system into experiments, enabling real-time visualization of fall impacts and fracture at speeds 1000X faster than the blink of an eye.

**High-speed videos enable us to study injuries, recorded at speeds 1000x faster than an eye blink.**

## Car Rollover Simulator

Understanding how we tense and move our necks during a car crash is an important step towards designing vehicle safety system. We are developing a vehicle rollover simulator using an industrial robotic device. It mimics real rollover movements and allows us to study how people prepare for headfirst impacts during rollovers. We will measure their neck muscle activation with small wires that are inserted into the respective muscles and record neck motion with two on-board video X-ray systems. Understanding these conditions helps us develop ways to prevent severe cervical spine injuries in rollover accidents.



HUMAN INTERFACING DEVICES
CORE MEMBER

## IP & KNOWLEDGE TRANSLATION

- Novel innovations to prevent hip and spine injuries
- Enhance the recovery outcome of spinal cord injury patients
- Computational modelling platforms & experimental methods that enable realistic evaluation of injury-prevention devices like helmets and hip protectors

# RIZHI WANG

PROFESSOR

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**We study bone and orthopedic implants in the context of biomineralization, biomechanics, and biomaterials, focusing on material solutions to address clinical challenges.**

HUMAN INTERFACING DEVICES

CORE MEMBER

biomaterials | orthopaedic implants | additive manufacturing | hip fracture and prevention | bone structure and mechanics | antimicrobial surfaces | bone metastasis | osteoporosis

## Biomaterials for Bone Repair and Joint Replacement

Research in Wang's lab focuses on various biomaterials related issues in orthopaedics, specifically addressing bone structure, hip fracture and hip implants. Hip replacement has become a widely accepted surgical solution for various hip joint related diseases, including osteoarthritis and osteoporotic fractures. Wang's lab explores diverse materials technologies to further improve the outcomes of total hip replacement. Additive manufacturing is being researched for the design and production of orthopedic implants. Novel surface coating designs and processing techniques are being developed to promote implant-bone integration, and to minimize wear, peri-implant infections and adverse tissue responses. Bone and hip fractures form another core of Wang's research activities. The focus is on the structure, biomineralization, and fracture mechanics of bone, and the impact of bone diseases such as osteoporosis and bone metastasis. This information is crucial for improving implant-bone fixation and developing solutions to prevent hip fractures and treat various bone diseases.

The Wang Lab: https://biomaterials.mtrl.ubc.ca/

## RESEARCH EXCELLENCE

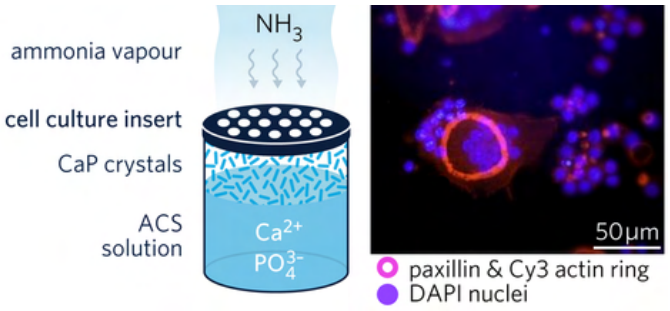
Wang's lab specializes in surface modification, implant evaluation, microscopy, mechanical testing, failure analysis, and bone histology, and has made significant progress developing novel antimicrobial coatings and wear-resistant coatings for orthopedic implants. The lab is recognized for studying bone deformation and microcracking mechanics at the microscopic level, and the unique structure and mineralization process in human femoral necks.

## Our Training Program

Trainees in Wang's team benefit from a truly multidisciplinary environment. Students can register to either Materials Engineering or Biomedical Engineering, and have direct access to state-of-the-art facilities and trainee support at Advanced Materials Process Engineering Laboratory (AMPEL) and the Centre for Aging SMART (CAS), a research base for >150 experts from diverse fields, including scientists, engineers, and clinicians.

## Biomaterial Assay for Osteoporosis and Bone Metastasis

Osteoclastic resorption of bones plays a central role in both osteoporosis and bone metastasis. A reliable in vitro assay that simulates osteoclastic resorption in vivo would significantly speed up the process of developing effective therapeutic solutions for those diseases. We developed a novel and robust nanostructured calcium phosphate coating in a double-chamber cell culture system by using an ammonia-induced mineralization (AiM) technique (https://doi.org/10.1021/acsami.1c00495). The processed calcium phosphate coating were demonstrated as a drug screening device by using alendronate, a widely used drug for osteoporosis. The application in studying bone metastasis was confirmed by using PC3 prostate cancer cell line. This novel assay provides a new platform for studying osteoclastic activities and assessing drug efficacy in vitro.




## Why can Bone Tolerate Defects?

Since the discovery of the Haversian system in human bone over three hundred years ago, researchers have been wondering about its mechanical advantages. Those Haversian canals are serious stress-concentration sites based on theory of fracture mechanics, and may initiate cracks leading to catastrophic failure. Surprisingly, osteonal bones do not seem to be sensitive to the presence of Haversian canals and have the capability to undergo large inelastic deformation. Our studies have discovered that the secrets lie in the unique concentric lamellar structure of the osteons and their even distribution within the bone cortex. The remarkable ierarchical structure in bone makes osteonal bones highly resistant to catastrophic failure. The progress points to a new direction of studying the fundamental mechanisms of bone fragility caused by osteoporosis, a disease that changes osteon's morphology.
doi: 10.1016/j.actbio.2011.11.013



## IP & KNOWLEDGE TRANSLATION

- New structural designs for orthopaedic implants.
- New surface technologies for antimicrobial applications.
- Impact of aging and cancers on bone quality.
- Solutions for hip fracture prevention.

# STEFANIE BLAIN-MORAES

ASSOCIATE PROFESSOR
stefanie.blain-moraes@ubc.ca

**We work with clinicians and caregivers to co-design, develop and implement technologies to assess consciousness and sustain relationships with minimally communicative persons.**

HUMAN INTERFACING DEVICES
CORE MEMBER

consciousness | assistive technology | anesthesia | EEG | arts-based interactions | minimally communicative persons

## Interacting with Minimally Communicative Persons

Over the past 30 years, improvements in medical life-saving and life-sustaining technologies have created "a new strain of human beings" with minimal to no ability to interact with others. Ranging from individuals with life-threatening injuries in critical care, to children born with severe multiple disabilities, to elders with advanced dementia, these individuals are minimally communicative. Caregivers from all backgrounds report uncertainty and ambiguity when interacting with them, which hinges upon two central questions. First, are these unresponsive individuals conscious? The answer to this question is foundational to relationships and care decisions, yet is currently based on guesswork for healthcare professionals and family members alike. Second, how might we accord these unresponsive individuals personhood? In other words – how can we develop relationships with these humans as social beings? We aim to address these two central questions by bypassing traditional modes of communication and interaction such as speech and movement, and designing novel physiological-based technologies to assess consciousness and personhood.

The Biosignal Interaction and Personhood Technology Lab: https://www.moraeslab.com/biapt

## RESEARCH EXCELLENCE

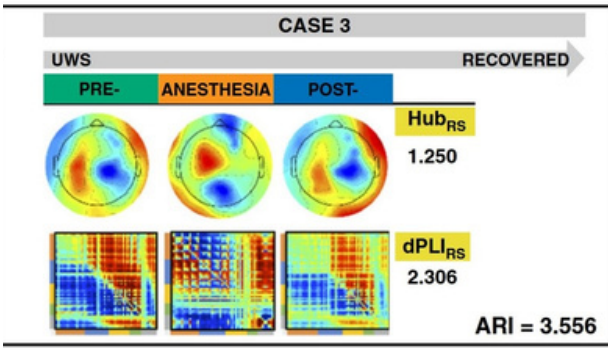
Our work has been recognized by numerous awards, including the Principal's Prize for Outstanding Emerging Researcher and membership in the College of New Scholars, Artists and Scientists in the Royal Society of Canada, and has been featured in National Geographic, STAT news, the New Scientist and CTV National News.

## Our Training Program

We strive to create a vibrant lab culture where all students are given tailored tools and training to grow as scientists in a supportive community. BIAPT students have received national and international recognition for their research and contributions to academia. The excellence of Dr. Blain-Moraes' teaching and training was recognized with the 2020 Faculty of Medicine Teaching Innovation Award from McGill University and by the 2023 Carrie M. Derrick Award for Graduate Teaching and Supervision.

## Assessing Levels of Human Consciousness

The quest for a biological understanding of consciousness has emerged as one of the most fundamental scientific pursuits of the 21st century. Human consciousness is widely understood to be underpinned by rich and diverse functional neural networks, whose breakdown results in unconsciousness. Our research has contributed to the development of candidate neural markers of anesthetic-induced unconsciousness. We apply these neural markers to develop diagnostic and prognostic tools for patients in disorders of consciousness in intensive care.




**The Adaptive Reconfiguration Index (ARI) developed in the BIAPT lab measures brain network reconfiguration in response to anesthesia to predict recovery of consciousness three months after admission to the intensive care unit with a severe brain injury.**

## Supporting and Augmenting Human Personhood

Our lab designed and is developing biomusic, a novel technology that translates significant changes in physiological signals into musical output. Biomusic has been shown to increase the sense of presence and personhood of persons who have diverse communicative capacities by enabling others to "tune in" to meaningful changes in an individual's physiological state. It pushes the boundaries circumscribing subjectivity by offering a potential new mode of becoming aware of others' reactions, presence and sensitivities. Using a participatory design approach, we co-design biomusic with a variety of users, including individuals with autism, individuals with dementia, parents of children in complex continuing care, and children and adults in pediatric palliative care.

HUMAN INTERFACING DEVICES
CORE MEMBER

## IP & KNOWLEDGE TRANSLATION

- Mes émotions sont à fleur de peau. Exhibit at Montreal Science Centre.
- Piece of Mind: Dementia. https://www.youtube.com/watch?v=y5LRTRkcwVA
- Piece of Mind: Parkinson's. https://www.youtube.com/watch?v=36_RBQOs8CU
- Living Rooms : une pièce partagée. Coeur de Science, Montreal, Quebec.

# TIM SALCUDEAN

PROFESSOR

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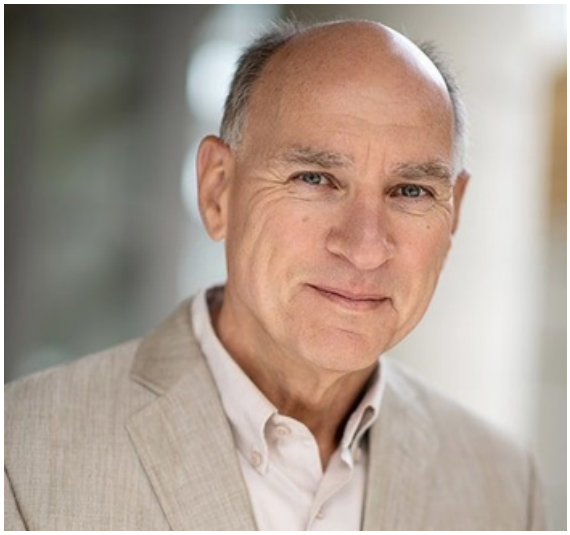


**We develop quantitative imaging and medical image analysis methods for diagnosis and treatment, and we integrate these into augmented and mixed-reality systems for procedure guidance.**

medical robotics | teleoperation | augmented and mixed reality | elastography | medical image analysis | ultrasound | multi-parametric imaging

HUMAN INTERFACING DEVICES

CORE MEMBER

## Medical Robotics and Medical Imaging

We're innovating augmented reality techniques for robot-assisted surgery systems to provide surgeons with pre-operative imaging of anatomy and pathology overlaid onto the conventional endoscope view. Our focus is on enhancing visualization and tissue tracking methods, collaborating closely with surgeons and industry partners. Current applications include robot-assisted prostate and trans-oral surgery.

Additionally, we're working on improving ultrasound's usability and effectiveness by developing quantitative imaging tools for specific tissue properties, such as Young's modulus and tissue fat percentage. Our research includes accurate measurement of tissue elasticity and viscosity. Moreover, we explore AI-driven techniques to generate MRI-like images from ultrasound, using multi-modal MRI-ultrasound datasets. We collaborate with physicians from VGH, St. Paul's, and BC Cancer, along with industrial partners, for liver assessment, and image-guided prostate cancer biopsy, surgery, and brachytherapy treatment.

## RESEARCH EXCELLENCE

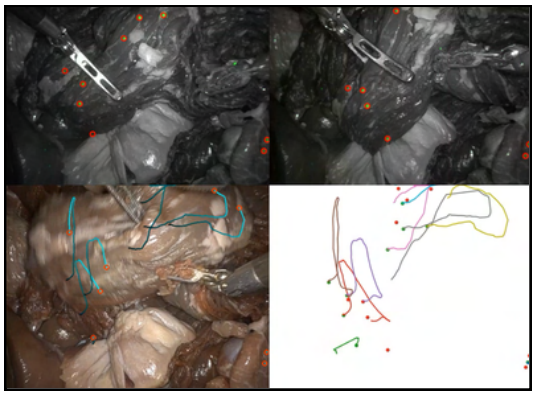
Ultrasound-guidance is vital for disease diagnosis and treatment, and by enabling registration to MRI and CT scans during procedures. Our work addresses robotics and imaging challenges, earning recognition at IPCAI, MICCAI, and Hamlyn conferences. Our prostate elastography system was featured in a recent IEEE TUFFC cover. Our innovations are used at BC Cancer for prostate cancer treatment and licensed to Sonic Incytes for diagnosing fatty liver disease.

## Our Training Program

Our team is globally diverse, uniting students from various engineering disciplines and countries. We prioritize student co-supervision, fostering collaborations with prestigious academic and industry partners. Many students benefit from MD co-supervision, while industrial internships and academic exchanges are actively supported. Our lab boasts exceptional infrastructure, including numerous ultrasound machines, three da Vinci systems, and superior computational resources.

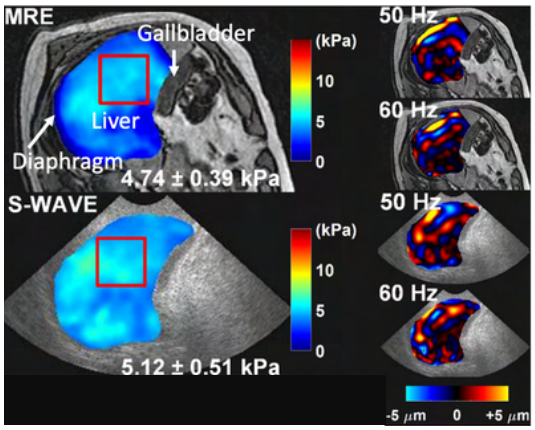
## Tissue Tracking

PhD student Adam Schmidt devised computer vision techniques to monitor tissue changes during surgery. "SENDD" detects and tracks sparse salient points via machine learning, with graph neural functions tracking tissue movements. We validated our method with "STIR," an open-source dataset of tissue interaction sequences. The figure displays tagged start and finish images alongside salient point trajectories.



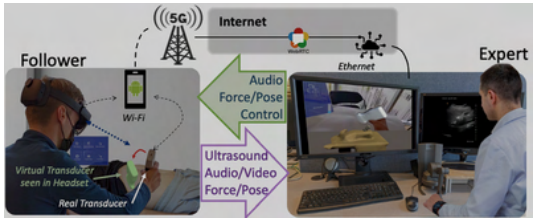
## Elastography

Elastography assesses tissue strain and mechanics. We developed S-WAVE, an ultrasound-based, cost-effective method using multi-frequency shear waves, with results closely matching MRE. The figure illustrates liver shear wave patterns in both MRE and S-WAVE (right column, microns) alongside elasticity maps (left column, kPa).




## Tele-Ultrasound

PhD student and Vanier scholar David Black is developing a new concept in ultrasound - human teleoperation - in which a novice follower (patient, family member or friend) is used as a safe, cognitive robot, to track the motion of a virtual transducer controlled by a remote expert.




HUMAN INTERFACING DEVICES
CORE MEMBER

## IP & KNOWLEDGE TRANSLATION

- Methodology for image guidance and evaluation in patients (liver - non-alcoholic fatty liver disease, prostate cancer, oropharyngeal cancer)
- Quantitative, operator-independent ultrasound imaging techniques
- Tele-health methods to enable remote examination in under-served communities
- New medical image analysis and medical computer vision methods

# ZHENWEI MA

ASSISTANT PROFESSOR

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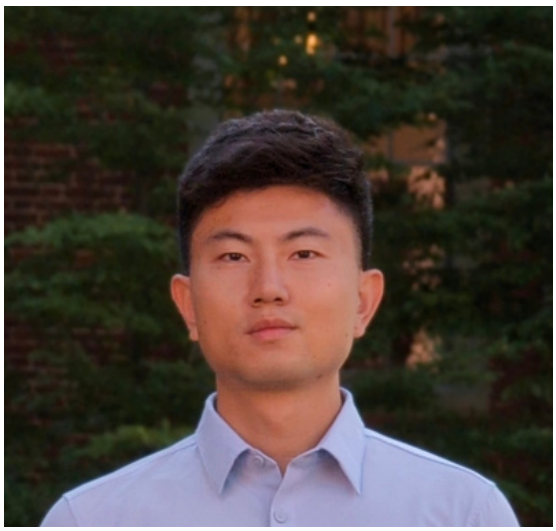


**We design, engineer and manufacture precision biointerfaces, biomaterials and devices to monitor, mimic and regulate human pathophysiology.**



biomaterials | biointerface | biofabrication | regenerative medicine | drug delivery | medical implants | reconstructive surgery | mechanotherapy

## Translational Biointerface Design

Existing human-interfacing devices struggle to integrate seamlessly with living tissues that are mechanically dynamic, biologically complex and immensely diverse. These limitations can lead not only to device failure and insufficient therapeutic efficacy, but also to delayed recovery, chronic complications and reduced quality of life for patients. As a group of interdisciplinary scientists, engineers and clinicians, the Ma Lab aims to overcome these challenges by redesigning and redefining how next-generation biointerfacing devices engage with their target tissues. Our research focuses on creating biomaterials that establish precisely controlled spatiotemporal biomechanical and biochemical interfaces with the human body across multiple scales, ultimately enabling true biointegration and functional symbiosis. These advances hold significant promise for tissue regeneration, rehabilitation and cancer treatment, along with broader applications in reconstructive surgery, trauma management and implantable therapeutic technologies.

The Ma Lab: https://www.zhenweima.ca/

## RESEARCH EXCELLENCE

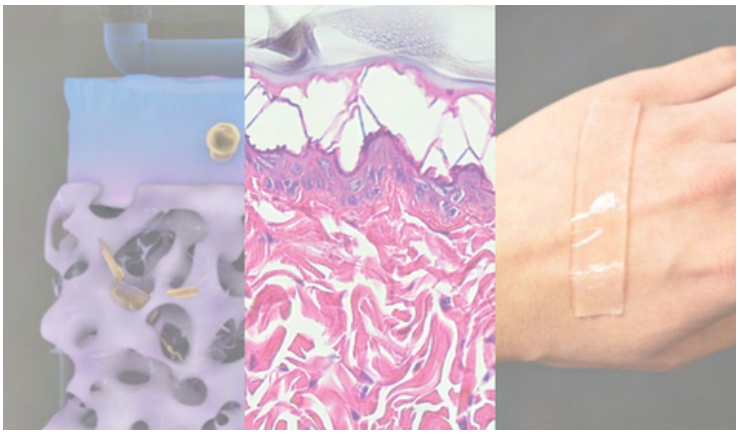
We reported unprecedented spatiotemporal control of tough bioadhesion (Science 2022), engineered multifunctional medical devices (Science Advances 2021), and expanded the additive manufacturing capability of these platforms in (Advanced Functional Materials 2024), collectively laying a strong foundation for our next generation biointerfacing technologies that enable diverse biomedical and clinical applications.

## Our Training Program

Our training program integrates application oriented engineering with curiosity driven science, providing trainees with a strong foundation in biomaterials, biofabrication and translational bioengineering. We foster an interdisciplinary, inclusive, and diverse environment where individuals from varied backgrounds contribute unique perspectives that enrich our lab culture.

## Precision Biointerface Engineering

This research direction focuses on engineering precisely defined biointerfaces that integrate seamlessly with native biological tissues across multiple length and time scales. By leveraging advances in biomaterials design, we aim to establish controlled biomechanical, biochemical and bioelectronic interactions between engineered systems and living tissues. The overarching goal is to achieve stable, functional and adaptive biointegration that enables devices to communicate with, respond to and ultimately operate in harmony with complex biological environments.



**Bioprinted hydrogels, implantable grafts and wearable devices enabled by translational biointerface engineering.**

## Medical Device Functionalization

This research direction aims to design and optimize clinically relevant functionalities that expand the capabilities of next-generation medical devices. By integrating multiple therapeutic and diagnostic functions into a single platform, we seek to enable customizable solutions for diverse biomedical applications, including tissue repair, disease management and targeted therapy. These efforts focus on translating engineering innovations into practical device functions that enhance clinical performance, usability and patient outcomes.

## IP & KNOWLEDGE TRANSLATION

- We collaborate with clinicians and surgeons to ensure clinical feasibility and workflow integration.
- We generate and protect intellectual property to enable translation of core technologies.
- We engage industry partners to accelerate development and real world deployment.

THE UNIVERSITY OF BRITISH COLUMBIA
School of Biomedical Engineering
Faculties of Applied Science and Medicine

# Core Facilities

**SBME researchers have access to a wide range of state-of-the-art core facilities that support cutting-edge biomedical engineering research. These shared resources enable researchers to accelerate discovery and innovation across diverse research areas.**

# SBME Genotyping


The SBME Genotyping Facility provides you with fast and convenient transgenic mouse genotyping services, which helps you save time and allows you to focus on your important research activities.

From molecular engineering to multi-scale systems biology, from point-of-care PCR-based genotyping services are performed to screen mouse mutations such as transgenes and knockouts. The investigator provides ear, tail, cell samples, primers, and positive controls etc. We extract genomic DNA or isolate RNA from your samples and perform assays including positive and negative controls on a conventional PCR, qPCR.

**Lab Manager: Taka Murakami**
taka.murakami@ubc.ca | 604-822-9491
https://bme.ubc.ca/home/genotyping-facility/

**Services Available:**

- Gel Electrophoresis Analysis
- Melting Curve Analysis
- Copy Numbers Analysis
- Single Nucleotide Polymorphisms Analysis

**Facility Equipment:**

- ProFlex PCR System
- Veriti 96-well Thermal Cycler
- QuantStudio5 Real-Time PCR
- QuantStudio6 Pro Real-Time PCR
- QIAxcel Capillary Electrophoresis

# SBME Sequencing


The SBME Sequencing Core (formerly BRC-Seq) is dedicated to providing Single-Cell and Next-Generation Sequencing Services and training to the Research Community. We work collaboratively with the Michael Smith Genome Sciences Centre and the Michael Smith Laboratories, and are located at the Biomedical Research Centre at UBC.

**Facility Manager: Tara Stach**
tara.stach@ubc.ca | 604-827-3381
https://bme.ubc.ca/home/sequencing-facility/

## Services Available:

- Quality Control
- Next Generation Sequencing Library Preparation
- Sequencing utilizing Illumina Instrumentation
- 10x Genomics Single Cell Capture
- 10x Genomics Visium & Xenium Spatial Pipeline
- Bioinformatic Analysis

## Facility Equipment:

- Illumina NovaSeqX
- Illumina NextSeq 2000
- 10x Genomics Chromium X
- 10x Genomics Xenium
- 10x Genomics CytAssist
- Agilent Bioanalyzer & TapeStation
- Eppendorf epMotion 5075

# Conconi Family BioDevice Foundry

## SBME Core Facility

The Conconi Family BioDevice Foundry is a new UBC core facility—the first in Western Canada purpose-built to integrate microdevice engineering with life sciences research. Its unique strength lies in its ability to link cleanroom microfabrication with biofunctionalization, characterization, rapid prototyping, and precision machining, enabling end-to-end development of microscale biodevices for biological and clinical applications. The Foundry supports users throughout the entire biodevice innovation pipeline, including design, fabrication, testing, and characterization. By consolidating specialized infrastructure and expert technical staff, the Foundry lowers barriers to device development, accelerates proof-of-concept studies, and supports both academic and industry collaborators.

Reimagining what a core facility can be, the Foundry strives to serve as a hub where microdevice engineering and life sciences converge—empowering researchers to translate bold ideas into practical biomedical tools and next-generation clinical technologies.

**Lab Manager: Dr. Huawei Li**
huawei.li@ubc.ca
https://bme.ubc.ca/biodevice-foundry/

**Infrastructure:**

- Cleanroom
- Bio-Functionalization
- Rapid Prototyping
- Machine Shop

**Applications:**

- Bioanalytics-on-a-chip devices
- Organ-on-a-chip devices
- Biomanufacturing-on-a-chip devices

# SBME Antibodies - Proteomics - Protein Engineering


The UBC AbLab (Antibody, Proteomics, and Protein Engineering Core) supports the research community and biotechnology sector with antibody, biologics, and multiplexed proteomics services. The facility provides high quality in-house reagents at cost. With extensive experience in protein technologies and bioconjugation, AbLab supports projects from antibody and recombinant protein production to custom downstream processing and modification, including labelling, conjugation, fragmentation, and assay development. AbLab has particular expertise in custom antibody conjugation and the development of highly multiplexed antibody panels for advanced profiling platforms, including CITE-seq, CODEX, Cell DIVE and CyTOF, and is the first centre to offer Olink multiplexed proteomics services in Western Canada.

AbLab also maintains an extensive inventory of commonly used monoclonal antibodies conjugated to multiple fluorophores, along with recombinant proteins, to support a wide range of research applications.

**Lab Manager**
**Michael Williams**
michael.williams@ubc.ca
604-822-8060
www.AbLab.ca

## Services Available:

- Antibody & Protein services
- Multiplexed Proteomics
- Support for bioassay development
- Hybridoma subcloning, validation, banking

## Facility Equipment:

- Akta Pure ALIAS™ with Autosampler
- Akta Smart Purification Systems
- Olink Signature Q100 (multiplexed proteomics)