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Dear students,

Congratulations on completing a productive and rewarding summer term as a research student!

I hope your research experience has given you a deeper perspective of what being a scientist is all about, helped you learn new skills and more about your interests, and led to new friendships and collaborations. In addition, I hope you appreciate that your contributions this summer are an important part of the research endeavor at York University. Your hard work and achievements will leave a lasting impact on science at York 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 2018 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,

Ray Jayawardhana
Dean, Faculty of Science
York University

MESSAGE FROM THE DIRECTOR

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

Since 1980, the Natural Sciences and Engineering Research Council of Canada (NSERC) has supported research experiences for university students early in their careers through the Undergraduate Student Research Awards (USRA) program. The program currently provides direct support for research work terms for approximately 3,000 students each year. NSERC also supports an additional 6,000 undergraduate students indirectly, through researchers who use their NSERC grant funds to hire students to assist with their research.

We hope that this research experience will nurture your interest and help develop your potential for a research career in the natural sciences and engineering. Should you wish to undertake graduate studies in these fields, remember that you may be eligible to apply for other NSERC scholarships. You can visit the Students and Fellows section of NSERC’s website at http://www.nserc-crsng.gc.ca/Students-Etudiants/index_eng.asp for more information.

We would like to express gratitude to the professors who hosted and supervised your research experience. We want to thank any graduate students, postdoctoral fellows and technicians from York 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,

Serge Villemure
Director, Scholarships and Fellowships Division
NSERC
Raman Abbaspour is a second-year biomedical student in the Faculty of Science. Under the supervision of Professor Hongmei Zhu at the Department of Mathematics and Statistics, he is investigating efficient methods for time series change point detection.

As exemplified by the rapid development of digital technology in hospitals, extracting clinically relevant information from large amounts of medical data to aid disease detection has become an important part of clinical routine. Being able to process and analyze big data efficiently and to detect abnormality requires the innovative development of optimal data representation that can efficiently reveal the desirable characteristics embedded in data. He uses mathematical transforms, such as wavelets and various time-frequency techniques to approach this. Data can be transformed from measured space to another space where features can be sparsely represented and easily extracted. This research integrates mathematics, statistics, computing, and applications development. Raman’s work is highly interdisciplinary and makes good connection of math to real-world problems.

Avani Abraham is entering her fourth-year of Biology Honours BSc in the Faculty of Science and is supervised by Professor Ronald Pearlman.

Work in the Pearlman lab in the Department of Biology uses the eukaryotic animal model organism, the ciliate protozoan *Tetrahymena thermophila*, as an experimental system. Unique features of this system have made it an extremely valuable system to address many important questions and the organism has led to Nobel Prize work on telomeres and telomerase, catalytic RNA and the concept of ‘an RNA world’ as the origin of life, and much more including chromatin modification and epigenetics. With a now fully sequenced genome and proteomic analysis developed through the Pearlman lab and collaborators, as well as the identification of many homologues of human disease genes, many important questions are addressed exploiting this biological system.

Avani’s work focuses on functional analysis of important genes and proteins, in particular those involved in the very important biological process of cell signaling involving the tyrosine kinase pathway, a pathway critical for cell cycle regulation and diseases such as cancer in mammalian cells. Avani’s approach is to address questions about protein localization using the imaging technique of indirect immunofluorescence. These approaches will lead to information about gene/protein function in these critical cellular pathways.
Usman Akhtar is a third-year Biology major in the Faculty of Science who is supervised by Professor Carol Bucking.

Usman’s research focuses on studying the transport of magnesium ions (Mg²⁺) in Zebrafish, Danio rerio. Magnesium is a key ion in all animals as it helps to drive many biochemical reactions by acting as an enzymatic cofactor. One of the main transporters of Magnesium is SLC41a1, which he studies using the Scanning Ion-Selective Electrode Technique (SIET). This allows him to measure both the direction of movement and concentration of Mg²⁺ in zebrafish.

Furthermore, to examine how SLC41a1 is regulated, Usman measures Mg²⁺ flux in both saltwater and freshwater conditions and notes any difference in the flux measured. Another way he studies the role of SLC41a1 is by knocking down the genes related to SLC41a1 and observing the effects on Mg²⁺ transport.

Usman believes that studying the role and regulation of SLC41a1 will provide a greater understanding of the same transporter in humans, which can potentially be related to magnesium-related illnesses.

Anthony Atallah is a recent graduate of a General Science major and is supervised by Professor Rene Fournier.

Anthony is working on an optimization problem in computational chemistry. He is trying to find the most stable 6-atom bimetallic clusters among a list of 9,024 possibilities. He calculates the energy of clusters by Density Functional Theory with the Gaussian software running on Sharcnet computers. An energy calculation typically takes a few hours. Therefore, he cannot do an exhaustive search. Instead, Anthony will calculate energies for a subset of a few hundred clusters and then do a nonlinear regression by Kernel Ridge Regression or Random Forest to predict the energy of the remaining clusters. If he can demonstrate that this methodology works, he will apply it to bigger systems (13- and 55-atom bimetallic icosahedra) where there are millions of possible clusters.

Finding stable bimetallic clusters is important for a few reasons: (a) it helps predict the surface composition of real bimetallic catalysts; (b) it suggests targets for the synthesis of useful, stable, nanoparticles; (c) it helps predict and understand the geometric structure and melting point of nanoparticles; and (d) it improves our fundamental understanding of metal nanoparticles.
Krstina Banyameen is a second-year Honours Biology student in the Faculty of Science. She is currently pursuing a structural biology project under the supervision of Professor Vivian Saridakis. Her project is to crystallize and determine the three-dimensional structure of the MATH domain of the TRIM37 protein.

TRIM37 gene is located on chromosome 17 and its protein product, TRIM37, is a member of the tripartite motif family. TRIM37 consists of zinc-binding domains (B-box), an N-terminal RING domain, a MATH domain and a coiled-coil domain. The possession of the RING domain enables it to ubiquitinate and degrade specific protein substrates, making it a potential target for cellular regulation. TRIM37 has been shown to be involved in developmental patterning and oncogenesis. Research showed that mutations in the protein are linked to Mulibrey Nanism, resulting in abnormal growth in muscles, liver, brain, and eyes. However, to enable further studies on the disease, the three-dimensional structure of the protein must be determined to help identify why mutations cause the protein to malfunction and cause disease.

Krstina will investigate such structure in collaboration with her lab by growing *E. coli* cells expressing the his-tagged MATH domain of TRIM37, lyse them and purify the protein with Ni²⁺ resin and gel filtration chromatography. Crystal trials will be setup with various crystallization conditions. When protein crystals are obtained, specific buffer, salt or precipitant conditions will be refined to enhance the crystal for x-ray diffraction studies. Until then, Krstina will continue to purify and crystalize more TRIM37 MATH domain.

Danica Chahariangi just completed her undergraduate degree in biomedical Science in the Faculty of Science at York University. She is conducting her summer research under the supervision of Professor Vivian Saridakis in the Department of Biology.

A number of protein-protein interactions that are essential in eukaryotic protein processing and ubiquitination involve the mephrin and TRAF-C homology (MATH) domain. A family of MATH domain-containing proteins have been identified; however, multiple structures remain to be determined. Ubiquitin Specific Protease 47 (USP47), a deubiquitinating enzyme (DUB), is one such protein. USP47 has been identified as the central enzyme that deubiquinates and stabilizes DNA polymerase beta (POLB), an essential base excision repair protein. Thus, USP47 plays a significant role in DNA damage repair and the prevention of mutagenesis and oncogenesis.

The student’s role over the summer is to overexpress and purify USP47 for use in sitting drop crystallization trials, with the goal of establishing the protein's structure. This research will further progress knowledge of DUBs and their involvement in disease pathogenesis. By determining their molecular structure, the research ultimately improves our understanding of their function, contributing to the long-term goal of designing small molecules that can manipulate their activity in therapeutic applications.
Nicholas Chrobok is a Biomedical Science student in the Faculty of Science. Having recently completed his third-year of study, Nicholas is pursuing mathematical biology research under the supervision of Professor Jane Heffernan in the Department of Mathematics & Statistics.

In particular, Nicholas aims to develop and refine a deterministic model of the p53/MDM2 network that incorporates MDMX as well as DNA damage as a consequence of ionizing radiation. p53 is a tumour suppressor involved in genomic stability and apoptosis; thus, mathematical modelling will advance an understanding of this vital protein beyond in vivo and in vitro observations. As the summer progresses, Nicholas hopes to continue developing his coding and mathematics skills which, he recognizes, play an increasingly integral role in the advancement of numerous biological subfields.

Robert Cheung is a second-year Biology major in the Faculty of Science who is supervised by Philip Johnson of the Chemistry Department while studying structural analysis of nucleic acids.

While continuing research at the Johnson lab as a former research practicum student, Robert is investigating specifically for the three-dimensional structure of synthetic, cocaine-binding DNA aptamers, by means of X-ray crystallography. Well-ordered crystals of cocaine-binding aptamers are difficult to produce, but with the use of spliceosomal protein U1A as a crystallization module inspired by Jennifer A. Doudna and Adrian R. Ferré-D’Amaré, he hopes to deduce the structure of our cocaine-binding aptamer of interest for greater understanding of binding site locations for greater specificity and understanding of cocaine-binding aptamers. Unique properties Cocaine-binding aptamers have biosensing and therapeutic applications.
Joyce Costa is a third-year Biology student in the Faculty of Science. Under the supervision of Professor Derek Wilson in the Department of Chemistry, Joyce is investigating the dynamics of the Glutathione-S-Transferase (GST) enzyme.

Glutathione-S-Transferases (GST) are a superfamily of detoxifying enzymes that prevent electrophilic xenobiotic species from damaging cellular macromolecules. These xenobiotic species include, but are not limited to, reactive oxygen species, carcinogens and environmental toxins. In order to prevent cellular damage, GSTs conjugate reduced glutathione (GSH) to a wide variety of electrophilic xenobiotic substrates, making the substrates more water soluble and easier to metabolize.

Using NMR and X-ray crystallography, many different forms, or ‘iso-enzymes’, of GST have been discovered and have been classified into 8 different groups using structural similarities - alpha, kappa, mu, omega, pi, sigma, theta and zeta. Despite extensive study of their structure, the enzyme dynamics and catalytic mechanism of GST enzymes are still not well understood. In the past, it has been suggested that binding GSH to the GST enzyme prior to exposure to the xenobiotic substrate prepares the enzyme for catalysis.

Joyce is studying the GST- mu 1 (M1) isozyme and observing its catalytic dynamics with and without its substrate, trans-4-phenyl-3-buten-2-one, using Time Resolved Electrospray Ionization Hydrogen- Deuterium Ion Exchange Mass Spectrometry (TRESI-HDX MS).

Anna Danilova is a third-year student in the Faculty of Science, conducting her research under the supervision of Professor Laurie Wilcox in the Department of Psychology.

Humans use binocular disparity to perceive the relative depth of objects. There are also monocular cues to depth that tell us about the shape and distance of objects. One such cue, motion parallax, provides us with depth information based on the speed and direction of observer motion as well as the displacement of the objects relative to one another.

Anna’s project focuses on the effect of observer-produced motion parallax on the perceived depth of objects in virtual environments and its interaction with binocular disparity in depth perception. Anna is using the Oculus Rift head-mounted display to present virtual cylinders and asking observers to judge their size. To assess the contribution of motion parallax, observers make their depth estimates binocularly (both cues present) and monocularly (binocular disparity absent). In subsequent studies she will evaluate how depth estimates are impacted when these two depth cues are inconsistent.

The results of this project have implications for our understanding of fundamental visual processing by revealing how depth cues are combined in naturalistic scenarios. The results are also relevant to the design and use of virtual reality systems where display optics and motion sensing may provide inconsistent depth information.
Avishai Gasner is entering his fourth-year majoring in Biology in the Faculty of Science. He is completing a DURA for Professor Ronald Pearlman. Work in the Pearlman lab in the Department of Biology uses the eukaryotic animal model organism, the ciliate protozoan Tetrahymena thermophila as an experimental system. Unique features of this system have made it an extremely valuable system to address many important questions and the organism has led to Nobel Prize work on telomeres and telomerase, catalytic RNA and the concept of ‘an RNA world’ as the origin of life, and much more including chromatin modification and epigenetics. With a now fully sequenced genome and proteomic analysis developed through the Pearlman lab and collaborators, as well as the identification of many homologues of human disease genes, many important questions are addressed exploiting this biological system.

Avishai’s work focuses on the development of efficient and effective mutational analysis using small hairpin RNA in order to address important questions about gene function focusing on chromatin dynamics and epigenetics, RNA transcription and gene expression, and homologues of human disease genes.

Sergei Issaev is a third-year student in the Faculty of Science at York University. As a biology major, he is studying the molecular biology of various chromatin-interacting proteins in Professor Peter Cheung’s lab. In a human cell, negatively charged DNA is wrapped around a repeating unit of eight positively charged proteins (two each of H2A, H2B, H3 and H4), known as histones. These individual histone proteins combine to form nucleosomes, which in turn are compacted to form chromatin. A variety of histone post-translational modifications can influence gene expression. This is accomplished via a wide range of chromatin associated proteins which interact with these post-translational modifications.

Differential salt extraction allows one to determine the salt concentration necessary for the removal of chromatin associated proteins. By initially starting with a low salt concentration solvent then incrementally increasing salt concentrations between extractions, samples can subsequently be run via western blot and analyzed for presence and relative amount of specific proteins. Sergei will be analyzing the salt extraction profiles of chromatin associated proteins found within human embryonic kidney (HEK) cells that are subjected to various histone-modifying drugs. This research can lead to the discovery of novel drugs effective in cancer pharmacotherapy, if it is found that the drugs can negatively affect the proliferative capabilities of the cells.
Avideh Khalili just completed her undergraduate degree in Biomedical Science in the Faculty of Science. She is conducting her summer research project under the supervision of Professor Amro Zayed in the Department of Biology. Research in the Zayed lab focuses on bee genetics and conservation.

Honey bees are one of the most important pollinators of food crops and flowering plants. However, there has been a global decline in their population due to factors such as disease, destruction of habitat, and insecticides. Neonicotinoids are the most commonly used insecticide in the world and have been found to cause toxicity in honey bees. Professor Zayed’s team have found that honey bees have various levels of sensitivity to neonicotinoids. This brings into question whether the variation in sensitivity to neonicotinoids is due to genetic factors.

One of Avideh’s projects will be to genotype bees treated with a lethal dose of neonicotinoids using eleven microsatellite molecular markers. She will compare allele combinations at each microsatellite locus to group the bees based on their paternity. This analysis will help determine whether the bees that died were paternally related, indicating a possible genetic link to neonicotinoid toxicity. If a genetic correlation is found, the goal will be to identify the genes responsible for the survival from neonicotinoid exposure. Identifying the genes that lead to neonicotinoid resistance will help conservation practices for honey bees.

My Ha Le has just completed her fourth year in the Biomedical Science Program in the Faculty of Science. Her research project focuses on applying RNA aptamer called Broccoli into studying one of the long-distance RNA-RNA interactions (LDRIs) in a model plant virus Tomato Bushy Stunt Virus (TBSV), under the supervision of Professor Karl Andrew White in the Department of Biology.

TBSV replicates its genome and makes five different proteins using host translation machinery in a regulated manner by utilizing different gene expression strategies. One of the strategies is expressing smaller mRNA fragments called subgenomic (sg) mRNA. To facilitate this process, different parts of the viral single stranded genome are known to base pair with each other, forming LDRIs. The distal element (DE) and core element (CE) is an important LDRI for sg mRNA expression.

My’s summer research project involves the incorporating of Broccoli aptamer into DE and CE sequences and investigating this LDRI in TBSV. By taking advantage of Broccoli RNA aptamer fluorescence activity, DE-CE long distance interaction can be studied both in vitro and in vivo. This could allow the research lab to further elucidate the role of DE-CE formation in sg mRNA expression regulation. The research could help the research lab gain better understandings in viral transcription and gene expression strategies, potentially enhancing the development of effective antiviral approaches.
Do Eon Lee has just completed his third-year in Biomedical Science in the Faculty of Science and is currently working in Professor Jean-Paul Paluzzi’s Lab as a NSERC USRA research student. Professor Paluzzi’s lab studies the molecular physiology and neuroendocrinology of blood-feeding arthropods, such as mosquitoes and ticks.

*Aedes aegypti*, also referred to as yellow fever mosquito, is known to be a vector of several diseases such as dengue and yellow fevers as well as Zika virus. Transmission of the disease-causing pathogens occurs during blood feeding, which is an essential process for female mosquitoes to synthesize yolk proteins deposited in their eggs. After acquiring a blood meal, the female mosquitoes must regulate ion balance by secreting excess water and ions while maintaining the nutrients in the vertebrate blood.

In *Aedes aegypti*, studies have shown that there are six aquaporins (AQPs), which are transport channels that increase water permeability across cell membranes and are expressed in osmoregulatory organs (i.e. midgut, Malpighian ‘renal’ tubules, hindgut). Although extensive research has been done on AQPs in larvae and on hormonal regulation of AQP in mammals (for example, anti-diuretic hormone control of AQP2 in the renal nephrons), studies on AQPs in adult mosquitoes as well as their potential hormonal regulation remains unexplored. Under the supervision of Professor Paluzzi, Do Eon’s summer research project will explore the potential regulation of mosquito AQPs involving neurohormones and their second messengers (e.g. cyclic AMP) in osmoregulatory organs in adult *Aedes aegypti* mosquitoes.

Parth Patel is a second-year Biomedical Science major in the Faculty of Science who is supervised by Professor Philip Johnson of the Department of Chemistry.

Parth’s role at the Johnson Lab is to design an online platform that can be utilized to automate the process of gene synthesis using Assembly PCR. PCR (Polymerase Chain Reaction) is a technique that is routinely employed in labs to amplify DNA sequences. However, the technique in itself is not ideal for amplifying long strands of DNA. To circumvent this constraint, researchers use a technique called Assembly PCR.

To accomplish this task, Parth develops algorithms and uses a diverse set of computational models and programming tools. The main program and algorithms are implemented in Python with some extensions being written in C++ for improved performance. In addition, Parth also utilizes other computational algorithms and biological models to ensure that the oligodeoxynucleotides designed by the program satisfy certain criteria. Once the program designs the oligodeoxynucleotides from a given sequence, the team tests the accuracy of output of the program in the lab by conducting empirical analysis.

Assembly-PCR is increasingly becoming a prominent tool in systems biology and genomics. It enables researchers to perform structural analysis on proteins of manageable size and also allows them to investigate the role of specific structural DNA elements. Hence, it is important the scientists develop an accessible, effective and modern tool that can automate this process.
Jennifer Porat is a third-year Biomedical Science student in the Faculty of Science. She is studying all things tRNA in Professor Mark Bayfield’s lab in the Department of Biology, with a special interest in how post-transcriptional modifications influence translation and cellular fitness. Most of her efforts (and occasional frustrations) thus far have been focused on characterizing the tRNA methyltransferase Trm1.

Trm1 in the fission yeast *Schizosaccharomyces pombe* has two possible start codons, allowing for dual targeting to the nucleus and mitochondria. Perhaps puzzlingly, overexpression of the mitochondrial-targeted isoform, but not nuclear, impairs growth. Moreover, the mitochondrial isoform appears to affect translation in a codon-specific manner, suggesting a possible link between tRNA body modifications and decoding ability. The main goal of her project is to investigate the mechanism by which this occurs. As such, her work involves a great deal of northern blotting, RNA chaperone assays, and primer extensions — along with whatever new experiments sound the most exciting.

Megan Schwegel has just finished her second-year of Biology at Glendon College. Working alongside Professor Valerie Schoof and her PhD student, Kyle Hendrikson, Megan is studying vervet monkeys in Uganda, specifically infant development as influenced by the relationships between mothers and their infants under one year old.

Female vervets inherit their mother’s dominance rank, while male vervets obtain their dominance rank through agonistic interactions. Mothering style is affected by maternal dominance rank, stress hormone levels, and estrogen levels, but little is known about how mothering style affects infant development and dominance rank for male infants.

The objective of Megan’s work is to determine a relationship between mothering style and dominance rank by analyzing maternal behavioural patterns, including permisiveness (determined by the distance the infant is found from the mother) and weaning attempts. She is also extracting hormones — e.g. estrogen and cortisol — from fecal samples to identify associations between these hormones and individual maternal behaviour. Her research leads to a more thorough understanding of the evolution of behavioural variation in parental care of vervets and, by studying a closely related primate, will provide unique insights into human behavioural development.
Chanhee Seo is a recent graduate of the Biology program in the Faculty of Science and is supervised by Professor Patricia Lakin-Thomas.

Circadian rhythm is an endogenously generated cycle of about 24 hours found in all domains of life. This fundamental property of living things is the work of an intricate 24-hour transcription-translation feedback loop (TTFL). One key gene involved in this process is the frequency (frq) gene that produces the frequency protein (FRQ). Interestingly, there have been multiple reports of rhythms in the absence of frq, pointing to a possibility of a FRQ-less oscillator (FLO). Professor Lakin-Thomas’s lab has identified several genes that may be part of the FLO.

To understand how frq interacts with other components of the FLO, Chanhee will attach an epitope tag to the FRQ protein by genetically engineering the model organism, the filamentous fungus Neurospora crassa. Tagging the FRQ protein will enable him to detect the protein using Western blotting to assay the FRQ protein expression and functional levels at different time points of the circadian cycle. Finally, he will introduce the FLAG-tagged FRQ construct into mutant strains in which putative FLO components have been deleted and investigate how the rhythmicity of the FRQ protein is modified. In so doing, a deeper understanding of the molecular interactions between the central clock mechanism TTFL and the FLO could be accomplished.

Apinaya Sorupanathan is a second-year student in the Faculty of Science in the Biomedical Science program. Under the supervision of Professor Krylov Sergey and Researcher Vasilij Koshkin in the Department of Biology, Apinaya is researching the effect of temperature on the MDR (multidrug resistance) transport in cancer cells.

Cancer cells develop resistance to chemotherapy by extrusion of anti-cancer MDR transporters, which lead to the failure of cancer treatment. One of promising approaches in this field is combination of chemotherapy with other therapeutic modalities, e.g., hyperthermia. However, since elevated temperature can activate MDR transport, studying of temperature dependence of MDR activity is expected to have predictive capacity for combined therapy development. In this project, MDR transport in ovarian cancer cells will be studied in the common hyperthermic temperature range 37-42°C. To this end, the kinetic rate of fluorescein efflux is measured using single cell analysis. Single cell analysis is used due to the difference of efflux of individual cells which cannot be noted when a whole population average is studied. This research will contribute to understanding mechanism of hyperthermia treatment, and can overall be applied to developing better ovarian cancer planning and treatment.
Parastoo Tashakorinia is majoring in Honours Biomedical Science in the Faculty of Science. She has completed the third-year of her program this year. Parastoo is working as a DURA research student under the supervision of Professor Gary Sweeney on the molecular mechanisms underlying the association of obesity and various metabolic diseases.

Obesity and the high-fat diet are one of the major risk factors for various metabolic disorders like type 2 diabetes and cardiovascular disease. Lipotoxicity is considered a serious concern in high-fat diet condition since the accumulation of lipids in non-adipose tissue such as skeletal muscle cells could lead to stress response and various cellular dysfunction. Previous studies show that adiponectin, a novel adipocyte-specific protein circulating in high concentration in the blood, could decrease oxidative stress and cell death by increasing fatty acid uptake and oxidation and decreasing esterification of fatty acids to triglycerides. However, adiponectin levels are considerably low in obese individuals and type 2 diabetes patients.

In this study, Parastoo will examine the effects of palmitate, a common saturated fatty acid, along with AdipoRon, an agonist of the adiponectin receptors, on L6 rat skeletal muscle cells. It is predicted that palmitate induces cell death, as well as generating reactive oxygen species, ROS. Cell death will be measured by LDH and MTT assays. Generation of reactive oxygen species can be determined by DCFDA assay and Cell-Rox fluorescent microscopy. Finally, autophagic flux could be measured through Western blotting of LC3-II antibody as well as CytoID fluorescent microscopy.

Esther Wolf is a fourth-year student majoring in the Specialized Honours in Biochemistry program with the Faculty of Science. Over the course of the summer, she will be working as a DURA student in the Centre for Research in Mass Spectrometry under the supervision of Professor Derek Wilson. Mass spectrometry (MS) has an array of applications, especially in that of proteomics.

The goal of her research project is to become more familiar with MS while gaining insight into the function of Glutathione-S-Transferase (GST). In the cell, GST plays a critical role in detoxification. It catalyzes the conjugation of a small peptide called glutathione to foreign, potentially harmful molecules, which increases their solubility and facilitates their excretion.

The unique properties of the mass spectrometer allow GST to be characterized by its mass and charge as it passes through a magnetic field. Knowing the mass of GST is useful in studying how it binds its substrates, such as detecting which parts of the enzyme are involved in binding and how the enzymes structure changes once a substrate is bound. HDX-MS, a technique which observes the exchange of hydrogen in the amide backbone of the protein with deuterium in solution, is a power tool in such analysis.
Simona Yakobov earned a Bachelor of Science degree in York University’s Faculty of Science, majoring in Biomedical Sciences. Her love for physics and biology converged on the work of Professor Peter Backx where she is honoured to work for more than a year, concentrating on cardiovascular physiology.

Cardiovascular diseases are the leading cause of death internationally, surpassing cancer, and are often interrelated and causative of one another. Recently it has been shown that intensive exercise can lead to atrial fibrillation, the most common arrhythmia, as well as remodeling in mice hearts. The current project is aimed at researching the dose of exercise required to cause unwanted remodelling of the heart in mice. Mice were placed in a sealed chamber and oxygen measurements were taken to assess performed work. In order to vary exercise dose the wheel was equipped with a resistance ability, whereby some mice had to put more work to turn the wheel while running.

In the future, performed work during exercise will be correlated with cardiac remodeling as well as distance ran. In order to correct for confounding variables such as humidity and atmospheric pressure, a custom built apparatus was made and connected to the system. It was shown that humidity effects oxygen measurements in a predictable manner and sheds light on data analysis limitations and corrections. Furthermore, in the future the data can be compared to a similar project in the laboratory whereby exercise is measured using a model of swimming instead of running. Such data will be of importance not only to scientists working on cardiovascular physiology but also to the public as fitness is becoming an increasingly important component of lifestyle.

Carmen Chu is a fourth-year student majoring in Chemistry at the University of British Columbia. She is completing a summer research project with Professor Thomas Baumgartner in the Department of Chemistry of the Faculty of Science, York University.

One of the Baumgartner group’s main building blocks is the strongly blue fluorescent dithienophosphole system. The emission of this system can be tuned to higher wavelengths, that is, all the way to red via green and yellow, by extending the pi-conjugation of the core through cross-coupling reactions with suitable aromatic substituents. Previous studies have shown that dithienophospholes can interact with Bronsted acids and Lewis acids, resulting in a visible red shift in their emission profile, which enables their practical application as sensor materials.

Throughout the summer, Carmen will be synthesizing dithienophospholes with different emission colours to function a Lewis-base sensor for Lewis acids. The strength of various Lewis acids will be evaluated by the fluorescence shift of the acid-base complex in collaboration with the Caputo group. Although interest in main group Lewis acids has grown in recent years, a universal quantitative scale for Lewis acidity is not well established. A few techniques have been employed to assess the strength of Lewis acids, such as the Gutmann-Beckett method and the Childs method, but these techniques often lead to inconclusive or even contradictory results. This project will use fluorescence to provide a quick assessment of Lewis acidity, and its simplicity will benefit research in main group Lewis acid catalysis.
Prakriti Das is entering her fourth-year of Biochemistry Honours in the Faculty of Science and is working in Professor Ryan Hill’s lab.

Short peptide sequences can catalyze a broad scope of chemical reactions. To discover new catalytic peptide sequences, the Hill lab group will synthesize and screen a DNA-encoded library comprising millions of peptide sequences. Prakriti Das, entering her fourth-year of Biochemistry Honours at York University, is thrilled to be participating in this project for the summer.

To create a DNA-encoded library of peptides, amino acids are coupled to a double-stranded DNA hairpin. As each amino acid is coupled, a corresponding DNA barcode is ligated to the growing peptide chain to record the synthesis and identity of the peptide. The amino acid sequence of each member of the library can thus be determined by DNA sequencing.

A molecule that participates in the reaction of interest is also attached to the DNA hairpin. When exposed to affinity tagged substrate, successful catalytic members of the library will couple the tag to its DNA, allowing them to be isolated by affinity chromatography.

The use of DNA-encoded libraries can greatly accelerate the discovery of novel catalysts which can be used to improve the efficiency of fine chemicals synthesis and expand our understanding of the molecular interactions that contribute to catalysis.

Shrey Desai has just completed his third-year of Biochemistry in the Faculty of Science. He is working in Professor Sergey Krylov’s Lab under the supervision of An Le Thi Hoai in the Department of Chemistry.

Shrey’s project is primarily in aptamer selection from a random-sequence generated DNA library through a process called Systematic Evolution of Ligands by Exponential Enrichment, or SELEX. It is a combinatorial chemistry technique used to select for single-stranded oligonucleotides that bind with high affinity to ligands such as proteins. It involves multiple rounds of alternating partitioning and polymerase chain reaction (PCR) amplification steps. Surface-based methods such as filter- and magnetic-beads-based partitioning are widely used in SELEX but are inefficient in separating the target DNA-ligand complex due to non-specific non-binder DNA adsorption to the surface. A technique called Non-Equilibrium Capillary Electrophoresis of Equilibrium Mixtures (NECEEM) provides an alternative means of partitioning in SELEX. It is a gel-free kinetic capillary electrophoresis (KCE) technique where target-ligand complexes move faster than non-binders, thus allowing them to be fractionated out away from the unbound DNA molecules.

This project aims to increase the separation efficiency of NECEEM-based partitioning, which can then be used to select for target-binding ligands from DNA-encoded libraries of small molecules such as pharmaceutical drugs.
Shakiba Ghaffari is a third-year student in the Pharmaceutical and Biological Chemistry program in the Faculty of Science. She is working with Professor Jennifer Chen, assistant professor of the Department of Chemistry.

The Chen group is developing optical sensing systems using plasmonic nanoparticles made of various noble metals. Localized surface plasmonic resonance is a special phenomenon that occurs when the metal nanostructures are much smaller in size than the wavelength of incident light. Due to the ease of surface functionalization, signal transduction, and high sensitivity of these metal nanoparticles, they have received great interest for use in biosensors.

Shakiba is synthesizing silica (SiO₂) core nanoparticles with gold (Au) nanoshells for optical sensing of biomarkers such as microRNA. Gold nanoshells are desirable because they are non-cytotoxic and biocompatible with living systems. SiO₂ and Au nanoparticles were synthesized using bottom-up sol-gel method, which is essentially generating colloidal stabilized nanoparticles from liquid precursor. Shakiba is characterizing the size and concentration of these nanoparticles via analysis with Ultraviolet-Visible spectrometer and Scanning-Transmission Electron Microscopy. She is also working to incorporate fluorescent dyes within the inner layers of the silica cores which can provide signals once the nanoparticles have been taken into cells or added to complex media.

Brandon Khan is a recent graduate of the BSc Honours Chemistry program in the Faculty of Science and is currently working under the supervision of Professor Gino G. Lavoie.

The Lavoie Group develops catalysts that incorporate and explore the utility of new structural fragments to mediate chemical transformations used in the chemical industry to produce high-value chemicals, including drugs and high-performing materials.

The team’s systems are inspired by previously-reported well-defined transition metal catalysts that have demonstrated good performance in the oligomerization and polymerization of alkenes. These catalysts however have major shortcomings, such as poor functional group compatibility, poor comonomer building block incorporation, and poor thermal stability and catalyst lifetime, to name a few. These issues stem from the design of the catalytic system, which includes the structural features of the supporting ligand.

Throughout the summer as a DURA awardee, Brandon is incorporating inversely-polarized phosphaalkene fragments into novel ligand scaffolds and catalytic systems. Inversely-polarized phosphaalkenes are a scarcely studied class of compounds that combine features from the ubiquitous N-heterocyclic carbenes (NHC) and tertiary phosphines, used as ligands for decades by coordination chemists. These phosphaalkenes are prepared from NHCs and phosphines, and thus draw from and leverage the strengths of both precursors, making them excellent candidates as ligands. These new ligands have the potential to greatly enhance the scope and performance of catalysts used by the industry, thereby giving access to high-value small and large compounds otherwise not available through other means.
Jin Shi is a second-year student majoring in Chemistry in the Faculty of Science. Under the supervision of Professor Jennifer Chen in the Department of Chemistry, Jin is developing analytical experiments for second-year chemistry lab.

She is validating a spectrophotometric technique for the determination of the concentration of iron. A series of standard solutions containing known concentrations of iron complex is analyzed using a spectrophotometer to establish the calibration curve. The method is applied to the analysis of iron content in vitamin supplements. She is also testing the methodology for determining the solubility constant of iron(III) hydroxide. The formation of Fe(OH)₃ is related to the environmental chemistry that occurs in local streams impacted by acid mine drainage. The concentration of the hydroxide ion (OH⁻) is determined by a pH meter, while the amount of the ferric ion (Fe³⁺) is analyzed spectrophotometrically.

These educational researches test the feasibility of the experiments, optimize the experimental procedure, and improve the experimental method to determine the applicability of educational theory and principles of the experiments.

Lucas Torres will be entering his fourth-year of BSc Hons in Chemical Biology at McMaster University. He is currently conducting his summer research project with Professor Christopher Caputo of the Faculty of Science, York University.

Lewis acids serve a vital role in catalysis as electron pair acceptors which facilitate chemical processes by increasing the reactivity of their substrates. Utilizing Lewis acids for organic transformations have been shown to be very diverse, notably for performing cycloaddition reactions, Friedel-Crafts type alkylations and acylations, as well as for olefin polymerizations. Interest in quantifying Lewis acidity has been revitalized due to the growing demand for inexpensive metal-free catalysts that show promise as novel complexes capable of promoting small molecule activation. Several spectroscopic and computational models have been developed to predict Lewis acidity, however, major discrepancies arise when comparing the results of these techniques which suggests a more definitive method is desired.

In collaboration with the Baumgartner Group, Lucas will aim to propose a well-defined method for Lewis acid quantification utilizing a fluorescent dithienophosphole oxide probe molecule. The lab has shown that dithienophosphole oxides coordinate to main group Lewis acids resulting in a red shift of the probe’s native emission. Lucas will aim to determine whether the severity of this shift visualized upon complexation can be directly correlated to Lewis acidity. Unlike previous methods which predominantly rely on NMR spectroscopy, fluorescence is entirely unexplored and should provide superior sensitivity while simultaneously giving insight to the photophysical and electronic properties of these novel Lewis adducts.
Sharon Dhami has completed her fourth-year in Applied Mathematics (major) and Biology (minor) program in the Faculty of Science and is supervised by Professor Huaiping Zhu of Mathematics and director of Laboratory of Mathematical Parallel Systems (LAMPS).

The white-nose syndrome (WNS) is an emerging disease caused by the invasive fungus Pseudogymnoascus destructans and is speculated to be native to Europe or Asia. WNS is responsible for the recent collapse of bat populations across Canada and the United States. In Ontario, the first confirmation of a WNS infected bat was observed in the eastern region during winter 2009-2010. Since then WNS has spread to other parts of Ontario and four bat species have been classified as 'Endangered' under the federal Species at Risk Act (SARA) and Species at Risk Ontario (SARO) list.

Under the supervision of Dr. Zhu and the LAMPS team, Sharon will be developing maximum-entropy based model using MaxEnt to project the spatial distribution of P. destructans in Ontario while considering local climatic factors. Although future spread data of the WNS is available in the United States, there is currently no study estimating the progression of WNS spread in Canada. This study is important as it provides an additional piece of information in terms of forecasting the WNS in North America, while raising awareness of P. destructans and bat conservation. Moreover, the results of this research can be aligned with conservation efforts aiming to recover bat populations in Ontario.

Wes Eardley is going into his fourth-year in Actuarial Science at the University of Western Ontario. He is supervised by Professor Ed Furman at York University and Professor Ricardas Zitikis of University of Western Ontario.

Whenever we are dealing with something that is dependent on an individual’s life status, we are dealing with some sort of randomness. Think of a life insurance company that receives payments while an insured is alive and then pays out a lump sum upon death to the individual’s beneficiary. Consider the thousands of contracts that this life insurance company is taking on; surely there will be a lot of uncertainty as to what the companies stream of payments is going to look like. When one is dealing with uncertainty, or randomness, it is often important to assess the amount of variability that there is in the data.

For many years, companies have used the so called Hattendorfs Theorem to analyze the dispersion among their future cash flows. This uses the commonly known variance-standard deviation approach of measuring variability. Wes's research will be applying a new measure of variability, namely the Gini Mean Difference, to the life insurance reserves. The Gini possesses some nice superiorities over the variance and the team hopes that this measure will provide life insurance companies with a more accurate representation of the riskiness in their cash flow streams.
Ling Lin is in her fourth-year in the Statistics program and is supervised by Professor Augustine C.M. Wong in the Faculty of Science.

Analysis of variance (ANOVA) is widely used in experimental design with three assumptions: normality, independence of observations and equality of variance. But for most cases, assumption of homogeneity of variance has been violated. Welch ANOVA and the Kruskal-Wallis test (a non-parametric method) can be applicable for this case.

This is a continuing work for last year’s project. Last year, Ling found the bartlett correct factor from the bootstrap method can well improve the performance of the standard F-test for the ANOVA model in two and three group cases. This year, Ling wants to compare it with two more common used methods (Welch ANOVA and the Kruskal-Wallis test) in higher-level of groups in terms of the empirical type I error rate and power, when heterogeneity of variance occurs and find out which method is the most suitable with which cases including balanced/unbalanced, small/large sample size.

Daniel Park is a fourth-year Statistics student in the Faculty of Science. Under the supervision of Professor Tom Salisbury in the Department of Mathematics and Statistics, he is using Monte Carlo simulation to pin down the critical value at which a novel percolation model experiences a phase transition.

Phase transitions happen when a tiny change in some parameter causes a big change in behaviour. This research project considers a mathematical model called oriented percolation, in which there is a network through which one can make small movements, but its connections get randomly turned on/off with probabilities $p$ and $1-p$. If $p$ increases, the distance one can travel before getting blocked will go up. And at some critical value of $p$, things open up and suddenly long-distance travel becomes possible. The problem is to find that value using simulation.

A number of percolation models have already been studied intensively, because of applications to statistical physics or to the physics of porous media. But the model considered in this research project hasn’t been looked at much, so very little is known about it. The reason it is interesting is that unexpectedly, it helps answer parts of a completely different problem from probability theory, which is random walk in a random environment. Mathematicians know a lot about homogeneous random motion (e.g., in modelling stock prices), but struggle to understand random motion through disordered media. This percolation research project should help shed some light on this.
Jordan Teitelbaum is a fourth-year student majoring in Mathematics in the Faculty of Science. He is working with Professor Ada Chan and Professor Paul Szeptycki on Hadamard matrices and their associated Nomura algebras.

A Hadamard matrix is a $n \times n$ matrix with entries of 1 and -1 in which any two rows are orthogonal. This implies that they differ in exactly half of their entries. From every Hadamard matrix we can construct a pair of association schemes called its Nomura algebras. Until recently only Hadamard matrices up to size 28 were classified and it was found that all their Nomura algebras were trivial. The question of the existence of Hadamard matrices with non-trivial Nomura algebras has been open for over 20 years. In 2012 all Hadamard matrices of order 32 were classified and it was found that there are over 13 million of them up to equivalence.

Jordan will be computing the Nomura algebra of all Hadamard matrices of size 32 in order to find any which are non-trivial. Hadamard matrices and association schemes have important applications in coding theory, for example in error correcting codes.

Jiyu (Gates) Wang is entering his fourth-year in Spec. Hon. Applied Mathematics in the Faculty of Science and is working alongside with Professor Walter P Tholen.

Much of mathematics concerns the study of spaces, defined to be sets of points endowed with some algebraic, geometric or numerical structure. The interaction of spaces of the same type, or category, is described by mappings between them that respect their structure in some way, and it is important to be able to compose such mappings consecutively. However, systemic limitations may prevent us from evaluating such composite mappings exactly.

In a 2017 article, A. Aliouche and C. Simpson proposed the notion of Approximate Categorical Structure in order to address the situation just described. It is based on a distance function (between functions) which, rather than satisfying the classical triangle inequality, will obey only a tetrahedral inequality. Amazingly, they were still able to establish an appropriate replacement for a cornerstone of category theory, Yoneda embedding. Their result places their AC-structure inside an ordinary one, in which composition of mappings can be given exactly.

In his research project, Jiyu investigates to extent the numerical values of the distance function may be replaced by more general “values”, could be the elements from some kind of sets with “complete” order. For example, rather than given by a number, a distance distribution function itself might be the “value”. This approach has been successfully applied in other contexts and should help advance the mathematical scope of the theory of approximate categorical structures.
Guanfu Qiao is in his second-year in the Actuarial Science program in the Faculty of Science and is supervised by Professor Xin Gao.

Given two data sets, whether their average value (mean value) are the same is often an interesting topic. This project is about using applied statistics methodology to test on the data sets to draw conclusions about their individual mean values. Traditional hypothesis tests, like likelihood ratio test, only deal with independent data or data with cognition of complete distribution, which limits their range of application. To overcome this problem, Guanfu introduces composite likelihood, which replaces the complete likelihood by the production of conditional or marginal densities. In this case, the only required knowledge is the marginal or conditional distribution of data, which reduce the dimension of problem, and then can handle correlated problem. Noticing that composite likelihood is an approximation of complete likelihood which add variance to the estimate results, Guanfu plugs in Bartlett’s coefficient to correct the test statistics to improve the quality of the test. In order to examine the new method, Guanfu simulates two correlated normal-distributed data sets and uses composite likelihood ratio test to check if the mean of two date sets are equal or not.

Nader Allam is a third-year Biophysics Major in the Faculty of Science assisting Professor Randy Lewis of the Department of Physics & Astronomy in his investigation of the $b\bar{b}\bar{u}\bar{d}$ tetraquark.

In the field of Quantum Chromodynamics (QCD), physicists study the strong force interactions between quarks and gluons in composite structures called hadrons. Historically, hadrons made up of 3 quarks (baryons, e.g. protons, neutrons) and those made up of 2 quarks (mesons, e.g. $J/\psi$) had been first discovered nearly a century ago. Conversely, tetraquarks are exotic structures of a pair of mesons, whose existence has been the subject of speculation for a long time due to their expected instability. Only within the last decade, the first candidate tetraquarks began appearing in the results of the Belle Collaboration.

The next challenge experimentalists face is in identifying tetraquarks consisting of 2 light quarks and 2 heavy quarks, e.g. $b\bar{b}\bar{u}\bar{d}$ tetraquark in question. Nader’s role will be in developing and adapting a code to solve the Schrödinger Equation with QCD potential and fine structure perturbative adjustments in order to predict the mass of $b\bar{b}u\bar{d}$ through a non-relativistic model and evaluate its stability. This theoretical work will help approximate the results to expect in the search of $b\bar{b}u\bar{d}$.
Kevin Borsos is entering his fourth year in the Biophysics program in the Faculty of Science and is working with Professor A. Kumarakrishnan of the Department of Physics and Astronomy.

The lab has developed an optical tweezers setup in which the optical dipole force is used to confine dielectric particles at the focus of a laser beam. Kevin’s research project demonstrates the confinement of micron sized polystyrene beads in solution and the trapping of carbon black particles in free space. The displacement of the trapped particles is measured using CCD cameras and position sensitive photodiodes. This data can be used to infer the spring constant of the trap and study the correlation time of the trapped particles. These experiments rely on high power, home built laser systems that consist of a narrow line width diode laser and a semi-conductor waveguide amplifier. This setup may make it feasible to extract dielectric constants based on measured intensity gradients and permit the rapid in situ identification of a variety of trapped particles.

Fasil Cheema is a third-year double major in Physics and Mathematics in the Faculty of Science and is supervised by Professor Adam Muzzin.

Fasil’s project is focused on galaxy evolution with a focus on the local environment in which they reside. The LEGA-C survey is a recent survey set to complete in mid 2018 of 3200 K-band selected galaxies at redshift z = 0.6-1.0, with stellar masses $10^{10}$ times the mass of our sun. Another much larger survey is the UVISTA survey which contains 262615 galaxies. His project is to create an nth nearest neighbor search for nearest neighbors of the galaxies and then to cross reference galaxies in the LEGA-C survey to their nth nearest neighbors in the much larger UVISTA survey. From this, hopefully information will be revealed on what variables affect galaxy evolution in their local environment of nearby galaxies. In addition, Fasil will help create other data structures to help analyze and observe relationships in the two surveys using python.
Jordan David Fliss has just graduated from the Biophysics program in the Faculty of Science and is being supervised by Professor Derek Wilson for his DURA this summer.

Disulfide bonds are a troublesome feature of many proteins that must be removed in order to conduct mass spectrometric analysis on them. Under the supervision of Professor Derek Wilson last summer, Jordan designed and constructed a microfluidic electrolytic cell that removes disulfide bonding in proteins for mass spectrometry applications. The purpose of his current project is to modify and characterize his previously designed electrolytic cell. The device is a simple, cost-effective, and reproducible way to remove disulfide bonding from proteins. It attaches on-line with mass spectrometers and eliminates the need for additive chemical reducing agents which make analysis more difficult. Once his device is properly modified and characterized, Jordan will publish a manuscript of the design so that laboratories will have an accessible way to do high quality mass spectrometric analysis.

Please also note that Jordan previously gave a talk at the 2017 undergraduate conference while the device was still being designed. He is eager to give a presentation this year now that he is able to report the data which demonstrates the efficacy of the device.

Yaniv Khaslavsky has completed his second-year in the Physics program in the Faculty of Science this year. Under Professor Sean Tulin, he is looking at the viability of using pulsar timing to detect dark matter in the universe.

Millisecond pulsars are astrophysical bodies with a highly stable period of revolution which emit a beam of radiation. This makes them excellent natural clocks which can be found in our galaxy. One can make use of pulsars to study Dark Matter via a relativistic effect called Shapiro Time Delay. This effect is caused by the presence of a gravitational field which changes the light travel time of beams passing through it. Researchers may make use of the Shapiro Time Delay to detect dark matter (which interacts gravitationally) as it passes through the line-of-sight of a pulsar and the Earth.

Since pulsars are such accurate clocks, a sufficiently massive Dark Matter halo can exert a measurable time delay for the pulses of light that we detect. Yaniv is looking to compare the theoretical time delays that different dark matter models would have on the pulsar-emitted beams. This work will allow other researchers to recognize the effects of Dark Matter in the data gathered from observing pulsars.
Neil McCall is entering his fifth-year in the Biophysics program in the Faculty of Science. He is supervised by Professor Eric Hessels.

The Standard Model (or ‘SM’) of physics is the most accurate mathematical description of reality ever constructed. However, we know it’s incomplete; among other things, it does not predict the observed existence of neutrino masses or dark matter. To account for these unexplained phenomena, various new theories - called SM ‘extensions’ - have been proposed. In order to verify untested theories, traditional practice was to use multi-billion-dollar particle accelerators, but experiments at these have not yielded any results unexplained by the current form of the SM. However, the SM and all of its proposed extensions predict different values for the as-yet unmeasured electric dipole moment (or ‘EDM’) of the electron. Thus, to measure this quantity is to verify a standard model extension: the holy grail of modern physics.

A new experiment in Professor Hessels’s lab, called EDM Cubed, hopes to explore energy scales billions of times higher than any particle accelerator will ever reach by measuring the electron’s EDM for the first time. Using laser spectroscopy, the team will watch the precession of valence electrons in barium fluoride molecules trapped in a cubic crystal of solid argon cooled to nearly absolute-zero. For the summer, Neil is designing and building the first incarnation of the cryostat that will grow this argon crystal.

Karin Saltoun has just completed her second-year in Biophysics in the Faculty of Science and is supervised by Professor Eric Hessels from the Department of Physics & Astronomy.

The Standard Model (SM) of physics is one of the most accurate models in science and has precisely predicted the existence of many particles to extremely high accuracy. It is not complete, however, and fails to predict a number of observed phenomena, such as the existence of dark matter or matter/antimatter asymmetry. Extensions to SM have thus been made to help answer these questions, however, they are incomplete as few have been shown to experimentally proven.

Notably, however, these extensions to SM, as well as SM itself, all predict different values for the electron’s electric dipole moment (eEDM). Therefore, measurements of the eEDM can prove essential to guiding our understanding of physics beyond the Standard Model.

The EDM cubed project’s proposed method is expected to measure the eEDM up to a billion times more accurate than current measurements. This incredible increase in accuracy is possible through measurements of stationary molecules embedded in a matrix, which allow for longer measurement times as well as larger counts than current experimental measurement techniques.
Hin Man Yau is a fourth-year student majoring in Physics in the Faculty of Science. He is completing his summer research with Professor Cody Storry in the Department of Physics & Astronomy.

Hin Man’s research focuses on the investigation of Matter and Antimatter Asymmetry through experimental methods. Matter and Antimatter Asymmetry is a fascinating topic that remains unresolved, as the Big Bang should produce an equal amount of matter and antimatter in the early universe, hence, all the antimatter should annihilate all matter with pure energy left in the universe. However, the observable universe is filled with matter with no antimatter to be seen. What tips the annihilation balance is the question that is left unanswered.

Building an MCP-phosphor screen device can provide a diagnosis of the spatial profile of the positron beam used in the experiment. The micro-channel-plate (MCP) produces electrons when bombarded with positrons. The ejected electrons will excite the phosphor screen at the back to produce a bright image on the screen. By observing the image on the MCP-phosphor screen system, the beam size, beam shape, and the effect of different magnetic field applied to the coil along the beam path can be observed.

Polina Zavyalova is going into her fourth-year in the Physics Specialist program in the Faculty of Arts and Science in the University of Toronto. She is being supervised by Professor Adam Muzzin of the Faculty of Science at York University.

Large agglomerations of galaxies, called galaxy clusters, are among the biggest gravitationally bound structures in the universe. They are believed to form at centers of lumps, or halos, of dark matter, which is the dominant gravitational component in the universe. The relationship between the mass of dark matter halos and the mass of the galaxies that form in them is arguably the most fundamental relation in galaxy formation.

Measuring the mass of dark matter halos directly has been a challenge until recently. The space between galaxies in clusters is filled with extremely hot gas that interacts with photons of the cosmic microwave background radiation (CMB) in a process known as the Sunyaev-Zel’dovich (SZ) effect. In 2013, the Planck collaboration explained the measurements of anisotropies of the CMB through the SZ effect, providing accurate measurements of density perturbations of the universe, including those due to dark matter halos. Polina uses the results published by the collaboration to examine dark matter halo mass to galaxy mass relation for galaxy clusters with photometric data available from the Panoramic Survey Telescope and Rapid Response System (PanSTARRS). With the relation currently measured for slightly over 20 clusters, she aims to increase the sample by contributing over 100 measurements.
Ali Dehghani is going into his fourth-year as a major in Kinesiology and minor in Psychology in the Faculty of Health and is working alongside Professor Chris Perry.

Cancer cells mainly utilize glycolysis despite the presence of adequate oxygen and have low levels of mitochondrial energy production. When cancer cells are forced to increase their mitochondrial activity, elevated oxidative phosphorylation produces reactive oxygen species (ROS) as a by-product. Cancer cells with inadequate capabilities to counteract the ROS succumb to cell death, whereas cells that are able to buffer the elevated ROS will survive.

With the goal of identifying a cancer specific marker to target tumorigenic cells, the lab has previously demonstrated that cancer cells with low GSH are susceptible to death by mitochondrial activation when given palmitoylcarnitine (PCarn). Breast cancer cells with high GSH and normal cells were not harmed by PCarn. Contrary to the team’s hypothesis that low levels of GSH could be a cancer specific marker for PCarn treatment, liver cancer (HepG2) with low GSH surprisingly demonstrated greater growth when given PCarn. In order to better understand the lab’s model, our current focus is elucidating other factors that may influence the ability of HepG2 cells to survive PCarn induced elevations of ROS. This can give the team insight as to what factors can be used to target cancer cells specifically, while leaving healthy cells unscathed.

Aly Fawzy is a third-year student in the Faculty of Health, majoring in Kinesiology and Health Science. He is an NSERC USRA Summer research student in Professor Tara Haas’s Lab, School of Kinesiology and Health Science.

Aly’s research project is focused on angiogenesis, which is the process by which new blood vessels are formed from pre-existing vessels. Angiogenesis is a critical physiological process that takes place for a variety of reasons, such as maturation, exercise, disease, tumors, etc. It has been previously shown that mesenchymal stem cells could influence this tightly regulated process through the secretion of leptin. However, the exact pathways are not yet firmly established. Leptin is a hormone that acts as a regulator of skeletal muscle angiogenesis.

Aly is investigating the different pathways and signals that are involved in leptin-induced angiogenesis on mouse models, focusing on the production of vascular endothelial growth factor (VEGF), a signal protein that stimulates the formation of blood vessels. Additionally, he is investigating the influence of different stimuli (i.e. drugs and hormones) on mesenchymal stem cells that cause them to produce leptin for capillary generation. Understanding and mapping the different pathways of angiogenesis as well as how drugs and/or hormones influence these pathways has great implications to humans, especially for patients with vascular diseases such as peripheral artery disease who might have difficulty producing new and healthy blood vessels.
Syed Hassan is a recent graduate from the Kinesiology BSc program in the Faculty of Health and is supervised by Professor Ali Abdul-Sater.

Inflammasomes are protein complexes that are essential for the production of a particularly potent inflammatory molecule called interleukin-1 beta (IL-1). This inflammatory molecule plays an important role in the immune response to invading pathogens. However, excessive release of this molecule is associated with several human diseases including cardiovascular diseases, diabetes, cancer and autoimmune diseases.

The aim of Syed’s project is to investigate how various physical activity patterns affect inflammasome activation. To this end, specific immune cells called macrophages were prepared from the bone marrow of mice that had undergone various durations of moderate exercise intensity. These macrophages were exposed to molecules that mimic pathogens, and inflammasome activation was evaluated by measuring several parameters including IL-1 and caspase-1. The results indicate that mice engaged in prolonged exercise exhibited elevated levels of inflammasome activation when compared to sedentary mice. The results of this research would further understanding of the relationship between exercise and inflammation, which might have important implications for protection from infections and inflammation-driven diseases.

Tenzin Chosang is a third-year student in the BSc Specialized Honours Psychology program in the Faculty of Health and is supervised by Professor Joseph Desouza.

Previous research on action observation and recalling visualization of dance indicated that expertise and experience modulate alpha and beta oscillations. The research project aims to explore if modulation of these oscillations can also occur through the practice and execution of a dance which utilizes only ocular movements, or an ‘eye dance’. Their learning will be measured using a combination of eye-tracking technology and fMRI scanning. The implications of this research are substantial. While dance therapy is a common form of neural rehabilitation for individuals living with neurodegenerative disorders, all individuals may not have the level of motor ability required to partake in this dance therapy (ex. quadriplegics, or very advanced Parkinson’s disease). If this dance is shown to return similar neural benefits to dance therapy, as we have shown in expert ballerinas, it introduces a novel mode of rehabilitation for those with decreased motor repertoires.
David Jesin is entering his third-year in the Honours Psychology (BSc) program in the Faculty of Health and is supervised by Professor Ellen Bialystok.

A growing body of research has demonstrated that lifelong bilingualism is associated with improved cognitive functions based on effortful selection and control. Thus, bilingual children develop executive control earlier than monolingual children and bilingual older adults show a slower decline of these processes with healthy aging than monolinguals. Most dramatically, older bilinguals display symptoms of dementia about 4 years later than monolinguals even though the progression of the disease is comparable, giving bilingual adults with dementia several years to live independent symptom-free lives. An outstanding question in this research is how these attention processes differ between monolinguals and bilinguals, particularly in young adults.

The study uses a novel technique to assess executive control in monolingual and bilingual young adults. Research with children and older adults typically show better performance by bilinguals on these tasks, but studies with young adults generally show no differences. In this study, a combination of response time, mouse-tracking trajectories, and eye movement patterns are combined to provide a more detailed description of performance to uncover differences in these crucial processes in young adults.

David’s role in the project has been to recruit participants, administer the task, and enter and organize the data. He will also be involved in some preliminary data analyses.

Farzana Teymori is a third-year student in the Information Technology (IT) program in the Faculty of Liberal Arts & Professional Studies and is supervised by Professor Jimmy Juang.

Natural language processing (NLP) is a challenging branch in artificial intelligence which is rapidly growing. The goal of NLP is to allow humans to interact with computers the same way they interact with other humans, using natural language. NLP can be applied to automated language translation, chatbots, plagiarism detection, and question answering tasks. Using deep neural networking in NLP has improved performance in many NLP tasks.

Farzana will be researching and working with word vector representations, window-based neural networks, recurrent neural networks, long-short-term-memory models, recursive neural networks, convolutional neural networks as well as some very novel models, with code implementations using Keras. She will mostly concentrate on paraphrase detection and question answering tasks in NLP. Paraphrase detection is used to determine whether two sentences have the same meaning and requires thorough syntactic and semantic analysis. It can be used to identify similar or duplicate questions on forums or even detecting plagiarism.