UBC School of Biomedical Engineering

SYNERGY RESEARCH DAY

AUGUST 17, 2023

Trainee Rapid Talks

In partnership with:

GSAT

UBC THE UNIVERSITY OF BRITISH COLUMBIA
Life Sciences Institute

icord

UBC THE UNIVERSITY OF BRITISH COLUMBIA
Michael Smith Laboratories

Djavad Mowafaghian CENTRE FOR BRAIN HEALTH

Type-2 innate immune signals are dispensable for muscle regeneration and progression of Duchenne muscular dystrophy pathology in mdx mice

Omar Husain Syed

Applied Biology | Kelly McNagny Lab

Type-2 immunity plays key roles at mucosal surfaces in allergic responses, as the first line of defense against large parasites, and tissue repair. The latter has also been demonstrated in sterile injury of skeletal muscle for which eosinophils and type-2 innate IL-4/IL-13 signaling have been shown as essential regulators of muscle resident fibro-adipocyte progenitors (FAPs) proliferation. FAPs in turn promote the proliferation of muscle stem cells (MuSc) resulting in growth and muscle regeneration. In this study, we further investigated this observation using STAT6−/− mice that have impaired type-2 innate signaling as well as ΔdblGATA mice that lack eosinophils. Contrary to previous findings, we found that neither STAT6-/- mice nor ΔdblGATA mice show differences in their regenerative capacity compared to wild-type mice following acute skeletal muscle injury. We also show that STAT6-/- mice have no significant differences in the number of proliferative FAPs and MuSc indicating that type-2 innate signals are not essential for their proliferation. Lastly, we investigated if the absence of type-2 innate signaling impacts skeletal muscle pathology, specifically fibrosis deposition in mdx mice - a mouse model of Duchenne muscular dystrophy. We observed that neither 3-month old nor 10-month old MDX:STAT6-/- mice showed a difference in disease progression compared to mdx mice with functional type-2 signaling. In conclusion, type-2 innate signaling is dispensable for skeletal muscle regeneration after acute injury as well as for fibrosis deposition in chronic skeletal muscle disease.

Microscale Molecular Gradients on Open Biological Surfaces

Jake Pringle

BioEngineering | Govind Kaigala Lab

Biochemical gradients are abundant in dynamic biological systems for guiding the growth, migration and differentiation of cells within living tissues. Their simulation in vitro would allow the study of various physiological and pathological conditions; yet, systems able to replicate the spatiotemporal nature of biologically relevant gradients are limited. In the present work, a cohort of microfluidic probes (MFPs) for generation of biochemical gradients on open biological surfaces were designed. MFP employs hydrodynamic flow confinement (HFC) to localize species at the microscale above a substrate, via the simultaneous injection and aspiration of fluid from microchannels at controlled rates. Thereby, computer aided design, digital light processing 3D printing, finite element flow simulation, and pneumatic controlled flow systems were employed to develop MFPs and operating conditions able to produce linear, exponential, and gaussian shaped concentration profiles in both smooth and stepwise function types, within the flow confinement. Given the HFC exists in the open space, the gradient could potentially be applied to any liquid-submerged sample underlying the device's apex. In addition, changing the injection flow rates demonstrates the ability to tune the gradient's profile in the time domain, while changing the substrate's position via a motorized stage introduces a spatial dynamic of the gradient generating system. Overall, the ability to generate temporally and spatially tuneable gradients in the open space is presented as a toolbox for those interested in studying and designing dynamic biological systems.

Quality Assessment of Cell Lineage Trees

Chaehyeon Lee

Biomedical Engineering | Nozomu Yachie Lab

Recent progress in synthetic biology has led to the development of CRISPR–Cas9-based high-resolution cell lineage technologies that can continuously introduce random nucleotide mutations at synthetic “DNA barcodes” over time. When applied in conjunction with high-throughput single-cell RNA sequencing, lineage-specific barcode mutation and transcriptomic profiles at single-cell resolutions can be retrieved. The mutation profiles from single cells allow for their cell lineage reconstruction using phylogenetic tree reconstruction algorithms, and the resulting lineage trees that capture their lineage information can facilitate various downstream analyses, such as embryonic development, cancer metastasis, and cell population dynamics.

While there are several cell-specific lineage tracing technologies, no quantifiable metrics that measure the accuracy of the reconstructed lineage trees have been developed or applied to any of the previous studies. Therefore, this project aims to a develop quantifiable metric that allows the extraction of highly accurate sub-trees for downstream analyses. By repeatedly reconstructing trees with down-sampled DNA barcode information and averaging the node-specific Nye similarities, it is proposed that highly reliable downstream analyses can be performed using high-scoring nodes.

Development and Testing of a Disposable and Reusable Cattle Breath Nostril Sampler for Rapid Breath Sampling

Qide Ma

Manufacturing Engineering | Jane Hill Lab

Breath sampling enables fast and non-invasive disease diagnosis by collecting biomarkers from the breath to the sampler bag. Thus, developing an air-tight, affordable and resilient sampler interface is a critical part of breath sampling collections. Breath sampling is very commonly implemented in the diagnosis of human and animal diseases due to its non-invasive nature. This project report will mainly focus on the development of the cattle breath sampler interface to ensure that the interface can deliver the breath sampler with the consideration of biodegradable and cost-effective material for sustainability. This presentation will outline the background information of the project, the methodology to make the prototype and testing mechanism, and the analysis of the results.

The development and design of an omnidirectional surrogate neck for impact testing

Sabine Lim

Biomedical Engineering | Peter Cripton Lab

Injuries to the cervical spine region are the most common of central nervous system injuries and can result in the most devastating neurological consequences (i.e. tetraplegia). This summer, I worked on designing and developing an omnidirectional surrogate neck for the evaluation of protective equipment to prevent these types of injuries. I'm continuing the project (as it has been ongoing for a few years) by advancing the design to address previous challenges faced by my predecessors and moving into the testing phase. The core components of the design are the vertebrae, the intervertebral discs, the ligaments, and the muscles, each of which yield their own unique properties that are difficult to replicate. Most of my design and prototyping work includes sourcing new ligament materials, molding and 3D printing different intervertebral discs, and assembling necks to achieve a feasible muscle design. In this talk, I'll discuss the design iteration process I went through and focus on the challenges I overcame throughout the project. I am so grateful for this experience and the opportunity to work on such a novel and necessary device and I would like to share what we've been working on. When finalized, this device will significantly advance anthropometric crash testing technology. Researchers will be able to understand better and prevent these catastrophic cervical spine injuries.

TBISeq - A Spatial Transcriptomics Atlas of the Mouse Brain Following Traumatic Brain Injury

Adi Swaro

Neuroscience | Mark Cembrowski Lab

In Canada, an individual suffers a traumatic brain injury (TBI) every three minutes on average. Individuals that receive a TBI can suffer from a wide range of debilitating physical and mental symptoms. Despite this high rate of injury, and significant quality-of-life consequences, little is known about how TBI mechanistically changes brain structure and function. That is why we built TBISeq. TBISeq is an interactive web app that serves as a resource for other researchers to understand how TBI affects the mouse brain. It was built on spatial transcriptomics data following TBI in mice. The Cembrowski and Wellington Lab generated this large database in order to understand how TBI dysregulates the molecular properties of the brain. However, due to the high-dimensionality of whole-brain spatial transcriptomics data, understanding this dataset can be a challenge. TBISeq overcomes this challenge by computing complex machine learning clustering functions in the backend, and displaying friendly low-dimensional figures at the user-interface. The result of this is an efficient web app, where any researcher can quickly explore how their favorite gene, brain region, or cell type is differentially expressed following TBI in mice. We believe that TBISeq will accelerate research into TBIs' molecular dysregulation mechanisms, and set the groundwork for research into targets for therapeutic treatment.

Charting Cognitive Maps: Navigational Insights from Rats to Robots

Matin Narimani

Biomedical Engineering | Manu Madhav Lab

In this talk, we delve into the intricate realm of spatial navigation and cognitive mapping, spanning the fascinating spectrum from rats to robots. Our research, conducted within the Neural Circuits for Computation, Cognition, and Control Lab, focuses on unraveling the neural mechanisms underlying spatial awareness across different species and technological platforms.

At the heart of our investigation lies the innovative Dome, a virtual reality apparatus that immerses rats in environments where a variety of sensory cues are intentionally in conflict. This immersive setup unveils the adaptive prowess of the cognitive map, illuminating its capacity to encode not only spatial features but also non-spatial attributes such as associating specific frequencies of sound with a reward zone.

Additionally, we introduce the Maze, a versatile apparatus allowing both rodents and humans to navigate dynamically reconfigurable routes through adjustable wall placements. From untethered rat locomotion to human virtual reality immersion and robotic control, the Maze enables cross-species comparisons, unveiling insights into navigational strategies and its interspecies differences.

We seek to quantify when behavioral performance in rats and humans drops as the complexity increases, and identify a corresponding degradation of neural representations that may underlie these navigational behaviors.

Looking ahead, we aim to harness navigation as a diagnostic tool for neurodegenerative disorders, particularly Alzheimer's disease. By probing the cognitive map's resilience in the face of neural degradation, we aspire to revolutionize interventions that enhance cognitive well-being.

ABOUT SBME SYNERGY

SBME SYNERGY is our Undergraduate Summer Research Program, running May-August 2023. Participating undergraduate students have the opportunity to get hands-on research experience with researchers from the Life Sciences Institute (LSI), the Michael Smith Laboratories (MSL), the Djavad Mowafaghian Centre for Brain Health (DMCBH), the International Collaboration on Repair Discoveries (ICORD), the Genome Science and Technology Graduate Program (GSAT), and of course, SBME.

SBME Synergy awards are open to all undergraduate and medical students.

In partnership with:

GSAT

THE UNIVERSITY OF BRITISH COLUMBIA
Life Sciences Institute

icord

THE UNIVERSITY OF BRITISH COLUMBIA
Michael Smith Laboratories

Djavad Mowafaghian
CENTRE FOR BRAIN HEALTH

CONNECT WITH US: