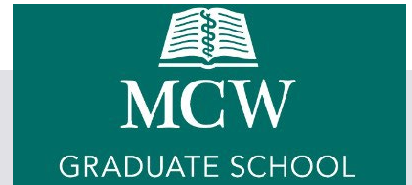


2024-25

## PHARMACOLOGY & TOXICOLOGY

Degree Offered: Doctor of Philosophy



### Program Description

The Pharmacology & Toxicology Doctoral program provides diverse research opportunities in the areas of cardiovascular, cancer, and neurosciences. An emphasis is placed on cellular and molecular pharmacology/toxicology and signal transduction. The primary objective of our program is to provide students with an academic background, professional skills, and expertise in state-of-the-art scientific approaches needed to investigate and solve the important biological problems that will be the focus of research in the decades to come. Our graduate degree program is multidisciplinary in nature and has strong associations with researchers in other basic science and clinical departments.

There are three major components to the program: graduate level coursework, successful completion of a combined written and oral qualifying exam, and the completion of a novel, publishable research project.

The coursework requirements of the doctoral program are flexible and tailored to the needs of individual students as much as possible. However, emphasis is placed on instruction in the areas of basic pharmacological principles, mechanism of drug action, signal transduction, and pharmacological techniques.

After completion of the initial coursework, students take a qualifying examination. The qualifying examination is designed to ensure a solid biomedical knowledge base has been established and consists of writing and defending a research proposal. The exam typically takes place in the second year of the doctoral program.

After a student has successfully passed his or her qualifying examination and completed the basic coursework, his or her time is spent engaged in a cutting-edge research project in the laboratory of a member of the department's graduate faculty. The final requirement of the program is for the student to write and defend a dissertation describing their research project.

### Admission Requirements

In addition to the general [Graduate School admission requirements](#), this program requires students to have a specific interest in pharmacology. This interest should be described in the personal statement section of the application.

Entry to the Pharmacology & Toxicology Graduate Program is through Direct Admission, [Interdisciplinary Program in Biomedical Sciences \(IDP\)](#), [the Neuroscience Doctoral Program \(NDP\)](#), or the [Medical Scientist Training Program \(MSTP\)](#). The student is admitted after completion of the first-year curriculum or through the Medical Scientist Training Program following the second year of Medical School. The student elects to complete their dissertation work with faculty of the Pharmacology & Toxicology Graduate Program. The student will then have the opportunity to continue graduate studies by selecting among a

wide range of courses offered from the Graduate School as well as other programs affiliated with the Medical College. Courses to be taken are based on the student's interests and consultation with the student's advisor.

## Fields of Study

Research opportunities in the department are available in four general areas:

### Cardiovascular Pharmacology

- Cellular pharmacology of vascular smooth muscle and endothelium
- Molecular biology of cell adhesion molecules and other inflammatory mediators
- Mechanisms of action of anti-hypertensive and anti-ischemic drugs
- Therapeutic development for the treatment of cardiovascular disease

### Cancer Biology

- Study of cellular signaling pathways that promote malignancy and metastasis
- Identification of genes and genetic mutations that increase susceptibility to cancer
- Therapeutic development for the treatment of cancer

### Neuropharmacology

- Biochemical and molecular mechanisms of action of centrally acting neurotransmitters and drugs
- Signal transduction mechanisms involving receptors, ion channels and protein trafficking
- Biochemical mechanisms and behavioral effects of drugs of abuse
- Therapeutic development for the treatment of neurological and psychiatric diseases

### Structural Biology and Signaling

- Fundamentals of structural biology, molecular biology, and biochemistry are applied to mechanisms of drug action
- Ongoing projects include studies of the structures of drug targets and the effects of drugs on signal transduction processes, including receptors and intracellular signaling molecules

## Credits Required to Graduate

60 credits minimum

## Program Credit Requirements

All students who enter the program must take 10222 Ethics and Integrity in Science, 10444 Research Ethics Discussion series, the 07301 Seminar course offered by the Pharmacology & Toxicology Doctoral program, and 07100 Foundations in Pharmacology. In addition, nine additional credits of advanced elective coursework are required; 6 of these credits must be from elective courses offered from the Pharmacology & Toxicology Doctoral program listed below (up to 3 credits can be of graduate level courses offered from any program at MCW). All students entering directly into the Pharmacology & Toxicology program are required to complete the IDP curriculum during their 1<sup>st</sup> year. Alternatively, the program director may waive these requirements.

## Required Courses

**10222 Ethics and Integrity in Science Course.** 1 credit.

This course provides the basis for understanding the ethical issues related to basic scientific and medical research, including animal and human subject research, fraud, and

misconduct, and governmental, institutional, and researcher responsibilities. Bioethics 10222 is offered during the spring and summer terms only.

**10444 Research Ethics Discussion Series.** *1 credit. Prerequisite: 10222 Ethics and Integrity in Science.*

The course is directed by members of the Bioethics Faculty and provides facilitated discussions of a series of topics in research ethics. Discussions are led by members of the Basic Science faculty and are focused on ethical issues that commonly come up in biomedical research. The course is meant to not only reinforce the basic ethics taught in the online course Ethics and Integrity in Science (Bioethics 10222B), which is a prerequisite, but also to explore the gray areas of the individual topics. The intent is to offer students illustrative examples of ethical issues that might arise in their careers, to emphasize the ethical principles that apply in such situations, and to provide practical guidance on how these types of situations should be correctly handled. This course is offered as a discussion series. Students are expected to attend and participate in the discussion. Bioethics 10444 is offered during the spring terms only.

**07100 Foundation in Pharmacology.** *2 credits.*

This course is divided into three modules. The first module provides a brief introduction into fundamental concepts of pharmacology, methods to study actions of drugs, and nontraditional therapeutic approaches, including gene targeting and biologics. The second and third modules are primers on pharmacological therapies in cancer, cardiovascular disease, and neuropsychiatric disease. The course includes in-class lectures, three written exams, and an oral presentation by each student. Offered during the spring terms only.

**07301 Seminar.** *1 credit.*

Weekly invited seminar speakers present their research on selected topics. This is a required course for all Pharmacology & Toxicology students except those taking dissertation.

**07399 Doctoral Dissertation.** *6-9 credits.*

This course is required for the completion of the PhD degree. The PhD candidate must submit a dissertation based on original research of a high scholarly standard that makes a significant contribution to knowledge in their chosen field.

**16211,16212, 16213, 16214 Introduction to Biomedical Research I-IV.** *1 credit each.*

This course reflects student's participation in laboratory research rotations and their attendance at seminars and/or journal clubs.

**16215 Foundations in Biomedical Sciences I.** *3 credits.*

This course is a didactic based course that will provide the background for understanding the biochemical basis of life. Students will learn about thermodynamic principles that drive biochemical and enzymatic reactions, protein structure and protein dynamics and the thermodynamic principles that define these structures and their interactions with other biomolecules, the principles that define their functional activities and then an application of this knowledge to an understanding of metabolic pathways. Students will also learn how foundational biochemical principles apply to certain physiological settings in health and disease and how pharmacological intervention can modulate physiological responses. The format of the course involves lectures and review sessions which are designed to promote class discussion of the relevant material.

**16216 Foundations in Biomedical Sciences II. 3 credits.**

This is an interdisciplinary course that provides students with a foundation in the areas of gene expression, and basic and contemporary cell biology. The material is primarily presented in lecture format, but significant number of discussion sections and data interpretation discussions are also included. Students are expected to gain fundamental knowledge in the areas of gene regulation, translational and posttranslational control and cellular architecture.

**16217 Foundations in Biomedical Sciences III. 3 credits.**

Module III builds on the cell biology fundamentals introduced in the latter part of Modules I and II. This course starts with three lectures on cell signaling and a discussion of a primary research article on the topic. This forms the basis of Exam 1. The second part focuses on proteins specialized for ion flux and transport. Themes are exemplified by case studies on several diseases that affect either epithelial transport or excitable cells. Exam 2 captures this material. The third and last part of the course focuses on DNA homeostasis, genetic principals, the basis of stem cells and cancer. Exam 3 closes out the Fall semester.

**16218 Foundations in Biomedical Science IV. 3 credits.**

This course is designed to give students fundamental introductory concepts impacting the fields of Microbiology and Immunology, Neurobiology and Pharmacology in three modules. Topics were selected and the three modules integrated based on the essential concept that human biological responses and development are shaped by chemical cues. The impact on human biology from contact or colonization with microorganisms and the innate and adaptive immune responses to contact are discussed in the first module. Module 2 focuses on the physiological aspects of how signals are perceived and interpreted by the human nervous system. Module 3 communicates fundamental aspects of pharmacology, emphasizing the molecular and cellular levels of signaling and signal transduction. Each session was designed to incorporate current analytical methods, computational and statistical aspects of data analysis and clinical or practical impacts on human health and disease.

**16242 Techniques in Molecular and Cellular Biology. 2 credits.**

The primary objective for this course is to provide information and conceptual knowledge of a number of the most common techniques required for biomedical research. The information presented in this course should facilitate comprehension of the scientific literature and introduce procedures that students will commonly use in their research projects. The lecture materials will present the theory behind each technique, the practical limitations of each technique and the questions that each technique addresses. Additional lectures will assist the student in use bioinformatics and biostatistics methods and in preparing results for publication. The course emphasizes the following core competencies: biomedical knowledge of a variety of commonly used research techniques, research skills through understanding published literature and experimental design, critical and creative thinking through the ability to judge information in the literature related to the techniques covered, interpersonal and communication skills through class participation and discussion and written exams, professionalism by interacting respectfully with others in the class, arriving to class on time and being prepared to participate, and lifelong learning by developing new learning and independent thinking skills.

**16245 Statistics for Basic Sciences. 1 credit.**

This course is designed to provide graduate students working in the research laboratory or studying the experimental sciences with fundamental knowledge in biostatistics. It

focuses on descriptive statistics, elements of probability theory, estimation, tests of hypotheses, methods of categorical data tabulation and analysis. After completion of the course, students should be able to develop an appropriate study plan to explore a biomedical research question and execute simple statistical analysis of the data collected in the study. Emphasis is placed on understanding concepts as well as learning to apply the covered statistical techniques. Students also learn how to read, interpret, and critically evaluate statistical concepts in the literature.

**16290 Professional Development I.** *1 credit.*

Emphasis in this course will be placed on oral and written communication, critical literature review, and responsible conduct in research. Students will learn good practices for peer review and perform interactive exercises to review each other's work.

**16291 Professional Development II.** *1 credit.*

Professional Development follows a multidisciplinary approach to promote individual career development in the biomedical sciences. The course includes lectures, discussion, sessions, seminars, and hands-on activities. Topics of particular emphasis are oral and written communication and rigor and ethics in scientific research.

**16292 Writing a Scientific Paper.** *1 credit.*

This course will present a step-by-step approach to putting together a scientific paper. Students will be divided into groups of 3, and these groups will stay together for the duration of the course. Each group will be given an identical set of data with which to compose a manuscript. Each week, a different aspect of paper writing will be discussed, and students will be given a take home assignment to write that particular component of the paper within the small groups. In the final week of the class, the finished papers will be peer reviewed by 2 other groups and a member of the faculty. The course will be graded on attendance, successful and timely completion of the assignments and evaluation of the final manuscript.

**16293 Writing an Individual Fellowship.** *2 credits.*

This course provides a systematic approach towards writing a F31-like individual research fellowship. Topics include the organization of the NIH, how the NIH invites investigators to submit applications to support their doctoral studies, how PhD trainees and their mentors respond to these invitations, and how the NIH reviews a fellowship application. A weekly didactic session will be presented to the entire group of students who will have weekly individual writing assignments to complete and will have a weekly small group session to share their progress towards the completion of their writing assignments. Each student will identify a mentor-approved research topic that will be developed into a fellowship proposal, emphasizing the writing of a Summary, Specific Aims Page, and Research Plan as outlined in PA-19-195 and SF-424(F).

**Required Courses as Needed**

**07002 Master's Thesis Continuation.** *0 credits.*

This is a form of registration available to students who have completed all of the required coursework, including thesis credits but have not yet completed the writing of the Thesis. Continuation status is limited to three consecutive terms following the completion of Thesis credits.

**07003 Doctoral Dissertation Continuation.** *0 credits.*

This is a form of registration available to students who have completed all of the required

coursework, including dissertation credits but have not yet completed the writing of the Dissertation. Continuation status is limited to three consecutive terms following the completion of Dissertation credits.

**07299 Master's Thesis.** *1-6 credits.*

Students in the Ph.D. degree program who cannot or elect not to complete that program may be allowed to transfer to the Master's program. This transfer must be approved by the student's advisor, the Program Director, the Chair, and the Graduate School. To transfer to the Master's Program, the student must be in good academic standing according to regulations established by the Graduate School.

### **Elective Courses**

At least 8 hours of electives are required for graduation. At least two courses to meet this requirement must be departmental courses that are in this list:

**07225 Ion Channels and Signal Transduction.** *3 credits.*

This course provides discussion of the function of ion channels in mammalian cells. This course provides an in-depth presentation of mechanisms of drug action at a level designed for doctoral students in the Biomedical Sciences. The emphasis is on ion channel structure, function, and regulation as well as the action of drugs and toxins that interact with ion channels.

**07226 Current Concepts of Cancer Biology.** *3 credits.*

This course provides students with basic knowledge of cancer biology. Topics include signaling pathways that promote malignancy and metastasis, cancer susceptibility genes, and chemoprevention.

**07250 Current Topics in Cancer Pharmacology.** *1 credit.*

This course consists of student-led discussions of primary literature. The course director will be available to assist students in their presentations of journal articles and will also assist in facilitating discussions amongst the class. The course will feature a blend of historical and current journal articles, including literature that focuses on structure-activity relationships of drugs and relevant biological variables in the study of pharmacology.

**07252 Current Topics in Cardiovascular Pharmacology.** *1 credit.*

Participating faculty will advise and assist students with presentation of journal articles and lectures, and lead discussions on contemporary topics in pharmacology.

**07254 Current Topics in Neuropharmacology.** *1 credit.*

This course consists of student-led discussions of primary literature. The course director will be available to assist students in their presentations of journal articles and will also assist in facilitating discussions amongst the class. The course will feature a blend of historical and current journal articles, including literature that focuses on structure-activity relationships of drugs and relevant biological variables in the study of pharmacology.

**07256 Current Topics in Structural Biology and Therapeutics.** *1 credit.*

This course is structured around student-led discussions of primary literature, providing a platform for in-depth exploration of pivotal research articles. Under the guidance of the course director, students will actively engage in presenting and critically evaluating journal articles. The course emphasizes a comprehensive approach by incorporating both historical milestones and contemporary breakthroughs, with a specific focus on literature pertaining to structure-activity

relationships of drugs and pertinent biological variables in the field of pharmacology. The course director will play a crucial role in supporting students throughout their presentations and fostering collaborative discussions within the class, ensuring a rich and interactive learning experience.

**07260 Professional Development in Pharmacology.** *1 credit.*

This course supports graduate student professional development through experiential learning, and includes portfolio building, learning how to engage community partners and policy-makers, and faculty-guided independent work focused on trainee-identified professional goals. Students will work with faculty mentors to establish an individualized development plan focused on teaching, community engagement, policy, industry, or independent academic research that includes experiential learning and professional milestones and will participate in instructor-guided biweekly learning community meetings at which they will discuss their experiences in addition to building a professional development portfolio.

**07295 Reading and Research.** *1-9 credits.*

The course of study for Reading and Research is designed by each student with his/her advisor to focus on readings in literature in the student's field, to build bibliographic resources for the dissertation, and to conduct supervised, independent research.

**16275 Understanding Cell Signaling Through Therapeutic Drugs.** *2 credits.*

This course will present advanced concepts in cellular signaling by analyzing the signaling mechanisms responsible for the therapeutic benefit, unanticipated toxicity, and limited effectiveness of particularly well-known drugs that target specific signal transduction pathways. The topics are designed to promote an enhanced understanding of the complexities of multiple signaling pathways, and a sophisticated appreciation of how these pathways are integrated to produce cellular responses. The course has a translational emphasis by focusing on the multiple molecular actions of current FDA-approved drugs, as well as discontinued drugs that were removed from the market due to unanticipated toxicity or limited effectiveness. Lectures presented by the instructors will provide an in-depth overview of different signaling pathways, and manuscript discussions will promote additional advanced analysis that will creatively engage the students.

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