

Toxicology Graduate Student Handbook



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Interdisciplinary Graduate Program in Toxicology

FIELD OF TOXICOLOGY

Toxicology is the scientific discipline that deals with the harmful effects of chemical and physical agents on living organisms. It is essentially the study of poisons and pollutants.

At the University of Saskatchewan (U of S), research and postgraduate teaching in toxicology is coordinated and led by the Toxicology Centre, with significant participation from members of the University's Toxicology Group. The Toxicology Group is an interdisciplinary body under the umbrella of the College of Graduate and Postdoctoral Studies (CGPS) that consists of faculty members from many University departments, as well as scientists and adjunct faculty from various government research institutions located on or near campus.

Members of the Toxicology Group are actively engaged in research across a broad spectrum of toxicology sub-disciplines, thus providing prospective graduate students with varied research opportunities.

ABOUT THE PROGRAM

The Graduate Program in Toxicology was established in 1981, the first of its kind in Canada. The Program offers both conventional PhD and MSc programs (with research and thesis). The Toxicology Graduate Program has a focus on aquatic toxicology and environmental issues faced by indigenous and northern people, as highlighted by the Northern Ecosystems Toxicology Initiative (NETI) through which five of our core faculty were hired. Many of our faculty conduct research on environmental impacts that affect aboriginal communities and regularly communicate and work with these communities on important environmental issues. The Toxicology Graduate Program encourages applications for admission from aboriginal students and other under-represented communities to strengthen our connections with all groups to ensure representation of all voices and sources of knowledge. Including all voices will increase the relevance and improve the perspective of the environmental and toxicological issues we research.

In addition to general toxicology, activities and specializations within the Program include analytical toxicology, aquatic toxicology, ecotoxicology, forensic toxicology, immunotoxicology, molecular and biochemical toxicology, nutritional toxicology, soil toxicology, risk assessment, veterinary toxicology, human toxicology and wildlife toxicology. The Masters and Doctoral programs allow candidates to develop toxicology as their major area of research expertise. The durations of MSc and PhD programs are ideally 2 and 3-4 years, respectively. Students in the first two years of their MSc who have excelled both academically and in research may have the opportunity to transfer to a PhD program without completing their MSc. See the appropriate section in this handbook for further details.

ADMISSION REQUIREMENTS

The basic requirements for admission to the College of Graduate and Postdoctoral Studies (CGPS) at the University of Saskatchewan should be consulted. Applicants to the Toxicology Graduate Program must possess a recognized undergraduate (4-year minimum) degree in the life sciences, such as a BSc, BSA, BSP, or a clinical degree such as an MD or DVM. International students may also need to provide sufficient scores on English proficiency exams if they attended universities where English was not the primary language of instruction and examination. Consult the CGPS website for minimum scores on English proficiency tests and if they are required (<http://www.usask.ca/cgps>).

Students will not be officially accepted into the research-based MSc or PhD programs until a suitable supervisor with adequate research funding has been identified and has agreed to take on the applicant. We do not accept self-funded students.

SELECTION OF A SUPERVISOR

It is suggested that applicants (1) identify toxicology group member(s) that are doing research that interests them, and then (2) contact the faculty directly to see if there is mutual interest and funding in place for a position. If a potential supervisor is secured, then applicants should proceed with a formal application to the program. When contacting a potential supervisor it is useful to include a statement of research interests, transcripts, English proficiency test scores (if needed) and a CV. A list of potential

supervisors and their research interests is provided on the Toxicology Centre website (<https://toxicology.usask.ca/>).

It is highly recommended that applicants identify a supervisor first, then apply, but it is not a requirement. Applicants can also apply formally, pay the application fee, and applications will be reviewed by the Graduate Chair. Applications that meet minimum requirements will be designated as potentially acceptable, but full acceptance will not occur until the student has identified a supervisor that has agreed to supervise them. High quality applications may be advertised to all toxicology group members, but it is normally the applicant's responsibility to find a supervisor that is willing to pay their stipend. Alternatively, some student may enter with a full scholarship, but must still identify a supervisor willing to supervise them. Self-funded students will not be admitted.

APPLICATION PROCEDURES

Application for admission is done through the online application (see CGPS website <http://www.usask.ca/cgps>). Applications are accepted year round, but most decisions regarding scholarships and admission are made December - April of each year. Preferred starting dates for the Program are January, May or September, although students can technically start any time pending approval from their chosen supervisor.

THE ACADEMIC YEAR

The Regular Session consists of two 13-week terms; the first, or Fall term, runs from September through December and the second, or Winter term, from January through April. In general, a one-term course is worth three credit units and a two-term course six credit units. Most Toxicology Graduate Program courses are offered during the Regular Session, but a few are offered in compressed format during late Spring or early Summer term. Research components of our graduate programs continue all year and students must maintain continuous registration throughout the year, including during the spring and summer sessions (May to August).

Tuition and student fees are paid three times per year at the beginning of Fall, Winter and Spring/Summer terms, but students can arrange to pay tuition in installments. Consult the CGPS website for details and tuition rates (<http://www.usask.ca/cgps>). Mandatory student fees provide graduate students with full health and dental insurance coverage, transit passes and free access to the campus athletic facilities, among other things. Consult the CGPS website for details of fee amounts and what they are used for (<http://www.usask.ca/cgps>).

PROGRAM DESCRIPTION

Master's and Doctoral programs require anywhere from 6 to 15 credit units from the core toxicology graduate courses (depending on the student's academic background) and research. Additional undergraduate Toxicology courses may be required by the student's Advisory Committee for the student to obtain sufficient knowledge in the broader discipline of toxicology. A working knowledge of statistical methods is required of all candidates, but statistics courses do not count toward the required Toxicology graduate course credits. The following guidelines for determining minimum numbers of course credits at the graduate and undergraduate level will be used:

General guide for course requirements

MSc program:

- No background in toxicology - 15 credit units, which will include 6 credit units of undergraduate Toxicology courses and 9 credit units of core Toxicology graduate courses.
- Previous BSc in toxicology (or similar) - 9 credit units of core Toxicology graduate courses.

PhD program:

- *No formal training in toxicology* - 15 credit units of core Toxicology graduate courses plus 6 credit units of undergraduate Toxicology courses.

- *Previous MSc in a non-toxicology program, but with a toxicology-focused thesis or toxicology courses taken* - up to a maximum of 6 of the required 15 credit units of core Toxicology graduate courses may be given if the previous MSc thesis area was focused on toxicology and supervised by a trained toxicologist. The credits given for the MSc are ultimately at the discretion of the PhD student's thesis advisory committee and subject to final approval by the Toxicology Graduate Studies Committee. Credit for prior graduate courses in toxicology, even if taken in a non-toxicology program, may also be granted up to a maximum of 6 credit units. Finally, the required 6 credit units at the undergraduate level can also be waived if the student has taken suitable undergraduate courses elsewhere at the discretion of the student's thesis advisory committee and subject to final approval by the Toxicology Graduate Studies Committee. When all credits for previous courses and thesis work are taken into account, the minimum number of additional credit units of core toxicology graduate courses for any incoming PhD student is 6 credit units.
- *Previous MSc in a toxicology program* - 6 credit units of core Toxicology graduate courses.

COURSES

Current Core Courses

TOX 821.3 Human Health Chemical Risk Assessment

Human health risk assessment is now playing a major role in the environmental management of chemicals, from both operational and regulatory perspectives. The overall objective of this course is to provide the basic knowledge to conduct, evaluate and interpret human health risk assessments of chemicals present in the natural and built environments.

Prerequisite(s): None.

TOX 840.3 Wildlife and Eco Risk Toxicology

Provides a broad exposure to the principles and practices of ecological risk assessment in Canada, with an emphasis on terrestrial habitats and wildlife receptors. In vitro and in vivo laboratory methods and field studies to assess toxicity and sub-lethal exposure in fish and wildlife will also be discussed.

Prerequisite(s): TOX 300 and TOX 301, or permission of instructor.

TOX 842.3 Biochemical Toxicology

Students will gain a comprehensive understanding of various biochemical mechanisms of toxicity, from both biomedical (human) and ecotoxicological perspectives. The focus will be on applying basic knowledge of biochemistry and physiology to the science of toxicology. Classes will involve discussions on topics related to the current scientific literature.

Prerequisite(s): Background knowledge in toxicology.

TOX 843.3 Environmental Chemodynamics

Provides students with an understanding of the processes that control the movement of organic and inorganic contaminants in the atmosphere, hydrosphere and lithosphere, and will also provide an understanding of the methods used to monitor environmental behaviour of potentially toxic contaminants in biotic and abiotic matrices.

Prerequisite(s): One course in ecology or environmental biology and one course in general or environmental chemistry, or permission of the instructor and student's advisor/advisory committee.

TOX 844.3 Toxicology Techniques

Provides theoretical background and hands-on experience in methods and techniques typically applied by toxicology professionals in academia, industry, and government. It is a modular course that covers a broad spectrum of procedures, ranging from proper handling of field equipment to biological test methods and analytical processing of samples. **Permission of course coordinator required.**

Prerequisite(s): Successful completion of Laboratory Safety course and GSR 962.

TOX 850.3 Aquatic Toxicology A comprehensive overview of the technical aspects of predicting, monitoring, and evaluating the effects of toxic substances in aquatic systems. The class will cover levels

of biological organization from sub-cellular to ecosystem. It is designed as an in-depth coverage of aquatic toxicology for students pursuing graduate degrees in the aquatic sciences. Students will be exposed to materials that will be useful in setting exposure standards and assessing hazards to aquatic ecosystems due to point or non-point releases of toxic substances.

Prerequisite(s): Permission of the instructor.

TOX 898.3 Contaminants in Plant-Soil Systems

An in-depth examination of a series of research articles, and reviews will be supported by lectures. Group discussions and workshops will be used to gain knowledge of remediation strategies used in natural plant-soil systems and the underlying mechanisms on which these strategies rely. The importance of soil properties, plant traits and plant-soil interactions in determining appropriate remediation approaches will be discussed.

TOX 898.3 Environmental Effects Assessment & Monitoring

This course will introduce students to key principles for designing robust environmental effects studies from industrial activities on the landscape. It will cover selection of appropriate ecological effects and measurable parameters (endpoints) that can be used for both pre-construction environmental assessments in regulatory approval applications and post-construction environmental effects monitoring programs, with an emphasis on mechanisms of physical and chemical effects on invertebrates, fish and wildlife.

Prerequisite(s): None

TOX 898.3 Next-Generations Methods in Toxicology

This course will provide an overview of 21st-century approaches in toxicology covering all levels of biological organization, from molecules to ecosystems. “Omics” methods to explore the impacts of chemical stressors on the diversity of transcripts (transcriptomics), proteins (proteomics), and metabolites (metabolomics) will be particularly emphasized. Exciting novel concepts, such as epigenetics and environmental DNA (eDNA) will be introduced and their use in toxicology and chemical risk assessment discussed. Last, students will be acquainted with various computational tools required to process the very large datasets resulting from these methods.

Prerequisite(s): Toxicology undergraduate degree/major, or permission from the instructor on a case-by-case basis.

BIOE 850.3 Synchrotron X-Ray Imaging

Will introduce some synchrotron specific imaging modalities such as K-edge subtraction, diffraction enhanced imaging, and phase contrast imaging with connections made to conventional imaging. The first part of the course will cover x-ray interactions, detection, dose estimation and source properties (conventional and synchrotron).

Prerequisite(s): Permission of the instructor.

BIOL 875.3 Ecotoxicology Theory & Practice

This course examines how principles and theories in ecology can better inform ecotoxicology problems at multiple levels of biological organization (individuals to ecosystems). Much of the science of this relatively young discipline has traditionally lacked a conceptual basis and major recent advances are being drawn from ecological theories, models and approaches to strengthen the field. Students will examine current advanced topics and contemporary approaches that add ecological relevance and predictive strength to both field and laboratory ecotoxicology studies.

Prerequisite(s): At least 1 undergraduate or graduate course in Ecotoxicology or permission from instructor – attendance of BIOL 475 undergraduate lectures may satisfy this prerequisite.

BIOL 865.5 Physiological Toxicology

Description: This course examines how various environmental stressors including contaminants alter vital physiological functions and cause toxic effects in aquatic animals. Students will explore the current state of science and also learn how the physiological knowledge and principles can be applied to regulatory decision making for the protection of aquatic life.

Prerequisite(s): Animal Physiology and Environmental Toxicology at Undergraduate level and permission of the Instructor.

ENVS 832.3 Risk Assessment & Negotiation of Environmental Issues

This course helps students develop a comprehensive understanding of the interdisciplinary nature of environmental issues, and will teach them the roles that science and society have in the assessment and management of such issues. The class will elucidate the perspectives of the different stakeholders using classic and interactive elements.

Prerequisite(s): None

ENVS 898.3 Chemical Risk Assessment

The safe and sustainable management of chemicals requires a precise assessment of the risk posed by those chemicals. While many chemicals pose hazards to the environment the application of risk assessment techniques can be used to identify concerns and can provide strategies for minimizing those risks. Similarly when chemicals are already in the environment the development of appropriate clean-up strategies requires the use of risk assessments to identify clean-up goals and procedures. Accurate risk assessments are based on a combination of appropriate sampling design and collection, appropriate and accurate chemical analysis and application of appropriate risk assessment paradigms. This class will address all aspects of the risk assessment process by looking at several case studies.

Prerequisite(s): None

GEOG 7010.3 Environmental Monitoring (University of Manitoba Course)

This is a mixed classroom and field-based course in the science and social considerations behind the protection and evaluation of water quality and biota. The focus is on surface waters (lentic and lotic) within a Boreal/Manitoba context. We aim to understand the potential impacts that resource development (e.g., mining, pulp and paper, oil and gas, as well as municipal wastewaters) can have on freshwater systems from an ecological and human health perspective, as well as socio-cultural. Special emphasis will be given to First Nation, northern, and rural perspectives, with the aim to inform community-based monitoring programs.

Prerequisite(s): There is no formal prerequisite for the course, but a reasonable background/interest in ecology, chemistry and biology (ideally at 3rd and 4th year level) is required.

GEOL 851.3 Synchrotron Hard X-ray Absorption Spectroscopy

The course will describe the physical principles, experimental technique and data analysis of X-ray absorption spectroscopy. Frequent reference to practical applications will be included, and relevant synchrotron technology will also be reviewed. This course will equip the student with a practical working knowledge of the technique and its capabilities.

Prerequisite(s): Permission of the instructor.

MCIM 820.3 DNA Repair & Mutagenesis

Explores the process of DNA damage, repair, mutagenesis and impacts on cell survival, molecular evolution and human diseases. Emphasis is given to molecular, cellular, genetic and biochemical analysis of each repair pathway in various organisms. Students are expected to be familiar with the technologies and strategies in the investigations.

Prerequisite(s): None

PHAR 848.3 Advanced Pharmacokinetics and Pharmacodynamics

Qualitative and quantitative aspects of drug absorption, distribution, metabolism and excretion, and drug pharmacodynamics. The course emphasizes the use of pharmacokinetic/pharmacodynamic equations and the analysis of the data.

Prerequisite(s): Basic course in pharmacokinetics or permission of the instructor.

PHAR 854.3 Metabolic Transformation of Xenobiotics

An advanced study of the basic principles of the metabolism of foreign compounds in mammals. The xenobiotics covered will include drugs, food additives, agricultural chemicals, and industrial chemicals. The detoxification and toxicological implications of metabolism are emphasized.

Prerequisite(s): None

PHAR 865.3 Analytical Mass Spectrometry

This course will cover modern state-of-the-art mass spectrometry techniques and their usefulness in research and discovery. The course will examine instrumentation-related topics, such as ionization sources, mass analyzers and hybrid tandem mass spectrometers. The advantages of each technique will

be highlighted and discussed. A second portion of the course will focus on mass spectra interpretation and the various applications of applied mass spectrometry, namely structural elucidation, quantification, proteomics, and related biomedical and environmental applications. The course will also include practical demonstration of the use of tandem mass spectrometry.

Prerequisite(s): None

SLSC 819.3 Remediation & Reclamation of Contaminated Sites

This course explains how one characterizes a contaminated terrestrial site; the risks associated with that site and identify remediation technologies that will mitigate the risks associated with the contaminated site. It will discuss how contamination interacts with industrial processes to create degraded landscapes and natural processes that help ameliorate this degradation of the ecosystem. Discussion of remediation will focus on the use of in situ and ex situ technologies for contaminated soil ecosystems and how these technologies reduce risk to not only soil, but also human and aquatic receptors.

VBMS 833.3 Subclinical Toxicology

Discusses subclinical manifestations to toxic agents. The emphasis will be on immunological and behavioral alterations produced by a variety of chemical agents. Animal models and testing methods used to evaluate the effects will be discussed, along with various public health considerations and significance.

Prerequisite(s): Permission of the instructor or registration in the Toxicology Graduate Program.

VBMS 855.3 Integrative Cardiovascular Physiology & Toxicology

The course will build on the content of VBMS 840 (Vascular Physiology & Toxicology) which is focused strictly on vascular tissue, examine ventricular/arterial coupling as well as how cardiac, pulmonary, renal, endocrine and/or neural systems integrate with cardiovascular responses for homeostatic control of blood pressure, examine how these homeostatic mechanisms are altered in pathological processes associated with major human diseases and toxic agents encountered by humans. Relative emphasis on disease versus toxicants will be adjusted according to students' backgrounds each year.

Prerequisite(s): Permission of the Instructor.

VTPA 841.3 Toxicologic Pathology

Covers mechanisms of toxicology as well as basic pathology, focusing on several major organ systems, but is geared toward DVM graduate students studying for pathology boards. This course is not suitable for students without a strong histology and pathology clinical background. The students' understanding of how clinical, environmental or pharmacological toxicants damage specific organs will be supported through didactic instruction, case studies, web-based cases, directed readings and structured group discussion.

Prerequisite(s): VTPA 342 & 343, or equivalent; or, TOX 402 & PATH 205, or permission of the instructor. Required courses which students must maintain continuous registration for the duration of their program:

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TOX 990 Toxicology Seminar

Weekly seminars presented by graduate students and invited speakers. Graduate students are required to attend and to present seminars.

TOX 994 Research

Students writing a Master's thesis must register for this course.

TOX 996 Research

Students writing a PhD thesis must register for this course.

All graduate students at the University of Saskatchewan are required to complete GPS 960: Research Ethics, and may be required to take either GPS 961: Ethics and Integrity in Human Research or GPS 962: Ethics and Integrity in Animal Research, depending on the nature of their project, thesis, or dissertation work.

STRUCTURE AND OPERATION OF ADVISORY COMMITTEES

All students registered in MSc and PhD thesis programs will require an advisory committee. An advisory committee will be established in consultation with the supervisor. For MSc candidates, the advisory committee will consist of the Graduate Chair (or designate), who is chair of the committee, the student's supervisor, and at least one additional member. For PhD candidates, the advisory committee will consist of the Graduate Chair (or designate), who is chair of the committee, the student's supervisor, one cognate member, and at least two additional members.

The advisory committee will establish a program of study (POS), supervise the student's progress, participate in qualifying and comprehensive examinations, provide guidance and advice to the student on coursework and research, provide permission to write, and approve the student's research proposal and final thesis. The POS meeting should be held no later than 1 month after entering the program.

MONITORING STUDENT PROGRESS

Monitoring a student's progress is the responsibility of the advisory committee. Students are responsible for arranging to have a minimum of once yearly committee meetings prior to permission to write or every 6 months after permission to write. However, meetings can be held more often than this if input from the committee is desired regarding revisions to what was proposed or difficulties with experiments. A document summarizing the purpose and content of the upcoming meeting (proposal, progress report or permission to write document) must be provided to the committee a minimum of one week in advance of any meeting. The document could be a word document or the PowerPoint file to be presented at the meeting. Providing an inadequate document or failing to provide it sufficiently in advance of the meeting could result in the committee postponing the meeting. Progress is reported by the Graduate Chair (or designate) to the Toxicology Graduate Committee and to the College of Graduate and Postdoctoral Studies.

ACADEMIC STANDARDS

All MSc students must maintain a 70% grade point average (GPA), with a minimum of 65% in each course. Undergraduate courses, if part of the student's POS, must be passed with a minimum of 70%.

PhD students must maintain a 70% GPA, with a minimum of 70% in each course. PhD and MSc students must also maintain satisfactory progress in their research project. Students are expected to maintain the highest standards of academic integrity while enrolled in the Toxicology Graduate Program, taking courses, publishing their research and writing their thesis and other thesis-related documents. Plagiarism, in whole or in part, will not be tolerated. Consult the CGPS website for guidelines and consequences (<http://www.usask.ca/cgps>).

SEMINARS

All graduate students will be required to participate in the TOX 990 seminar series, as part of the degree requirements. All MSc students must present one seminar before defending, while PhD students must present two seminars during their program. For both MSc and PhD students, they are expected to sign up to give a seminar in their second year if they have not yet given one. If a student has not signed up voluntarily, then they will be assigned a time to give their first seminar in their second year. For PhD students, the second seminar is normally given no later than during their third year in the program.

Graduate students are required to regularly attend TOX 990 seminars for the specified minimum length of time as partial fulfillment of their degree requirements, as prescribed by the College of Graduate and Postdoctoral Studies (CGPS) and as per policy of the Toxicology Graduate Program. Attendance will be recorded at each TOX 990 seminar. If a student is absent without having sent a prior email to the seminar coordinator, an email will be sent by the Toxicology secretarial staff to the student, the supervisor(s), and the Graduate Chair noting the absence.

MSc students must attend 990 seminars for 4 semesters, and PhD students must attend for 6 semesters unless you are no longer living in Saskatoon and area. Students that transferred to a PhD without completing their MSc will be required to attend 990 seminars for a total of 8 semesters during their graduate program. The TOX 990 attendance policy requires that graduate students attend a minimum of 75% of seminars in each term (fall and winter semesters). In instances where a student attends less than 75% of seminars for a given term, their case will be reviewed by the Graduate Studies Committee, which determines if absences were justified. An excused absence will not count towards the

25% allowed missed seminars. Students who did not meet the attendance requirement, and who did not have acceptable reasons for their absences, will be required to attend an additional semester of 990 seminars. In addition, students in violation of the policy will not be eligible for future Toxicology scholarships, teaching fellowships, and other awards administered through the Toxicology Centre.

Certain justifiable commitments may prevent attendance at all seminars, such as attending scientific conferences, conducting field research, spending time working in laboratories at other institutions, illness, and approved leaves. Such absences, if documented, will not be included in the attendance calculation. It is therefore important that students notify the seminar coordinator PRIOR to all absences with the reason(s) for the absence. However, both students and supervisors are expected to schedule research and other activities around TOX 990 seminars, as far as that is feasible.

QUALIFYING EXAMINATIONS & THESIS PROPOSALS

A qualifying examination, which takes the form of an extended proposal defense, is required for all students entering a PhD program in the Toxicology Graduate Program at the University of Saskatchewan. The purpose of this examination is to assess the candidate's communication skills, both written and verbal, and their ability to develop original research concepts in the form of a scientific research proposal. For both MSc and PhD students, the proposal is expected to be written and defended within 8 months of starting in the program.

Proposal Format

Students will be required to independently develop a PhD proposal, in consultation with their supervisor and Advisory Committee. The proposal must be within the scope of funding and research directions dictated by research grant(s) held by the supervisor. The student will be expected to prepare a research proposal containing the following headings:

- A. Title Page
- B. Background and Literature Review
- C. Rationale

- D. Objectives and Hypotheses
- E. Materials and Methods
- F. Experimental Design and Statistical Methods
- G. Anticipated Results and Possible Conclusions
- H. References

The length of the proposal may vary depending upon the extent of the literature review and the depth of the Materials and Methods section, and commonly ranges from 15-20 double-spaced pages of text, including references. The proposal must include sufficient detail to convince the Advisory Committee that the student has demonstrated an adequate knowledge and originality in the research area covered by the proposal. A thorough, well-referenced Background and Literature Review (introductory) section serves to immerse the student in the literature related to their research, convince the Advisory Committee that the student has a strong grasp of the literature, and in most cases provides a first draft of the Introduction chapter of their dissertation. The proposal should contain sufficient and practically feasible experiments that would require no more than three to four years to complete. A PhD proposal commonly describes 3 major experiments that will become the research chapters of their dissertation, and ideally individual manuscripts that are published or to be submitted for publication. It is common for a supervisor to provide a student with a copy of a previous PhD student's proposal to assist with formatting and scope of the proposal.

The written proposal will be edited by the supervisor. Once edits are approved by the supervisor, the proposal will be circulated to the Advisory Committee for consideration at least one week prior to the exam. At this meeting, the PhD candidate will be required to present the proposal to members of the Toxicology Group in an open seminar (20-30 minutes). Following the presentation, the general audience will have an opportunity to ask questions. The general audience will then leave the room and the candidate will defend the proposal and justify all aspects of the proposal in a process comparable to a thesis defense to the Advisory Committee. This process is expected to require approximately two hours.

Examination Results

There are several possible outcomes of the examination which the Advisory Committee may recommend.

- A. Approval and pass with minor or no revisions
- B. Approval and pass with moderate revisions - the revised proposal must be reviewed by the Advisory Committee and approved within two weeks
- C. Approval with major revisions - the student must revise the proposal and repeat the oral defense of the proposal, within four months.
- D. Non-Approval and failure

Students who fail the exam with a previous MSc will be allowed to repeat the examination process within a maximum of four months. Permission of the Dean of CGPS will be required to repeat the examination.

Students failing the examination without previously completing the MSc degree will not be allowed to transfer into a PhD program. A second attempt to pass the examination will not be permitted. The student will be required to complete the MSc program.

Students failing the PhD qualifying examination for a second time must withdraw from the program or may elect to continue as an MSc student at the discretion of the Advisory Committee.

TRANSFER FROM AN MSc TO A PhD

Students registered in the MSc program who already hold an MSc degree in another discipline may transfer to a PhD program if they have: successfully completed a qualifying examination; attained a minimum 85% GPA in courses taken as part of their MSc program; shown satisfactory progress and evidence of originality in their research; and demonstrated adequate written and verbal communication skills (as evidenced by a submitted peer-reviewed manuscript with the student being the first author). Transfer (i.e. the Qualifying Exam) from a MSc to a PhD program needs to occur during the first two years of study.

Students registered in the MSc program who do not hold an MSc degree in another discipline may transfer into a PhD program if exceptional progress is evident, including: outstanding performance during a qualifying examination; a minimum 85% GPA; a high level of productivity and originality in their research as indicated by peer-review research publications/submitted manuscripts (with the student being the first author) or exceptional progress; and demonstrated excellent written and verbal communications skills. This option is available to only a limited number of outstanding students. Students are considered outstanding if, in addition to the criteria listed above (85% GPA, submitted peer-review research manuscript), they are eligible or holding an NSERC award, Dean's scholarship, or have received other national scholarships. Transfer from MSc to PhD programs needs to occur before the end of the second year of study.

COMPREHENSIVE EXAMS

A comprehensive examination is required for all PhD students registered in the Toxicology Graduate Program at the University of Saskatchewan. A PhD student graduating from the Toxicology Graduate Program is expected to have a broad-based knowledge of the discipline of toxicology. Thus, the purpose of this examination is to assess the PhD student's knowledge of toxicology in the broad sense, albeit with greater emphasis directed toward the coursework completed by the student and the areas of expertise related to the thesis topic. Data interpretation, animal ethics, and statistical design will also be evaluated with the examination.

EXPECTATIONS

All PhD students will be required to complete the examination near the end of their PhD program. The examination should be taken following completion of all coursework, and when considerable portions of the thesis research have been completed. Ideally, at least one manuscript should be accepted for publication from the thesis work before the examination can be held. The examination must be completed at least six months prior to completion of the program. The examination will consist of a written and oral component. The Examination Committee will consist of five members of the Advisory Committee (chair, supervisor, cognate, and two regular members).

WRITTEN COMPONENT

The written component of the examination will consist of a series of questions in designated areas identified by the Advisory Committee. A PhD Advisory Committee usually has five members (Chair, supervisor, cognate member, and two additional members). For the written comprehensive examination, each advisory committee member (other than the supervisor) will create a question from the four broad categories of topics shown below (general toxicology, systemic toxicology, toxicants, and other/miscellaneous). One topic from each category shall be chosen. The Chair will coordinate the designation of topics among committee members. These topics should be viewed as examples; there is flexibility, at the Chair's discretion, in the selection of topics depending upon a student's general area of research and coursework, as well as the expertise of each committee member.

The student's supervisor will choose a published article from a toxicological journal (research paper, not review) and the PhD student will conduct a written critique/peer review of that article. The review must include discussion of experimental design and statistical analyses.

In summary, the written component will consist of four questions (from four committee members) and a journal article critique (from the supervisor). In cases where there is co-supervision of the student, and/or where there are more than four committee members other than the supervisor, the examination will be limited to the four questions and journal article critique. The four questions must be chosen from each of the four broad categories shown below. At least one question shall address experimental design in the expected answer. Questions will be open-book format. Each question should be created with the intention of the student spending approximately 8 hours to complete their answer. As a guideline, each answer written by the PhD student should consist of approximately 8-12 double-spaced pages of text, although this may vary depending on the conciseness of their writing, whether they use diagrams in their answers, etc.

Examples of Topics for PhD Comprehensive Examinations

General Toxicology	Systemic Toxicology	Toxicants	Other
Dose-response	Reproductive toxicology	Insecticides	Analytical toxicology
Toxicokinetics	Immunotoxicology	Fungicides	Veterinary toxicology
Mechanisms of action	Neurotoxicology	Herbicides	Clinical toxicology

Antidotes	Teratogenicity	Feed additives	Diagnostic toxicology
Animal models	Hepatic toxicology	Dioxin-like chemicals	Occupational toxicology
In vitro models	Cardiovascular toxicology	PAHs	Forensic toxicology
Experimental design	Renal toxicology	Oil/hydrocarbons	Nanotoxicology
Toxicopathology	Respiratory toxicology	Solvents and vapours	Regulatory toxicology
Carcinogenicity	Ocular toxicology	Gases	Contaminated soil/sediment
Mutagenicity	Endocrine toxicology	Pharmaceuticals	Ecological toxicology
Oxidative stress	Skin toxicology	Household products	Animal ethics
Biotransformation	Hematotoxicology	Metals	Nutritional toxicology
Risk assessment		Animal and plant toxins	Radiation toxicology
		Vitamins	Environmental fate/transport
		Mycotoxins	QSAR

At least 3 months prior to the written examination, the student will be advised about the examination. The student is permitted to contact individual Examination Committee members to receive advice on the designated category their question falls into, and suggested readings to prepare for the written examination.

The student will normally be given up to one week to complete the examination, although in certain circumstances an extension may be granted by the Chair, up to a maximum of two weeks. Once the timeframe for the written examination is set, the Graduate Secretary will administer all of the questions to the student. The questions will be open-book format. The answers must be submitted electronically (MSWord/PDF) to the Graduate Secretary upon completion, who will then distribute to the Examination Committee. Each Examination Committee member will grade the answer to their question on a percentage basis. An average grade of 70% will be considered a pass. A student failing to obtain 70% will not be allowed to take the oral portion of the exam. The following guide can be used to assign a grade:

Grading Rubric for Comprehensive Examination

90-100%	Excellent. A thorough response, well-written and structured with a detailed list of references from the primary literature. The committee member will likely have learned something new when reading the student's paper.
80-89%	Very good. Important points discussed in response to the question, although certain gaps apparent in expected response. Good reference list and well-written document.
70-79%	Good. Sufficient response to pass, but several expected points not covered in answer. Lack of depth in written response and reference list.

< 70% **Fail.** Inadequate response to question. Poorly written and poorly referenced document that missed the majority of points expected by the committee member.

ORAL COMPONENT

The oral examination will normally occur within two weeks after completion of the written exam, and no later than one month. The oral portion of the exam will focus on clarification and/or expansion of answers from the written examination. The oral examination usually takes less than two hours to complete. To pass the oral examination, the student must receive a pass from the majority of the Examination Committee members. Abstentions will be considered negative votes.

EXAMINATION RESULTS

The results will be communicated to the College of Graduate Studies and Research. Students failing the PhD comprehensive examination may withdraw from the program or transfer to the MSc program.

Students failing the examination may also elect to repeat the examination within a maximum of four months. A student failing the examination a second time will be required to withdraw from the PhD program or transfer to an MSc program. Permission from the Dean of Graduate Studies will be required to transfer to the MSc program or to repeat the examination for a second time.

PERMISSION TO WRITE

Upon completion of all data collection, including experiments, field collections, and/or laboratory analyses, a permission to write meeting shall be organized. This meeting should take place between 3 and 6 months prior to an anticipated defence date.

At least one week prior to the meeting, the student will provide the committee with a word document that includes the following:

- Summary of timeline for your program (start date, proposal defence date, progress meetings, and upcoming milestones such as anticipated date the complete thesis will be submitted to your supervisor, when the committee can expect the thesis for approval and proposed date range for your defense)

- Fully formatted thesis table of contents (don't include page numbers). See CGPS website for details on thesis template.
- All figures and tables (with captions) including all major statistical analyses should ideally be completed prior to the meeting, but only a few key figures/tables that show major findings should be included in the document
- Courses taken (with grades received)
- List of publications that have/will arise(n) from the research (published, submitted & anticipated) listed as formatted journal citations. Provide the names of all co-authors and their contributions relative to yours.
- List of presentations/posters given at conferences
- List of awards and other recognitions during program

At the meeting, the student will provide a brief (15-20 minute) oral presentation that outlines:

- The proposed thesis organization (manuscript or traditional), with major chapters and objectives/hypotheses outlined
- Key tables/figures for each data chapter
- Summary of any new data not presented in previous meetings
- Any data requiring input from the committee
- Timeline for completion

The committee will determine if the information presented is of sufficient quantity and quality for the degree sought, then vote to give permission for the student to proceed to writing.

NOTE: The student will be required to have additional committee meetings every six months after permission to write until the thesis is successfully defended. The rationale for this is that it should not take longer than 6 months to defend the thesis after permission to write has been granted.

MAXIMUM TIME IN PROGRAM & EXTENSIONS

As mandated by CGPS, the maximum time in program for an MSc is 5 years and 6 years for a PhD, not including any time for official leaves of absence (e.g. parental, medical or compassionate). Students who

have reached their maximum time in program will be eligible to submit one extension request. See the CGPS website for details on forms to be completed and information needed. Details for completing the form must be discussed and agreed upon by the student, supervisor and thesis advisory committee, then approved by the graduate chair.

PLEASE NOTE: If the program is not completed by the end of the timeline approved in the extension request, a requirement to discontinue (RTD) would automatically be enacted by the CGPS.

THESIS REQUIREMENTS

For MSc and PhD degrees, a thesis must be prepared by the student on their research. Toxicology does not have a specific thesis format and instead uses CGPS rules for formatting and structure. Consult the CGPS website for details regarding thesis format and to download thesis template files. The thesis must be defended by the student subsequent to approval by the advisory committee. For each MSc and PhD defense, an external examiner is added to the examination committee. After the defense, an electronic copy of the final version of the thesis must be submitted to CGPS. A bound copy of the thesis is required by the program at the Toxicology Centre.

SCHOLARSHIPS AND AWARDS PROGRAM

Toxicology Devolved Scholarships

The Toxicology Graduate Program offers partial scholarships to outstanding students each year through the devolved scholarship program. Devolved scholarships are currently valued at 50% of the \$18,600 and \$21,600 stipends for MSc and PhD students, respectively, in Toxicology. The remaining stipend is usually matched by the faculty supervisor's research funds. Consult the Criteria for the Award of Toxicology Devolved Scholarship document for details of eligibility and criteria for selection. This document is available from the Toxicology graduate secretary or emailed annually to students and faculty prior to each competition deadline.

The award of devolved scholarships will be decided by the Toxicology Awards Committee. Under normal circumstances, applications for scholarships are due in March, with applications reviewed in March-April to start in the new fiscal year (starting in May). A limited number of additional scholarships may be awarded throughout the year, as fund availability allows.

Graduate Teaching Assistants & Fellowship

One or more graduate teaching assistants or fellowships (GTF) are also available to students in the Toxicology Graduate Program. The recipients of these fellowships are required to provide teaching assistance with undergraduate courses of up to 12 hours per week, although less time is generally required. The value of each fellowship varies, depending on the source of funding and the course assigned for teaching from a half-stipend (matched by funds from the supervisor's research funds) for TOX 400, to \$5,000 for each term for TOX 490. Selection of candidates for the TOX 400 GTF is made by the TOX 400 instructor, with approval by the Toxicology Awards Committee. Selection of candidates for the TOX 490 teaching assistants is made by the Toxicology undergraduate coordinator. For both positions, preference is generally given to strong PhD students that have finished their own course work, but MSc students with exceptional leadership qualities and strong academic standing may also be considered.

Internal Awards

In addition to standard graduate scholarships and fellowships, the Toxicology Graduate Program provides the following special awards to full-time graduate students:

C.S. Sisodia Award

The C.S. Sisodia Award is presented annually to a full-time graduate student registered in the Toxicology Graduate Program who has completed a minimum of two years of formal course work. The \$1,000 award recognizes academic excellence in the field of toxicology.

Toxicology Centre Graduate Student Poster Competition Awards

At the Toxicology Group Annual General Meeting students have an opportunity to present their research findings in poster format. Awards of \$300 (first place), \$200 (second place), and \$100 (third place) are provided annually to students working towards a MSc or PhD in toxicology.

H.B. (Bruno) Schiefer Graduate Student Travel Award

The H.B. (Bruno) Schiefer Graduate Student Travel Award has been created in honour of Dr. H. B. (Bruno) Schiefer, the first Director of the U of S Toxicology Centre, and is intended to help cover costs associated with toxicology graduate students attending national or international conferences to present results from their thesis research. One award of \$500 will be awarded in the Fall/Winter Term and one award of \$500 will be awarded in the Winter/Spring Term of each year.

The eligibility criteria are as follows:

- students must be first author on, and personally deliver, either a platform or poster presentation at a recognized national or international conference or meeting;
- the conference/meeting must take place during the fiscal year in which the award is provided (May to April);
- students must be registered in a full-time M.Sc. or Ph.D. program in toxicology;
- the presentation must be on their toxicology thesis research;
- the award can only be held once per degree.

Selection criteria:

- research quality, and quality of abstract submitted;
- importance of attending conference/meeting to students current academic program and/or future career;
- academic standing;
- financial need.

Toxicology Graduate Student's Association Travel Award

The purpose of this award is to give monetary assistance to students who have had limited opportunity to attend conferences. All Toxicology Graduate Program students are eligible, but preference is given to those who demonstrate financial need, have never attended a conference out of the province during their current degree, and have actively participated in activities associated with the TGSA or another organization related to their field of study. Calls for applications with details of application requirements and criteria for judging will be sent to Toxicology graduate students prior to each competition. There are

two awards valued at \$250 each and they will be awarded annually or biannually depending on the availability of funds from the TGSA.

TOXICOLOGY GROUP MEMBERS AND RESEARCH INTERESTS

Members of the Toxicology Group who may be in a position to supervise students within the Toxicology Graduate Program are listed below. Names have been grouped within sub-disciplines of toxicology and a brief description of each member's research interests provided. Please contact the Graduate Chair (see Contact Information) for further information on faculty who might be actively seeking graduate students in conjunction with specific research projects. (Affiliations of members who are not University of Saskatchewan faculty but Adjunct Faculty are given in parentheses.)

Analytical and Forensic Toxicology

- George, G.** Sulfur K-edge X-ray absorption spectroscopy as a probe of sulfur biochemistry in intact tissues.
- Headley, J.** Environmental mass spectrometry. (Environment Canada)
- Pickering, I.** Synchrotron studies of metals and other elements of concern to determine chemical speciation and microscopic distribution; including both environmental studies and vertebrate and human toxicology.

Biomedical and Human Toxicology

- Alcorn, J.** Infant exposure to xenobiotics; maturation of clearance mechanisms; toxicokinetics.
- Bharadwaj, L.** Cardiovascular toxicology.
- Blakley, P.** Clinical teratology; Fetal Alcohol Syndrome; genetic predisposition to teratogenesis.
- Krol, E.** Xenobiotic metabolism of naturally occurring phenols; reactive intermediates.
- Krone, P.** Endocrine modulation/developmental toxicology; use of stress proteins as biomarkers of toxicity in fish embryos.
- Papagerakis, P.** Circadian rhythm disruption and environmental exposure to carcinogenic molecules, saliva biomarker development, targeted personalized treatment and oral cancer
- Papagerakis, S.** Basic, translational and clinical research within research intensive academic health settings. Encompasses qualitative and quantitative patient oriented research; cancer epidemiology

- Paterson, P.** Biochemical and physiological functions of trace elements; nutrition and eye function; effects of nutrients on antioxidant pathways in stroke.
- Weber, L.** Tobacco smoke and air pollution effects on cardiovascular disease; pathophysiological mechanisms, animal models, role of polycyclic aromatic hydrocarbons.
- Wu, M.** Environmental toxicology, molecular genetics, stress biology, aging
- Xiao, W.** Mechanisms of action of genotoxic chemicals and cellular responses to DNA damage.
- Zello, G.** Protein and amino acid metabolism in humans and animals investigated using stable isotope methodology; effects of drugs on protein metabolism, drug-nutrient interactions.

Veterinary and Wildlife Toxicology

- Blakley, B.** Immunotoxicology - environmental aspects, nutritional states; applied veterinary toxicology; heavy metal toxicity (Pb, Cd).
- Morrissey, C.** Avian ecology and ecotoxicology. Testing biomarkers of exposure (ecophysiological, stable isotope methods) and effects of pollutants in wild birds.
- Wickstrom, M.** Effects of pesticides and metals in wildlife; cyanobacterial toxins; clinical veterinary toxicology; environmental risk assessment.

Ecological and Aquatic Toxicology

- Davies, J-M.** Nutrient impacts on algal ecology; drinking water quality. (Saskatchewan Water Security Agency)
- Giesy, J.** Discovery and assessment of emerging contaminants of concern, including perfluorinated and endocrine modulating compounds; development of novel bioanalytical tools; biochemical indicators of stress in aquatic organisms.
- Haakensen, M.** Bioremediation and passive/semi-passive water treatment (Contango Strategies)
- Hecker, M.** Development, validation and application of novel bioanalytical techniques; endocrine disruption and reproductive toxicology in oviparous vertebrates; ecotoxicological risk assessment of persistent organic compounds, pesticides and metals in vertebrates.
- Hogan, N.** Developmental, reproductive and immune toxicology in aquatic species.

- Janz, D.** Reproductive physiology and endocrinology of oviparous vertebrates; endocrine toxicity; biochemical toxicology; mechanisms of toxicity; cytochrome P450.
- Jardine, T.** Use of stable isotopes to investigate linkages between hydrology, ecology and food web trophodynamics in contaminated aquatic ecosystems.
- Jones, P.** Fate and effects of organic pollutants in the environment and wildlife. Use of biochemical and molecular biology techniques in environmental toxicology.
- Liber, K.** Metal bioavailability and toxicity in aquatic ecosystems, especially in sediments; mining impacts on aquatic ecosystems.
- Niyogi, S.** Assessment of waterborne metal bioavailability and toxicity using the Biotic Ligand Model (BLM) approach; uptake, regulation, and toxicity of dietary metals in freshwater fish.
- Raine, J.** Developmental physiology and endocrinology; endocrine disruption; mechanisms of toxicity; thyroid hormone regulation and signaling
- Siciliano, S.** Soil ecotoxicology, investigation of trace contaminant effects in northern terrestrial ecosystems using molecular tools
- Stewart, K.** Herbicide persistence and toxicity in northern soils and vegetation; Soil amendment technology and practices for remediation and restoration of plant-soil systems impacted by hydrocarbons and heavy metals

TOXICOLOGY GRADUATE STUDENT ASSOCIATION

The Toxicology Graduate Student Association (TGSA) is a student council group that represents toxicology graduate students and provides a link to the University of Saskatchewan Graduate Students Association (GSA). The TGSA holds various student social, fundraising, outreach, and sports activities during the academic year. In the past, the TGSA holds welcome potlucks and barbeques in the fall and winter sessions, clothing sales, winter retreats, various tours on and off campus, fundraising events, and presentations to school groups. The TGSA participates regularly in campus recreational sports. It represents toxicology graduate students and provides information and support for students regarding campus activities and policies.

CONTACT INFORMATION

For further information on the Interdisciplinary Graduate Program in Toxicology, please contact:

Graduate Chair
Toxicology Graduate Program
Toxicology Centre
44 Campus Drive
University of Saskatchewan
Saskatoon, Saskatchewan S7N 5B3
CANADA

Telephone: (306) 966-7441
Facsimile: (306) 931-1664
E-mail: tox.centre@usask.ca

For additional information visit:

Toxicology Centre website - <https://toxicology.usask.ca/>

University of Saskatchewan website - <http://www.usask.ca>

College of Graduate and Postdoctoral Studies website - <http://www.usask.ca/cgps>