2023

SUMMER UNDERGRADUATE

RESEARCH CONFERENCE

NSERC CRSNG

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Acknowledgements

The Faculties of Science, Health, and Environmental & Urban Change would like to thank the **Natural Sciences and Engineering Research Council of Canada (NSERC)** and the **Canadian Institutes of Health Research (CIHR)** for its support in funding summer research positions at York University through their respective Undergraduate Student Research Awards programs.

The Faculty of Science is grateful to **Dr. Earle Nestmann** for his support in creating the Earle Nestmann Undergraduate Research Award program in the Faculty of Science, which funded 10 positions this summer.

As well, thank you to the **York University Bookstore** for sponsoring gift cards awarded to presentation winners at the conference.

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Rui Wang

Dean, Faculty of Science

Dear students,

The Faculty of Science is proud to host the Summer 2023 Undergraduate Research Conference for students across York University. Thank you for joining us for this special occasion.

Congratulations on receiving a prestigious research award and completing a productive summer term as a research student. I hope that your experience was rewarding and provided an opportunity to explore your interests in science and research, develop new skills and techniques, and grow professionally and intellectually as a student. I would also like to thank you for your hard work; your contributions make a positive impact on the research culture, productivity and achievements of York University and they are deeply appreciated.

I welcome you to view and download this booklet, which highlights and celebrates the exciting research projects conducted by you and your peers this summer. I also wish you a wonderful conference experience and hope that you enjoy sharing your work, learning about what your peers have accomplished, and making new connections with students and faculty.

Yours truly,
Rui Wang

Denis Godin

Director of Scholarship & Fellowships Division, NSERC

Congratulations to all students completing their Undergraduate Student Research Awards (USRA) this summer.

The USRA program provides an exceptional opportunity for Canadian researchers to access top student talent. It is meant to nurture their interest and develop their potential for graduate studies and future research careers in the natural sciences and engineering (NSE) disciplines.

The Natural Sciences and Engineering Research Council of Canada (NSERC) views the USRA program as a key component of the Canadian research ecosystem. Since 1980, NSERC has supported research experiences for students through the USRA program. The program provides direct support for research work terms for more than 3,000 students each year.

This year, the new Black scholars funding from Canada's Budget 2022 is being implemented to increase support for Black scholars at all stages of their careers, including at the undergraduate level. These new funds will help address the disproportionate underfunding of Black scholars and strengthen efforts to break down barriers as well as address inequities as laid out in the Tri-agency EDI Action Plan for 2018–2025. In turn, this will contribute to making Canada's research culture more equitable, diverse and inclusive, and to augmenting Canada's innovation potential.

Should you wish to undertake graduate studies in the NSE fields, you may be eligible to apply for other NSERC scholarships. Refer to the Students and fellows section of NSERC's website for more information.

We would like to express gratitude to the professors who hosted and supervised your research experiences and to all graduate students, postdoctoral fellows and technicians from York University who played a mentorship role and otherwise supported your efforts. We would also like to express our appreciation to the York University staff members who manage the USRA program. The time and attention that you have invested in training the next generation of researchers in Canada are invaluable.

Sincerely,
Denis Godin

BIOLOGY

Ron Alesker

NSERC Undergraduate Student Research Award

PROJECT

Investigating the Molecular Evolution of Lens Crystallin Genes in Frogs

PROGRAM

Biology

SUPERVISOR

Ryan Schott

In order to best understand the present-day diversity in frog vision, it is important to look into the evolutionary patterns by which it arose. One candidate for investigation is the ocular lens, as it exhibits variation in property and function across different frog lifestyles and habitats. An essential component of the frog lens is its underlying crystalline proteins. These proteins influence a len's refractive index, meaning that differences in crystallin gene-sequence may help frog species meet the refractive requirements of their visual environments. Therefore, studying the molecular evolution of crystallin genes is essential to unravel the adaptive significance of the lens in frog vision.

Using BLAST searches, we extracted 10 crystalline genes from 40 frog genomes and 80 frog-eye transcriptomes. PhyML and PAML modelling will be used to infer maximum-likelihood gene trees and selective patterns across species. We will also examine long-term shifts in selection patterns related to species ecology (e.g., habitat, activity pattern) to determine the impact of environmental factors on lens crystallin gene evolution. These findings will establish a foundation for future research on the lens's adaptive role in frog vision.

Taline Apelian-Sutor

York Science Scholars Award

PROJECT

Constructing mutant fungal strains to assay the importance of the TOR nutrient-sensing pathway for circadian rhythmicity in *Neurospora crassa*

PROGRAM

Biology

SUPERVISOR

Patricia Lakin-Thomas

Virtually all organisms – from bacteria to humans – exhibit circadian rhythmicity. This fundamental property of living things is an endogenous process that controls physiology and behaviour over a 24-hour period. Biological (circadian) clocks are said to be generated by the cyclical expression of specific genes. In the filamentous fungus Neurospora crassa, the *frq*, *wc-1* and *wc-2* genes are deemed crucial to the circadian oscillator. When these genes are expressed, their protein products interact in a well-studied transcription-translation feedback loop (TTFL). Importantly, rhythmicity is still seen under certain conditions when this feedback loop is disrupted. This suggests the existence of a FRQ-less oscillator (FLO). We aim to identify the components of the FLO and how they interact with the known TTFL. Employing standard genetic techniques, I am introducing different clock-affecting mutations into a single fungal strain, many of which code for components of the TOR (Target of Rapamycin) nutrient-sensing pathway. These mutant fungal strains will be used to investigate the TOR pathway as a potentially crucial component of the FLO. This research is expected to provide valuable insight into how organisms tell time and help deepen our understanding of contingent processes in humans, including sleep, metabolism, and immune function.

Relam Bashanfar

Earle Nestmann Undergraduate Research Award

PROJECT

Identification of H2A.Zub-interacting proteins by split TurboID

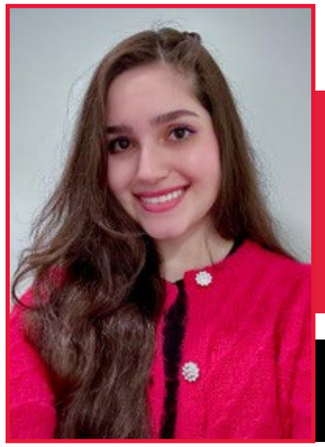
PROGRAM

Biomedical Science

SUPERVISOR

Peter Cheung

H2A.Z is a histone variant important for transcriptional regulation, and we found that ubiquitylated H2A.Z (H2A.Zub) is specifically linked to transcriptional silencing. Since many histone post-translational modifications function by recruiting downstream effector proteins, we hypothesize that H2A.Zub functions by recruiting proteins that act to silence transcription. Therefore, identifying H2A.Zub-specific interacting proteins in human cells could reveal the transcription-silencing mechanism of this histone variant. This will be achieved by using the split-TurboID technique which is useful for identifying protein interactions in vivo since it labels protein interactors of ubiquitylated H2A.Z with biotin which further allows for protein identification through mass spectrometry.



Rozita Bayat

Earle Nestmann Undergraduate Research Award

PROJECT

Development of beta-catenin inhibitors

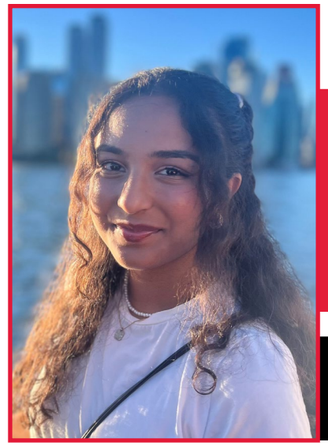
PROGRAM

Biomedical Science

SUPERVISOR

Chun Peng

With a growing and aging population, Canada faces an increase in cancer cases and deaths. In 2022 an estimated 233,900 people in Canada were diagnosed with cancer, and 85,100 cancer-related deaths were expected. The seventh most common cancer for women is ovarian cancer. Among all gynecological malignancies, epithelial ovarian cancer has the highest mortality rate. The Wnt/β-catenin pathway has a significant role in epithelial ovarian cancer. Interaction between ß-catenin and TCF4 promotes the expression of the genes involved in tumor development. Our labs have recently identified C21 as one of the effective inhibitors of the interaction between ß-catenin and TCF4 while having anti-tumor effects. In this project, the anti-tumor effects of C21 will be tested on various cell lines using different methods like cytotoxicity assay, Cell titer Glo assay, and CCK8 assay. The project aims to identify potential therapeutics for epithelial ovarian cancer and positively impact the outcome for patients afflicted with this severe disease.



Areeba Chaudhry

NSERC Undergraduate Student Research Award

PROJECT

Exploring the role of NLRC5 in trophoblast differentiation during placental development

PROGRAM

Biomedical Science

SUPERVISOR

Chun Peng

The placenta is a multifunctional organ responsible for facilitating nutrient and gas exchange between the fetus and mother during pregnancy. During placental development, trophoblast differentiation diverges into two pathways to produce extravillous trophoblasts (EVT) and syncytiotrophoblasts (STB). STBs mediate nutrient transfer between the fetus and mother while EVTs proceed to invade the uterus and help remodel the arteries to increase blood flow to the placenta. Insufficient differentiation of EVTs can decrease blood flow to the placenta, resulting in the onset of a common pregnancy complication known as preeclampsia. As a result, exploring the molecular mechanisms of EVT differentiation is of interest to better understand preeclampsia pathogenesis.

Peng lab has recently identified isoforms 17 and 18 of the NLRC5 protein as potential biomarkers of preeclampsia. The 17/18 isoforms promote STB differentiation at the expense of suppressing EVT differentiation. The goal of my project is to uncover the mechanisms by which the 17/18 isoforms regulate trophoblast differentiation. Through immunoprecipitation-mass spectrometry, splicing factor FUS was identified as an interacting protein of these NLRC5 isoforms. Elucidating the nature of the interaction between the 17/18 isoforms and FUS will provide new insights into the function of NLRC5 in regulating placental development.

Mahnoor Chauhan

NSERC Undergraduate Student Research Award

PROJECT

Biochemical Characterization of Transcription Factors involved in Oxidative Stress

PROGRAM

Biotechnology

SUPERVISOR

Terrance Kubiseski

Intracellular oxygen radicals are becoming recognized as important signaling molecules and have been implicated in many age-related diseases such as Parkinson's, Alzheimer's and cancer. Protein signaling pathways in cells become activated to regulate reactive oxygen species by generating detoxification enzymes that limit the exposure of an organism to long-term damage. We propose to use biochemistry to look at the regulation of expression of detoxification enzymes. We plan to carry out a biochemical analysis of the C. elegans transcription factors and mediators involved in the oxidative stress response. Using molecular genetic studies with C. elegans, we have recently identified 20 transcription factors (such as tbx-2, fkh-9, nhr-14 and others) potentially involved in regulating the gene expression of enzymes involved in the detoxification of oxygen radicals that arise from normal aerobic metabolism. I will test these transcription factor's ability to interact with the genes for the detoxification proteins gst-4 and sod-3 using luciferase fused promoter constructs expressed in tissue culture. Using co-immunoprecipitation and western blot analysis, I will also test for protein-protein interactions of these transcription factors to each other and with transcription factors already known to be involved in the oxidative stress response (skn-1 and daf-16).

Shirley Chen

Earle Nestmann Undergraduate Research Award

PROJECT

A Diamond in the Rough: Biodiversity Implications of Diamond Cholla Plant-Animal Interactions in the Mojave Desert

PROGRAM

Major/Minor Biology & Psychology

SUPERVISOR

Christopher Lortie

Diamond cholla (Cylindropuntia ramosissima) is a wide-ranging species of shrub-like cactus native to the gravelly, desert scrubland areas of Southwestern United States and Northwestern Mexico. Blooming at night, the relatively unknown visitor guild of diamond cholla was studied using a camera trap survey within the Mojave desert in Southern California. Importance of cactus morphology, site density, and biotic associations on animal visitation were evaluated as independent factors. The hypothesis that foundation species provide key ecological functions that support local and regional biodiversity was tested.

In addition, another survey of diamond cholla in the surrounding Mojave area was done to assess regional patterns in its flowering and morphology. Influence of these traits and spatio-temporal differences on animal visitation rates will be further investigated for implications on nocturnal moth-cacti pollinator networks, cacti microhabitat provisions, and reciprocal animal-host associations in desert ecosystems more broadly.

The implications of this research include a deeper understanding of the associational connections that support plant-animal interactions, the extent that foundation species can support and enhance biodiversity, and results from a novel test using camera trap observations that will enable conservation in desert environments.

Chiara Di Scipio

NSERC Undergraduate Student Research Award

PROJECT

Investigating the signaling cascade of a CAPA neuropeptide in the Malpighian tubules of the fruit fly, Drosophila melanogaster

PROGRAM

Biomedical Science

SUPERVISOR

Jean-Paul Paluzzi

Despite being the most common animals on our planet, insects are subject to a great deal of osmotic stress as a result of their large surface area to volume ratio. To overcome this challenge, insects possess a tightly controlled osmoregulatory system, allowing for the maintenance of water and ion homeostasis. The fruit fly, Drosophila melanogaster, possesses Malpighian 'renal' tubules (MTs) that modulate primary urine formation. Since the MTs are not innervated, the fine-tuning of these osmoregulatory organs involves a variety of neurohormones, including factors that stimulate (or diuretic) and those that inhibit (or anti-diuretic) fluid secretion. Previous studies have largely focused on diuretic regulators in Drosophila while little attention has been given to anti-diuretic hormones, which are fundamental for preventing desiccation by avoiding water loss. This study investigates an antidiuretic neuropeptide in Drosophila and aims to elucidate its signaling cascade linking hormonal control of the renal organs. To do so, we combine powerful genetic, molecular, and physiological techniques, including qPCR and the Ramsay bioassay. Comparatively, this study provides vital insight into the hormonal control of excretory organs in other insects, including agricultural pests and disease vectors, that may uncover new tools to mitigate their burden around the globe.

Jacqueline Duhon

Earle Nestmann Undergraduate Research Award

PROJECT

Mechanisms of adiponectin-mediated protection against high glucose-induced cell death in H9c2 cardiomyoblasts

PROGRAM

Biomedical Science

SUPERVISOR

Gary Sweeney

Adiponectin is a hormone that is secreted mainly by fat tissue and mediates numerous cardioprotective effects. Upon binding to its receptors on the cell surface, adiponectin activates the AMPK signalling pathway with the consequences of improved insulin sensitivity, substrate metabolism, and cardiac function. One of the cellular processes that AMPK activates is autophagy, a regulatory process that maintains cellular homeostasis by removing damaged cellular contents. High glucose (hyperglycemia) has been shown to suppress autophagy, leading to cell death in skeletal muscle cells and cardiomyocytes. My study examines the ability of adiponectin to attenuate high glucose-induced cell death and the functional significance of autophagy in mediating this effect. H9c2 cells were treated with high glucose containing media for 24 hours, ± pre-treatment with an adiponectin-mimetic peptide (ALY688). Using a colorimetric method to detect lactate dehydrogenase release from dead cells, I found that ALY688 reduced the amount of cell death induced by high glucose. I will next determine the functional importance of autophagy in this effect of ALY688 by repeating the study in cells which have been made autophagy deficient via CRISPR mediated knockout of Atg7. My studies will provide new mechanistic insight into the cardioprotective effects of adiponectin.

Minoosh Fathi

NSERC Undergraduate Student Research Award

PROJECT

Investigating the phylogenetic diversity and origins of vertebrate opsins through phylogenetic and molecular evolutionary analyses

PROGRAM

Biomedical Science

SUPERVISOR

Ryan Schott

Light detection in animals is mediated by the presence of light-sensitive visual pigments composed of a vitamin A-based chromophore and an opsin protein. Opsins can be broadly grouped into those involved in image-forming vision (visual opsins) and those with non-image-forming functions (nonvisual opsins) such as the regulation of circadian rhythms and responses to seasonality. Across vertebrates, a diversity of species exist that inhabit unique light environments that influence the evolution of opsin genes. Although previous research has examined opsin sequence diversity, there has yet to be a study investigating the evolution of opsin genes across the full phylogenetic diversity of vertebrates. In addition, research comparing the selective pressures and evolutionary rates among the different opsin families, especially the nonvisual opsins, is limited. In my study, we will use phylogenetic and molecular evolutionary analyses to investigate patterns of opsin gene evolution across vertebrates. This research will improve our understanding of the evolution of photoreception and light detection in vertebrates and will serve as a useful foundation upon which to analyze species-specific adaptations to unique spectral environments. On top of this research, we will be working on sequencing and assembling the first eye transcriptomes in salamanders focusing on species that inhabit distinct light environments. These will be used to extract expressed opsin and other visual genes to produce datasets for use in future studies.

Isaac Kogan

York Science Scholars Award

PROJECT

Utilizing Machine Learning to Interpret Antigen Test Results

PROGRAM

Biology

SUPERVISOR

Sergey N. Krylov

Rapid antigen testing is widely used for point-of-care viral detection due to its simplicity and affordability. A potential area for improvement in these tests is to reduce the human error involved in interpreting them. This project sought to design a machine learning model to instantly classify the results of antigen tests, removing the potential for human mistakes and biases in their interpretation. It was developed using the TensorFlow library in Python, and trained on 2,500 labeled images of both positive and negative tests. The model learned to identify the specific features that distinguish positive and negative results: the presence of a single or double line. The design was a Convolutional Neural Network with 3 convolutional layers. It managed to achieve an accuracy of 94.88% and a precision of 94.50%. Although the model reduced human error as expected, it introduced new sources of error due to its reliance on technology. In the future, an even more accurate model could be developed and integrated into mobile devices, providing on-the-fly test result interpretation without human involvement, further lowering the knowledge barrier for individuals to take these tests at home, and reducing the chance for human error.

Christian Nakla

NSERC Undergraduate Student Research Award

PROJECT

Behaviour in social and solitary nests of a small carpenter bee

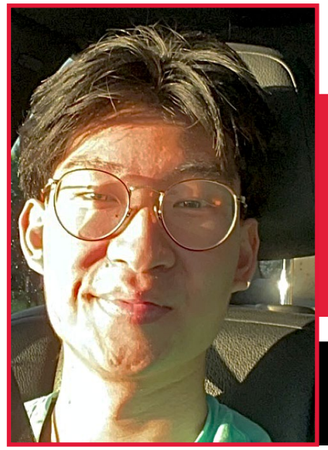
PROGRAM

Environmental Biology

SUPERVISOR

Sandra Rehan

The modern decline of bee abundance and its many ties to ecosystem services have been largely attributed to harmful land use and biochemical applications, but behavioural factors have been scarcely considered. Behaviour encompasses temporospatial regulation of metabolic and physiological activity elicited by environmental stimuli and is corralled to an individual's fitness. The small carpenter bee, Ceratina calcarata, is a facultatively social hymenopteran. This species' social polyphenism is denoted by facultative production of a worker-like dwarf eldest daughter: an undernourished daughter, physically coerced to care for siblings, thereby contributing to her inclusive fitness. Solitary mothers forgo dwarf daughter production and these solitary mothers care for their offspring alone. C. calcarata's natural variation in solitary and social nesting provides a basis for documenting the effects of social environment on its foraging, reproductive, and offspring care. We collected and examined natural solitary and social C. calcarata nests throughout the summer, conducted observation assays to investigate in-nest behaviours, with a long-term goal to establish solitary and social breeding lines to examine the genetic basis of social traits. This research will be applied when integrating C. calcarata's nesting behaviour, niche requirements, and land use to implement suitable conservation and land management practices.



Lewis Nguyen

NSERC Undergraduate Student Research Award

PROJECT

Intergenerational Divergence in Fatty Acid Profiles of Plant Cells

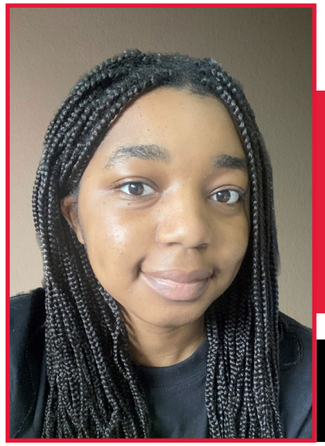
PROGRAM

Biomedical Science

SUPERVISOR

Amro Zayed

The western honey bee, Apis mellifera, is a prolific generalist pollinator that plays a crucial role in crop production systems. Their populations have been threatened by colony decline, brought on by the entangled effects of multi-stressor exposure. Nutritional stress has been implicated as a key contributor to colony decline, but little is known about the role fatty acids play as critical micronutrients. Addressing this knowledge gap could improve our understanding of nutritional stress and provide meaningful information to improve colony management strategies. Work aimed at characterizing the fatty acid composition of pollen diets has been hindered by the cost of mass spectrometry and insufficient data on the micronutrient profile of pollen species. To resolve this, I set out to explore if the fatty acid profile of parental plant cells could be used to infer the fatty acid profile of pollen cells. Implementing a metanalytic approach, my work found no significant correlation in the ratio of omega 3:6 fatty acids. Pollen grains contain a substantially different fatty acid profile than the vascular tissue of the parent plant, rendering this approach unfeasible for nutritional characterization.



Ibifuro Opuso-Jama

NSERC Undergraduate Student Research Award

PROJECT

Analysis of genomic data from the targeted capture of visual genes across frogs using multiple bioinformatic approaches

PROGRAM

Biochemistry

SUPERVISOR

Ryan Schott

Varying activity periods, life histories, and behaviors are factors known to influence the evolution of visual systems in vertebrates but have not been well studied in frogs. Our group has recently assembled large datasets of visual genes from frogs through whole-eye transcriptome sequencing and sampling from available whole genomes. While these analyses are revealing interesting patterns of visual evolution in relation to ecology, we are still only able to sample a small fraction of the over 9000 species of frogs due to the difficulties in obtaining eye tissue. To further increase the breadth and depth of our sampling we are using a targeted capture approach to selectively enrich the genomes of frogs for visual genes prior to high throughput parallel sequencing. This approach allows us to leverage genomic DNA obtained from frozen tissue collections.

We have recently updated our assembly and analysis pipeline and will test these improvements on the target capture data in comparison to data generated using or other, published pipelines. This will allow us to make continued improvements to our pipeline.
Further, we will compare the results of our target capture experiment, in terms of the number and completeness of the genes recovered, with previous experiments to make methodological recommendations for future studies.

Umael Qudrat

York Science Scholars Award

PROJECT

Investigating the Current and Potential Clinical Applications of Spontaneous and Evoked Otoacoustic Emissions in Humans

PROGRAM

Neuroscience

SUPERVISOR

Christopher Bergevin

Of the many remarkable qualities of the human ear, one such characteristic is the generation of otoacoustic emissions (OAEs), whereby the inner ear produces sound, then transmits it through the middle ear and into the external ear canal, where it can be recorded and measured. OAEs vary in type, but can be broadly categorized as spontaneous otoacoustic emissions (SOAEs), or evoked otoacoustic emissions (EOAEs). With the former, the ear generates sound in the absence of acoustic stimuli, while the latter involves evoked responses to certain acoustic stimuli. The presence of OAEs is a reliable indicator of a healthy ear and provides an objective, non-invasive tool for hearing assessment. Thus, for roughly 40 years, OAEs have been a valuable asset to clinicians, their medical applications vast, and their practical potential untapped. This literature review aims to summarize the diverse and prominent clinical applications of OAEs, contributing to a collective understanding of their current role in modern clinical settings, and potential future applications.

Vida Razmjou

NSERC Undergraduate Student Research Award

PROJECT

Enhancing the Understanding of the Cannabinoid Gene Regulatory Network

PROGRAM

Biology

SUPERVISOR

Nik Kovinich

Cannabis, renowned for its psychoactive compound delta-9-tetrahydrocannabinol (THC), contains a diverse array of over 500 bioactive compounds, with around 100 identified as cannabinoids. These cannabinoids exhibit significant pharmaceutical potential, offering symptom relief and pain management, as well as a possible neuroprotective effect for neurodegenerative disorders such as Parkinson's disease and Alzheimer's. Despite the recent legalization of Cannabis and its increasing demand, there remains a dearth of research on the gene regulatory network of Cannabis, particularly for bioengineering purposes and future applications. This knowledge gap hampers the exploration of its commercial and pharmaceutical potential. The primary objective of my project is to unravel the intricate biosynthetic pathways of cannabinoids, with a specific focus on a known regulator called the transcription factor AP2. By investigating the interactions between AP2 and other regulatory elements and transcription factors, we aim to shed light on the underlying mechanisms governing cannabinoid production. This will facilitate the development of plant varieties optimized to generate chemical compounds of pharmaceutical relevance, thereby meeting the demands of emerging and future markets. Through elucidating the cannabinoid gene regulatory network, our research will contribute to unlocking the full potential of Cannabis, enabling the creation of tailored plant varieties that meets diverse pharmaceutical needs and drive innovation in the field.

Brittney Remnant

NSERC Undergraduate Student Research Award

PROJECT

The La protein Mlp1 functions through protein and RNA complexes during non-coding RNA biogenesis in Tetrahymena thermophila

PROGRAM

Biomedical Science

SUPERVISOR

Mark Bayfield

La proteins are conserved RNA binding proteins that function in the biogenesis of non-coding RNAs, including pre-tRNAs and snRNAs. La dependent pre-tRNA processing is highly conserved in eukaryotes: the tandemly arranged La motif (LaM) and RNA recognition motif-1 (RRM1) bind pre-tRNA 3'-uridylate trailers and protect from 3'-exonuclease mediated processing. The La protein, Mlp1, in Tetrahymena thermophila lacks the conserved RRM1, and despite its architecture, our group has characterized Mlp1 as a genuine La protein that functions through an alternative processing mechanism that we hypothesize may involve Mlp1 associated protein factors. When Mlp1 associated Serine/Threonine Kinase, Tgp1 and Tgp3 proteins are co-expressed with Mlp1 in Schizosaccharomyces pombe, they stabilize a distinct pre-tRNA intermediate species, implicating these complexes in an uncharacterized pre-tRNA processing mechanism in T. thermophila. Additionally, ribonucleoprotein immunoprecipitation coupled to RNA sequencing identified Mlp1 associations with the mature snRNAs comprising the spliceosome. Specifically, Mlp1 interacts with the U4/U6 di-snRNP. We characterize Mlp1 binding to the U6 snRNA through a uridylate independent mechanism in which Mlp1 amino acids in a short basic region (226-250) seem to be an important binding determinant. Our work characterizes novel features of Mlp1 protein and RNA complexes and has potential to highlight variability across eukaryotic species.

Yash Shrestha

NSERC Undergraduate Student Research Award

PROJECT

Exploration of altered synaptic pruning in an autism model mouse

PROGRAM

Health Science

SUPERVISOR

Steven Connor

At a cellular level, memory formation is linked to changes in synapses, specialized communication zones between brain cells (neurons). Neurodevelopmental disorders, including autism, show synapse changes that impair cognition, including learning and memory. The underlying deficits may emerge during early “critical” periods of brain development, however, the nature of these changes and associated effects on synaptic plasticity remain unknown. MAM-domain containing GPI anchor protein 2 (MDGA2) is genetically linked to autism. Interestingly, MDGA2 is a synapse suppressor which is highly expressed during critical periods. Accordingly, I tested if genetic reduction of MDGA2 during a major critical period alters synaptic plasticity in the mouse hippocampus, area CA1. My project investigated a major form of synaptic plasticity (long-term depression; LTD) during “synaptic pruning” a critical period wherein excess synapses are removed (“pruned”) to optimize neural circuits, in our mouse autism model (Mdga2+/-). Given that MDGA2 suppresses synapse development, I predicted that reduced pruning in the absence of MDGA2 will impair LTD, reflected as increased excitatory (glutamatergic) synapse number or function. Collectively, my results provide important insights into how the loss of synapse regulation during critical periods of brain development contributes to the cellular basis for autism.

Mina Soufi

NSERC Undergraduate Student Research Award

PROJECT

Rhythmicity of S6 phosphorylation in shaking liquid media

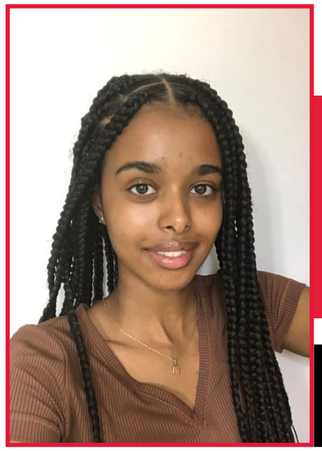
PROGRAM

Biology

SUPERVISOR

Patricia Lakin-Thomas

Most organisms on the earth, including humans, have adopted a circadian clock that regulates their behavioral and physiological activities in response to the 24-hour rotation period of the earth. Even though circadian clocks are found in most eukaryotic organisms, the mechanisms are not completely described. We use the fungus N. crassa as our model organism, using superb genetic and biochemical tools to identify new clock-associated genes and their functions. The purpose of my research project is to investigate whether the clock is running in shaking liquid media in the constant dark or not, and to answer this question, I am investigating whether the phosphorylation state of S6 protein is rhythmic or not (previously, Dr. Lakin Thomas’s lab has developed an assay to quantitate the phosphorylation of a downstream target of TOR, S6 ribosomal protein which is associated with rhythmic circadian clocks). The vital role of circadian clocks in regulating human behavioral and physiological activities and how our knowledge of circadian clocks can be beneficial in preventing some human diseases, including cancer and diabetes, indicates the importance of studying the underlying mechanisms of these clocks.



Asli Yusuf

NSERC Undergraduate Student Research Award

PROJECT

Evaluating Long-term Ecological Change in Frame Lake Using Diatom Subfossils as Paleolimnological Indicators

PROGRAM

Environmental Biology

SUPERVISOR

Jennifer Korosi

Frame Lake is in the city of Yellowknife, Northwest Territories, Canada. The water quality of this lake is poor due to eutrophication from urban development, and legacy arsenic contamination from former gold mining operations. Eutrophication caused under-ice winter oxygen depletion. As a result of this winter anoxia, Frame Lake is unable to support fish.

A remediation plan has been proposed to install an aerator in Frame Lake during the winter, to rehabilitate Frame Lake by reoxygenating the water to allow it to support fish. But before the plan is initiated, it is important to characterise the ecological impact of legacy arsenic contamination and eutrophication, and to establish a reference point from which to evaluate the success of the remediation project moving forward.

Paleolimnology is the scientific field that analyses sediment cores retrieved from inland aquatic water bodies to reconstruct environmental conditions over time. Using paleolimnological techniques, I am analysing diatom (phytoplankton, Class Bacillariophyta) subfossils in a sediment core that was retrieved from Frame Lake as paleolimnological bioindicators. The age of the sediment core had been determined. Therefore, I am using the diatom species assemblages to infer the environmental conditions of Frame Lake prior to, during, and after the impact.

CHEMISTRY

Fraser Coombs

NSERC Undergraduate Student Research Award

PROJECT

5-Formylcytosine DNA Extension

The 5-formylcytosine modification found in DNA is written by TET proteins that oxidize 5-methylcytosine. The f5C modification is often removed, resulting in the demethylation of DNA. DNA methylation is an important epigenetic modification that is responsible for the regulation of gene expression. The loss of DNA methylation can reveal new sites for transcription factor binding that can result in transcriptional changes that result in cancer.

This is a project to quantify the amount of f5C modifications in DNA using qPCR. DNA that contains higher levels of the f5C modification should be extended more than DNA without the modification, which will be observed using qPCR. This will be a step towards identifying individuals who have a higher risk of developing cancer, as elevated levels of f5C indicate transcriptional changes in that individual.

PROGRAM

Biochemistry

SUPERVISOR

Ryan Hili

Nicole Frias

NSERC Undergraduate Student Research Award

PROJECT

Exploring the Reactivity of Carbyne Anion Precursors with Lewis Acidic Boranes

Diazoalkanes are known as “masked carbenes”, shown to undergo N2 elimination to form both persistent and transient carbenes. Carbenes have divalent, neutral carbon centers and can undergo a plethora of reactivity. One major area of interest is the reactivity of diazoalkanes with boranes, in which it has been shown that carbenes can insert into boron-carbon bonds. This reactivity has been applied in Frustrated Lewis Pair (FLP) chemistry, defined by sterically-hindered Lewis acid-base pairs possessing unique catalytic properties.

Recently, monosubstituted diazoalkanes have shown to form stable carbyne anion precursors upon deprotonation. These have been utilized to form metal-carbyne complexes with the carbyne carbon in its singlet state, stabilized by π-donor substituents. However, there is no precedent for how these carbyne anion precursors react with Lewis acidic boranes. It is suspected that the insertion of a carbyne into a boron-carbon bond could produce highly reactive borataalkenes (boron-containing analogues of alkenes). Over this 4-month research term, the goal is to synthesize and fully characterize these borataalkenes, analyzing the structure and properties that may be used to activate small molecules. This could be applied towards metal-free catalysts, which is a more sustainable approach by replacing the use of precious metals in organic transformations.

PROGRAM

Biochemistry

SUPERVISOR

Christopher Caputo

Owen Gray

Earle Nestmann Undergraduate Research Award

PROJECT

Investigation of Transition Metal Oxide as an Efficient Catalyst for the Oxygen Evolution Reaction

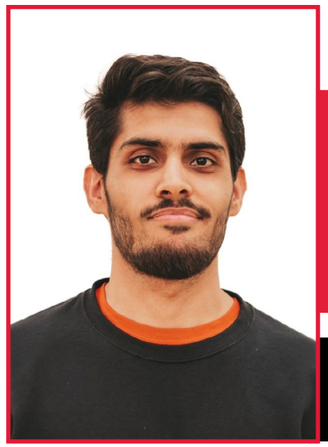
PROGRAM

Biochemistry

SUPERVISOR

Sylvie Morin

Obtaining hydrogen gas (H2) through water electrolysis in an alkaline media is a promising alternative to non-renewable energy sources that contribute to climate change. However, it is still too expensive to produce green H2, because the oxygen evolution reaction (OER) taking place at the anode proceeds at an inefficient rate and limits H2 production. This inefficiency can be solved using rare and expensive iridium or ruthenium electrocatalysts, but this is not a realistic approach due to high prices. Our research explores alternative catalysts for the OER that are composed of readily available and affordable 3d transition metals. Electrochemical methods are used to examine the electrocatalytic properties of cobalt spinel oxide catalysts that contain varying concentrations of copper, iron, and nickel to understand how the composition and structure of the catalyst is linked to its electrochemical properties. In this project, we are interested in the effect of spinel (crystalline/ordered) versus amorphous (disordered) structures on the performance towards the OER. In conclusion, our project aims to improve the production of hydrogen gas by identifying an affordable and efficient OER catalyst.



Ebadullah Kabir

Earle Nestmann Undergraduate Research Award

PROJECT

Determining the optimum configuration of an electrochemical cell (EC) for online reduction of disulfide bonds for incorporation in Hydrogen/Deuterium Exchange Mass Spectrometry (HDX-MS) experiments.

PROGRAM

Analytical Chemistry

SUPERVISOR

Derek Wilson

Hydrogen/Deuterium Exchange Mass Spectrometry (HDX-MS) is a powerful technique for assessing protein shape, motion, folding, and interactions. Electrochemical reduction of disulfide-bonded proteins in HDX-MS has recently been successfully established using an electrochemical cell (EC). An EC is favored over conventionally used chemical reductants, such as tris(2-carboxyethyl)-phosphine (TCEP), due to better reactivity in ‘HDX-MS’ conditions. Although previous research has tackled the technical challenges of using an EC, such as compatibility with specific buffers and unwanted side reactions, this project aims at finding the best way of attaining the greatest sequence coverage of disulfide-bonded proteins using an EC. We achieve this by determining the optimum locus of an EC within a typical HDX-MS workflow, i.e., its configuration. Additionally, this project aims at determining if the optimum configuration is protein-based using three model proteins: insulin, vascular endothelial growth factor (VEGF), and lysozyme. The finding of this research has the potential to shed new light on a concrete mode of incorporating an EC into HDX-MS experiments that allows us to analyze proteins with greater depth and confidence. The outcome of this project is vital to healthcare research as it is an important step forward to better assessing the conformation and dynamics of disulfide-rich proteins associated with diseases.

Jessica Latimer

NSERC Undergraduate Student Research Award

PROJECT

Practical Accuracy Assessment of Equilibrium Dissociation Constants

PROGRAM

Arts & Science, and Molecular Biology & Genetics (McMaster University)

SUPERVISOR

Sergey N. Krylov

The equilibrium dissociation constant (Kd) characterizes the stability of a target-ligand complex and Kd values are used in therapeutic and diagnostic applications. However, laboratories have reported different Kd values for the same complex. Previous research in the Krylov Lab developed a workflow to evaluate the accuracy of Kd using a single binding isotherm, offering and alternative to experimentally intensive methods of Kd validation. This project seeks to automate this methodology and create a practical Kd assessment tool using a Python script. The program streamlines data input, error propagation, non-linear fitting, analysis and reporting with a graphical user interface and PDF report. The computerized process allows for rapid investigation of Kd accuracy within a single platform and facilitate research avenues that would be infeasible manually.

Hannah Le

Earle Nestmann Undergraduate Research Award

PROJECT

Value-Added Vat Orange 3 Dyes For Functional Materials Development

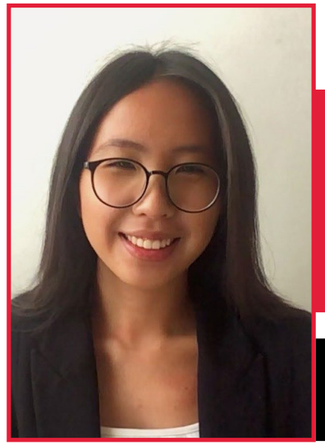
PROGRAM

Biochemistry

SUPERVISOR

Thomas Baumgartner

Neutral organic dyes are garnering attention due to their carbon -rich, π -conjugated scaffold that allow for fine-tuning in their photophysical properties. Vat dyes are of interest in particular due to their low-cost and fused ring structure that leads to attractive features such as strong π -π interaction and luminescence. Recently, the chemistry of vat dyes is being explored to develop value-added materials that can potentially be studied for advanced biological applications due to their absorption/emission in the near-infrared region of the optical spectrum.
This work is expected to provide valuable insights into making advancements towards stable and biocompatible fluorescent probes that can be used for bioimaging and medical diagnostic testing. To further this investigation, the expansion of the VAT Orange 3 dye backbone by incorporating phosphorus heterocycles into the framework is explored. This research focuses on the development of synthetic strategies used towards the VAT Orange 3 system via systematic variations of the scaffold that will provide access to a range of different materials. Along with the synthesis, advanced characterization of the derivatives will be performed to analyze the system's overall electronics and photophysical properties as a function of phosphorus incorporation and the presence of different electron withdrawing/donating motifs.



Nhu Nguyen

NSERC Undergraduate Student Research Award

PROJECT

Direct Synthesis of Acyl Fluorides from Carboxylic Acids through the In Situ Generation of Difluorophosgene

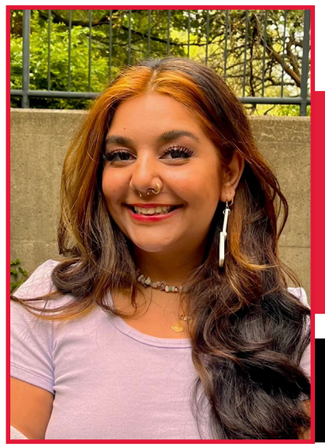
PROGRAM

Chemistry

SUPERVISOR

Christine Le

Acyl fluorides have garnered attention as versatile intermediates in organic synthesis owing to their unique reactivity and stability compared to other acyl halides. Widely utilized as acylating, arylating (alkylating) and fluorinating reagents, some applications of acyl fluorides include its use in nucleophilic substitution reactions, especially in amide (peptide) synthesis, and in transition-metal catalysis. The typical route to access acyl fluorides is through the direct conversion of carboxylic acids. Since many of the current methodologies employ the use of toxic reagents or harsh reaction conditions, new synthetic approaches are coveted. This research explores the synthesis of acyl fluorides through the deoxyfluorination of carboxylic acids using a methodology developed by the Le group that produces difluorophosgene in situ. In detail, the combination of a difluorocarbene source and mild oxidant in the presence of a carboxylic acid can afford the corresponding acyl fluoride in good to excellent yields after a simple purification. Its scope and potential applications in the one-pot syntheses of amides, esters and thioesters are also examined. We anticipate that the operational simplicity of this method will help expand the toolbox that organic chemists can use to access medicinally relevant compounds.



Aleeza Qayyum

NSERC Undergraduate Student Research Award

PROJECT

The Hyperphosphorylation of Amyloidogenic Tau

PROGRAM

Biomedical Science

SUPERVISOR

Derek Wilson

Tau is a microtubule-associated protein that plays a critical role in stabilizing neuronal microtubules. Tau can undergo modifications, including hyperphosphorylation by glycogen synthase kinase 3β (GSK3β). This leads to abnormal aggregates that are toxic to neurons, resulting in neurological diseases known as Tauopathies, with Alzheimer's disease being the most recognized. With estimated 152 million cases of Alzheimer's worldwide by 2050, it is essential to develop strategies to halt the progression of Tauopathies. In this study, we optimized the in vitro synthesis of phosphorylated Tau (pTau) using various techniques and parameters. The optimization of in vitro pTau expression is crucial in developing treatments for neurodegenerative disorders. We utilized Time-Resolved Electrospray Ionization Hydrogen-Deuterium Exchange Mass Spectrometry (TRESI-HDX-MS) to investigate the structural behaviour of pTau. This labelling technique allows analysis of the conformational dynamics and structural changes of proteins. Our results indicate that when Tau is hyperphosphorylated, there is a global increase in deuterium uptake, and the regions that bind to the microtubule show significant deuterium uptake. These findings provide insight into how pathogenic pTau behaves and will be helpful in understanding the mechanisms behind Tauopathies. Ultimately this will aid in developing new therapeutic strategies for Tauopathies and improving existing therapeutics.

Pariya Rastegar

Earle Nestmann Undergraduate Research Award

PROJECT

Design and Synthesis of Novel Aminouracil Derivatives for Inhibition of the Oncogenic m6A Reader YTHDF1

PROGRAM

Biochemistry

SUPERVISOR

Ryan Hili

YTHDF1 is a member of YTH domain proteins that are classified as m6A readers. m6A is the most prevalent epigenetic modification in many eukaryotic mRNAs. YTHDF1 recognizes and binds the m6A modification within the DRACH sequence motif. YTHDF1 binding enhances the stability, translation, and initiation rate of the m6A-RNA by promoting ribosome assembly and increasing RNAse resistance. This leads to overexpression of proteins, thus influencing the oncogenesis and metastasis of various cancer cells. Inhibiting this reader would suppress the expression of these proteins. Yet, current inhibitors are weak or have unfavourable characteristics. Known binders include Ebselen, Tegaserod, Uracils, and to a small extent purines and pyrazolopyramidines. Ebselen is an irreversible inhibitor, since YTHDF1 is involved in many regulatory pathways its total elimination is not desired. Of the reversible inhibitors, uracils provide the most promising scaffold for modificiation due to high ligand efficiency. This project focuses on building on uracil units by modifying the C6 position as aminouracil derivatives, and extension at the C3 position to enhance affinity. Developing a YTHDF1 inhibitor with low IC50 and high LD50, with adequate difference between the two values, is of utmost importance in providing safe treatments for m6A related diseases such as cancer.

Hossein Shahidinejad

York Science Scholars Award

PROJECT

Aptamer-Based Lateral Flow Immunoassay Assisted by Electrophoresis for COVID-19 Diagnostics

PROGRAM

Biochemistry

SUPERVISOR

Sergey N. Krylov

The pandemic of COVID-19 has sparked intense global need for quick and accurate techniques that detect the SARS-CoV-2 virus. The most commonly used tests for COVID-19 are reverse transcription polymerase chain reaction (RT-PCR) and immunoassays. The choice of test depends on the application: RT-PCR is more accurate, effective, and ideal for asymptomatic cases, but is quite more expensive and time-consuming. Immunoassays lack such precision, but are faster, less costly, and can be used for rapid screening in large populations. On that note, we are now pioneering a high-speed screening test for COVID-19 without compromising its acuity, through the adoption of our newly created electrophoresis-assisted multilayer assembly of nanoparticles for sensitive lateral flow immunoassay (LFIA). This modified LFIA system has been proven to increase the diagnostic sensitivity of conventional immunoassay from 73% to 98% for hepatitis B. Furthermore, we are working to replace the use of antibodies in the current assay with aptamers to improve its cost-friendliness and performance for COVID-19 diagnosis.

MATHEMATICS & STATISTICS

Muhammad Azeem

Dean’s Undergraduate Research Award

PROJECT

The Distance From Rank r Projections to Nilpotents on C^n

Building upon MacDonald’s paper on the “Distance From Projections to Nilpotent” and Cramer’s paper on “The Distance From a Rank n - 1 Projection to Nilpotent Operators on C^n”, our project aims to investigate Cramer’s conjecture regarding the distance between rank r projections of size n x n, where r ranges between 1 and n. To begin our investigation, we focused on a rank 2 projection of size 4 x 4. Our objective was to determine whether it is possible to find a distance smaller than 1/√2, which was proposed by Cramer to possibly be the shortest distance for size 4 x 4 with rank 2 projections. We used various methods for these calculations, primarily utilizing the Arveson Distance Formula for an arbitrary projection of size 4 x 4 with rank 2. Additionally, we used optimization techniques from multivariable calculus to determine the minimum value for each eigenvalue we obtain from Arveson, which would provide us information about the distance.

PROGRAM

Double major in Mathematics and Physics

SUPERVISOR

Paul Skoufranis

Taiye Estwick

NSERC Undergraduate Student Research Award

PROJECT

Optimal behaviour strategies for public health policy during COVID-19

The aim of this project is to assess adherence of non-pharmaceutical interventions (NPIs) during the first wave of COVID-19 in each of the Canadian provinces and compare them to optimal strategies. We do this by simulating a compartmental SIR model through the different stages of the disease including testing rates, the exhibition of symptoms, and behavioral patterns, such as contact reduction through implementation of NPIs and fatigue from isolation. Using provincial case data in the first wave of the pandemic we determine testing and adherence parameters and contrast healthcare outcomes to those if no mitigations were present. The inferences derived from this research will provide insight into the optimization of these non-pharmaceutical interventions, should a similar situation arise.

PROGRAM

Applied Mathematics

SUPERVISOR

Iain Moyles

Ravish Kamath

NSERC Undergraduate Student Research Award

PROJECT

Correlational Methods in Microbiome Data

It is well known that the changes in composition of the gut microbiome have been associated with various diseases such as asthma, obesity and inflammatory bowel disease. However, measuring compositional data presents its own unique challenges, as the numbers in the data matrix can only be interpreted relative to the other measures in the same sample. A common analysis tool is to conduct correlation analysis, however traditional techniques (such as Pearson, Spearman and Kendall's tau) may not be appropriate. This project aims to first simulate realistic microbiome datasets and then apply and compare the correlation techniques to ascertain how reproducible the results are with different methods on the simulated dataset.

PROGRAM

Statistics

SUPERVISOR

Kevin McGregor

Eniola Ogunjimi

NSERC Undergraduate Student Research Award

PROJECT

Applying machine learning to invert cryptographic hash functions

PROGRAM

Applied Mathematics

SUPERVISOR

Michael Zabrocki

Within cryptography a cryptographic hash function (CHF) has many applications, though in particular it provides a single number which acts as a signature for a given input. The most important property of a CHF is that it should be infeasible to determine the input from the given value of the output. However, this research project aims to investigate whether the use of Machine Learning processes such as neural networks and deep learning, have any significant impact on the predictability of finding the inverse of a specific cryptographic hash function, the SHA256 hash function. Through the examination of any possible relationship between the SHA256 hash and its binary representation, we hope to explore this possibility further or rule out any correlation between the two. Our ultimate objective is to be able to predict the input based on the information we receive from output with a probability greater than chance (50%). The importance of this project is to report on what methods were used and their corresponding results (whether negative or positive), to build upon the research of this task within the field of cryptography and cybersecurity.

Thi Hong Uyen Pham

Earle Nestmann Undergraduate Research Award

PROJECT

Read-depth modelling in microbiome data

PROGRAM

Actuarial Science

SUPERVISOR

Kevin McGregor

The gut microbiome plays a crucial role in the human digestive system by breaking down dietary fibers and has implications in immunity and in brain health. Many diseases have been shown to be associated with changes in the composition of the gut microbiome. While a plethora of modeling techniques have been developed to address the unique statistical challenges in microbiome data analysis, there have not been any studies relating to how to effectively model the read depths, which refer to the total number of “reads” generated per sample in the sequencing process. Typically, models treat read depths as fixed quantities, but in reality, they are random variables and should thus be modelled using an appropriate distribution. This project involves using various modeling techniques to fit the read depths of gut microbiome sequencing data, using different real-life datasets to seek the most appropriate methods. Model performance will be evaluated using QQ plots and Kolmogorov-Smirnov tests. Our goal is to compare performance and outline the advantages and disadvantages of the different read depth modeling methods.

Joe Tran

NSERC Undergraduate Student Research Award

PROJECT

The Distance From Rank r Projections to Nilpotents on C^n

Building upon MacDonald's paper on the "Distance From Projections to Nilpotent" and Cramer's paper on "The Distance From a Rank n - 1 Projection to Nilpotent Operators on C^n", our project aims to investigate Cramer's conjecture regarding the distance between rank r projections of size n x n, where r ranges between 1 and n. To begin our investigation, we focused on a rank 2 projection of size 4 x 4. Our objective was to determine whether it is possible to find a distance smaller than 1/√2, which was proposed by Cramer to possibly be the shortest distance for size 4 x 4 with rank 2 projections. We used various methods for these calculations, primarily utilizing the Arveson Distance Formula for an arbitrary projection of size 4 x 4 with rank 2. Additionally, we used optimization techniques from multivariable calculus to determine the minimum value for each eigenvalue we obtain from Arveson, which would provide us information about the distance.

PROGRAM

Mathematics for Education

SUPERVISOR

Paul Skoufranis

Sunqiaohe Zheng

Earle Nestmann Undergraduate Research Award

PROJECT

Exploring L1 Regularization pruning to identify relevant words and interactions on twitter trends

This study aims to harness the potential of LASSO regularization in identifying significant features in sparse linear associations. Specifically, we intend to apply this methodology to analyze trends in Twitter data. In this context, tweets serve as inputs, words as features, and the output variable represents their trendiness. By employing standard text processing techniques, the data will be transformed into a bag-of-words format. Subsequently, LASSO-based machine learning models, such as GLM-lasso, will be utilized to select relevant features (i.e., words). Additionally, an exploratory analysis of the identified words and their interactions will be conducted to provide meaningful insights into the Twitter topic under investigation.

PROGRAM

Statistics

SUPERVISOR

Jairo Diaz-Rodriguez

PHYSICS & ASTRONOMY

Hemish Ahuja

York Science Scholars Award

PROJECT

Quantum error mitigation for SWAP gates using Dynamical Decoupling

PROGRAM

Honours Physics & Minor in Computer Science

SUPERVISOR

Randy Lewis

A noiseless quantum computer could perform certain calculations exponentially faster than any classical computer, but today's quantum computers are not noiseless. A quantum state can easily lose information or coherence due to high sensitivity to environmental noise.

While many types of errors can arise in a quantum circuit, idling errors can be especially consequential. An idling error happens when one or more qubits remain momentarily idle in an algorithm, which causes those qubits to undergo decoherence.

In our study, we tried to mitigate idling errors for a 3-qubit system where SWAP gates are used. We chose SWAP gates because they are multi-step entangling gates that occupy a long time within the circuit, with other qubits often left idle during that time.

The mitigation method we used is called Dynamical Decoupling (or DD). While the usefulness of DD is established in principle, application-level usage for this context has yet to be achieved. Our project involves designing and testing various DD options for the SWAP gate that can work in any general circuit to improve the overall fidelity. It provides a small step of progress toward the massive goal of quantum error mitigation.

Tirthrajsinh Chauhan

NSERC Undergraduate Student Research Award

PROJECT

Towards a Measurement of the Electron Electric Dipole Moment

EDMcubed stands for the electric dipole moment of the electron will be measured to high precision. The measurement takes advantage of the large electric field that an electron experiences inside of a polar molecule (BaF in this case), and takes advantage of the large number of these molecules that can be embedded into a cryogenic sample of solid Argon. The project focuses on building and testing one of the many systems including a cryogenic system, a vacuum system, a magnetic field system, a radio-frequency system, and an optical detection system needed to perform the experiment.

PROGRAM

Physics

SUPERVISOR

Eric Hessels

Sarah Powell

NSERC Undergraduate Student Research Award

PROJECT

Theoretical particle physics on quantum computers

My research project for this summer is to help develop material for a quantum computing summer school being held at the Thomas Jefferson National Accelerator Facility in Virginia. I will be presenting and developing this material alongside my supervisor Dr. Randy Lewis and Dr. Natalie Klco who is a professor at Duke University. The material will be based directly on our research simulating lattice gauge theories on quantum computers. It will focus largely on understanding how to mitigate errors made by the quantum computers. Current hardware is very noisy and error-prone, so developing and utilizing techniques that mitigate the mistakes made by the devices is essential to performing quantum simulations. Our presentation will feature a hands-on activity where students will be able to run a simulation on actual quantum computers and mitigate errors made by the devices themselves. In addition to preparing for the summer school, I will continue to look for ways to refine our current techniques for mitigating errors on quantum devices.

PROGRAM

Physics

SUPERVISOR

Randy Lewis

Jaskaran Randhawa

NSERC Undergraduate Student Research Award

PROJECT

Inexpensive Radio Frequency Synthesizer for Atom Interferometry with Cold Atoms

PROGRAM

Physics

SUPERVISOR

Ananthanraman Kumarakrishnan

We present the design and characterization of an inexpensive, high-stability radio frequency (RF) synthesizer that uses phase locked loops to derive multiple outputs for atom interferometry experiments with cold atoms. The synthesizer allows digital control of frequency while maintaining frequency stability with respect to a master reference oscillator. Here, we utilize commercially available components to produce dual RF outputs that are tunable over 50 MHz in the vicinity of 250 MHz. The difference frequency between outputs can be tuned from 1 μHz to 50 MHz. We achieve exceptional frequency stability by phase-locking the RF outputs to a 10 MHz rubidium clock with a short-term stability characterized by a 1s Allan deviation of 2 × 10^(−11). Our implementation also includes a method for correcting the phase of the output when the frequency is changed. This device will be used for frequency domain experiments involving atom interferometers that require two or more RF signals that differ in frequency. Optical pulses with the appropriate central frequency will be generated with this RF source by driving resonant acousto-optic modulators (AOM).

Aster Schnell

Dean's Undergraduate Research Award

PROJECT

Role of dark matter in the formation of the first stars

PROGRAM

Specialized Honours Physics & Astronomy (Astronomy Stream)

SUPERVISOR

Sean Tulin

Dark matter is a key component when considering the formation of the first stars in the Universe. The early stars are thought to have formed in dense dark matter structures, but dark matter itself remains poorly understood. This can be attributed to the fact that dark matter does not interact electromagnetically and only its gravitational influence on ordinary matter has been observed thus far. The most popular model of dark matter, cold dark matter, assumes dark matter interacts only gravitationally, but different models exist which consider different interactions and forces. Our project is both theoretical and computational and aims to explore the role different models of dark matter play by simulating a primordial gas cloud collapsing into a star within a dark matter structure. Different dark matter models will yield different results and may be able to better explain certain astronomical observations. One topic of interest is the formation of supermassive black holes, which exist at the centre of many galaxies including the Milky Way but whose formation remains unexplained by our current understanding of the Universe.

Sophia Thompson

NSERC Undergraduate Student Research Award

PROJECT

Space Charge Layers in Solid and Liquid Electrolytes

Batteries are built using two electrodes (positively and negatively charged) to facilitate the continued flow of electrons in a circuit, and an electrolyte between them for transferring lithium ions. Most electrolytes are liquid, but solid electrolytes are recently becoming a more prevalent option due to their higher power density and lower self discharge. Regardless of electrolyte type, the charge transfer mechanism results in space charge layers forming near the electrode-electrolyte interface. Mathematical models of batteries assist in assessing a battery's state of charge and in understanding and optimizing battery mechanisms.

PROGRAM

Physics

For this work, we extend a space charge layer analysis for solid electrolytes by Keane and Moyles to liquid electrolytes. We have developed a mathematical model of liquid electrolytes as well as a code to simulate the electrolyte model for both liquid and solid types. We compare the space charge layers that form, particularly their composition and thickness. Classifying and modelling the structural differences between the types of electrolytes will provide insight into adapting traditional liquid-electrolyte models to solid electrolytes and inform important differences.

SUPERVISOR

Iain Moyles

ENVIRONMENTAL AND URBAN CHANGE

Summer Solmes

NSERC Undergraduate Student Research Award

PROJECT

Protected areas and biodiversity conservation: are insects declining?

PROGRAM

Environmental Studies

SUPERVISOR

Sheila Colla

This project aims to quantify the affects of anthropogenically-induced climate change on insect biomass and diversity at Ontario's first Priority Place, the Long Point World Biosphere Reserve. It will compare changes in insect communities across a 30-year period, between the 1990s (1992-1994) and the 2020s (2021-2023), to address questions regarding the gravity of various threats driving decline, which insect groups are most affected, and to what degree current conservation management has proven effective in this protected area. As an USRA, my roles and responsibilities include conducting fieldwork using various collection methods, sorting and identifying insects to the taxonomic level of Order, obtaining wet and dry biomass results for each sample obtained, and pinning and identifying specimens to the level of Genus, and species where possible.
The significance of this research works to improve understanding about the waning relationship between biodiversity and humans via the affects of unsustainable land-use development and climate change by highlighting the direct consequences of insect population declines on ecosystem services provided by such. Determining the severity of these impacts can help inform the design of protected area management to better facilitate the conservation of biodiversity and embolden the importance of maintaining biodiversity on a global scale.

Mira Bhattacharya

NSERC Undergraduate Student Research Award

PROJECT

Neuronal Correlates of Flexible Decision Making

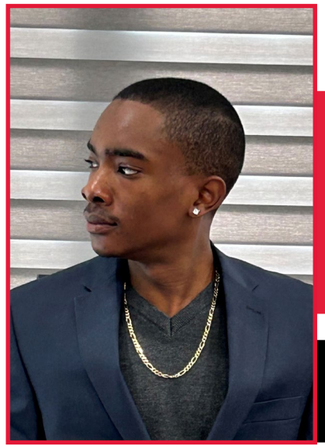
PROGRAM

Cognitive Science

SUPERVISOR

Liya Ma

Humans and other animals rely on cognitive flexibility to adapt to changes in their environment. This ability enables a flexible switch between rules when context changes. For instance, when a traffic light turns yellow, cognitive flexibility allows individuals to decide whether to press the gas pedal or apply the brakes. Impaired cognitive flexibility, as observed in disorders such as obsessive-compulsive disorder and schizophrenia, significantly compromises people's independence and well-being. Cognitive flexibility is supported by an extended brain network that includes multiple areas in the frontal lobe. However, it remains unclear how neurons within and across brain regions interact to facilitate the switch between alternative rules. Rats were trained to flexibly switch between win-stay and win-shift strategies. Simultaneously, neuronal activities were recorded from two brain areas known to support rule-based decision making: the anterior cingulate cortex (ACC) and the frontal orienting field (FOF). Using custom-written MATLAB algorithms, we will identify ACC and FOF neurons that respond to the rule and the upcoming motor response while the animals wait and prepare for target onset. We hypothesize that during the preparation for each response, (1) Neuronal representations of the rules are more prevalent and reliable in the ACC than in the FOF, and (2) The reverse holds true for the motor response. This study aims to shed light on the brain network-level mechanisms that support cognitive flexibility.



Malachi Blackman

NSERC Undergraduate Student Research Award

PROJECT

Using Photo Paradigms to Investigate Memory Development

PROGRAM

Cognitive Science

SUPERVISOR

Thanujeni Pathman

The research conducted was focused on memory development. Specifically, we examined how well children remember specific past events and how well they remember the events' spatial contexts (where events happened) and temporal contexts (when events happened). To obtain our research goal, children of different ages were given the opportunity to explore outdoor events and capture photos of those events using cameras we provided. Two days later, our team interviewed children about these events to evaluate memory. We investigated whether children at different age groups could later on identify which photos they took and also where and when the photos were taken. This research is important to better understand how well children of different ages remember and correlate any similarities/differences. This work has implications for our understanding of memory development, but also has implications for forensic settings (i.e., child eyewitness testimony) and educational settings.

This research opportunity has enabled me to demonstrate my skills and apply my knowledge in a real world setting. As well as being able to develop and improve analytical, strategic and problem solving skills in an inclusive and hard-working environment. The opportunity has been a great learning experience and I look forward to sharing my experiences and furthering my understanding of child development.

David De Caprio

NSERC Undergraduate Student Research Award

PROJECT

The Ketogenic Diet & Cholesterol Homeostasis

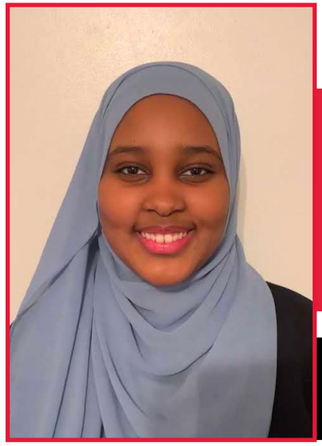
PROGRAM

Kinesiology and Health Science

SUPERVISOR

Rolando Ceddia

Since it's inception in the 1800s, The Ketogenic Diet is the most thoroughly studied diet in existence. Originally used to treat epilepsy & diabetes, The Ketogenic Diet involves limiting carbohydrate intake to approximately 5-10% of one's daily calories. The remaining caloric needs are met with 70% fats and 20% proteins. This forces the body to utilize fat as its main energy source. This is called being in a state of ketosis. Even today, for epileptic patients who are non-responsive to pharmacotherapies, a strict Ketogenic Diet remains the only effective protocol. The Ketogenic Diet has proven itself clinically beneficial for over a century, yet the increase in oral cholesterol intake remains its main criticism. These aspersions rely on outdated research from "The diet-heart hypothesis". Harsh critics of the diet religiously assert that improper cholesterol homeostasis can only be managed with Statins, earning themselves a healthy $20 billion/year in revenue. This study aims to investigate the role of The Ketogenic Diet in cholesterol homeostasis. 3 groups of rat were devised and subsequently fed; a standard diet, an obesogenic diet, and the ketogenic diet. After 16 weeks, tissues from each group were probed for different metabolic parameters related to cholesterol biosynthesis & homeostasis.



Maryam Farah

NSERC Undergraduate Student Research Award

PROJECT

Episodic Memory Development

PROGRAM

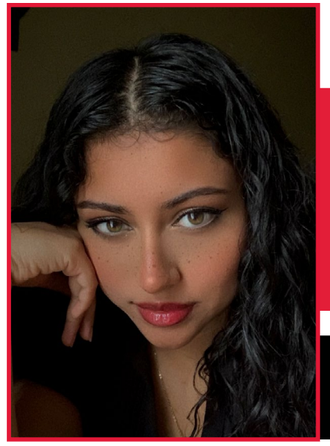
Neuroscience

SUPERVISOR

Thanujeni Pathman

The research we conducted was about memory development. Specifically, we examined how well children remember specific past events and how well they remember the events' spatial context (where events happened) and temporal contexts (when events happened). To obtain our research goal, children of different ages were given the opportunity to explore outdoor events and capture photos of those events using cameras we provided. Two days later, our team interviewed children about these events. We investigated whether children at different age groups could later on identify which photos they took and also where and when the photos were taken. This research is important to better understand how well children of different ages remember. This work has implications for our understanding of memory development, but also has implications for forensic settings (i.e., child eyewitness testimony) and educational settings.

I have always been interested in memory and working on this project has allowed me to explore this interest and to learn more about episodic memory. Working on this study has helped me learn new skills and has also allowed me to improve my professional and interpersonal skills.



Christina Fernando

NSERC Undergraduate Student Research Award

PROJECT

Meaning vs Engagement: Lingering of Non-Narrative Content

What makes an experience memorable? Prior research suggests that the meaningfulness and coherence of a story contribute to its lingering effect on readers (Bellana et al., 2022). However, it remains unclear if narratives are the only means to evoke such lasting experiences. Can intense engagement in a non-narrative task also produce similar effects? To address this question, I collaborated with Dr. Bellana on an Independent Research Project last year, building upon his published work (Bellana et al., 2022). We developed three engaging non-narrative tasks inspired by the game Wordle by the New York Times. Currently, we are integrating this game into an experimental framework for participant administration. Our goal is to complete data collection by the end of summer and initiate data analysis soon after. In addition, I have conducted an extensive literature review. Currently, meaning and engagement are not differentiated as separate potential causes for lingering, and narrative stimuli are the primary source of investigation. However, it is possible that engagement alone may predict lingering, thus we aim to disentangle this relationship by looking at how non-narrative stimuli such as Wordle may elicit similar lingering though lacking inherent “meaning” or a narrative framework.

PROGRAM

Specialized Honours Psychology BA

SUPERVISOR

Buddhika Bellana

Mirianna Georges

CIHR Undergraduate Student Research Award

PROJECT

Gendered differences in the relationship between housing insecurity and diarrheal diseases in the informal settlements in Kenya: a population-based study.

Housing insecurity, which is the lack of secure, affordable, safe, acceptable, and decent housing, has deleterious consequences for women living in poor resource settings. However, little is known about the mechanism by which it influences diarrheal diseases. Therefore, this project investigates the gendered differences in the association between housing insecurity and diarrheal diseases in slums and informal settlements in Kenya. Drawing from data collected from households (N=1010) in three informal settlements in Kenya and using logistic regression models, this study explores the possible interactions between gender, resource insecurity, Water, Sanitation and Hygiene (WASH), and health-seeking behaviours and their relationship to diarrheal infections. The findings of this research will lead to an increase in our understanding of the mechanisms by which 1) housing insecurity influences diarrheal diseases; 2) the factors influencing diarrheal diseases among children under-five years of age in these settlements; and 3) the development of recommendations and programs aimed at addressing the gendered aspects of housing insecurity and its effect on diarrheal diseases in informal settlements. Understanding the nuances of the effect of gender on housing insecurity will allow stakeholders and policymakers to develop focused interventions that enhance intestinal health outcomes in residents of informal settlements.

PROGRAM

Global Health

SUPERVISOR

Godfred O. Boateng

Nathaniel Goldstein

NSERC Undergraduate Student Research Award

PROJECT

Augmented reality (AR) and the functional dissociation between perception and action

Wearable immersive technologies like virtual reality (VR) provide users with realistic virtual environments to guide visuomotor actions. Virtual objects nevertheless typically lack important visual and haptic depth cues when interacted with. Consequently, research has shown that people reach and grasp differently with real versus virtual objects. Nevertheless, we do not know what aspects of the virtual environment the visual system is responding to that drives these differences.

Augmented reality (AR) offers an exciting opportunity to address this by allowing users to experience 3D real and virtual objects simultaneously in a real physical environment. The project's main goal is to examine whether the aforementioned differences in interaction exist with real and virtual objects in this unique environment, through the Microsoft HoloLens AR headset and OptiTrack motion tracking technology.

Specifically, we are assessing participants' grasping precision for real and identical AR rendered virtual objects presented in a real environment. We are varying object size to determine whether precision scales with size in both cases, as suggested by the fundamental psychophysical principle of Weber's law. Study results will provide important insight into fundamental human visual processing and can inform the design of more realistic AR content and technology through future work.

PROGRAM

Psychology

SUPERVISOR

Erez Freud and Laurie Wilcox (co-supervision)

Patrick Hewan

NSERC Undergraduate Student Research Award

PROJECT

Microstructural integrity of the Locus Coeruleus is related to decision-making in older adults

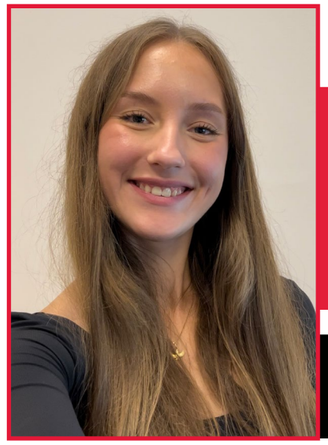
Balancing the familiar and the unknown is a consistent challenge in daily life, as it involves grappling between tried-and-true options or venturing into uncharted territory. This is known as the exploration vs. exploitation decision-making dilemma, and the balance between exploration-based versus exploitation-based choice has been shown to be altered in older adulthood. Flexibly shifting between exploration versus exploitation to optimize decision-making outcomes involves attention modulation and noradrenergic (attention) systems in the brain. This neurotransmitter projection system originates in the locus coeruleus (LC) of the brainstem and can be difficult to image with traditional MRI methods. To test whether decision-making performance is associated with the integrity of the LC in later life, we administered a laboratory-based measure of exploration and exploitation (foraging) and collected high resolution measures of LC integrity using novel quantitative MRI (qMRI) methods in a sample of 153 typically aging older adults. As predicted, greater structural integrity within LC was associated with a more optimal balance between exploration and exploitation-based decisions and a more consistent decision-making strategy. These findings suggest that optimal decision-making performance is associated with the integrity of the LC in older adults and demonstrate the potential of qMRI for brainstem imaging.

PROGRAM

Psychology

SUPERVISOR

Gary R. Turner



Lorna-Maureen Krelove

NSERC Undergraduate Student Research Award

PROJECT

Portable neuroimaging during standing balance: a pilot fNIRS project in distraction, attention, fall risk, and ageing

PROGRAM

Neuroscience

SUPERVISOR

George Mochizuki

Remaining upright often seems automatic. Maintaining balance while performing simultaneous tasks, such as talking while standing, usually demands little effort. However, distractors divide attention and increase balance challenge, indicating that postural control may not be as automatic as it feels. Since active attention is allocated to environmental stimuli challenging balance, a question arises: where is attention paid while distracted during a balance task? Attention allocation mediated by the frontal lobes determines how much attentional resource stimuli receive. Upon cognitive distraction, the frontal lobes determine if one's priority is remaining upright or completing the cognitive task. Age is a determining factor; young adults prioritise cognitive tasks, whereas stability is prioritised with age. Monitoring this allocation creates potential for fall-risk diagnostics, an important development for an ageing population and the health decline that is common post-fall. To assess brain activity associated with varied attention between balance or cognitive tasks, frontal lobe activity was monitored using a novel functional near-infrared spectroscopy (fNIRS) system. fNIRS measures cortical blood-oxygen using light, generating results similar to fMRI in a portable, non-restrictive manner highly amenable for postural tasks. This work develops knowledge on cortical attention processing during balance challenges and links ageing, fall risk, and attention allocation

Nikan Movahedi

Dean's Undergraduate Research Award

PROJECT

Symmetry Responses in the Human Visual Cortex to Naturalistic and Novel Three-Dimensional Objects

PROGRAM

Kinesiology and Health Science

SUPERVISOR

Peter Kohler

Visual symmetries generate robust neural responses in humans and other animals (Bertamini et al., 2018). This sensitivity is believed to support symmetry's importance as a cue for object recognition and scene perception during natural vision (Treder, 2010).

Consequently, researchers have largely pursued this topic in the context of reflection symmetry using random dot patterns. This straightforward approach involves the shifting and reflecting of dots about a central axis which produces symmetry in the image and the retina. However, symmetries in an animal's visual environment are often subjected to perspective distortion and do not give rise to symmetrical patterns (Keefe et al., 2018). Using Steady-State Visual Evoked Potentials with high-density EEG, we studied the symmetry-specific responses in the human visual cortex using novel, naturalistic objects in perspectively distorted and undistorted conditions.

Ryley Nathaniel

NSERC Undergraduate Student Research Award

PROJECT

Rule-based flexible decision making in rats

PROGRAM

Psychology

SUPERVISOR

Liya Ma

Survival in a dynamic environment requires cognitive flexibility, which is the brain's ability to flexibly adjust actions according to changes in the context. Cognitive flexibility plays a key role in the life of many animals, from rats to humans. For example, when the traffic light changes suddenly from green to yellow, drivers should make a flexible decision by releasing the gas pedal and pressing the brake, as long as the distance permits. Impairment in cognitive flexibility is a transdiagnostic deficit in numerous neuropsychiatric disorders, including schizophrenia, leading to diminished independence and wellbeing. In this study, rats were trained to flexibly switch between abstract, win-shift and win-stay strategies. Task rules had to be discovered through trial-and-error and rats were rewarded for correct shifts or stays. As rats were implanted with microelectrode arrays, both neural and behavioural recordings were collected. These recordings produced a large dataset on which current investigations of performance, error and reaction time are being conducted. This current analysis uses Python and MATLAB to examine how position, stage, rule and response side affect the accuracy and reaction times of rats' responses in rule-based flexible decision-making.

Amireza Nikzadfar Goli

NSERC Undergraduate Student Research Award

PROJECT

Examining the relationship between metabolic dysfunction and histopathology in two models of striated muscle myopathy

PROGRAM

Kinesiology and Health Sciences

SUPERVISOR

Christopher Perry

Mitochondrial dysfunction is considered a major contributor to muscle dysfunction, yet, the precise relationship between mitochondrial stress and tissue histopathology remains unclear. This project explores this relationship in two unique models of myopathy: autoimmune myositis and ischemia-reperfusion (IR) injury during Coronary Artery Bypass Graft (CABG) Surgery. Autoimmune Myositis encompasses a range of autoimmune disorders exhibiting diverse symptoms. Immunohistological analyses in an experimental autoimmune myositis (EAM) mouse model were used to assess muscle-specific damage by identifying muscle-specific immune cell infiltration. Separately, the pathologic mechanism of Ischemia-Reperfusion injury is thought to be due to various stressors that compromise mitochondrial functions post-reperfusion, resulting in reduced post-operative cardiomyocyte function and worsened patient recovery after surgery. Right Atrial Appendage (RAA) tissue obtained from patients pre- and post-aortic cross-clamping were assessed using mitochondrial respirometry, western blot assay, and immunohistochemistry to assess function, protein content, and tissue health, respectively. By studying both EAM and IR models, we aim to identify commonalities in the mechanisms by which disease-related stressors disrupt the intricate balance between metabolism and histopathology. These shared pathways can provide insights into underlying processes of muscle wasting and cardiomyopathies, ultimately leading to the development of targeted therapeutic interventions for these debilitating conditions.

Nora Pourhashemi

NSERC Undergraduate Student Research Award

PROJECT

Exploring the role of modified optic flow gain in balance control

The visual system plays an integral role in maintaining upright stance. When optic flow-related visual feedback is amplified by increasing the gain, a tighter control of upright stance is observed. In addition, when optic flow-related visual feedback is reduced to zero, the amplitude of postural sway increases. It currently remains unknown how much optic flow is required to maintain normal levels of postural sway. Therefore, this study aims to better understand how visual feedback specific to optic flow is used during quiet stance, and to determine the amount of optic flow required for normal amounts of postural sway within healthy adults. Using a virtual reality head-mounted display, optic flow gain will be manipulated while the participant stands on firm and foam support surfaces. Using a repeated measures design, participants will complete eleven trials over varying gain conditions ranging from zero (sway referencing the visual scene) to one (normal optic flow), through 0.1x increments. Upright stance will be quantified using kinetics (centre of pressure calculated from ground reaction forces and moments recorded from a force plate) and head kinematics. Displacement amplitude will be quantified using root mean square.

PROGRAM

Neuroscience-Kinesiology

SUPERVISOR

Taylor Cleworth

Parmin Rahimpoor - Marnani

Dean’s Undergraduate Research Award

PROJECT

The Effect of Multilingualism on Exceutive Functioning

Multilingualism is quickly becoming the norm rather than the exception in our societies, which is why it is ever more relevant to understand the effect of multilingualism on cognitive processes. Unfortunately, the results in this field remain ambiguous, rely on smaller samples and specific multilingual populations such as English as Second Language (ESL) tend to be underrepresented. The goal of the current study is to assess the effect of multilingualism on the top-down attention and impulse control cognitive processes.

PROGRAM

Kinesiology and Health Science

SUPERVISOR

Denise Henriques

Caitlin Terao

NSERC Undergraduate Student Research Award

PROJECT

Dissociations in Perceptual Discrimination Following Lesions to “Memory” Structures of the Brain Occurring Early in Life

PROGRAM

Psychology

SUPERVISOR

R. Shayna Rosenbaum

Developmental amnesia occurs when memory-related brain regions develop atypically or sustain injury in early life. Developmental amnesia is associated with impairments in episodic memory, but the extent to which this affects perception is unclear. In adult-onset amnesia, damage to the hippocampus, which provides direct input to the anterior nucleus of the thalamus via the fornix and mammillary bodies, is associated with reduced perceptual discrimination of spatial scenes, whereas damage to the perirhinal cortex, which provides direct input to the medial dorsal nucleus of the thalamus (MDN), is associated with reduced perceptual discrimination of scenes, objects, and faces. The current study examined the performance of two individuals with developmental amnesia due to atypical development of the hippocampus, fornix, and mammillary bodies (H.C.) vs. MDN (N.C.) relative to controls on measures of complex perceptual discrimination. Perceptual discrimination was measured using an oddity paradigm for size, colour, high-ambiguity artificial and everyday objects, and low- and high-ambiguity faces and scenes. H.C.’s performance was indistinguishable from that of controls, whereas N.C. demonstrated selective impairment for high-ambiguity faces. The results indicate dissociable patterns of spared and impaired perceptual discrimination following early-onset compromise to brain regions that were long viewed as playing a specialized role in memory.