



MEMORANDUM

To: Executive Committee of Faculty Council (September 28, 2021)
 Faculty Council (October 18, 2021)

From: Professor Julie Audet
 Chair, Engineering Graduate Education Committee (EGEC)

Date: September 13, 2021

Re: **EGEC Information Update**

REPORT CLASSIFICATION

This is a routine or minor policy matter that has been approved by the Engineering Graduate Education Committee on behalf of Faculty Council¹. It will be considered by the Executive Committee for endorsing and forwarding to Faculty Council for information.

NEW COURSES APPROVED

APS1053	Case Studies in AI in Finance
BME1500	Topics in Neuromodulation
ECE1658	Geometric Nonlinear Control of Robotics Systems
ECE1659	Robust and Optimal Control
ECE1785	Empirical Software Engineering
MIE1625	Machine Learning for Medical Image Analysis
MIE1666	Machine Learning for Mathematical Optimization
MIE1745	Surface Engineering
MIE1769	AI in Automotive and Manufacturing

MINOR MODIFICATIONS

APS2000Y – <i>Summer Engineering Practicum</i>	Course title changed to <i>Engineering Practicum</i> , no change in course description
--	--

¹ As a result of the 2005 Task Force on Graduate Education at the University of Toronto, EGEC has delegated authority to “consider and approve on behalf of Faculty Council and/or recommend to Faculty Council and/or SGS, matters relating to graduate curriculum, policy, new initiatives, program and course changes”.

MINOR MODIFICATIONS, continued

MIE1453 – <i>Introduction to Sensors and Sensor Network</i>	Course code and titled changed to MIE1050 – <i>Design of Intelligent Sensor Networks</i> , no change in course description
TEP1502- <i>Leading Engineering Design Projects</i>	Course title changed to <i>Leadership in Product Design</i> , no change in course description
MEng (CIV, MIE)	Creation of a new Emphasis in Waterpower (see Appendix 1)

MAJOR MODIFICATIONS

PhD (CHE)	Students now have the option to enrol in the Collaborative Specialization in Next-Generation Precision Medicine (PRiME) [Lead Faculty is Leslie Dan Faculty of Pharmacy] (see Appendix 2)
-----------	---

RECOMMENDATION FOR FACULTY COUNCIL

For information.

University of Toronto

Minor Modification Proposal

Change to an Existing Graduate Program or Collaborative Specialization

This template should be used to bring forward all proposals for minor modifications to program or admissions requirements for existing graduate programs or collaborative specializations under the University of Toronto's Quality Assurance Process.

Program/Collaborative Specialization being modified:	MEng in Civil Engineering MEng in Mechanical Engineering
Graduate unit:	Civil and Mineral Engineering Mechanical and Industrial Engineering
Faculty/academic division:	Applied Science & Engineering
Dean's office contact:	Julie Audet, Vice-Dean, Graduate Studies
Version date:	August 31, 2021

1. Summary

	Changing admission requirements		Renaming field, concentration or emphasis
	Changing program requirements		Renaming of program or collaborative specialization (please notify VPAP before governance)
	Changing timing of program requirements	X	Creating a new emphasis
			Changes to programs affecting an MOA
<p>Summary: MEng students in the Departments of Civil and Mineral Engineering, and Mechanical and Industrial Engineering can earn an emphasis in the area of Waterpower by completing four courses from the lists described in Appendix A.</p>			

2. Effective Date of Change

September 1, 2021

3. Academic Rationale

As the world strives for decarbonization, the energy supply is in transition, and waterpower is uniquely positioned to support this change. As the oldest form of low carbon energy, waterpower's role is becoming even more important. The energy transition is demanding more flexibility to support other renewable technologies, upgrading of aging infrastructure that not only support the electricity grid but are imperative for integrated water management in supporting flood mitigation, navigation, and recreation. There are exciting opportunities with new energy storage facilities and investment in small waterpower at the distribution level. The challenges with climate change and balancing water resources are many, but waterpower stations are suited to tackle these challenges, embedded in communities and ecosystems all across Canada. They are long-term assets, in a world of short-term investment. A new curriculum focused on waterpower aims to prepare students for the unique challenges of this technology and growth opportunities in the industry, drawing on its long history and the many lessons learned, especially in the domain of sustainable development.

4. Impact on Students

Students eligible for the emphasis can, at the end of their program, earn the emphasis by requesting the notation on their transcripts to the FASE graduate office.

5. Consultation

Support from Industry

The Emphasis in Waterpower has been developed with consultation from the [Ontario Waterpower Association](#) (OWA), with the intention of connecting students to potential careers, and facilitating continuing education for industry practitioners. The OWA is a not-for profit organization, representing a membership made up of generators, engineering firms, environmental consultants, legal, project financing and insurance firms, First Nations communities and other organizations, all sharing the common interest of advancing waterpower in Ontario. To support the development of the Emphasis in Waterpower, the OWA has organized an industry Advisory Committee. The curriculum is being designed in close collaboration with the Committee, including two new courses, which will be ready for the 2021-2022 academic year.

OWA leadership has expressed their support for the emphasis:

“Educating the next generation of waterpower professionals has been an ongoing need for some time,” said Bill Touzel, OWA Board member. “This new University of Toronto Master’s emphasis has specific hydropower-focused courses that aim to bridge the gap between engineering students, industry professionals, and those who are interested and passionate about the unique

attributes that waterpower technology can bring to the table to solve future challenges.”

“Providing an academic pathway for waterpower professionals is of the utmost importance to our industry,” said Paul Norris, President of OWA. “Waterpower has been the backbone of the electricity system for over a century and now, more than ever, newly trained waterpower professionals are needed to balance the ongoing complexities of economic, environmental, and social challenges we face as a society.”

Further, prospective students from industry have been invited to enroll in the new courses, with roughly a dozen people expressing strong interest in enrolling this academic year.

Consultation with UofT students

A group of six students in CIV401: Design of Hydroelectric and Wind Turbines were consulted. They gave positive feedback, expressing an interest in having courses with industry connection, and further curricula on waterpower. Students in CIV 1303 in the Fall of 2020 also showed some interest in the new program.

Support from UofT Faculty

Bryan Karney, Associate Dean of Cross-Disciplinary Studies (until June 30th, 2021), has given continuous consultation throughout the development of the emphasis.

Jennifer Drake, Professor in Civil & Mineral Engineering, has expressed her support for the emphasis, the new courses, and is working with the OWA advisory group to introduce waterpower content into her course, CIV550: Water Resources Engineering. David Meyer in Civil and Mineral Engineering and David Sinton in Mechanical and Industrial Engineering have been informed about the intention of created this program and have been generally supportive, though their own interests are already diverse.

The Vice-Dean, Graduate Studies was consulted, first in February, 2021 and kept informed through the first half of 2021.

Both Brent Sleep, Chair of Civil and Mineral Engineering, and Markus Bussmann, Chair of Mechanical and Industrial Engineering, have been consulted in 2021.

6. Resources

There are minimal resource implications as major increases in enrolment are not expected for any of the eligible courses listed given the significant number of them. A FASE-level administrator with access to ROSI will be responsible for verifying that students from the different participating units have completed the required courses and for adding the emphasis notation on their transcripts. It is intended that resources will be sought for both marketing and development of course material. Prof. Karney intends

to continue to oversee and guide the implementation process for at least the first five years of the program's life.

7. Governance Approval

Unit sign-off (Committee name and meeting date)	MIE, June 29, 2021 CIV, June 30, 2021
Dean's Office sign-off	Julie Audet, Vice-Dean, Graduate Studies, June 28, 2021
Faculty/division council approval (or delegated body) if applicable	Approved on July 26, 2021 by the Engineering Graduate Education Committee (EGEC) on behalf of the Council of the Faculty of Applied Science & Engineering. Submitted to the Council of the Faculty of Applied Science & Engineering for information on October 18, 2021.

8. Appendix A: Calendar Entry

Please use track changes to indicate where changes have been made.

MEng students must successfully complete **four half courses (2.0 FCE), including** one core course. The remaining coursework may be taken from the following lists.

Core course

APS1410H: Waterpower Essentials (pending approval)

Group A - choose at least 1 of the following courses

APS1411H: Renewal of Waterpower Facilities (pending approval) (Waterpower Essentials is a prerequisite for this course)

CIV550H: Water Resources Engineering

Group B – choose at least 1 of the following

APS1024H: Infrastructure Resilience Planning

APS1032H: Introduction to Energy Project Management

CIV1001H: MEng Project (topic must receive prior approval by emphasis Director)

CIV1252H: Repair and Maintenance of Concrete Structures

CIV1303H: Water Resources Systems Modelling

CIV1420H: Soil Properties and Behaviour

CIV1163H: Mechanics of Reinforced Concrete
CIV1171H: Earthquake Engineering and Seismic Design
CIV1275H: Construction Modelling Methods
CIV1279H: Construction Contract Documents
CIV1281H: Asset Management: Quantitative Tools and Methods
~~CIV1399H: Special Studies in Civil Engineering~~

CIV1XXXH: to be cross listed with CIV401H: Design of Hydro and Wind Electric Plants
CIV514H: Concrete Technology
CIV523H: Geotechnical Design
CIV580H: Engineering and Management of Large Projects

AER1410H: Topology Optimization
ECE514H: Power Electronics: Converter Topologies
ECE533H: Power Electronics
ECE1049H: Special Topics in Energy Systems
ECE1059H: Special Topics in Energy Systems
ECE1093H: Electrical Insulation Design and Coordination
ECE1094H: Power Systems Operations and Economics
ENV1001H: Environmental Decision Making
ENV1701H: Environmental Law
ENV1703H: Water Resource Management and Policy
MIE1201H: Advanced Fluid Mechanics I
MIE1207H: Structure of Turbulent Flows
MIE1210H: Computational Fluid Mechanics and Heat Transfer
MIE1222H: Multiphase Flows
MIE1241H: Energy Management

University of Toronto

New Graduate

Collaborative Specialization

Major Modification Proposal

This template has been developed in line with the University of Toronto's Quality Assurance Process.

This template should be used to bring forward all proposals for new graduate Collaborative Specializations (CSs) for governance approval under the University of Toronto's Quality Assurance Process.

Name of proposed collaborative specialization: Please specify exactly what is being proposed. E.g., a Collaborative Specialization in...	Next-Generation Precision Medicine
Lead Faculty/academic division:	Leslie Dan Faculty of Pharmacy
Lead Faculty/academic division contact:	Jamie Kellar, Associate Dean Academic Shana Kelley, Program Director
Anticipated start date of new collaborative specialization:	Sept 1, 2021
Version date:	April 14, 2021

New Graduate Collaborative Specialization Proposal

Next-Generation Precision Medicine
Lead Faculty: Leslie Dan Faculty of Pharmacy
University of Toronto

Contents

1	Specialization Rationale.....	3
2	Participating Programs, Degrees and Names of Units	4
3	Objectives, Added Value for Students.....	5
4	Admission and Specialization Requirements	7
5	Degree Level Expectations, Program Learning Outcomes and Program Structure	14
6	Assessment of Learning	21
7	Resources	22
8	Administration	23
9	Governance Process.....	23
	Appendix A: Collaborative Specialization Requirements and Degree Program Requirements	24
	Appendix B: Core Faculty Research Synopses	26

[right-click to update entire table]

Please include all sections with page numbers and a full list of appendices in the Table of Contents. Assuming styles embedded in this document have been maintained and headers used, the Table of Contents will update automatically by right-clicking on it and selecting “Update Field” and then “Update Entire Table.”

1 Specialization Rationale

- What is being proposed? What is the academic focus?
- Rationale for establishing the Collaborative Specialization.

The Collaborative Specialization in Next-Generation Precision Medicine is designed to encourage cross-disciplinary training and collaboration across diverse departments at the University of Toronto (UofT). The academic research focus is on cutting-edge technologies and methods to develop novel therapeutic strategies, create new tools for disease diagnosis, and enable a deeper understanding of disease biology through integration of principles and methods across the physical and life sciences, and engineering.

Future advances in precision medicine will require a multi-disciplinary perspective and creative solutions beyond conventional genomics and mutational profiling. The proposed Collaborative Specialization in Next-Generation Precision Medicine aims to equip researchers with a true understanding of research that crosses many disciplines in order to address the unmet challenges of human disease. The unique focus will be on fostering an inter-disciplinary approach to research, which will be facilitated through the students’ thesis projects and through the course modules offered in this CS. The seminar course will allow students to present their research and exchange ideas with trainees and investigators from different faculties and disciplines to support collaborative, cross-faculty research. It is envisioned that, with a better understanding of mechanisms to foster research collaboration and translation, graduates with this Collaborative Specialization will help advance research discoveries into impactful outcomes for patients.

The Precision Medicine initiative (PRiME) was established as a Institutional Strategic Initiative at UofT in 2019 to align research efforts in the broad area of Precision Medicine. With over 70 leading investigators across four Faculties at the University,

many of whom have experience in entrepreneurship and industry, PRiME brings together world-renown experts in disease biology, diagnostics and therapeutics to support graduate student training through this CS. In addition to the support of research excellence and scholarship offered by faculty members within PRiME, the initiative under the direction of Prof. Shana Kelley also strives to build community and empower trainees with skills that will enable successful careers upon graduation. Toward this latter goal, PRiME is also invested in building the local biotech ecosystem to enable more career opportunities for graduates in related industry fields.

All of the faculty members participating in this Collaborative Specialization are members of PRiME. The Institutional Strategic Initiative is open to admitting new members of investigators conducting research in an areas related to drug discovery and diagnostic development, or more broadly defined precision medicine. PRiME will support the Collaborative Specialization by leveraging its existing activities and programming to create graduate courses and seminars, as well as provide workshop opportunities for the enrolled CS students.

2 Participating Programs, Degrees and Names of Units

- E.g., History program, MA, PhD, Department of History.

Leslie Dan Faculty of Pharmacy
Pharmaceutical Sciences, PhD, Department of Pharmaceutical Sciences
Faculty of Arts & Science
Chemistry, PhD, Department of Chemistry
Faculty of Applied Science & Engineering
Chemical Engineering and Applied Chemistry, PhD, Department of Chemical Engineering and Applied Chemistry
Temerty Faculty of Medicine
Molecular Genetics, PhD, Department of Molecular Genetics

3 Objectives, Added Value for Students

- What are the academic objectives of the specialization?
- What is the anticipated demand for the proposed Collaborative Specialization and how has that been assessed?
- How will the Collaborative Specialization serve the interest of its students (academic interests, career preparation, etc.)?
- Explain the value that is added to the student's educational experience by participating in the Collaborative Specialization, and explain how the added value is provided (e.g., course requirements, multidisciplinary focus, exposure to other viewpoints, topics of thesis research, etc.).
- Identify the common learning experience for all students.
- Explain how the Collaborative Specialization is different from and/or the same as others offered by the University of Toronto.

The Collaborative Specialization in Next-Generation in Precision Medicine aims to provide a diverse and cross-disciplinary approach to training. It looks to bridge expertise in the natural sciences and engineering with approaches or understanding of the life sciences in order to better equip scientists of the future.

In addition to the departments currently confirmed within the PRiME CS, we have had consultations with both PRiME's Steering Committee, composed of two Faculty members from each of the representative Faculties (LDFP, FoM, FASE and FAS) and PRiME's Trainee Advisory Committee, which has both graduate student and postdoctoral fellow representation from each Faculty. We proposed creating a CS to expand the inter-disciplinary research and training focus in precision medicine that exemplifies the vision of PRiME to a broader group of trainees.

At both the faculty and student levels, the feedback regarding this proposed CS was positive and indicated that this offering would fill gaps in current graduate training, and would provide programming and training supports that would benefit graduate students interested in multidisciplinary training.

Currently, PRiME hosts monthly inter-faculty Research Rounds which draw high engagement from both faculty and students for exposure to new, cutting-edge technologies that can advance a wide range of projects. These Rounds also provide discussion and ideas about collaboration between the natural and biological sciences in the area of precision medicine. This will be developed into a for-credit seminar course for the CS to provide perspectives and discussion regarding novel collaborations to advance drug discovery and diagnostic development research from the broader PRiME community.

To date, PRiME has created training opportunities for graduate students and postdoctoral fellows of PRiME investigators in interdisciplinary research through not-for-credit seminars and workshops including both research and career skills development. As mentioned above, PRiME Monthly Research Rounds showcase cross-faculty research collaborations at the university, while numerous trainee-focused events provide students with training in communication, entrepreneurship, and other skills needed for their career development. The current offering of PRiME Research Rounds will be developed into a mandatory, for-credit seminar course for students in the CS and will provide an opportunity for them to describe their research to those outside their field, at both trainee and faculty level. It is expected that questions, feedback, and discussion with this wider audience outside of their respective fields will also enable students in the CS to identify novel approaches to their research and prove to be an avenue for extending collaborations and applications of their work.

The CS will leverage existing graduate courses from participating departments, as well as create new modular graduate courses for the Collaborative Specialization's curriculum (0.25 full-course equivalent [FCE] each) that will provide students with additional preparedness for careers in the biotechnology or pharmaceutical industries, with focussed topics that are not covered in other life science or engineering graduate programs or Collaborative Specializations. The planned course curriculum within this CS will provide foundational information in emerging models for drug discovery, novel therapeutic targets and modalities, diagnostic development, commercialization and entrepreneurship, and clinical aspects of therapeutic development that many researchers today will need to understand as their careers advance post-graduation. It will leverage existing courses and develop new modules where needed.

PRiME will also make its other programming, including both research and non-research focused workshops and seminars, available as optional, non-credit opportunities for the enrolled students in this CS. In this way, the Next-Generation in Precision Medicine Collaborative Specialization aims to equip students with practical knowledge and training that will supplement their learning from courses in traditional graduate programs.

It is our expectation that the breadth of courses offered through the Next-Generation in Precision Medicine Collaborative Specialization, cutting-edge research in these areas being conducted by the core CS Faculty members, along with the required seminar course will provide added value to a student's experience by providing distinct viewpoints and diverse examples of collaborative, cross-disciplinary research to address challenges in precision medicine.

The cross-disciplinary nature of PRiME's Collaborative Specialization most similarly reflects that of the Biomedical Engineering Collaborative Specialization; however, a key difference lies in the courses offered/required. While the Biomedical Engineering CS focuses on the application of engineering methods, tools, and principles to solve biological and medical problems, PRiME's CS examines novel strategies in developing diagnostics and therapeutics, and breaks down the process of bringing life sciences innovations to the bench and market. Additionally, while there is some overlap in the core faculty and departmental graduate units, PRiME includes many faculty members that will bring a more biological/life sciences view point to the content of the seminar course.

4 Admission and Specialization Requirements

- Define the admission requirements to the Collaborative Specialization. Note: all Collaborative Specialization students must apply to and be accepted by both the home degree program and the Collaborative Specialization.
- If individual students are allowed to complete the Collaborative Specialization at both the master's and PhD levels, please clarify how each specialization is distinctive.

- If new courses are proposed, please make this clear and include short course descriptions. (Please note that new courses must be proposed and approved separately following established procedures.)

Admission Requirements

Students interested in joining must first apply and enrol into a PhD program in one of the collaborating departments. Once accepted into a PhD degree program, either through reclassification from a MSc program or direct entry into a PhD program, students can then apply for admission to the Collaborative Specialization in Next-Generation Precision Medicine.

To apply to the Next-Generation Precision Medicine Collaborative Specialization, students will be asked to fill out the application form on the CS website and submit it to prime.education@utoronto.ca. The CS Committee will then review the application and notify applicants of acceptance into the CS. Students admitted to the CS must already have a supervisor and a thesis project determined, as well as follow a program of study that meets the requirements of both the collaborating department and Collaborative Specialization in Next-Generation Precision Medicine. The application form available on the CS website asks for the name of the applicant's supervisor, department and faculty information, as well as a short thesis project description (250 words) that is meant to detail the interdisciplinary nature of the project and its relevance to drug discovery, diagnostics or disease biology. This application form will be reviewed by the CS Committee for admission to the CS.

Applicants to the PRiME Collaborative Specialization must be supervised by a core faculty member of the CS, and are encouraged to have at least one member of their supervisory committee with research expertise in a different field of study related to drug discovery, diagnostics and disease biology. Similarly, the thesis project should already be planned and is expected to be focused on drug or diagnostic development or another topic related to next-generation precision medicine.

Specialization Requirements

Note: This Collaborative Specialization is only available to students enrolled in PhD level studies.

Students will be required to take one core seminar course, PHM1500H Next Generation Precision Medicine Seminar Series (0.5 FCE; description below) and any combination of the modules recognized by this CS to give a total of 0.5 FCE. Thus, the total CS course requirement will be 1.0 FCE (combined coursework and seminar course) and a thesis related to drug discovery or diagnostic development.

A full list of course modules recognized by this CS are:

- PHM2102H Module: Introduction to Fundamentals of Drug Discovery **(0.25 FCE)**

Instructor: A. Aman

This course is intended for graduate students. The course will present an overview of the drug discovery process. Starting with target selection then screening at the target, identification of hits, optimization to lead and preclinical candidate. After successful completion of this course students will have a better understanding of modern drug discovery process in the pharmaceutical and biotechnology industry.

- PHM2101H Module: Precision in vitro Diagnostics **(0.25 FCE)**

Instructor: S. Kelley

This course will cover recent advances in diagnostic medicine that are enabling analysis of clinical specimens with increased sensitivity and speed. Topics covered in this course will include infectious disease diagnostics — including those use to manage the COVID-19 pandemic — as well as the emerging area of liquid biopsy. The basics of diagnostic development will be covered along with information regarding regulatory and commercialization channels. The emphasis of the course will be on new technology platforms that are emerging to enhance global health.

- CHM1056H Techniques for Studying the Chemical, Structural and Dynamic Properties of Biomolecules **(0.5 FCE)**

Coordinator: V. Kanelis

This course will cover current techniques for studying the structure, chemical properties, and mobility of biological molecules. Techniques will be described in terms of theory and application and will provide a fundamental understanding of the information potential and limitations of each technique. The specific topics will vary, depending on the interests of the faculty and students, but could include mass spectrometry, nuclear magnetic resonance spectroscopy, fluorescence spectroscopy,

molecular modeling and calorimetry. The course will be team-taught by faculty from St. George, UTSC and UTM. Students will be responsible for short (15- to 20-minute) presentations at the end of the course, expanding on specific topics covered in the course. In the spirit of the tri-campus system, lectures will be taught at the campus where each faculty member is located.

- **CHM1059H Chemical Biology in Complex Systems (0.5 FCE)**

Chemical biology is providing new methods to visualize and quantify processes in intact model organisms. The course will focus on discussion and critiques of the most recent research in chemical biology. Students will develop proposals for new research in the area and go through the peer review process of their ideas. This course is best suited to doctoral students in their second or higher years.

- **CHM1068H Topics in Biological and Medicinal Chemistry (0.5 FCE)**

The course will focus on the use of chemical approaches for answering key biological questions. Topics will include the design of fluorescent probes, the design of inhibitors and reporters of cell function, chemical genetics, caged compounds, techniques for chemical modification of proteins including non-natural amino acid mutagenesis, expansion of the genetic code, combinatorial approaches to the design of proteins and small bioactive compounds, protein design, protein folding and stability, and biological cell-based assays for drug design.

- **CHE1334H Organ-on-a-chip Engineering (0.5 FCE)**

Instructor: M Radisic

This graduate course will focus on the latest developments in the field of Organ-on-a-Chip Engineering, with a specific focus on Organ-on-a-Chip Industry. Topics related to on-chip engineering of heart, kidney, cancer, vasculature and liver will be discussed.

- **CHE1333H Introduction to Nanomaterials and Nanomedicine (0.5 FCE)**

Instructor: F. Gu

Overview of principles of nanoengineering for biotechnology and pharmaceutical industries. This course will study the formulation and manufacturing processes for producing nanomaterials for medical applications; pharmacokinetics, biocompatibility, immunogenicity of nanobiomaterials. The course will also introduce basic concepts in entrepreneurship and regulatory affairs associated bringing

nano/bio-technologies from a lab environment to commercial products. In addition to course lectures, students will complete two laboratory exercises that will provide hands-on learning in emulsified formulations and characterizations involving nanostructures.

- **CHE1134H Advances in Bioengineering (0.5 FCE)**

This course, designed for graduate students whose research is at the interface of Engineering and Biology, will explore recent advances in the areas of bioprocess engineering, environmental microbiology and biotechnology, biomedical engineering, bioinformatics and other related topics. Each week, students will be required to prepare a critical review of assigned high impact journal articles. Discussion of the scientific, technological, environmental, economic, legal and ethical impacts of the research will follow.

NEW COURSE (REQUIRED - Seminar course to be approved by Pharmaceutical Sciences) as part of this major modification proposal.

- **PHM1500H: Next Generation Precision Medicine Seminar Series (0.5 FCE)**

This course is the required seminar series for the Collaborative Specialization in Precision medicine offered annually through the Graduate Department of Pharmaceutical Sciences. The seminar course will take place annually, starting each September and running through to June of the following calendar year. Attendance at 80% of the presentations is required and will be monitored as part of the course credit. Students will be required to enrol in the seminar course once during their studies but may choose to participate (without credit) in other years. While enrolled in the course for credit, students will present their thesis research once and are expected to provide feedback and/or participate in discussions during other presentations.

- SGS Calendar copy
 - ▶ Please provide a full program description and complete Collaborative Specialization requirements, including core course, seminar requirements, etc. and state clearly whether the requirements are in addition to the participating program requirements

- Please complete Appendix A which provides a detailed description of how the requirements for the Collaborative Specialization can be accommodated within the requirements **for each** participating program.

CALENDAR ENTRY

Next-Generation Precision Medicine

Lead Faculty

Pharmacy

Participating Degree Programs

- Pharmaceutical Sciences, PhD
- Chemistry, PhD
- Chemical Engineering and Applied Chemistry, PhD
- Molecular Genetics, PhD

Supporting Units

- Graduate Department of Pharmaceutical Sciences
- Precision Medicine Initiative at U of T (PRiME)

Overview

The graduate programs listed above participate in the Collaborative Specialization in Next-Generation Precision Medicine, which offers the opportunity for cross-disciplinary research leading to doctoral degrees.

The Collaborative Specialization in Next-Generation Precision Medicine is designed to foster cross-disciplinary training and collaboration across diverse departments at the University. The academic research focus is on cutting-edge technologies and methods to develop novel therapeutic strategies, create new tools for disease diagnosis, and enable a deeper understanding of disease biology through integration of principles and methods across the physical and life sciences and engineering.

Future advances in precision medicine will require a multidisciplinary perspective and creative solutions beyond conventional genomics and mutational profiling. This collaborative specialization aims to equip researchers with novel approaches to

addressing the unmet human challenges by providing its students with an understanding of commercialization and translation activities that will help advance research discoveries into impactful outcomes.

Upon successful completion of the PhD degree requirements of the participating home graduate unit and the collaborative specialization, students will receive the notation “Completed Collaborative Specialization in Next-Generation Precision Medicine” on their transcript.

Contact and Address

Christine Misquitta

Web: www.education.prime.utoronto.ca

Email: prime.education@utoronto.ca

Telephone: (416) 946-7022

Collaborative Specialization in Next-Generation Precision Medicine
144 College Street, Room 905
Toronto, Ontario M5S 3M2
Canada

Doctoral Level

Admission Requirements

- Applicants must meet the admission requirements of both the home graduate unit and the collaborative specialization.
- Applicants must apply to and be admitted to both the collaborative specialization and a participating doctoral degree program.
- Applicants must be supervised by a core faculty member of the Collaborative Specialization (list can be found on CS website) and are encouraged to have a co-supervisor or a member of their supervisory committee with research expertise in a different field of study.
- Applicants must have a thesis project focused on drug discovery, diagnostic development, or another topic related to next-generation precision medicine.

Specialization Requirements

- Students must meet the degree requirements of the School of Graduate Studies, the participating home program, and the collaborative specialization.
- The student's thesis in their home graduate program must be in the area of next-generation precision medicine.
- The plan of study will include at least 1.0 full-course equivalent (FCE) (combined course modules and seminar course as described below):
 - ▶ Students must complete PHM1500H *Next Generation Precision Medicine Seminar Series* (0.5 FCE); offered through the Graduate Department of Pharmaceutical Sciences.
 - ▶ Course modules (0.25 or 0.5 FCE each) will be offered through the CS and participating departments. Students must take any (one or two) of the modules recognized by the CS to total 0.5 FCE.

Completion of Specialization Requirements

All students enrolled in the Collaborative Specialization must complete the specific course requirements of the Collaborative Specialization, in addition to or within those requirements for the degree program in their home graduate unit, where possible. The Collaborative Specialization Director is responsible for certifying the completion of the Collaborative Specialization requirements, with recommendations from the Specialization Committee. The home graduate unit is solely responsible for the approval of the student's home degree requirements.

5 Degree Level Expectations, Program Learning Outcomes and Program Structure

- Clearly describe the learning outcomes (LOs) of the proposed Collaborative Specialization. Please note that the LOs are specific to the Collaborative Specialization and thus in no way are meant to address all degree level expectations (DLEs). In every instance, the LOs of the home program in which the student is registered are critical in addressing the DLEs at the master's or doctoral level. The LOs of the CS must be understood to identify the additional capacity students may have in addition to those deriving from the home program.
- Demonstrate the clarity and appropriateness of the specialization's requirements and associated LOs in addressing the institution's DLEs.

A Collaborative Specialization is intended to provide an additional multidisciplinary experience for students enrolled in, and completing the requirements of a degree program. The requirements for the Collaborative Specialization in Next-Generation Precision Medicine are **in addition to** the degree requirements and are not meant to extend the student's time to degree.

As stated above, the primary aim of the Next-Generation in Precision Medicine Collaborative Specialization is to provide a diverse and cross-disciplinary approach to training. It looks to bridge expertise in the natural sciences or engineering with approaches to understanding of disease biology in order to better equip its students for translational and impactful careers as scientists in a number of diverse sectors related to drug discovery, biotechnology, and diagnostic development. The program learning outcomes of the CS are in addition to the learning outcomes of the degree program, and map to the Depth and Breadth of Knowledge and Research and Scholarship degree level expectations. The table below outlines the specific PLOs within those DLEs, and how the program design supports achievement of the PLOs.

Table 1: Doctoral DLEs

DOCTORAL DEGREE LEVEL EXPECTATIONS (based on the Ontario Council of Academic Vice Presidents (OCAV) DLEs)	DOCTORAL PROGRAM LEARNING OBJECTIVES AND OUTCOMES	HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES
<p>EXPECTATIONS This Next Generation Precision Medicine Collaborative Specialization is awarded to students who have demonstrated:</p>		
<p>1. Depth and Breadth of Knowledge A thorough understanding of a substantial body of knowledge that is at the forefront of their academic discipline or area of professional practice.</p>	<p>Depth and breadth of knowledge is defined in Next Generation Precision Medicine as a broad understanding of scientific principles and interdisciplinary strategies in drug discovery and diagnostic development with a vision toward translating basic science to applications.</p> <p>This is reflected in students who are able to:</p> <ul style="list-style-type: none"> a) examine novel strategies in therapeutic and diagnostic development; b) assess need for collaborative relationships across the biological, natural, and applied sciences in order to develop the best solutions in precision medicine; c) develop skills relevant to the commercialization and translational 	<p>The program design and requirement elements that ensure these student outcomes for depth and breadth of knowledge are:</p> <ul style="list-style-type: none"> a) course modules focused on scientific strategies and next generation technology, as well as clinical translation and commercialization b) a seminar series that exposes students to diverse viewpoints and interdisciplinary collaborations and requires presentation of their own work to a broad, non-expert audience of peers c) feedback from an audience of interdisciplinary researchers (faculty and peers) during the seminar course will help

DOCTORAL DEGREE LEVEL EXPECTATIONS (based on the Ontario Council of Academic Vice Presidents (OCAV) DLEs)	DOCTORAL PROGRAM LEARNING OBJECTIVES AND OUTCOMES	HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES
	activities, and the non-scientific skills needed in drug and device development careers	promote multidisciplinary thinking during the development of the thesis project d) the thesis, requiring a supervisory or committee member with a different area of expertise, is expected to broaden the approach taken by CS students e) the thesis, as the student’s culminating work, will provide students with the opportunity to demonstrate their ability to critically apply knowledge in their field, but also to evaluate opportunities for translation of their work in related fields towards developing novel precision medicine solutions
2. Research and Scholarship a) The ability to conceptualize, design, and implement research for the generation of new knowledge, applications, or understanding at the forefront of the discipline, and to adjust the research design or methodology in the light of unforeseen problems;	Research and Scholarship is defined in Next-Generation Precision Medicine as the ability to develop and implement research for the generation of novel ideas and technologies for precision medicine. This is reflected in students who are able to:	The program design and requirement elements that ensure these student outcomes for research and scholarship are: a) exposure to cross-disciplinary mentorship; b) continued peer networking through participation in a required seminar course that will involve analysis and discussion of

DOCTORAL DEGREE LEVEL EXPECTATIONS (based on the Ontario Council of Academic Vice Presidents (OCAV) DLEs)	DOCTORAL PROGRAM LEARNING OBJECTIVES AND OUTCOMES	HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES
<p>b) The ability to make informed judgments on complex issues in specialist fields, sometimes requiring new methods; and c) The ability to produce original research, or other advanced scholarship, of a quality to satisfy peer review, and to merit publication.</p>	<p>a) integrate new techniques and principles in study design toward developing innovative solutions to current and future healthcare needs; and c) identify and integrate translational elements of research into their own thesis project.</p>	<p>their own thesis project from different scientific perspectives, as well as other existing projects outside their area of expertise. c) the research thesis will provide students with the opportunity to demonstrate their ability to describe and justify their method and research tools used; it will allow for direct engagement in specialized research with an inter-disciplinary focus; it will allow the students to create new knowledge, and build their knowledge dissemination skills through research publications, conference attendance, and seminar presentations. These opportunities will strengthen their ability to discuss their findings in light of the existing literature and highlight the contributions and identify the key limitations of their research findings.</p>
<p>3. Level of Application of Knowledge The capacity to i) Undertake pure and/or applied research at an advanced level; and</p>	<p>Level of Application of Knowledge is covered through the program learning outcomes of the home program.</p>	<p>N/A</p>

DOCTORAL DEGREE LEVEL EXPECTATIONS (based on the Ontario Council of Academic Vice Presidents (OCAV) DLEs)	DOCTORAL PROGRAM LEARNING OBJECTIVES AND OUTCOMES	HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES
ii) Contribute to the development of academic or professional skills, techniques, tools, practices, ideas, theories, approaches, and/or materials.		
4. Professional Capacity/Autonomy a) The qualities and transferable skills necessary for employment requiring the exercise of personal responsibility and largely autonomous initiative in complex situations; b) The intellectual independence to be academically and professionally engaged and current; c) The ethical behavior consistent with academic integrity and the use of appropriate guidelines and procedures for responsible conduct of research; and d) The ability to evaluate the broader implications of applying knowledge to particular contexts.	Professional Capacity/Autonomy is covered through the program learning outcomes of the home doctoral degree program.	N/A

DOCTORAL DEGREE LEVEL EXPECTATIONS (based on the Ontario Council of Academic Vice Presidents (OCAV) DLEs)	DOCTORAL PROGRAM LEARNING OBJECTIVES AND OUTCOMES	HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES
<p>5. Level of Communication Skills The ability to communicate complex and/or ambiguous ideas, issues and conclusions clearly and effectively.</p>	<p>Level of Communications Skills is covered through the program learning outcomes of the home program.</p>	<p>N/A</p>
<p>6. Awareness of Limits of Knowledge An appreciation of the limitations of one’s own work and discipline, of the complexity of knowledge, and of the potential contributions of other interpretations, methods, and disciplines.</p> <p>Competence in the research process by applying an existing body of knowledge in the critical analysis of a new question or of a specific problem or issue in a new setting.</p>	<p>Level of Awareness of Limits of Knowledge is covered through the program learning outcomes of the home program.</p>	<p>N/A</p>

6 Assessment of Learning

- Please explain explicitly how the Collaborative Specialization will assess whether students are achieving the stated LOs and how it knows that students have the capacity it hopes to nurture.
- Describe how the methods for assessing student achievement are appropriate and effective relative to established program LOs and DLEs. In other words, how will faculty be able to determine whether students have learned and can do what we expect them to by the end of the specialization?
- How will the specialization document and demonstrate the level of performance of students consistent with the University's DLEs?

The Collaborative Specialization will use a variety of methods to assess student development and progression in the Degree Level Expectations of primary focus: namely 1) Depth and Breadth of Knowledge and 2) Research and Scholarship.

Course modules will be graded for direct assessment of course material knowledge by the faculty members teaching these units, and having focused expertise in these topics.

The Next Generation in Precision Medicine Seminar Series (Course PHM1500H) will have a two-fold method of assessment to help ensure the students are developing skills that are being nurtured by the CS:

- assessment of student's research thesis by a diverse audience of peers and attending faculty (through written feedback and questions)
- monitoring attendance and written feedback/questions while attending other CS students' research presentations

Students must attend 80% of seminars during the session enrolled (once a month from Sept to June). Students will need to present once (20 minute seminar) during their enrollment and have their supervising PI in attendance for the seminar.

Presentations are encouraged to take place in year 3 or 4 of study and students will be counselled on which year of study to take the seminar course. Those present at monthly seminar presentations will provide written feedback and questions for each

presenter that will be consolidated and passed on to the student by the course coordinator.

The course coordinator will monitor attendance and feedback to ensure those enrolled for credit have met the 80% attendance requirement and participated in the seminar series requirements.

7 Resources

- Faculty complement:
 - ▶ Core Collaborative Specialization graduate faculty must be members of a participating graduate unit.
 - ▶ Please include the standard wording below, adapting as necessary.
 - ▶ Please also complete Appendix B: a list, by participating program, of core graduate faculty member(s) whose teaching and research expertise relate to that of the Collaborative Specialization subject area.

Any students with a supervisor listed in the Collaborative Specialization's core faculty members are eligible to apply to the CS. Since the CS is at the doctoral level, and includes a thesis, it is expected that the student's home department thesis supervisor will be a core member of the CS. Anyone interested in joining the CS as a core member is encouraged to contact prime.education@utoronto.ca as we encourage additional membership. Core faculty members contribute to the Collaborative Specialization through teaching of the core course(s) and participating in the PRIME seminar series (CS seminar course) and other common learning elements. The list of core faculty members is available in Appendix B. Each participating degree program contributes to the Collaborative Specialization through student enrolments, although not necessarily every year.

Each Collaborative Specialization has a Director and a Specialization Program Committee. Together they are responsible for admitting students to the Collaborative Specialization and ensuring that the faculty associated with the program have the capacity to supervise all program students. Consequently, an assessment of

supervisory capacity occurs twice: once when students are admitted to their home degree program and once on their application to the Collaborative Specialization. The University finds that the participation in a Collaborative Specialization does not normally add significantly to a faculty member's supervisory load. For the most part, students in the Collaborative Specialization will continue to have their thesis or major research project supervised by a faculty member in their home program who also participates in the Collaborative Specialization.

Please see Appendix B for a list, by program, of core graduate faculty for this CS.

8 Administration

Please see Appendix C: Memorandum of Agreement.

9 Governance Process

Steps	Levels of Approval Required
Development and consultation with unit(s)	
Consultation with Dean's Office (and VPAP)	
VPAP sign-off	
Graduate unit approval	
Faculty/divisional governance	
Submission to Provost's Office	Upon approval
Report to AP&P	May 5, 2021
Report to Ontario Quality Council	July 2021

Appendix A: Collaborative Specialization Requirements and Degree Program Requirements

Please provide the following information for each participating program. The purpose is to clarify how the Collaborative Specialization requirements are accommodated within each participating program.

Following the format below, please explain if the Collaborative Specialization requirements are in addition to the home program requirements or if they may be counted towards regular home program requirements. State explicitly, for example, “The core course (X FCE) may be counted as one of the electives.”

For Collaborative Specialization students in a degree program that requires a thesis or major research paper, the topic should be in the area of the Collaborative Specialization. For students in a coursework-only master’s degree program, at least 30% of the courses for the home degree must be in the area of the Collaborative Specialization — this includes the core course for the Collaborative Specialization (please see the [Quality Assurance Framework “Collaborative Specialization” definition](#) for more details). It is not necessary to reiterate all the requirements for each degree program.

Graduate Department of Pharmaceutical Sciences:

[Please alter the wording if the Collaborative Specialization requirements are in addition to the home program requirements and may not be fulfilled with elective courses.]

- **PhD in Pharmaceutical Sciences**

PhD requirements: 2.0 FCEs total
courses are determined in consultation with the supervisor

1.0 FCE (coursework and seminar course) required for the Collaborative Specialization may be counted as electives if approved by supervisor.

Department of Chemistry:

- **PhD in Chemistry**

PhD requirements: 2.0 FCEs total
courses are determined in consultation with the supervisor

1.0 FCE (coursework and seminar course) required for the Collaborative Specialization may be counted toward program FCE if approved by the home program.

Department of Chemical Engineering and Applied Chemistry:

- **PhD in Chemical Engineering and Applied Chemistry**

PhD requirements: 2.0 FCEs total coursework
0.5 FCE required courses (CHE 1102H)
1.5 FCEs elective space for courses

0.5 FCE (coursework) required for the Collaborative Specialization may be counted towards total electives needed.

Note: this program requires additional seminar courses CHE3001H (0.5 FCE each, taken 4 times over program) and CHE2222H (0.5 FCE).

The CS seminar course (PHM1500H, 0.5 FCE) would be taken in addition to the above.

Department of Molecular Genetics:

- **PhD in Molecular Genetics**

PhD requirements: 1.5 FCEs total
1.5 FCEs required courses (MMG1031Y; MMG1041H)
0.0 FCE elective space

1.0 FCE (coursework and seminar course) required for the Collaborative Specialization would be taken in addition to the total FCE home program requirements.

Appendix B: Core Faculty Research Synopses

Note for proponents: Please provide a full list **of all faculty** who intend to participate in the Collaborative Specialization from each participating degree program. In each instance, provide two to four recent publications that show active engagement in the field.

Core faculty members are those who are eligible to teach and/or supervise in the Collaborative Specialization, as appropriate. Core faculty members must hold graduate faculty membership in one of the participating degree programs. The process of identifying a graduate faculty member as a Collaborative Specialization core faculty member is initiated by the faculty member or the Collaborative Specialization Director. Both the faculty member's home graduate unit chair or director and the Collaborative Specialization Director must agree, as well as the faculty member involved. The Collaborative Specialization Director is responsible for maintaining records of agreements concerning assignment of core faculty members to the Collaborative Specialization. Formal cross-appointments to the graduate faculty are not required for core faculty members.

There must be at least one faculty member listed from each participating graduate program. Collaborative Specialization students must have a core Collaborative Specialization graduate faculty member from the student's home graduate unit as a supervisor, where a supervisor is required.

All teaching staff identified as members of the Collaborative Specialization are core faculty of the participating approved graduate programs and have been approved by the chair or director of their home unit for cross-appointment to the Collaborative Specialization. In bringing forward a proposal for a new Collaborative Specialization, the concern is that, in addition to being approved members of the graduate teaching staff, all proposed faculty be active in the area of the Collaborative Specialization. This list highlights peer review publications by the approved faculty members in the Collaborative Specialization area.

Pharmaceutical Sciences, PhD, Graduate Department of Pharmaceutical Sciences

1. Christine Allen

- Dou YN, Dunne M, Huang H, et al. Thermosensitive liposomal cisplatin in combination with local hyperthermia results in tumor growth delay and changes in tumor microenvironment in xenograft models of lung carcinoma. *J Drug Target*. 2016;24(9):865-877. doi:10.1080/1061186X.2016.1191079
- Houdaihed L, Evans JC, Allen C. In Vivo Evaluation of Dual-Targeted Nanoparticles Encapsulating Paclitaxel and Everolimus. *Cancers (Basel)*. 2019;11(6):752. Published 2019 May 29. doi:10.3390/cancers11060752

2. Stephane Angers

- MacLeod G, Bozek DA, Rajakulendran N, et al. Genome-Wide CRISPR-Cas9 Screens Expose Genetic Vulnerabilities and Mechanisms of Temozolomide Sensitivity in Glioblastoma Stem Cells. *Cell Rep*. 2019;27(3):971-986.e9. doi:10.1016/j.celrep.2019.03.047
- Steinhart Z, Pavlovic Z, Chandrashekar M, et al. Genome-wide CRISPR screens reveal a Wnt-FZD5 signaling circuit as a druggable vulnerability of RNF43-mutant pancreatic tumors [published correction appears in *Nat Med*. 2017 Nov 7;23(11):1384]. *Nat Med*. 2017;23(1):60-68. doi:10.1038/nm.4219

3. Shana Kelley

- Labib M, Wang Z, Ahmed SU, et al. Tracking the expression of therapeutic protein targets in rare cells by antibody-mediated nanoparticle labelling and magnetic sorting [published online ahead of print, 2020 Jul 27]. *Nat Biomed Eng*. 2020;10.1038/s41551-020-0590-1. doi:10.1038/s41551-020-0590-1
- Labib M, Philpott DN, Wang Z, et al. Magnetic Ranking Cytometry: Profiling Rare Cells at the Single-Cell Level [published online ahead of print, 2020 Jul 14]. *Acc Chem Res*. 2020;10.1021/acs.accounts.0c00179. doi:10.1021/acs.accounts.0c00179

4. Keith Pardee

- Sadat Mousavi P, Smith SJ, Chen JB, et al. A multiplexed, electrochemical interface for gene-circuit-based sensors. *Nat Chem*. 2020;12(1):48-55. doi:10.1038/s41557-019-0366-y
- Huang A, Nguyen PQ, Stark JC, et al. BioBits™ Explorer: A modular synthetic biology education kit. *Sci Adv*. 2018;4(8):eaat5105. Published 2018 Aug 1. doi:10.1126/sciadv.aat5105

5. Carolyn Cummins

- Amini MA, Ahmed T, Liu FF, Abbasi AZ, Soeandy CD, Zhang RX, Prashad P, Cummins CL, Rauth AM, Henderson JT, Wu XY. Exploring the transformability of polymer-lipid hybrid nanoparticles and nanomaterial-biology interplay to facilitate tumor penetration, cellular uptake, and intracellular targeting of anticancer drugs. *Expert Opin Drug Deliv.* 2021 Mar 11.
- Rasheed A, Shawky SA, Tsai R, Jung RG, Simard T, Saikali MF, Hibbert B, Rayner KJ, Cummins CL. The secretome of liver X receptor agonist-treated early outgrowth cells decreases atherosclerosis in Ldlr^{-/-} mice. *Stem Cells Transl Med.* 2021 Mar 10(3):479-491.

Chemistry, PhD, Department of Chemistry

1. Alan Aspuru-Guzik

- Roch LM, Saikin SK, Häse F, et al. From Absorption Spectra to Charge Transfer in Nanoaggregates of Oligomers with Machine Learning. *ACS Nano.* 2020;14(6):6589-6598. doi:10.1021/acsnano.0c00384
- Zhavoronkov A, Ivanenkov YA, Aliper A, et al. Deep learning enables rapid identification of potent DDR1 kinase inhibitors. *Nat Biotechnol.* 2019;37(9):1038-1040. doi:10.1038/s41587-019-0224-x

2. Robert A. Batey

- Beveridge RE, Hu Y, Gregoire B, Batey RA. Di-*tert*-butyl Ethynylimidodicarbonate as a General Synthone for the β -Aminoethylation of Organic Electrophiles: Application to the Formal Synthesis of Pyrrolidinoindoline Alkaloids (\pm)-CPC-1 and (\pm)-Alline. *J Org Chem.* 2020 Jul 2;85(13):8447-8461. doi: 10.1021/acs.joc.0c00781. Epub 2020 Jun 22. PMID: 32495626.
- Tarasewicz A, Ensan D, Batey RA. An Alumino-Mannich Reaction of Organoaluminum Reagents, Silylated Amines, and Aldehydes. *Chemistry.* 2018 Apr 20;24(23):6071-6074. doi: 10.1002/chem.201801012. Epub 2018 Mar 26. PMID: 29518283.

3. Scott Prosser

- Huang SK, Pandey A, Tran DP, Villanueva NL, Kitao A, Sunahara RK, Sljoka A, Prosser RS. Delineating the conformational landscape of the adenosine A_{2A} receptor during G protein coupling. *Cell* 2021 Mar 15:S0092-8674(21)00230-0. doi: 10.1016/j.cell.2021.02.041. Epub ahead of print. PMID: 33743210.

- Ye L, Neale C, Sljoka A, Lyda B, Pichugin D, Tsuchimura N, Larda ST, Pomes R, Garcia AE, Ernst OP, Sunahara RK, Prosser RS. Mechanistic insights into allosteric regulation of the A_{2A} adenosine G protein-coupled receptor by physiological cations. *Nat Commun.* 2018 Apr 10; 9(1):1372. Doi:10.1038/s41467-018-03314-9. PMID: 29636462; PMCID: PMC5893540.
4. Gilbert Walker
 - Ip S, MacLaughlin CM, Joseph M, et al. Dual-Mode Dark Field and Surface-Enhanced Raman Scattering Liposomes for Lymphoma and Leukemia Cell Imaging. *Langmuir.* 2019;35(5):1534-1543. doi:10.1021/acs.langmuir.8b02313
 - Ho K, Kim KS, Gilburd L, Mirzoyan R, DeBeer S, Walker GC. Nanoscale Subsurface Morphologies in Block Copolymer Thin Films Revealed by Combined Near-Field Infrared Microscopy and Mechanical Mapping. *ACS Appl. Polym. Mater.* 2019, 1, 933-938. doi: 10.1021/acsapm.9b00189.
 5. Aaron Wheeler
 - Dixon C, Lamanna J, Wheeler AR. Direct loading of blood for plasma separation and diagnostic assays on a digital microfluidic device. *Lab Chip.* 2020;20(10):1845-1855. doi:10.1039/d0lc00302f
 - Zhang S, Scott EY, Singh J, et al. The optoelectronic microrobot: A versatile toolbox for micromanipulation. *Proc Natl Acad Sci U S A.* 2019;116(30):14823-14828. doi:10.1073/pnas.1903406116

Chemical Engineering and Applied Chemistry, PhD, Department of Chemical Engineering and Applied Chemistry

1. Alison McGuigan
 - Dean T, Li NT, Cadavid JL, Ailles L, McGuigan AP. A TRACER culture invasion assay to probe the impact of cancer associated fibroblasts on head and neck squamous cell carcinoma cell invasiveness. *Biomater Sci.* 2020;8(11):3078-3094. doi:10.1039/c9bm02017a
 - D'Arcangelo E, Wu NC, Chen T, et al. Gels for Live Analysis of Compartmentalized Environments (GLANCE): A tissue model to probe tumour phenotypes at tumour-stroma interfaces. *Biomaterials.* 2020;228:119572. doi:10.1016/j.biomaterials.2019.119572
2. Molly Shoichet

- Czupiel P, Delplace V, Shoichet M. Nanoparticle delivery of a pH-sensitive prodrug of doxorubicin and a mitochondrial targeting VES-H₈R₈ synergistically kill multi-drug resistant breast cancer cells. *Sci Rep.* 2020;10(1):8726. Published 2020 May 26. doi:10.1038/s41598-020-65450-x
- Arnold AE, Smith LJ, Beilhartz G, et al. Attenuated diphtheria toxin mediates siRNA delivery. *Sci Adv.* 2020;6(18):eaaz4848. Published 2020 May 1. doi:10.1126/sciadv.aaz4848

Molecular Genetics, PhD, Department of Molecular Genetics

1. Gary Bader

- Idicula-Thomas S, Gawde U, Bhaye S, Pokar K, Bader GD. Meta-analysis of gene expression profiles of lean and obese PCOS to identify differentially regulated pathways and risk of comorbidities. *Comput Struct Biotechnol J.* 2020;18:1735-1745. Published 2020 Jun 21. doi:10.1016/j.csbj.2020.06.023
- Pai S, Hui S, Isserlin R, Shah MA, Kaka H, Bader GD. netDx: interpretable patient classification using integrated patient similarity networks. *Mol Syst Biol.* 2019;15(3):e8497. Published 2019 Mar 14. doi:10.15252/msb.20188497

2. Alan Cochrane

- Wong RW, Balachandran A, Cheung PK, Cheng R, Pan Q, Stoilov P, Harrigan PR, Blencowe BJ, Branch DR, Cochrane A. An activator of G protein-coupled receptor and MEK1/2-ERK1/2 signaling inhibits HIV-1 replication by altering viral RNA processing. *PLoS Pathog.* 2020 Feb 18;16(2):e1008307. doi: 10.1371/journal.ppat.1008307. PMID:32069328; PMCID: PMC7048317.
- Wong RW, Lingwood CA, Ostrowski MA, Cabral T, Cochrane A. Cardiac glycoside/aglycones inhibit HIV-1 gene expression by a mechanism requiring MEK1/2 ERK1/2 signaling. *Sci Rep.* 2018 Jan 16;8(1):850. doi: 10.1038/s41598-018-19298-x. Erratum in: *Sci Rep.* 2019 Dec 4;9(1):18656. PMID: 29339801; PMCID: PMC5770468.

3. Leah Cowen

- Hossain S, Lash E, Veri AO, Cowen LE. Functional connections between cell cycle and proteostasis in the regulation of *Candida albicans* morphogenesis. *Cell Rep.* 2021 Feb 23;34(8):108781. doi: 10.1016/j.celrep.2021.108781. PMID: 33626353; PMCID: PMC7971348.

- LeBlanc EV, Shekhar-Guturja T, Whitesell L, Cowen LE. Fluorescence Polarization-Based Measurement of Protein-Ligand Interaction in Fungal Cell Lysates. *Curr Protoc*. 2021 Jan;1(1):e17. doi: 10.1002/cpz1.17. PMID: 33484500; PMCID: PMC7850327.

4. Fritz Roth

- D-K Kim, JJ Knapp, D Kuang, P Cassonnet, P Samavarchi-Tehrani, H Abdouni, A Rayhan, D Sheykhkarimli, E Coyaud, S van der Werf, C Demeret, A-C Gingras, B Raught, Y Jacob, FP Roth. A flexible genome-scale resource of SARS-CoV-2 coding sequence clones. *Preprints* 2020 Apr 2.
- Kuang D, Weile J, Li R, Ouellette TW, Barber JA, Roth FP. MaveQuest: a web resource for planning experimental tests of human variant effects. *Bioinformatics*. 2020;36(12):3938-3940. doi:10.1093/bioinformatics/btaa228



UNIVERSITY OF
TORONTO

University of Toronto
MEMORANDUM OF AGREEMENT
Graduate Collaborative Specialization in
Next-Generation Precision Medicine

Effective September 1, 2021

Memorandum of Agreement concerning a Graduate Collaborative Specialization in Next-Generation Precision Medicine (the “Collaborative Specialization”).

1 Parties to the Agreement

In order to develop cooperative and multidisciplinary graduate education and research in novel therapeutic discovery strategies, diagnostic technologies, and methods to study disease biology, the following units agree to the participation of the following graduate degree programs in the Collaborative Specialization in Next-Generation Precision Medicine:

Participating Units

Department of Chemical Engineering and Applied Chemistry
Faculty of Applied Science & Engineering
Chemical Engineering and Applied Chemistry, Doctor of Philosophy
Molly Shoichet, Associate Chair and Graduate Coordinator
molly.shoichet@utoronto.ca

Department of Chemistry
Faculty of Arts & Science
Chemistry, Doctor of Philosophy
Robert A. Batey, Chair
rob.batey@utoronto.ca

Department of Molecular Genetics

Temerty Faculty of Medicine
Molecular Genetics, Doctor of Philosophy
Mike Wilson, Associate Graduate Coordinator
michael.wilson@sickkids.ca

Department of Pharmaceutical Sciences
Leslie Dan Faculty of Pharmacy
Pharmaceutical Sciences, Doctor of Philosophy
Micheline Piquette-Miller, Interim Director Graduate Department of Pharmaceutical
Sciences
m.piquette.miller@utoronto.ca

Lead Faculty

Leslie Dan Faculty of Pharmacy (“Lead Faculty”)
Lisa Dolovich, Dean
Leslie Dan Faculty of Pharmacy

Director of the Collaborative Specialization

Shana Kelley, (“Collaborative Specialization Director”)
Pharmaceutical Sciences, Leslie Dan Faculty of Pharmacy

Supporting Unit/s (if applicable)

Graduate Department of Pharmaceutical Sciences, Leslie Dan Faculty of Pharmacy (“Supporting Unit”)

Micheline Piquette-Miller
Interim Director Graduate Department of Pharmaceutical Sciences
Email: m.piquette.miller@utoronto.ca

Christine Park
Graduate Coordinator, Pharmaceutical Sciences
Email: pharm.sci@utoronto.ca

The Precision Medicine initiative (PRiME), Institutional Strategic Initiative (“Supporting Unit”)

Shana Kelley
Director, PRiME
Email: shana.kelley@utoronto.ca

Christine Misquitta
Director of Strategy & Partnerships, PRiME
Email: christine.misquitta@utoronto.ca

2 Admission and Program Requirements and Completion

Admission Requirements

Applicants must be accepted into a Participating Graduate Degree Program before being accepted into the Collaborative Specialization and must meet the admission requirements of both the Participating Graduate Degree Program and the Collaborative Specialization.

See attached calendar copy in section 10 for admission requirements. Changes to admission requirements are approved through governance as a minor modification.

Program Requirements

The student must register first in the Participating Graduate Degree Program. Thereafter, upon acceptance, the student must then apply to and register in the Collaborative Specialization. The student must meet all degree requirements of the Participating Graduate Degree Program, as well as the requirements of the Collaborative Specialization.

See attached calendar copy in section 10 showing program requirements. Changes to program requirements are approved through governance as a minor modification.

Program Completion

Upon certification by the Collaborative Specialization Director that all requirements of the collaborative specialization have been fulfilled, the designation “Completed [session date]— Collaborative Specialization [degree short form] in [name of program]” is shown on the graduate transcript. The Participating Graduate Unit recommends the granting of the degree.

3 Role of Participating Graduate Units and Core Faculty

Each Participating Graduate Unit shall retain its authority over admissions and program requirements for its own graduate degree program(s) and is responsible for providing adequate research supervision by a member of the graduate faculty (“core faculty”) in the unit. Students in the Collaborative Specialization normally are supervised by a member of the Collaborative Specialization’s core faculty or have a core faculty member as a member of the supervisory committee (where supervision and a supervisory committee are required). The *SGS Calendar* entry for Participating Graduate Units, their websites and other advertising material related to the Participating Graduate Degree Program shall include references to the Collaborative Specialization. The Participating Graduate Units will identify core faculty members from their respective programs to the Collaborative Specialization Director. Core faculty members are expected to contribute to the Collaborative Specialization through teaching, supervision and participation in the delivery of seminar series and other Collaborative Specialization learning elements and may serve on the Collaborative Specialization Committee. Not all Collaborative Specialization core faculty members necessarily participate each year and, in many cases, simply remain available to students seeking supervision. Some core faculty may teach courses in the subject area of the Collaborative Specialization in the Participating Graduate Program.

4 Administration of the Collaborative Specialization

Collaborative Specialization Committee

The Collaborative Specialization is administered by a committee (the “Collaborative Specialization Committee”) which will consist of two core faculty members from each Participating Faculty (Medicine, Arts & Science, Pharmacy, Applied Science & Engineering). As this will only be a sub-set of the participating departmental programs, members of the Collaborative Specialization Committee will rotate every two years. The Collaborative Specialization Committee shall be chaired by the Collaborative Specialization Director.

The responsibilities of the Collaborative Specialization Committee are as follows:

Administration and Management

- In collaboration with the Collaborative Specialization Director, maintains a list of current core faculty associated with the Collaborative Specialization.
- Together with the Collaborative Specialization Director, consults with chair(s) of participating units and Faculty Dean(s) on matters relating to the Collaborative Specialization.

Admissions and Academic Oversight

- In collaboration with the Collaborative Specialization Director, reviews and approves admissions to the Collaborative Specialization.

Collaborative Specialization Director

The Collaborative Specialization Director is accountable to the Dean of the Lead Faculty. The Collaborative Specialization Committee recommends the appointment of a new Collaborative Specialization Director to the Lead Faculty Dean after consultation with chairs/directors of Participating Graduate Units and with the current Collaborative Specialization Director. The Lead Faculty Dean appoints the Collaborative Specialization Director for a term normally up to five years (renewable for one term).

As outlined in the [Collaborative Specialization Guidelines](#), the responsibilities of the Collaborative Specialization Director are as follows:

Administration and Management

- Chairs the Collaborative Specialization Committee and ensures that the Collaborative Specialization Committee has appropriate representation from the participating programs.
- Administers the budget and any resources.
- Ensures that all materials (calendar, website etc.) are current.
- Maintains a list of core faculty associated with the Collaborative Specialization and any other records.

- Consults with academic lead(s)/chair(s) of participating units and lead Faculty Dean(s) or delegate(s) on matters relating to the Collaborative Specialization.

Admissions and Academic Oversight

- Reviews and approves admissions to the Collaborative Specialization with support of the Collaborative Specialization Committee.
- Provides guidance to students in managing Collaborative Specializations requirements and ensures appropriate graduate supervision.
- Confirms completion of program requirements for each student enrolled in the Collaborative Specialization, works with SGS to provide each student with a completion letter, and to ensure the Collaborative Specialization notation is recorded on the graduate transcript.

Governance

- Ensures that the Memorandum of Agreement (MOA) is revised appropriately including the addition or deletion of participating programs.
- Works with the lead Faculty to change admissions and program requirements through Faculty governance as necessary.

Program Requirements and University of Toronto Quality Assurance Process (UTQAP)

- Prepares any materials required as part of the UTQAP review process.
- Works collaboratively with the lead Faculty Dean and participating programs on the renewal of the MOA following the outcome of the review process.

Administration: General

Any administrative support required for the Collaborative Specialization will be met by the Supporting Units, particularly PRiME, as outlined in the section below.

5 Supporting Units

Supporting units provide resources of various kinds to the Collaborative Specialization. A supporting unit is not necessarily a Participating Graduate Unit, although a Graduate Unit may serve both functions. Not all Collaborative Specializations have supporting units.

The Collaborative Specialization in Next-Generation Precision Medicine has two supporting units:

- I. Graduate Department of Pharmaceutical Sciences, Leslie Dan Faculty of Pharmacy;
- II. Precision Medicine initiative (PRiME), Institutional Strategic Initiative.

The Graduate Department of Pharmaceutical Sciences will provide support for the Collaborative Specialization through scheduling PHM1500H and the module graduate courses it offers that are part of the CS. It will be responsible for all the course administrative work such as scheduling these courses in ROSI and add enrolled students' grades for these courses.

PRiME will organize activities (including advertising, and booking space & AV) for PHM1500H.

PRiME will also organize activities (including advertising, registration, and booking space & AV) for any non-credit workshops and programming offered to Collaborative Specialization students through PRiME.

PRiME will also provide administrative support for the Collaborative Specialization students, Collaborative Specialization Director and Collaborative Specialization committee as needed.

PRiME will maintain the Collaborative Specialization website, including payment of annual hosting fees, and ensuring program requirements, course offerings and core faculty are up to date.

6 Resource Issues

All financial resources required for the Collaborative Specialization, with the exception of duties outlined in Section 5 regarding graduate course scheduling and reporting of grades for any courses offered through the support units, will be the responsibility of PRiME. This includes any costs related to additional administrative support required for the Collaborative Specialization and all related expenses, such as advertising costs, website hosting and maintenance, charges for not for credit programming (workshops, seminars) offered to Collaborative Specialization students including any AV and room booking, or catering expenses.

7 Duration of Agreement and Renewal

This MOA shall be in effect until August 31, 2030, at which time it can be renewed following a UTQAP review of the Collaborative Specialization. The Lead Faculty Dean will commission a UTQAP review of the Collaborative Specialization in the academic year preceding the MOA expiry date. This review is a precondition for the renewal of the MOA and may result in a) renewal of the MOA, with any appropriate amendments to address the review findings; b) changes to the Collaborative Specialization and renewal of the MOA, with any appropriate amendments to address the review findings; c) decision to cease admissions to the Collaborative Specialization and bring forward a proposal to close the Collaborative Specialization following UTQAP protocols.

8 Amendments

With the exception of additions or subtractions to the Collaborative Specialization's list of Participating Graduate Degree Program(s), any amendment of this MOA will require approval from all signing Parties.

Academic changes to a Collaborative Specialization are normally minor modifications. The status of a change is decided in consultation with the Office of the VPAP.

9 Termination

This MOA can be terminated following governance approval of a UTQAP proposal to close the Collaborative Specialization. The proposal is initiated by the Lead Faculty.

10 Calendar Copy

Next-Generation Precision Medicine

Next-Generation Precision Medicine: Introduction

Lead Faculty of the Collaborative Specialization

Pharmacy

Participating Degree Programs

Chemistry — PhD

Chemical Engineering and Applied Chemistry — PhD

Molecular Genetics — PhD

Pharmaceutical Sciences — PhD

Supporting Units

Graduate Department of Pharmaceutical Sciences;

Precision Medicine Initiative at U of T (PRiME)

Overview

The graduate programs listed above participate in the doctoral Collaborative Specialization (CS) in Next-Generation Precision Medicine, which offers the opportunity for cross-disciplinary research leading to doctoral degrees.

This CS is designed to foster cross-disciplinary training and collaboration across diverse departments at the University. The academic research focus is on cutting-edge technologies and methods to develop novel therapeutic strategies, create new tools for disease diagnosis, and enable a deeper understanding of disease biology through integration of principles and methods across the physical and life sciences and engineering.

Future advances in precision medicine will require a multidisciplinary perspective and creative solutions beyond conventional genomics and mutational profiling. This CS aims to equip researchers with novel approaches to address unmet human health challenges by providing an understanding of commercialization and translation activities that will help advance research discoveries into impactful outcomes.

Upon successful completion of the PhD degree requirements of the participating home graduate unit and the CS, students will receive the notation “Completed Collaborative Specialization in Next-Generation Precision Medicine” on their transcript.

Contact and Address

Web: www.education.prime.utoronto.ca

Email: prime.education@utoronto.ca

Telephone: (416) 946-7022

Christine Misquitta

Collaborative Specialization in Next-Generation Precision Medicine

144 College Street, room 905

Toronto, Ontario M5S 3M2

Canada

Next-Generation Precision Medicine: Doctoral Level

Admission Requirements

- Applicants must meet the admission requirements of both the home graduate unit and the collaborative specialization (CS).
- Applicants must apply to and be admitted to both the CS and a participating doctoral degree program.
- Applicants must be supervised by a [core faculty member of the CS](#) and are encouraged to have a co-supervisor or a member of their supervisory committee with research expertise in a different field of study.
- Applicants must have a thesis project focused on drug discovery, diagnostic development, or another topic related to next-generation precision medicine.

Specialization Requirements

- Students must meet the degree requirements of the School of Graduate Studies, the participating home graduate program, and the collaborative specialization.
- The student's thesis in their home program must be in the area of next-generation precision medicine.
- The plan of study will include at least **1.0 full-course equivalent (FCE)** (combined course modules and seminar course as described below):
 - Students must complete PHM1500H *Next-Generation Precision Medicine Seminar Series* (0.5 FCE), offered through the Graduate Department of Pharmaceutical Sciences.
 - Course modules (0.25 or 0.5 FCE each) will be offered through the CS and participating departments. Students must take any (one or two) of the modules recognized by the CS for a total of 0.5 FCE.

Next-Generation Precision Medicine: Courses

Required Course

PHM1500H	Next-Generation Precision Medicine Seminar Series
----------	---

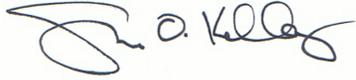
Modular Courses

Each modular course is worth 0.25 full-course equivalent (FCE).

CHE1134H	Advances in Bioengineering
CHE1333H	Biomaterials Engineering for Nanomedicine
CHE1334H	Organ-on-a-chip Engineering
CHM1056H	Techniques for Studying the Chemical, Structural, and Dynamic Properties of Biomolecules
CHM1059H	Chemical Biology in Complex Systems
CHM1068H	Topics in Biological and Medicinal Chemistry
PHM1500H	Next-Generation Precision Medicine Seminar Series
PHM2101H	Module: Precision in vitro Diagnostics
PHM2102H	Module: Introduction to Fundamentals of Drug Discovery

**PARTIES AGREE TO PARTICIPATE IN ACCORDANCE WITH ALL TERMS OUTLINED IN THIS
MEMORANDUM OF AGREEMENT**

Collaborative Specialization Director:



Date: June 21, 2021

Shana Kelley, Department of Pharmaceutical Sciences

**Participating Graduate Units and Faculties/Division Participating in Collaborative
Specialization:**

Date: _____

Michael D. Wilson

Associate Chair and Graduate Coordinator, Department of Molecular Genetics

Date: July 7, 2021

Justin Nodwell

*Vice-Dean, Research and Graduate Education, Temerty Faculty of Medicine responsible for the
above unit*



Date: June 22, 2021

D. Grant Allen

Chair, Department of Chemical Engineering and Applied Chemistry



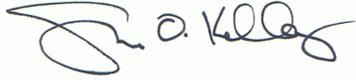
Date: June 22, 2021

Julie Audet

*Vice-Dean, Graduate Studies, Faculty of Applied Science & Engineering responsible for the above
unit*

**PARTIES AGREE TO PARTICIPATE IN ACCORDANCE WITH ALL TERMS OUTLINED IN THIS
MEMORANDUM OF AGREEMENT**

Collaborative Specialization Director:



Date: June 21, 2021

Shana Kelley, Department of Pharmaceutical Sciences

**Participating Graduate Units and Faculties/Division Participating in Collaborative
Specialization:**



Date: June 23, 2021

Michael D. Wilson
Associate Chair and Graduate Coordinator, Department of Molecular Genetics

Date: _____

Justin Nodwell
*Vice-Dean, Research and Graduate Education, Temerty Faculty of Medicine responsible for the
above unit*

Date: _____

D. Grant Allen
Chair, Department of Chemical Engineering and Applied Chemistry

Date: _____

Julie Audet
*Vice-Dean, Graduate Studies, Faculty of Applied Science & Engineering responsible for the above
unit*



Date: June 23, 2021

Robert A. Batey
Chair, Department of Chemistry



Date: June 23, 2021

Jay Pratt
Acting Vice-Dean, Graduate Education, Faculty of Arts & Science responsible for the above unit

Date: _____

Micheline Piquette-Miller
Interim Director, Graduate Department of Pharmaceutical Sciences

Date: _____

Lisa Dolovich
Dean, Leslie Dan Faculty of Pharmacy responsible for the above unit

Supporting Unit(s) :

Date: _____

Micheline Piquette-Miller
Interim Director, Graduate Department of Department of Pharmaceutical Sciences

Date: _____

Shana Kelley
Director, PRiME

_____ Date: _____

Robert A. Batey
Chair, Department of Chemistry

_____ Date: _____

Jay Pratt
Acting Vice-Dean, Graduate Education, Faculty of Arts & Science responsible for the above unit

Micheline Piquette-Miller
Digitally signed by Micheline Piquette-Miller
Date: 2021.06.22 14:37:47 -04'00'

_____ Date: _____

Micheline Piquette-Miller
Interim Director, Graduate Department of Pharmaceutical Sciences



_____ Date: June 22, 2021

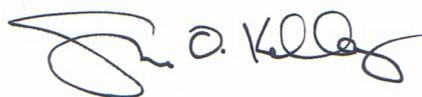
Lisa Dolovich
Dean, Leslie Dan Faculty of Pharmacy responsible for the above unit

Supporting Unit(s) :

Micheline Piquette-Miller
Digitally signed by Micheline Piquette-Miller
Date: 2021.06.22 14:38:24 -04'00'

_____ Date: _____

Micheline Piquette-Miller
Interim Director, Graduate Department of Department of Pharmaceutical Sciences



_____ Date: June 21, 2021

Shana Kelley
Director, PRiME



Date: June 22, 2021

Lisa Dolovich
Dean responsible for the above supporting units

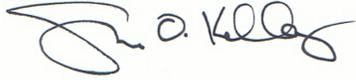
Lead Faculty 

Date: June 22, 2021

Lisa Dolovich
Dean, Leslie Dan Faculty of Pharmacy

**PARTIES AGREE TO PARTICIPATE IN ACCORDANCE WITH ALL TERMS OUTLINED IN THIS
MEMORANDUM OF AGREEMENT**

Collaborative Specialization Director:



Date: June 21, 2021

Shana Kelley, Department of Pharmaceutical Sciences

**Participating Graduate Units and Faculties/Division Participating in Collaborative
Specialization:**

Date: _____

Michael D. Wilson

Associate Chair and Graduate Coordinator, Department of Molecular Genetics

Date: July 6, 2021

Justin Nodwell

*Vice-Dean, Research and Graduate Education, Temerty Faculty of Medicine responsible for the
above unit*

Date: _____

D. Grant Allen

Chair, Department of Chemical Engineering and Applied Chemistry

Date: _____

Julie Audet

*Vice-Dean, Graduate Studies, Faculty of Applied Science & Engineering responsible for the above
unit*