PSCB90H3 Physical Sciences Research Experience (Fall 2021)

Course coordinator: Dr. Effie Sauer (effie.sauer@utoronto.ca)


This course provides an opportunity for students to work closely with a faculty member. Students will provide assistance with one of the faculty member's research projects, while also earning course credit. Students will gain first-hand exposure to current research methods, and share in the excitement of discovery and knowledge acquisition. Progress will be monitored by regular meetings with the faculty member and through a reflective journal. Final results will be presented in a written report and/or a poster presentation at the end of the term. Approximately 120 hours of work is expected for the course.

Prerequisite: Varies by project (see below)

Recommended Preparation: Completion of at least 4.0 credits in a relevant discipline.

Breadth Requirements: Natural Sciences

Link to UTSC Calendar Entry: https://utsc.calendar.utoronto.ca/section/physical-sciences

How to Apply:

Students must send an application to the Course Coordinator (Dr. Effie Sauer) for admission into this course. Applications must be received by the **end of August for Fall enrolment**, December 15th for Winter enrolment, and end of April for Summer enrolment. Typically, students enrolled in a program offered by the Department of Physical and Environmental Sciences and students who have a CGPA of at least 2.5 or higher are granted admission. Approved students will receive a signed course enrolment form that will be submitted to the Office of the Registrar.

Applications should include:

1. A letter of intent indicating the student's wish to enroll in the course
2. A ranked list of projects the student is interested in working on; students may list up to 4 projects with the first choice clearly indicated
3. A list of relevant courses successfully completed by the student, as well as any relevant courses to be taken during the upcoming semester

Environmental Sciences Projects

Project 1

Supervisor: Prof. Adam Martin (adam.martin@utoronto.ca)

Title: A review of plant functional trait databases and open access ecological data

Number of Positions: 1

Project Description: Open access databases on plant functional traits—the morphological, chemical, and physiological characteristics of plants and plant parts such as leaves, roots, and stems—have been instrumental in advancing our understanding of how environmental change is influencing terrestrial ecosystems worldwide. Owing to the popularity and utility of trait databases for ecological research, in recent years there has been an explosion of open access functional trait databases. There now exists dozens of individual trait databases, which cumulatively contain thousands of observations on plant traits across thousands of different plant species. Each database differs in its focal species, geographic location, or traits. As such, it has become challenging to 1) understand the differences of trait databases, and 2) quickly identify a trait database that is most applicable to a given research question or project. This PSCB90 project is focused on summarizing, categorizing, and documenting the dozens of plant trait databases that exist globally. Under the supervision of Dr. Martin, this project entails locating, reading, and summarizing scientific papers on functional trait databases, and management and analyzing this data in Excel. In doing so, this project is expected to contribute to an invited peer-reviewed publication in the journal *Functional Ecology* in 2022.

Project 2

Supervisor: Prof. William Gough (william.gough@utoronto.ca)

Title: Ozone weekend effect during the pandemic

Number of Positions: 2

Project Description: In many urban areas around the world tropospheric ozone, a secondary pollutant, peaks during weekends due to some interesting atmospheric chemistry. This effect has been documented for the Toronto area in past research (Beaney and Gough, 2002; Huryn and Gough, 2014). Preliminary results from the first wave (April to June 2020) indicate a substantial reduction in NO, NO2, likely the result of reduction in vehicular traffic (Gough and Anderson, 2021) and an increase in ozone on weekdays. The 2020 data was compared to a climatology based on the period 2010-2019. The relevant data is available publicly through the Ontario Ministry of the Environment, Conservation, and Parks. Two follow projects are proposed. The first is to do a similar analysis during the second wave (October to December) for the GTA. The second is to compare Toronto to other urban areas in Ontario (as was done in Huryn and Gough, 2014) in order to test if other less extensive urban areas responded in a similar fashion to pandemic societal measures.

Qualifications: Completion of either EESA09, EESB03; proficiency in Excel. Knowledge of Python would be an asset, but not required.

Project 3

Supervisor: Prof. Tanzina Mohsin (tanzina.mohsin@utoronto.ca)

Title: Climate Change Impact Assessment

Number of Positions: 1

Project Description: Scientific evidence for warming of the climate system is clear. Although attempts have been made to tackle the climate change, warming due to anthropogenic emissions of greenhouse gases will continue over the next two or three decades. This will continue to cause impacts on human system including infrastructure, industry and natural resources. Therefore, countries, regions, and cities will have to adapt to the changes that are already underway. A part of the solution to this problem is to provide climate information in formats tailored to fit into the planning and design decisions of a variety of industries and for different sectors of the society, which can be a baseline for making defensible climate change decisions. A student in this project will have the opportunities to work on a climate change impact assessment project with step-by-step guidance from the supervisor. This is an experiential learning opportunity which will allow the student to apply the IPCC framework of assessment using the AR6 and AR5 scenarios and, analyze and forecast the impacts of climate change in an area of interest. Some examples of projects are impact of climate change on extremes weather events causing flooding in cities, impact of climate change on production of wine grapes affecting the wine industries in Niagara Peninsula, or impact of climate change on occurrences of forest fire in vulnerable locations in British Columbia.

Qualifications: Completion of EESB03 or its equivalent.

Chemistry Projects

Project 4

Supervisor: Prof. Ruby Sullan (ruby.sullan@utoronto.ca)

Title: Identifying key determinants of stiffness sensing in bacteria

Number of positions: 2

Project Description: Whereas the sensitivity of eukaryotic cells to substrate stiffness is long- and well-established, we know little about the impact of stiffness on bacterial adhesion. Our group recently showed that, akin to mammalian cells, bacteria respond to the mechanical stiffness of the underlying substrate by adjusting their overall cell elasticity. This PSCB90 project aims to identify the key determinants of stiffness sensing in bacteria. Here, you will determine how the overall cell elasticity in *E. coli* is influenced by the presence of different antibiotics and small molecules that affect the different components of the cell wall and outer membrane as well as variations in turgor pressure. In the process, you will learn a suite of inter-disciplinary techniques spanning surface chemistry, microbiology, and quantitative biophysical approaches.

Qualifications: Completion of CHMA10, CHMA11, and CHMB16 with minimum grade of B+.

Project 5

Supervisor: Prof. Lana Mikhaylichenko (lana.mikhaylichenko@utoronto.ca)

Title: Development of the New Experiments for the CHMA12H3 General Chemistry Course

Number of positions: 2

Project Description: Students involved in this project will perform literature search for the new laboratory experiments for the new General Chemistry II CHMA12H3 course. Each experiment will be evaluated on relevance to the course material, price, and level of difficulty. Most promising experiments will be performed in a lab. Students will participate in preparation of the practical part of each experiment as well as prepare sets of potential quiz questions. The working schedule will be built based on the current situation and students' availability.

Qualifications: Completion of CHMB41/42 with a minimum grade of B+.

Project 6

Supervisor: Prof. Oleksandr Voznyy (o.voznyy@utoronto.ca)

Title: Electrochemical synthesis of ammonia

Number of positions: 1

Project Description: Our group is interested in electrochemical reduction of nitrogen gas into ammonia in water. The project will mainly involve electrochemistry testing of catalysts, optimizing electrochemical reactors, NMR analysis. Students could also be exposed to theoretical computations. Students will learn electrochemistry, material science, and chemical engineering knowledge. Students will work on this project led by the PhD student. This project requires in-person lab experiments.

Qualifications: Completion of CHMA10, CHMA11, and CHMB16 with minimum grade of B+.

Project 7

Supervisor: Prof. Oleksandr Voznyy (o.voznyy@utoronto.ca)

Title: Developing and Optimizing ligand exchange procedures for heavy-metal free quantum dot inks for thin-film solar cells.

Number of positions: 1

Project Description: One of the key challenges in the development of thin-film quantum dot based solar cells, involves converting CQD solutions to perfectly packed, high quality films. During the synthesis, the dots are covered with organic ligands, preventing aggregation in solution. These organic ligands need to be removed, to achieve a compact conductive active layer. This project will focus on investigating ligand exchange processes, which would allow for the conversion to very short conductive ligands composed of halides or inorganic compounds.

Qualifications: Completion of CHMA10, CHMA11, and CHMB16 with minimum grade of B+.

Project 8

Supervisor: Prof. Oleksandr Voznyy (o.voznyy@utoronto.ca)

Title: Developing Earth Abundant Metal Catalysts for Water Oxidation in Acid

Number of positions: 1

Project Description: Water oxidation is an integral component of various electrocatalytic processes such as CO2 reduction and water splitting. Unfortunately, its high energy requirements make the process a hinderance to the overall efficiency of the parent processes. Catalysts have been developed to minimize this bottleneck; however, the majority remain limited to alkaline conditions, with few counterparts capable of delivering in acidic conditions, the conditions of choice for PEM based fuel-cell systems. This project will focus on the development of novel high-performance earth abundant catalysts for OER.

Student will learn: Material synthesis and electrochemical characterization.

Time commitment: This will vary from week to week depending on the work. A minimum of 10-20 hours a week are recommended.

Qualifications: CHMB31 and CHMB42 are recommended but not necessary

Project 9

Supervisor: Prof. N. Thavarajah (nirusha.thavarajah@utoronto.ca)

Title: Developing a Culturally Relevant Public Health Communication Strategy to Promote COVID-19 Vaccination

Number of positions: 2

Project Description: Students will work with the faculty member and collaborate with students from the Diversity in the Workplace (MGHC23) course at UTSC and students from a South Asian University to create a scientific infographic to convey the importance of COVID-19 vaccination. Students will collect data on a targeted population to understand the reasons behind resistance to vaccinating and will design their infographics as a countermeasure to the COVID-19 "Infodemic" ("Infodemic'' is an overwhelming amount of false information in the form of a digital or physical form). The domestic and international student collaborations will give exposure to an ***Interdisciplinary and Global Classroom*** learning experience that will help students cultivate their research skills and scientific communication skills.

Qualifications: Completion of CHMB42H3 with a minimum grade of B+. Please include an up-to-date CV & transcript with your application.

Project 10

Supervisor: Prof. Shadi Dalili (sh.dalili@utoronto.ca)

Title: Developing New Lab Material for CHMB41H

Number of positions: 1-2

Project Description: Students involved in this project will be able to develop and modify new laboratory experiments for Introductory Organic Chemistry I (CHMB41H). Students will work with the course instructor to select new experiments from the chemistry education literature, test the experiments, and prepare accompanying lab manual instructions and demonstrator notes. Students will learn skills such as literature searching and analysis, and utilize essential lab techniques such as extraction, distillation, recrystallization, reflux, etc. to develop new labs for the course. Students will also develop written scientific and communication skills through preparing lab manual writeups, quizzes, and TA documents for each experiment developed.

Qualifications: Completion of CHMB42 with a minimum course grade of B+ and lab grade of A; must be available for lab work 2 full days during the week between 9am-5pm, ideally Tues, Wed and/or Thurs. Please include an up-to-date CV & transcript with your application.

Project 11

Supervisor: Prof. Shadi Dalili (sh.dalili@utoronto.ca)

Title: Developing New Tutorial Material for CHMB41H

Number of positions: 1-2

Project Description: Students involved in this project will be expected to develop new tutorial worksheets and quizzes based on current CHMB41H course content, using reputable scientific resources and textbooks. Students in this placement will work with the course instructor to select and develop appropriate questions and exercises from the chemistry education literature, textbooks, and online resources to prepare tutorial materials and quizzes, along with demonstrator notes. Students will learn skills such as literature searching and analysis, and proper design of problem sets and questionnaires. Students will also develop written scientific and communication skills through developing problem sets, quizzes, and TA documents for each tutorial section.

Qualifications: Completion of CHMB42 with a minimum course grade of B+. Please include an up-to-date CV & transcript with your application.