2022

SUMMER UNDERGRADUATE

RESEARCH CONFERENCE

NSERC CRSNG

science | YORK UNIVERSITÉ UNIVERSITY

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

Thank you to the Natural Sciences and Engineering Research Council of Canada (NSERC) for its support in funding summer research positions at York University through the NSERC Undergraduate Student Research Awards program.

The Faculty of Science is also grateful to ESBE Scientific for providing merchandise and prize items for the students attending our conference.

RUI WANG

Dean, Faculty of Science

Dear students,

Congratulations on completing your summer term as a research student. A lot of hard work and sacrifice went into getting here today and I applaud all of you.

I hope your research experience this summer was productive and rewarding, that it has given you a deeper perspective of what it's like to be a scientist, helped you learn new skills and more about your interests, and led to new friendships and collaborations. Your contributions this summer are an important part of the research endeavor at York University and will have a lasting impact here and beyond.

I welcome you to review this booklet, which highlights the exciting research projects you and your peers have carried out across the University this summer.

I also hope you enjoy the 2022 Summer Research Conference. The event is a wonderful opportunity to share your work and practice science communication, learn about what your peers have accomplished, and make new connections with students and faculty.

I trust that you will go on to do great things and wish you the very best in your future endeavors.

Yours truly,
Rui Wang

DENIS GODIN

Director of Scholarships & Fellowships Division, NSERC

Congratulations to all undergraduate researchers whose research is highlighted in this booklet.

The Undergraduate Student Research Awards (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 enterprise. Since 1980, NSERC has supported research experiences for university students early in their careers through the USRA program. The program currently provides direct support for research work terms for more than 3,000 students each year. Many of Canada's leading researchers in the NSE field began their academic careers with a USRA.

Each award has a value of $6,000 and the duration is 14 to 16 weeks on a full-time basis. Institutions are also required to contribute funds to the award.

Should you wish to undertake graduate studies in these fields, remember that you may be eligible to apply for other NSERC scholarships. You may visit 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. We want to thank any 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

ABDULLAH ABDUL HAKEEM

YORK SCIENCE SCHOLARS AWARD

PROJECT

Molecular Evolution of Inferred Refractive Indices of Frog Lens Crystallins During Major Ecological Transitions

PROGRAM

Biomedical Science

SUPERVISOR

Ryan Schott

OUTLINE

The lens is an important component of the visual system that serves to focus light onto the retina. The ability of the lens to create a crisp image depends on its refractive power, which determines whether incoming rays of light are focused correctly. The different optical properties of aquatic and terrestrial environments, however, require lenses with different refractive power. Our group has recently found that the many of the genes encoding structural lens proteins (crystallins) were differentially expressed between aquatic tadpole and terrestrial juvenile leopard frogs. We hypothesized that this change resulted in a shift in the refractive power of the lens to support vision in air versus water. Comparison among frog species that inhabit different light environments will allow us to further test this hypothesis. Using a dataset of 100+ frog eye transcriptomes and genomes, we will identify and extract lens crystallin genes and computationally estimate the refractive index increments of the encoded proteins. The refractive index increment defines how much a lens crystallin protein will contribute to the refractive index of the lens allowing us to investigate how frog lens crystallins may have evolved in species that inhabit distinct light environments.

RON ALESKER

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Molecular Evolution of Frog Lens Crystallin and Pigmentation Genes During Major Ecological Transitions

PROGRAM

Biology

SUPERVISOR

Ryan Schott

OUTLINE

The lens is an important component of the visual system that serves to focus light onto the retina but can also filter the wavelengths of light that reach the retina. Our group has recently found that the lenses of diurnal and climbing frogs transmitted less short-wavelength light than other species. We hypothesized that shortwave-absorbing lens pigments protect diurnal species from retinal damage due to bright light and provide higher visual acuity to climbing frogs that navigate complex visual environments. However, the molecular mechanisms underlying these patterns have yet to be explored and comparison among frog species that inhabit different environments will allow us to further test these hypotheses. Using a dataset of 84 frog eye transcriptomes and 16 whole genomes, we will identify and extract lens crystallin and pigmentation genes, compare gene complements among species, and infer gene duplications and losses. In addition, we will conduct molecular evolutionary analyses to investigate potential functional adaptation. The results of this study will provide important insights into frog visual biology and broadly to the constraints and opportunities of visual systems to evolving novel solutions to new life history modes and behaviours.

LOMESH CHOUDHARY

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Examining the Activity And Stability of Fmtaδ42, a Derivative of the Fmta Penicillin-Recognizing

PROGRAM

Biomedical Science

SUPERVISOR

Dasantila Golemi-Kotra

OUTLINE

The focus of this research project is FmtA, a penicillin-recognizing protein (PRP) from Staphylococcus aureus. S. aureus is a gram-positive bacteria that poses a risk to public health due to their antibiotic resistance capabilities, making these bacterial infections hard to treat. In fact, S. aureus are resistant to all β-lactam antibiotics, such as penicillin. FmtA is involved in the homeostasis of the cell wall in S. aureus. Cell wall is essential for bacteria survival and is the target of many antibiotics.

FmtA has hydrolytic activity and interacts with one of the cell wall components, teichoic acids, by removing D-Ala and thus altering the overall charge of the cell wall. Specifically, my project aims to construct a version of the FmtA enzyme that is stable in vitro. For this purpose, the first 42 amino acids (FmtAΔ42) will be deleted. The new FmtA construct will be characterized to measure the impact of the removal of these amino acids on the FmtA structure and its enzymatic activity, which will then compare the wild-type FmtA. My project also aims to probe the role of this protein in the cell through in vivo studies.

CLAIRE DEL ZOTTO

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Analysing Plant-Pollinator Interactions Across

PROGRAM

Biology

SUPERVISOR

Sandra Rehan

OUTLINE

Over 80 percent of the Canadian population is concentrated in urban centres, yet research on the impacts of urbanisation on pollinator health is still incredibly sparse. My project within the Rehan Lab involves analysing plant-pollinator interactions across urbanisation gradients in Toronto as part of a multi-year study on how cities impact the community composition and phylogenetic diversity of wild bees. Using field data from city gardens, pollinator-friendly backyards and parks, the project aims to determine how ecological factors such as plant richness and abundance impact bee communities. Ultimately, these assessments can be used to direct initiatives aimed at identifying at-risk species and implementing best practices in the designation of green space, thereby allowing wild bees to continue providing necessary ecosystem services for decades to come. Native species are not only crucial for maintaining biodiversity, but also sustaining human health and the economy by pollinating a majority of agricultural crops and accounting for 30 percent of global food production. Evidently, the impacts of this project extend far beyond the lab and the field, having a great potential to incite meaningful change within Toronto communities and beyond.

MINOOSH FATHI

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

Phylogenetic History and Molecular Evolution of Vertebrate Opsins

PROGRAM

Biomedical Science

SUPERVISOR

Ryan Schott

OUTLINE

The ability of animals to detect light from their external environment is mediated by the presence of light-sensitive visual pigments composed of a vitamin A-based chromophore and an opsin protein. There are numerous types of opsins that are essential for diverse biological functions and can broadly be distinguished by those involved in vision (visual opsins) and those involved in non-image-forming functions (non-visual opsins). Thus, understanding the phylogenetic history and molecular evolution of opsins is key to understanding the evolution of light detection and photoreception in animals. Although previous research has reviewed opsin sequence diversity across specific taxa, there has yet to be a study reviewing the evolution of opsin genes across the full phylogenetic diversity of vertebrates and that incorporates data from comparative genomics. In this project, we will identify and extract opsin genes across a representative sample of major vertebrate lineages and conduct phylogenetic analyses of their evolutionary relationships. We will also conduct molecular evolutionary analyses to investigate differences in evolutionary rates and selective pressures among the different opsin genes across vertebrates. The results of this study will provide deep insight into the patterns of evolution of opsin genes and will serve as a useful foundation upon which to analyze adaptations of different organisms in response to their unique light environments.

VANESSA GIGLIO

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Investigation of the Impact of E3 Ligase HUWE1 Under Various DNA Damage and in Post-Translational

PROGRAM

Biomedical Science

SUPERVISOR

Yi Sheng

OUTLINE

HUWE1 is an E3 ubiquitin-protein ligase that facilitates protein degradation via ubiquitination modifications. HUWE1 has recently been reported to be involved in the DNA damage response (DDR) and specifically our lab has focused on the HUWE1 regulation of double-stranded break repair pathways. This project will continue to investigate the impact of HUWE1 in different DNA damage-induced conditions. Quantification of this damage will be used to compare the effects HUWE1 knockdown has in cells treated under different types of DNA damage. Furthermore, HUWE1's functional role as an E3 ubiquitin ligase will be further investigated in connection to histone post-translational modifications and chromatin binding. The project will provide insight on possible cross-talk and regulation within DDR pathways mediated by HUWE1 ubiquitination. Our findings can provide further information and clarity into HUWE1's role in DDR which is not well understood. The potential for applications in treatment and disease connected to DDR makes this investigation of HUWE1's functional role in DDR very important.

SAESHA KUKREJA

YORK SCIENCE SCHOLARS AWARD

PROJECT

Molecular Evolution of the Rod/Cone Visual Cycle in Frog Visual Systems During Major Ecological Transitions

PROGRAM

Biomedical Science

SUPERVISOR

Ryan Schott

OUTLINE

Frogs are a highly diverse group that exhibit a wide variety of activity periods, life histories, and behaviours. These factors are known to influence the evolution of visual systems in other vertebrates but have not been well studied in frogs. Nor have differences in the functioning of rod/cone visual cycle proteins been given much consideration as potential avenues for adaptive evolution of visual systems to different light environments. The rod/cone visual cycle is the series of reactions that convert the light-activated visual chromophore (all-trans-retinal) back into its pre-activated form (11-cis-retinal) enabling visual pigments in the rod and cone photoreceptors to be returned to a state capable of responding to new light signals.

To investigate potential adaptive evolution in the visual cycle across frogs, we will extract visual cycle genes from a dataset of 100+ frog eye transcriptomes and genomes and conduct molecular evolutionary analyses. Using a previously developed ecological trait database, we will be able to infer shifts in selective pressure associated with differences in ecology that may indicate functional evolution. These data will contribute to ongoing work investigating the constraints and opportunities of visual systems to evolving novel solutions to new light environments, life history modes, and behaviours.

SHON LAZAREV

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Exploring LTP Decay Along the Dorsal-Ventral Hippocampal Axis

PROGRAM

Biology

SUPERVISOR

Steven Connor

OUTLINE

How the brain stores information remains a longstanding question in the field of neuroscience. The biological basis of memory is believed to involve changes in the strength of connections (synapses) between brain cells (neurons). Memory processes have been effectively modeled using Long-term potentiation (LTP), which recapitulates cellular and molecular changes observed during memory formation in brain circuits. However, how information is removed or “forgotten” has received considerably less attention.

Through exploring how LTP “decays” or reverses over time, I will identify synaptic mechanisms within the hippocampus, a brain structure essential for certain types of memories, which promote forgetting. An important receptor involved in this process is the N-methyl-D-aspartate (NMDA) receptor, although how the different subtypes contribute to LTP decay throughout the dorsal-ventral axis of the hippocampus remains unknown. Accordingly, determining which receptor subunits are involved in LTP decay along the dorsal-ventral axis is the focus of this project. This analysis will be done using electrophysiological (fEPSPs), molecular (western blotting) and pharmacological assays to measure the changes in function/composition of synapses during LTP decay.

This research will advance our understanding of mechanisms supporting forgetting and could reveal new approaches for treating conditions associated with memory impairments, including autism and Alzheimer’s disease.

NOUR NADER

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

Comparing the Potency of Novel B-catenin Inhibitors C10 and C21

PROGRAM

Biomedical Science

SUPERVISOR

Yi Sheng

OUTLINE

The Wnt-B-catenin pathway is involved in various physiological processes. Its dysregulation is associated with the development of Ovarian Cancer. When the ligand, Wnt, binds to the receptor, the B-catenin moves to the nucleus and binds to TCF 4 and they activate the transcription of target genes that are involved in oncogenesis. Our lab in collaboration with Dr. Peng's lab predicted a surface groove on B-catenin that is important for the interaction with TCF4. C10 was identified through in-silico screening to disrupt the B-catenin/TCF4 interaction and has also shown to have antitumor effects. C21 is a compound that has similar structure to C10. It was found by Dr. Peng's lab that C21 it is showing a better antitumor effects than C10 using different assays. I will be working on further comparing the potency of C21 and C10 on inhibiting the B-catenin pathway and the interaction between B-catenin and TCF4 using different methods such as Western blot and Co-Immunoprecipitation. The importance of this project is finding a potent inhibitor of the B-catenin pathway which might help in the development of therapeutic agent to help women suffering from Ovarian Cancer.

ASHLYN NGUYEN

YORK SCIENCE SCHOLARS AWARD

PROJECT

Honey Bees vs. The One-Two Punch: Synergistic Effect of Agrochemicals on Honey Bee Health

PROGRAM

Biomedical Science

SUPERVISOR

Amro Zayed

OUTLINE

Honey bees are crucial to Canada's agriculture and contribute up to $5.5 billion a year to our economy by pollinating valuable Canadian crops. However, the health of honey bees has been declining over the past decade. According to the Ontario Beekeepers' Association, beekeepers across Ontario are reporting major losses of up to 90% of their colonies this year, making 2022 one of the worst years on record for honey bee decline. As part of BeeCSI, a national project aiming to use genomic tools to develop a new health assessment and diagnosis platform powered by stressor-specific markers, this project analyses gene expression of honey bees exposed to a combination of agrochemicals, in particular Boscalid and Chlorantraniliprole. Using RNAseq, we plan to evaluate the transcriptomic response of exposed bees compared to controls at three different tissues (heads, guts and abdomens). Assessing the synergistic effects of two commonly used agrochemicals on bee health paints a better understanding of real-world scenarios for bees facing environmental stressors. The results will help build an omics based diagnostic tool that supports improved diagnostics to mitigate bee health declines.

BRITTNEY REMNANT

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

Pre-tRNA Processing in Tetrahymena Thermophila by an Unusual La Protein

PROGRAM

Biomedical Science

SUPERVISOR

Mark Bayfield

OUTLINE

La proteins are conserved RNA binding proteins that function in the processing and maturation of non-coding RNAs, including pre-tRNAs. Dysfunction in RNA processing has potentially detrimental effects on cellular proliferation and has been linked to the development of cancer in humans. La-dependent pre-tRNA processing is highly conserved in eukaryotes: the RNA recognition motif-1 (RRM) works with the La motif (LAM) to bind 3'-uridylates and protect them from degradation. The unconventional La protein Mlp1 in Tetrahymena thermophila lacks the conserved RRM and binds with lower affinity and specificity than LAM-RRM La protein, hinting at an alternative pre-tRNA 3'-end protection mechanism.

Previous work identified candidate Mlp1-associated proteins that we hypothesize may enhance Mlp1-dependent 3' end protection. These proteins were purified, and interactions were tested via in vitro GST-pulldown assays. Next, partner knockout strains will be produced to query pre-tRNA processing deficits. Additionally, we developed a 3'-exonuclease assay where La proteins and candidate Mlp1 binding proteins were bound to a pre-tRNA to assess their protective effects on exonuclease-mediated degradation. Identifying components and mechanisms of this alternative pre-tRNA processing pathway has potential to highlight pre-tRNA processing variability across eukaryotic species and may lead to new discoveries in conserved mechanisms of RNA processing in humans.

ETHAN SOOKLAL

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Role of the Tor Pathway in Circadian Rhythmicity

PROGRAM

Biology

SUPERVISOR

Patricia Lakin-Thomas

OUTLINE

The goal of our research is to describe the molecular mechanisms that produce circadian (24-hour) rhythmicity in eukaryotes. Circadian clocks are found in almost all eukaryotic cells, and play important roles in human health, but the mechanisms are not yet completely described. We use the fungus N. crassa as a model organism, using the superb genetic and biochemical tools that are available to identify new clock-associated genes and their functions. We have identified three genes that are required to maintain rhythms and are also components of the TOR (Target of Rapamycin) pathway, which is a nutrition-sensing pathway that activates growth in all eukaryotes. We have recently developed an assay for TOR activity using immunoblotting to quantitate the phosphorylation of a downstream target of TOR, S6 ribosomal protein. Using this method, we have discovered that the TOR activity is rhythmic. This raises the exciting possibility that rhythmic TOR may play a role in the circadian system. If so, then we predict that exposure to various activators and inhibitors of TOR could impact rhythmicity. We are focusing on TOR activators and inhibitors and using them to look for effects on TOR activity and also on clock function.

DASOL WI

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

Plant Regeneration for Genome Engineering of Cannabis

PROGRAM

Biomedical Science

SUPERVISOR

Nikola Kovinich

OUTLINE

Cannabis sativa can produce a secondary metabolite called (-)-trans-Δ9-tetrahydro-cannabinol up to 35% of its dry weight, but its potential for genome editing is limited by its inefficient regeneration rate. Still, there is no reliable protocol for stable genetic modification to promote Cannabis regeneration. Remarkable progress has been reported recently that overexpressing chimeric protein combining Growth Regulating Factor (GRF) and Growth Interacting Factor (GIF) has increased the plants' efficiency and speed of regeneration. However, constitutive overexpression of GRF-GIF factors has led to growth abnormalities that has lowered vitality of the transgenic Cannabis shoots.

A primary goal of our research is to develop a protocol for increasing the regeneration efficiency of Cannabis shoots and growing them into fully matured plants without abnormalities. To control the activity of the GRF-GIF factors, we will construct a G3 fusion that a translational fusion of a glucocorticoid receptor (GR) will be added to the GRF-GIF factors. The G3 will keep the GRF-GIF factors out of nucleus and only will enter the nucleus when applying dexamethasone. Moreover, we plan to test tissue cultures and soil plants of Cannabis whether regeneration efficiency can be increased by transformation with G3 fusion using different combinations of sonication and vacuum infiltration.

CHENYANG YUE

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

The role of circSKA3 in Ovarian Cancer Development

PROGRAM

Biology

SUPERVISOR

Chun Peng

OUTLINE

Epithelial ovarian cancer (EOC), which is the most common form of ovarian cancer, has the highest mortality rate of all gynecological malignancies. The low survival rate of EOC patients is mainly due to the asymptomatic nature of disease onset, the lack of reliable biomarkers for early detection, and limited treatment options for late-stage cancer. Circular RNAs (circRNAs) are a novel class of RNA molecules that form covalently closed continuous loops and act as gene regulators. Recent studies indicate that circRNAs participate in cancer progression by regulating various processes, including cell proliferation, migration, invasion and apoptosis. Although much remains to be elucidated about circRNA biology and mechanisms of gene regulation, these circRNAs are quickly emerging as potential biomarkers and therapeutic targets in cancer. We have obtained preliminary data suggesting that one circRNA derived from the SKA3 gene locus, termed circSKA3, has tumour-promoting effects in EOC cells. The objectives of this study are to further investigate the role of circSKA3 in EOC development and its mechanisms of action. Moreover, this study suggests circSKA3 as a potential diagnostic marker and therapeutic target for EOC, which is worthy of deeper exploration and greater research efforts in the future.

CHEMISTRY

ALEX AKHUNDOV

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

Synthesis Of Medicinally Relevant Nitrogen- And Fluorine-Containing Organic

PROGRAM

Chemistry

SUPERVISOR

Christine Le

OUTLINE

Many biologically active organic compounds contain heteroatoms such as nitrogen, oxygen, and fluorine, which are essential to the properties displayed by these molecules. Functional groups such as amides, ureas, and carbamates are ubiquitous in anti-bacterial, anti-cancer, and other small molecule drugs. Furthermore, the incorporation of fluorine into existing classes of drug molecules can greatly improve their biological activity and other physicochemical properties. Developing new ways to synthesize these functional groups allows for easier and more efficient access to these pharmaceutical targets. It also opens the door to the possibility of examining previously unexplored scaffolds in medicinal chemistry. Recent efforts in the Le Group have resulted in the application of difluorocarbene reagents as fluorine-containing synthons towards the synthesis of carbamoyl fluorides. These bench-stable carbamoyl fluorides are easier to handle and offer unique reactivity compared to their other halide analogues. This project will examine the synthesis of urea functional groups using carbamoyl fluorides as electrophilic partners in a cross-coupling reaction with silylated nucleophiles, catalyzed by green, nickel-based catalysts. It will also further explore the use of difluorocarbene sources to generate other fluorine-containing compounds as scaffolds and precursors to important biologically active classes of molecules, such as lactam antibiotics.

BIRUK BELACHEW

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

Strong Cationic Polyelectrolyte Capillary Coating by Successive

PROGRAM

Biology

SUPERVISOR

Sergey Krylov

OUTLINE

Capillary electrophoresis is a highly efficient separation method for protein analysis. The inherent negative charge on the inner wall of the silica capillaries causes protein adsorption which impacts the reproducibility of protein separation. Different methods of capillary coating have been implemented to improve reproducibility. Successive Multiple Ionic polymer Layers (SMIL) is a popular coating method where alternating cationic and anionic polyelectrolyte are rinsed through the capillary wall forming semi-permanent layers which modify the surface chemistry of the capillary.

Strong polyelectrolytes are reported to be resistant against protein adsorption and have pH independent electroosmotic flow. Here, I will prepare cationic SMIL coating for use as an alternative to permanent polyvinyl alcohol (PVA) coatings. Two SMIL coatings will be tested: 1) polybrene and dextran sulfate, 2) poly diallyldimethylammonium chloride and poly-styrene sulfonate. The proposed quantitative comparison will test the extent of protein adsorption, and reproducibility of electroosmotic flow. We will also perform statistical analysis to compare the two SMIL coatings with each other and with PVA.

AREEBA CHAUDHRY

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Generation of XNA Aptamer Libraries using Ligase-catalyzed OligOnucleotide

PROGRAM

Biomedical Science

SUPERVISOR

Ryan Hili

OUTLINE

Aptamers are single-stranded nucleic acids generated to bind desired targets with great affinity and selectivity. The growing field of aptamers continues to establish a role for genetic polymers beyond information transfer to therapeutic and diagnostic applications traditionally dominated by antibodies. This nucleic acid nanotechnology possesses advantages over its proteinogenic counterparts, including reversible denaturation and longer shelf-lives. Simultaneously representing both genotype and phenotype, aptamers can be rapidly evolved in vitro through iterative cycles of selection against biomolecular targets. However, a lack of chemical diversity in nucleic acids is the major limiting factor in the evolution of aptamers.

Hili Lab's Ligase-catalyzed OligOnucleotide PolymERization (LOOPER) method has been developed for sequence specific incorporation of chemical modifications, thereby diversifying the four canonical base pairs found in DNA. During my first NSERC placement, I explored a novel application of LOOPER using T3 DNA Ligase to generate highly stable, backbone-modified (XNA) aptamer libraries. The goal of my project this year is to analyze fidelity and yield using Next-Generation Sequencing, and apply the XNA libraries in selections against blood clotting factor human α-thrombin. Using T3 LOOPER, equipping nucleic acids with protein-like chemical diversity is anticipated to enable the evolution of high-affinity aptamers against various clinically relevant targets.

ALICE FOURS

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

Structural Characterization of TraY, a Protein Involved in F-like Bacterial Conjugation

PROGRAM

Biology

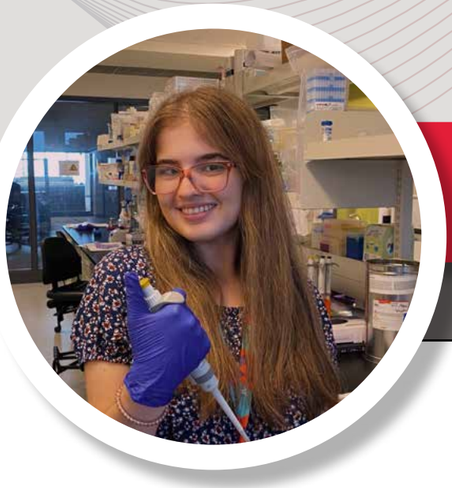
SUPERVISOR

Gerald Audette

OUTLINE

Bacterial conjugation is a prominent contributor to the spread of antibiotic resistance genes. The horizontal transfer of genetic material within a bacterial colony is a complex process with multiple steps involved in the transfer of DNA from a donor to a recipient cell. Proteins encoded by the F plasmid of E. coli help assemble the type IV secretion system (T4SS), a large protein complex that traverses the cell membrane and helps transfer DNA.

TraY is a relaxosome accessory protein of the T4SS that stabilizes the DNA to be cleaved and transferred to the recipient cell. Little is known about the structure of TraY, which is expected of proteins containing hydrophobic regions and involved in large complexes. My research project aims to elucidate the structure of TraY through crystallographic techniques to determine the protein's specific role in bacterial conjugation. Ultimately, studying the protein-protein interactions in the T4SS can provide insight into how bacteria evolutionarily gain survival in unique environments and can help create drug targets to lessen the proliferation of bacterial antibiotic resistance.



NICOLE FRIAS

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Photoredox-catalysed Hydroaminoalkylation for DNA-encoded Libraries

PROGRAM

Biochemistry

SUPERVISOR

Ryan Hili

OUTLINE

DNA-encoded libraries allow for the screening of a huge variety of small molecules by covalently linking an organic functional group to DNA and subsequently conducting chemical reactions with different building blocks. Through several rounds of binding to a biological target, the library is screened. The best molecules are identified through amplification and sequencing of the DNA tag. The focus of this project is to optimise a photoredox reaction that can be used to synthesise biologically-relevant molecules for medicinal purposes, including the treatment of diseases. The reaction involves a photoredox-mediated oxidation of alkylated anilines with subsequent radical addition to an alkene. Motivated by the needs of the pharmaceutical industries, it will be optimised for both aliphatic anilines and benzylanilines as substrates, concluding an ideal scope for high-throughput screening.

YURIKO FUJISATO

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Lewis Acid Catalyzed Atom-Economical Carbofluorination Reactions Driven by Reversible Fluoride Binding Catalysis

PROGRAM

Chemistry

SUPERVISOR

Christine Le

OUTLINE

Fluorine containing organic compounds are often involved in drug development. The introduction of fluorine into molecules can affect the drug properties such as pKa, lipophilicity, or metabolic activity. This research is about developing synthetic methods to access fluorinated organic heterocycles. The key reaction of this project is intramolecular cyclization of various alkyne bound acyl fluorides and carbamoyl fluorides using a Lewis acid to activate the key C-F bond allowing for two carbon expansions of the bond via nucleophilic capture of an alkyne (a pi-bind nucleophile). This reaction motif allows for the high value fluorine atom to be reincorporated back into the final product by using a catalyst able to both abstract and deliver a fluoride atom via reversible fluoride binding, generating the desired fluorinated organic heterocycle.

OWEN GRAY

YORK SCIENCE SCHOLARS AWARD

PROJECT

Investigation of Transition Metal Oxide as Efficient

PROGRAM

Biology

SUPERVISOR

Sylvie Morin

OUTLINE

The goal of our research is to make hydrogen gas production more economical so that it becomes a viable alternative to non-renewable energy sources, which pollute the environment and accelerate climate change. When water is split there is a hydrogen evolution reaction (HER) at the positively charged electrode and a rate limiting oxygen evolution reaction (OER) at the negatively charge electrode. The inefficiency of water splitting comes from the slow rate of the OER. Ruthenium and iridium-based catalysts are very good OER catalysts, but they are very expensive. The aim of our research is to replace these precious metal catalysts with 3d transition metals, which are readily available. Our research explores catalysts that are composed of cobalt oxide and contain either copper, iron, or nickel. Our findings suggest that adding iron to Co3O4 is effective at decreasing the overpotential and increasing the rate of oxygen production. Currently, we are attempting to measure the effect of bulk conductivity of amorphous and crystalline metal oxides on their OER performance. We are characterizing these structures by using x-ray diffraction, scanning electron microscopy, energy dispersive x-ray spectroscopy, and studying their electrocatalytic properties towards OER by cyclic voltammetry.

MELIKA JOULAEI

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Single-Cell Kinetic Study of GST Enzyme by Cytometry of Reaction Rate Constant

PROGRAM

Biomedical Science

SUPERVISOR

Sergey Krylov

OUTLINE

Cancer resistance to chemotherapeutic treatment is associated with heterogeneity of cancer cells. The drug-sensitive cells are affected by chemotherapy, while drug-resistant cells survive treatment. Drug-resistant cells use mechanisms of survival such as: 1) drug extrusion by multidrug (MDR) transporters and 2) drug inactivation by a vast number of metabolizing enzymes, such as: cytochrome P450 (CYP), aldehyde dehydrogenases (ALDH) and Glutathione-S-transferases (GSTs). Since chemoresistance often leads to bad prognosis, developing reliable chemoresistance predictors is of great clinical significance. A promising predictor of chemoresistance is the size of the resistant cell subpopulation in the tumor. Dr. Krylov Lab has developed a kinetic approach termed cytometry of reaction rate constant (CRRC), which is based on the kinetic mechanism of a particular reaction and performed at the single-cell level. CRRC provides an ideal tool to determine the size of the resistant cell subpopulation in the tumor based on activity of the aforementioned transporters and metabolizing enzymes. So far, MDR activity was studied, and preliminary experiments have been done on CYP450 and ALDH activities. As an undergraduate student, I learn CRRC experimentation, analyze data, get training on cell culturing, do literature review on GST enzyme, and potentially perform experiments on GST activity in cancer cells.

ALEEZA QAYYUM

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

TRESI-HDX-MS Analysis of Molecules Binding Specifically to Amyloidogenic Tau

PROGRAM

Biomedical Science

SUPERVISOR

Derek Wilson

OUTLINE

Tau is a microtubule-associated protein that stabilizes microtubules in neurons. In certain biological conditions, the tau protein can undergo modifications; the most common being hypo-phosphorylation. This can result in the creation of abnormal aggregates that are toxic to neurons and thus leads to neurological diseases known as tauopathies. The most recognized tauopathy is Alzheimer's disease, which is estimated to affect 152 million of the world population by 2050. The process of cerebral deposition of amyloid aggregates of Tau is referred to as amyloidogenesis, and it is a strong potential target in neurodegenerative disorder treatment.

In this project, Aleeza attempted to inhibit Tau fibrillation through a series of small molecules designed by a Toronto-based pharmaceutical company. She used Time-Resolved ElectroSpray Ionization Hydrogen-Deuterium Exchange Mass Spectrometry (TRESI-HDX-MS) to compare the potential efficacy of these molecules in inhibiting Tau assembly. Hydrogen/Deuterium eXchange (HDX) is a structure-dependant labelling technique that allows analysis of the conformational dynamics and induced structural changes of proteins due to factors like ligand binding and folding. Halting the aggregation process of tau is imperative in stopping the progress of Alzheimer's, and she hopes to progress the lack of findings in efficient and safe therapeutics against these neurological tauopathies.

MAHYA REZAEIFARIMANI

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

Synthesis of Monodisperse Silica Nanoparticles and the Incorporation of Fluorophores

PROGRAM

Chemistry (Pharmaceutical and Biology Stream)

SUPERVISOR

Jennifer Chen

OUTLINE

Silica nanoparticles have wide biological applications due to their benign, biocompatible nature and facile surface modifications. Fluorescent molecules such as organic dyes and quantum dots are ideal for biological tagging and imaging, but they can be unstable and toxic resulting in a challenge when utilizing them in a biological system. Through the incorporation of monodisperse silica nanoparticles of known sizes with various types of fluorophores, one can stabilize and lower the cytotoxicity of these fluorescent molecules which can be practical for a variety of applications. The goal of my project is to synthesize and grow monodisperse silica nanoparticles of various sizes using a biphasic system, and to incorporate a variety of fluorescent molecules with these nanoparticles. Through combining different types of fluorophores with the silica nanoparticles, we can construct a multiplexed system with distinct properties that can be used for biological applications and render areas for further research.

SHANGAVI SENTHURAN

YORK SCIENCE SCHOLARS AWARD

PROJECT

Anionic Successive Multiple Ionic - Polymer Layer (SMIL) Coating in Capillary

PROGRAM

Biochemistry

SUPERVISOR

Sergey Krylov

OUTLINE

Capillary Electrophoresis (CE) is a highly efficient analytical separation tool that is used for analyzing biomolecules. The efficiency of CE-based separation and analysis of proteins are often hindered by adsorption of proteins onto the bare fused-silica capillaries. This is due to the electrostatic, hydrophobic and hydrogen interactions that take place between the samples and the negatively charged silanol groups found on the inner wall of the capillaries. To improve the separation efficiency of such samples in capillary electrophoresis, capillaries can be coated. Successive Multiple Ionic-Polymer Layers (SMIL) is a well known coating technique used to minimize the adsorption of solutes in capillaries. Commercial polymers are simply deposited onto the inner capillary walls, these can be either charged (anionic/cationic) or neutral. I will be testing two anionic SMIL coatings: Polybrene/Polyvinyl sulfonate (PB/PVS) and Poly Diallyldimethylammonium chloride/Polystyrene sulfonate (PDADMAC/PSS). Direct comparisons of the extent of protein adsorption on a bare fused-silica capillary and a coated capillary will be made to measure effectiveness of each coating. This study will pave a new way for our lab on analyzing negatively charged proteins which previously were adhering to the bare fused-silica capillaries.

SAMIA ZAMAN

YORK SCIENCE SCHOLARS AWARD

PROJECT

Analysis of Antimicrobial Property of Nano-copper Particles on Texitile

PROGRAM

Biomedical Science

SUPERVISOR

Jennifer Chen

OUTLINE

One of the areas The Chen Research Lab focuses on is analyzing the fundamental properties of nanostructures to develop better nano-building blocks.

The project I'm assisting with focuses on using nano copper particles to enhance the antimicrobial property of textiles. Copper is known to have antimicrobial properties thus, at the nano-scale, copper particles can interact easily with bacterial membranes and kill bacteria cells more efficiently. For this project, E. coli is used to test the effectiveness of nano-copper particle coating on textile. Samia's work involves bacteria culturing which is an essential part of this project. With current events, Personal protective equipment is needed more than ever. The success of this project can open doors to cost-efficient PPEs and better hygiene conditions in the healthcare industry.

MATHEMATICS & STATISTICS

CAMERON ARBOINE

YORK SCIENCE SCHOLARS AWARD

PROJECT

Correlating Equity Metrics and COVID-19 Related

PROGRAM

Biomedical Science

SUPERVISOR

Jude Kong

OUTLINE

By analyzing temporal trends in healthcare utilization, we aim to identify how equity metrics such as race, age, and other factors impact COVID-19 related outcomes. With a focus on the Jane and Finch community, the goal is to support that disadvantaged communities are disproportionately affected by the consequences of the pandemic.

Using medical databases, we are working towards finding similarities in other comparable communities to guide the methodology of our study. This work is important because deprived and minority communities deserve advocacy and action. There is no one way to combat the pandemic that is effective for all regions. Our goal is to draw attention to an area that needs extra support, and to create a plan of action for COVID-19 response that ensures the community can be successful.

HALEEMA AHMED

YORK SCIENCE SCHOLARS AWARD

PROJECT

Cultural and Socio-Demographic Factors Affecting the Timing of NPI Decisions Across Canadian Universities

PROGRAM

Biomedical Science

SUPERVISOR

Jude Kong

OUTLINE

As COVID-19 commenced, university and college communities across Canada were challenged with interpreting and implementing non-pharmaceutical intervention guidance from local, provincial, and national policymakers and agencies to mitigate the spread of the coronavirus. Obtaining a national view of how this guidance was then adopted provides opportunities for further analysis on how these decisions were coordinated, why they were made, their effectiveness, and what influenced the timing of these decisions. An original database of the status and timing of NPI decisions and community measures was compiled and through a survival analysis approach, various cultural and socio-demographic factors were determined to impact the timing of these decisions shedding light on the Canadian pandemic response.

YUTONG CHEN

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

Statistical depth

PROGRAM

Statistics

SUPERVISOR

Cindy Fu

OUTLINE

The project involves the introduction of different statistical depth and evaluation of these statistics depth on picturing the dataset and the potential of this application can be further applied to classify data in the future.

NICHOLAS FELLETI

YORK SCIENCE SCHOLARS AWARD

PROJECT

Exercise and the Brain

PROGRAM

Biomedical Science

SUPERVISOR

Andrew Skelton

OUTLINE

A project centered around the H5P system designed for interactive learning and navigation through university. Providing its audience with the benefit of physical exercise and its capability to re-wire how the brain thinks and reacts. Using this information, we can improve cognitive function promoting better academic success. The system dictates the benefits while also allowing students to build their own schedule and workout plans based on their desired outcomes. Further, it promotes planning, time management and accountability skills that are truly tested under university conditions. It is built on the grounds of free access, hopefully allowing many to be touched by the topic and reach large audiences promoting physical activity.

MAHAKPRIT KAUR

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

Determining Predictors of the Timing of the First Covid-19 Case and Death In Long-Term Care Homes In Ontario

PROGRAM

Biomedical Science

SUPERVISOR

Jude Kong

OUTLINE

The still ongoing "Coronavirus Disease 2019" (COVID-19) pandemic has disproportionately affected and continues to affect long-term care facilities. We aimed to identify predictors of the timing of the first COVID-19 case and death in long-term care homes across Ontario during the first and second pandemic waves and to test for associations with the preparedness of health systems and government pandemic responses. We manually developed and curated a dedicated database which consists of factors that have been suspected to be associated with COVID-19 cases and deaths in long-term care homes in Ontario. Utilizing the database to analyze and identify predictors will help create a clearer picture of the shortfalls in our current pandemic response. Further, our research will aid in informing policies that have the potential to protect our seniors from communicable diseases heading into the future.

JEFFREY MARSHALL-MILNE

DEAN'S UNDERGRADUATE RESEARCH AWARD

PROJECT

Continuous Bourgains-Tzafriri Estimate over a Multidimensional Domain

PROGRAM

Mathematics

SUPERVISOR

Pavlos Motakis

OUTLINE

We discuss our work extending the well-known Bourgains-Tzafriri estimate to families of matrices varying continuously over a multidimensional domain.

DIEGO MONTALVO

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT **OUTLINE**

A Lattice Model for Polyelectrolyte Adsorption onto a Surface: Towards Designing Smart Biocompatible Coatings

PROGRAM

Physics

SUPERVISOR

Neal Madras

Biomimicry with biological polymers is an active field that holds great promise in tackling many of the challenges associated with the interface between humans and machines. In particular, some of these challenges include the biological coating of implantable materials into our bodies with the purpose of decreasing long-term rejection. In order to optimize the coating procedure all the way through each molecular layer, the first step is to understand and model the biophysical characteristics of charged polymers, polyelectrolytes, adsorbing onto a surface. Our approach focuses on treating these large polyelectrolyte chains and their configurations as self-avoiding random walks on a lattice. When ions and pH are used to control the fraction of charged mers on a polymer, as well as the fraction of the surface in which a polymer can adsorb to, there will be a competition between Entropy (the configurational properties) and Enthalpy (the contributions from electrostatic energies) that will drive preferences for certain polymer architectures that dictate mechanical, physical and biocompatibility properties of the modified surface. Our interest lies in polyelectrolyte loop formation, and our goal is to develop a theoretical model that describes instances in which these architectures will be favoured in accordance to experimental data.

XAVIER MOOTOO

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT **OUTLINE**

Majorization in Operator Algebras

PROGRAM

Mathematics

SUPERVISOR

Paul Skoufranis

The study of majorization on real-valued vectors has been applied to several areas including stochastic processes, economics, and physics. This definition of majorization can be extended naturally to the majorization of Hermitian operators, with important applications in quantum information theory. Further extensions have been studied, such as the majorization of abelian families of Hermitian operators by Francisco D. Martínez Pería, Pedro G. Massey, and Luis E. Silvestre (2005); and the majorization of selfadjoint elements within arbitrary C*-algebras by Ping Wong Ng, Leonel Robert, and Paul Skoufranis (2018). We investigate a special case within the context of majorization in C*-algebras, namely the continuous maps from a metric space to the n x n matrices with complex entries. In this context, we aim to prove an important property characterizing majorization involving the convex hull of the unitary orbit of selfadjoint elements which are being majorized. Proving this property will enable new methods to be generalized in the case of arbitrary C*-algebras, simplifying the results from 2018. While this line of inquiry may be more abstract than the original conception of majorization, all versions of majorization are intimately connected, and thus will unveil new applications to mathematics and the sciences.

NNEKA OKAEME

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Proportionality Based Association Metrics Applied to Count Compositional Data

PROGRAM

Statistics

SUPERVISOR

Kevin McGregor

OUTLINE

Compositional data, such as microbiome and single-cell RNA data, is such that each vector of the data matrix is constrained to sum to a constant. This type of data presents unique challenges in measuring associations between different pairs of the features (ex., taxa, genes) of the dataset. The most commonly used measures of association for compositional data utilize the proportions between the different features. An issue of interest is the differing sample read depths in empirical compositional data. This project focuses on remedying this by using values for the counts and read depths which are modeled from the multinomial logit-Normal distribution. Maximum likelihood estimates of the model parameters are then used for calculating the measures of association. The efficacy of this method is assessed by running various simulations. Additionally, by using single-cell RNA data from Skinnider et. al, the model-based estimation of these measures of association is assessed using estimators which introduce a penalization parameter, allowing for these measures of association to be calculated on datasets with a large number of genes relative to the sample size.

IFFAH PASHA

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

A Simple COVID Model

PROGRAM

Biomedical Science

SUPERVISOR

Iain Moyles

OUTLINE

My research is to compare the complex models that have been used to track COVID with a simple SRIS model that we create. The goal of this is to find if the simple models are useful enough to give us the big picture.

SAMAR SHEHTOU

YORK SCIENCE SCHOLARS AWARD

PROJECT

First-Year Experience Analysis

OUTLINE

The first-year experience modules are taken by first-semester undergraduates to help enhance their skills throughout university. This project investigates data obtained from learners during a pilot phase program in Fall 2019, 2020, and 2021, in which modules were embedded in an introductory mathematics course for non-mathematics majors.

PROGRAM

Statistics

I did a statistical analysis of 700 students who completed these modules. In which I analyzed students' success in courses and the impact of student participation rates as part of an Early Alert intervention program.

SUPERVISOR

Andrew Skelton

Some results are that students who completed more modules proactively, on average, tend to have higher grades. Moreover, there is no correlation between students' perceived value of the modules and their final grades; this indicates that students of all academic levels find value in the modules. On the other hand, there is a negative correlation between their perceived length and final grades; this indicates that the shorter the modules are, the better the final grades. In 2020 and 2021, the students were rewarded up to 5% of their final grade, and according to their feedback, the formal reward was appropriate.

The next phase of this project is to develop more open-source modules to ensure students' success.

LUCAS SMITH

YORK SCIENCE SCHOLARS AWARD

PROJECT

Achieving Success for University Students with Learning Disabilities

OUTLINE

This project aims be a guide for students with a learning disability as well as students who feel like they have a barrier when it comes to learning. The goal is to firmly remind these students that they are not alone, and that it's normal to struggle with a certain aspect academically. The other goal is to provide advice, tips, strategies and services that help not only be content with your struggles, but put in a mindset to thrive in a university environment. This is a very interactive module with a lot of open discussion, story telling and personable information that university students with and without a learning disability can relate to.

PROGRAM

Mathematics for Education

SUPERVISOR

Andrew Skelton

SELIN TAHIR

YORK SCIENCE SCHOLARS AWARD

PROJECT

Identifying Factors that Influence Mosquito Bites and the Spread of Malaria

PROGRAM

Biomedical Science

SUPERVISOR

Jude Kong

OUTLINE

This project looks into the factors that influence mosquito bites and the spread of malaria, specifically in the Global South, by identifying and studying factors. Accurate data has been collected using reliable sources to study the association between identifying factors to determine a correlation. It is important to study Malaria as it is considered an infectious disease. With so many people at risk for such a devastating illness, it is challenging to maintain stable economies and populations in underdeveloped regions of the world. Studying the factors that affect the spread of Malaria, gives hope to decrease the number of illnesses and deaths.

JARED WIECLAWEK

YORK SCIENCE SCHOLARS AWARD

PROJECT

Analysis of Episodic Data in Nursing Homes Across Canada

PROGRAM

Actuarial Science

SUPERVISOR

Jude Kong

OUTLINE

For my project I am analysing episodic data of COVID-19 cases in nursing homes across Canada. This will include determining the following in each nursing home: the peak value in each wave, how long the peak lasts, how long each wave lasts as well as the growth rate of cases. Once the above is determined for each nursing home the obtained values will be compared by each nursing home. This is important because if it is discovered that there are significant differences in these values for each nursing home they can then be used to investigate what factors caused said differences.

PHYSICS & ASTRONOMY

ALEXANDER BRISEBOIS

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Dark Matter and the First Minihalos

PROGRAM

Engineering Science

SUPERVISOR

Sean Tulin

OUTLINE

Under the supervision of Prof. Sean Tulin, and along with collaborators Aster Schnell and Yaqi Han, we are studying how the properties of dark matter may affect the structure of minihalos and the formation of the first stars in the universe. In order to study these effects, we are performing hydrodynamical simulations modeling star formation.

KATRINA CARVER

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Applying Ensemble Methods to Neural Networks for Determining Sleep State in Parkinson's Disease

PROGRAM

Physics & Astronomy

SUPERVISOR

Joel Zylberberg

OUTLINE

Parkinson's Disease (PD) is a progressive, chronic neurological disease affecting 1 in 500 Canadians, characterized by resting tremor, bradykinesia, and rigidity. Deep-Brain Stimulation (DBS), which runs continuously using one stimulation pattern, is effective at mitigating these life-altering movement-related symptoms. However, it does little to improve the sleep-related symptoms 75% of persons with PD report (Parkinson's Foundation, 2022). To solve this, an adaptive DBS device has been proposed — one that can provide state-specific modulation, i.e. include an "awake"-type stimulation to regulate movement and an "asleep"-type stimulation to regulate sleep. To implement this, the DBS device first must be able to recognize a person's sleep state based on the local field potential (LFP) data it collects. We are creating neural networks (NNs) to do such state determination that will eventually be incorporated into the DBS device. The purpose of my project is to apply ensemble methods from machine learning, such as bootstrap aggregating (bagging), to these NNs trained on the DBS LFP data to increase their accuracy and robustness when dealing with data from yet-unseen persons. I will then apply the same techniques to NNs trained on downsampled data and for additional state classification with the same aims of increasing accuracy and robustness.

KARINA KOFMAN

YORK SCIENCE SCHOLARS AWARD

PROJECT

Spiking Neurons and Delays: Computational Explorations via Hodgkin-Huxley

PROGRAM

Biology

SUPERVISOR

Christopher Bergevin

OUTLINE

Neurons are the fundamental unit of our nervous systems. They exhibit an all-or-nothing “action potential” (AP), or spike, as manifest in their trans-membrane voltage. Since its formulation in 1952, the Hodgkin-Huxley (HH) model has provided an explanation for electrical excitability in a single neuron. This framework has served as an indispensable example of a mathematical model applied to biology by quantitatively characterizing the passage of ions through cell membranes and associated nonlinear dynamics. In short, the HH model considers the cell (semi-permeable) membrane as an electrical circuit with four parallel conductive branches: capacitance, potassium (K), sodium (Na), and “leakage” (L). Here, we take an “in silico” approach to investigate the refractory period, which limits the number of action potentials that can fire per unit time, thus setting a bound on maximum firing rate. We sought to refute/support the following hypothesis: The external concentration of sodium is inversely related to the refractory period. That is, increasing the external Na concentration of sodium will shorten the refractory period, and vice versa. In assessing our hypothesis through simulation, we aim to set a stage to determine the suitability of the HH model to describe electrical excitability in non-neuronal cells (e.g., in plants).

MARIA MEHMOOD

DEAN’S UNDERGRADUATE RESEARCH AWARD

PROJECT

Measurement of the Anti Neutrino Charged Current Cross Section On CH as a Function of Muon Kinematics

PROGRAM

Physics & Astronomy, Mathematics for Education

SUPERVISOR

Deborah Harris

OUTLINE

The MINERvA experiment hosted at Fermilab uses the world’s most intense neutrino beam to collect data of neutrino and antineutrino interactions on a broad range of nuclei including carbon, iron, and lead. The data collected has provided ample statistics to make detailed neutrino and anti-neutrino cross section measurements which are essential to neutrino oscillation experiments and for understanding the weak structure of the nucleus. Some underlying questions which propel the world-wide neutrino physics program pertain to the neutrino mass ordering and CP violation, or whether neutrinos and antineutrinos oscillate at the same rate. Cross section measurements are an essential tool for answering these questions. They also lay the foundation for newer neutrino experiments on the horizon. My research project this summer is to make a measurement of the double differential anti-neutrino charged current cross section (anti-neutrino + CH -> anti muon + X) on hydrocarbon in terms of transverse and longitudinal muon momenta. This measurement has already been made in neutrino mode and when complemented with the measurement in anti-neutrino mode will paint a fuller picture of neutrino/anti neutrino interactions on hydrocarbon.

JASKARAN RANDHAWA

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Development of a Modulation-Free Laser Frequency Stabilization Setup for Atomic Lifetime Measurements

PROGRAM

Physics & Astronomy

SUPERVISOR

Anantharaman Kumarakrishnan

OUTLINE

We are pursuing precise, comparative determinations of the radiative lifetimes of the Rb 5P 3/2 and 5P 1/2 excited states using the technique of photon echoes. The experiment relies on laser frequency stabilization of homebuilt external cavity diode lasers to atomic resonances at 780 nm and 795 nm. A standard technique for stabilizing the laser frequency involves lock-in spectroscopy. Here, a lock-in amplifier is used to modulate the laser frequency and produce a dispersion-shaped error signal required to lock the laser frequency to the desired atomic resonance. The inherent disadvantage of this technique is the need to modulate the laser frequency. Alternative schemes that are modulation-free include the Dichroic Atomic Vapour Cell Laser Lock (DAVLL). By combining the DAVLL scheme with saturated absorption spectroscopy, we have developed a Doppler-free version of this technique (DF-DAVLL). We describe characterizations of the frequency stability of DF-DAVLL feedback loops operating at the desired wavelengths using measurements of the Allan Deviation (AD).

ASTER SCHNELL

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Role of Dark Matter in the Formation of the First Stars

PROGRAM

Physics & Astronomy

SUPERVISOR

Sean Tulin

OUTLINE

Dark matter structures play an important role in the formation of the first stars in the Universe, providing the gravitational seeds which allowed gas clouds from the early Universe to collapse into stars. Dark matter is still not well understood; it interacts gravitationally with matter but not electromagnetically and is therefore difficult to observe.

Our project explores the role of dark matter in the early Universe and considers different possibilities with regards to dark matter's microphysical properties, that is, its potential interactions and forces. The project is both theoretical and computational and consists largely of writing and running Python code which simulates a gas cloud collapsing into a star. The goal for this project is to provide us with insight as to the effect of different models of dark matter on the formation of early stars.

CONNOR WALSH

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Characterization of Microparticles using Optical Tweezers

PROGRAM

Physics & Astronomy

SUPERVISOR

Anantharaman Kumarakrishnan

OUTLINE

We have developed simple techniques to precisely characterize the physical properties of micrometer-sized particles trapped both in free space and liquid culture environments using optical tweezers. In these experiments, particles are confined in three dimensions by the optical dipole force in the vicinity of the focal plane of a laser beam. We image the kinematics of trapped particles on fast time scales using a video microscope containing a high-speed camera and an acousto-optic modulator to amplitude modulate the trapping forces. We describe techniques to rapidly characterize physical properties such as mass, damping coefficients and viscosity.

ARTS, MEDIA, PERFORMANCE & DESIGN

JOO PARK

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

A Tea Making Ritual in Mixed Reality for People with Dementia: Design for Quality of Life (QoL)

PROGRAM

Digital Media

SUPERVISOR

Shital Desai

OUTLINE

Prompting technologies have the potential to support older adults in early stages of dementia in activities they usually find difficult to complete by themselves. Successful adoption of prompting technologies can contribute to independence in execution of Activities of Daily Living (ADL) such as laundry and cooking in people with dementia (PwD). However, existing prompting systems are proof of concepts of technological innovations, and are undeployable in home settings. There is a need to develop prompting technologies that adapt to the context of use and needs of older adults with dementia without having to adjust settings, change versions, or use hacks. Mixed Reality (MR) Environments offer scalable options for development for prompting systems in PwD. These technologies should be designed with an understanding of older adults' technology needs in the context of their impairments.

The objective of this summer NSERC URSA funded project aims to develop and evaluate multimodal AR prompts using the Hololens 2 head mounted device (HMD). Interactive visual prompts such as animations, text, graphics, symbols and icons, will be prototyped. Audio prompts will entail exploring strategies such as audio description and Augmentative and Alternative communication (AAC) for prompting PwD in mixed reality environments.

ENVIRONMENTAL & URBAN CHANGE

RANDELLE ADANO

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Assessing the Holocene Paleoenvironmental History of Lake Scugog Inferred from Subfossil Midges Preserved In Lake Sediments

PROGRAM

Environmental Science

SUPERVISOR

Jennifer Korosi

OUTLINE

Lake Scugog is a large, shallow lake in Southern Ontario with a long history of anthropogenic impacts that include early European colonization, the building of the Lindsay Dam to regulate water flow, and the present-day abundance of multiple invasive species. Its hydrology and water quality are also highly vulnerable to anthropogenic climate change. Paleolimnology, the science of using biological, chemical, and physical remains preserved in the sediments of inland water systems, will be used to reconstruct the ecological history of Lake Scugog throughout the Holocene to provide a long-term perspective on the responses of the Lake Scugog basin to climate change. Using a sediment core retrieved in 2020 and sectioned into 1-cm intervals, I will process samples to isolate subfossil remains of Chironomidae, a family of non-biting midges that are valuable paleoenvironmental indicators. Chironomids are ubiquitous and can tolerate a wide range of habitats, although some species have specific preferences for different aquatic conditions, making them ideal indicators to reconstruct environmental changes. The abundances of different chironomid species will be graphed in a stratigraphy to assess how the community has changed over the last ~8000 years, a time period that encompassed multiple climatic shifts.

HEALTH

ORLY AZIZA

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Functional specialization of the visual system in Autism Spectrum Disorder

PROGRAM

Psychology

SUPERVISOR

Erez Freud

OUTLINE

Perceptual changes are a widely acknowledged but poorly understood feature of autism. One hypothesis is that those changes are the result of reduced cortical specialization. In my NSERC project, we seek to examine this hypothesis by exploiting the well-established functional dissociation between the ventral pathway that mediates vision-for-perception (i.e., object recognition), and the dorsal pathway that mediates vision-for-action (i.e., visuomotor control of objects). We will utilize motion-tracking technology to examine the effect of the experimental temporal context on perceptual and visuomotor behaviours in neurotypical and autistic individuals.

Neurotypical individuals' ability to detect a minimum size increment to a stimulus depends on the range of the other stimuli for which this just noticeable difference (JND) is being measured. Specifically, the JND around a standard stimulus is larger when the other stimuli within the same experimental session spread a larger range. Interestingly, this effect is limited to perceptual estimation tasks and is not observed for grasping tasks (Namdar, Ganel & Alon, 2018). We predict that due to reduced cortical specialization, autistic individuals will show a temporal context effect not only for perceptual estimation tasks but also for visuomotor tasks.

ANGELICA DREXLER

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Moderating factors in the 'Bilingual advantage'

PROGRAM

Psychology

SUPERVISOR

Andrée-Ann Cyr

OUTLINE

Many studies that examine the bilingual advantage find that bilinguals perform better on tasks that involve executive function abilities (e.g., task-switching, inhibition) relative to monolinguals. However, a number of studies have found no significant differences in executive performance between bilinguals and monolinguals. Recently, studies have suggested that this advantage stems from other factors and not bilingualism per se: Socioeconomic status, culture, language experience, and experience doing other activities that could improve cognitive function abilities (e.g. regularly playing video games, an instrument, etc).

My objective is to examine executive function performance among groups of bilinguals and monolinguals that are less likely to be socioeconomically and culturally different: French-English bilinguals and English-speaking monolinguals born in Canada. This is examined through the classic "Stroop task" and "Flanker task", which are response inhibition tasks that provoke selective attention and executive control.

Bilingualism is inherently enriching and provides a myriad of cultural, personal, and educational benefits for individuals. However, it is crucial that the bilingualism advantage be better understood in order to effectively guide pedagogy and policy.

MOHAMED ELSAYED ELGHOBASHY

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

The Effects of Interstitial Glucose Levels on Neuromuscular Fatigue

PROGRAM

Kinesiology and Health

SUPERVISOR

Arthur Cheng

OUTLINE

The goal of this project is to understand the role of interstitial glucose levels on exercise-induced fatigue. Endurance exercise performance is determined by the energy demand of the exercise being met by energy supply, with one such energy supply being carbohydrates consumed as food or carbohydrates stored within the muscle in the form of glycogen. During endurance exercise, it has been commonly proposed that muscle glycogen depletion is a major cause of fatigue (Ortenblad et al., 2013; Cheng et al., 2017) because glycogen is a readily available intramuscular storage form of glucose that can be rapidly broken down to supply ATP to contracting muscle. In addition, glucose is also available as an alternative energy source for contracting muscle via glucose uptake into the muscle from the extracellular milieu. However, glucose has not been previously deemed as a rate limiting cause of fatigue. Thus, the goal of this research is to identify whether fatigue during voluntary endurance exercise performed in humans is associated with interstitial glucose levels assessed with a continuous glucose monitor (CGM), and further we aim to distinguish whether fatigue-induced changes in interstitial glucose levels is due to central (neural) or peripheral (intramuscular) factors.

NATHANIEL GOLDSTEIN

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Perception of Size and Distance in Augmented Reality (Ar)

PROGRAM

Psychology

SUPERVISOR

Laurie Wilcox

OUTLINE

The human visual system integrates depth information to make judgements about the size and distance of objects around us. Monocular sources of depth information called pictorial cues (e.g., occlusion, texture gradients, perspective, and shading) provide information about whether objects are in front of or behind each other. In comparison, stereopsis is a binocular depth cue which provides precise information about the relative depth of an object.

In this project we are studying how depth from stereopsis is combined with depth from occlusion, and how the brain copes with conflicts between these two cues. Specifically, we are interested in the impact of these conflicts on perceived object size. To study this, we are using the HoloLens, an augmented reality (AR) display, to position virtual stimuli in the real world alongside physical objects. Previous work in our lab has shown that viewers underestimate perceived depth when stereopsis and occlusion are in conflict. We hypothesize that this will in turn affect the object's perceived size.

This project will help us understand how depth information is integrated by the human visual system. It will also provide important information concerning distortions in the perceived size and distance of objects in augmented reality displays.

PATRICK HEWAN

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Shifting Architectures of Cognition and Brain Function in Older Adulthood

PROGRAM

Psychology

SUPERVISOR

Gary Turner

OUTLINE

Understanding how the brain changes with age is crucial for mitigating age-related cognitive decline and developing treatments for neurodegenerative disease. However, we lack effective models that combine changes in cognition across the lifespan, with changes in the associated neural circuitry. This has led to the perception that aging is only associated with cognitive and neural losses, and a failure to appreciate that older adults may approach mentation from a different starting point. To support this hypothesis, we are conducting a combined behavioural and functional magnetic resonance imaging study. The behavioural protocol will be composed of three exploration-exploitation (E&E) tasks and the neuroimaging protocol will include a task-related functional scan during the performance of an E&E task. We will recruit 60 healthy young and 60 cognitively normal older adults who will complete a cognitive battery comprising cognitive control and semantic knowledge measures as well as the E&E battery. We predict an age-related exploitation bias across all behavioural tasks and an associated increase in functional connectivity between brain networks implicated in cognitive control and semantic cognition. Our findings will provide insight into cognition and brain function in older adulthood and support a more unitary account of mental functions in late-life development.

YEJI SEO

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Interaction of Cognition and Sensory Information for Balance Control

PROGRAM

Kinesiology

SUPERVISOR

George Mochizuki

OUTLINE

Balance control is an essential component of everyday life that allows us to engage in daily activities while also preventing injuries and reducing fall risk. Postural stability requires sensory input including vision, proprioception, and vestibular information. When any of these sensory components are disturbed, postural instability occurs. It is known from previous research that cognition also plays an important role in postural stability. Individuals with poorer cognition experience greater difficulty in balance control. However, although both sensory information and cognition play a role in balance control, the interaction between the two is not yet clear.

The specific research question is: how is sensory information used in situations when our attention is directed elsewhere other than to control balance? This question will be answered by varying the level of distraction and availability of sensory information while young adults stand on a forceplate. Spectral analysis of the center of pressure obtained from the forceplate will be used to characterize the cost of the cognitive load on sensory contributions to balance. This analysis will allow us to better understand how cognition and sensory information interact to safely maintain balance in the face of multi-tasking activities humans engage in on a regular basis.

SERAH SEO

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Comparing Endothelial Function Between Patients with Myalgic Encephalomyelitis/Chronic Fatigue Syndrome And Long-Covid, and Healthy Subjects

PROGRAM

Psychology

SUPERVISOR

Heather Edgell

OUTLINE

Patients with myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS) or long-COVID (LC) both experience symptoms that involve multiple systems. A significant overlap has been observed in the two conditions. A possible factor that is thought to lead to endothelial dysfunction in patients with ME/CFS and LC is persistent inflammation. Endothelial dysfunction may increase the risk of cardiovascular diseases and exacerbate symptoms of ME/CFS and LC. Despite the threat it poses to patient health and wellbeing, endothelial function has insufficiently been studied in these patient populations.

The goal of this study is to compare endothelial function between patients with ME/CFS and LC, and healthy subjects. Endothelial function will be assessed using flow mediated dilation (FMD), where ultrasound will be used to measure diameter of the brachial artery and blood flow at baseline (2 min), during forearm occlusion using a blood pressure cuff (5 min) and after cuff release (3 min). FMD will be calculated as the percentage change in arterial diameter after release of occlusion. The results of this project will provide a greater understanding of whether and how endothelial function in ME/CFS and LC compares to healthy subjects.

LIBERAL ARTS & PROFESSIONAL STUDIES

MING KAN LEUNG

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Large-Scale Declarative Video Analytics

PROGRAM

Information Technology

SUPERVISOR

Xiao Hui Yu

OUTLINE

We have witnessed an explosion of video data over recent decades. According to the Wall Street Journal there will be a billion cameras on the streets by 2021. However, the way of querying video streams is still primitive, and requires lots of human intervention. In scenarios such as surveillance applications, humans often have to visually inspect a large amount of video to identify persons or objects of interest. It is therefore crucial to develop systems that could support the extraction of meaningful information from videos in real time, utilizing declarative queries, in a way akin to how people are interacting with database systems today.

On the other hand, recent breakthroughs in Deep Learning have made it possible to achieve highly accurate results in tasks such as image classification, object detection and object tracking, providing the building blocks to make large-scale video query processing a reality.

The project aims to address these challenges by developing solutions that bridge the gap between the need for powerful video analytics and the capability of specific Deep Learning models. The objective is to develop the frameworks, models, algorithms, and systems for general-purpose structured video processing and analytics to unleash the vast potential of video data.

MEHRSA KHOSHPASAND

NSERC UNDERGRADUATE RESEARCH AWARD

PROJECT

Using Behavioural Profiling to Detect Malicious Activity on Network Layer (Netflowmeter)

PROGRAM

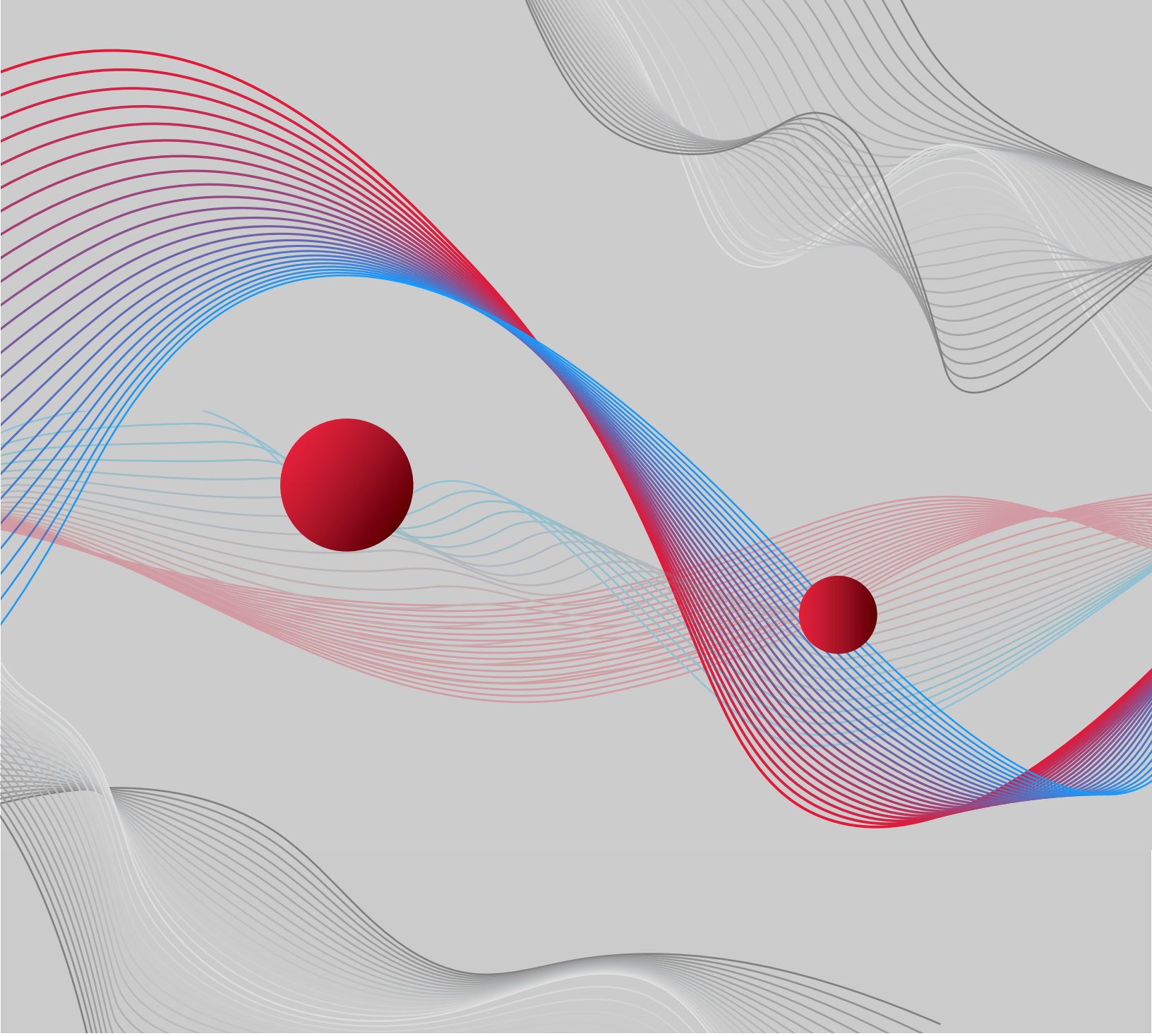
Computer Science

SUPERVISOR

Arash Habibi Lashkari

OUTLINE

As the world grows more reliant on networks, the threat of cyberattacks poses an increasingly dangerous problem. The issue of security against intrusions has caused many researchers to propose different intrusion detection systems (IDS) and intrusion prevention systems (IPS). In this research, titled NetFlowMeter, we propose an IDS based on extracting different flow-based and packet-based features of network traffic and using pattern recognition and behavioral profiling to detect malicious activity on the network layer. NetFlowMeter is a Python tool based on Scapy that extracts different packet-based and flow-based features from captured network activity. This tool takes network activity in the form of Pcap files as input and generates flows based on source port, destination port, source IP, destination IP and protocol, within the predefined idle timeout. Using these flows, different features such as IAT features, packet length features, and more are extracted and presented for use in different IDS and IPS. These features are then used to detect attacks such as Distributed Denial of Service (DDoS) attacks, using behavioral profiling. For example, in DDoS attacks, the attacker aims to overwhelm the server by sending a large number of packets such that the server is unable to respond to all. Using behavioral profiling, this type of activity can be recognized, labeled, and prevented from causing damage to the server. The research in this project aims to develop an open source tool for detecting malicious behavior on the network layer using packet-based and flow-based features. This project helps to make the detection of attacks on networks easier and more efficient, making the use of networks safer.



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