2025-26

PHYSIOLOGY

Degree Offered: Doctor of Philosophy

MCW GRADUATE SCHOOL

Program Description

The Physiology program at MCW features research leaders with strong programs in cardiovascular, renal, metabolic, and respiratory physiology, and utilize genetics, genetically manipulated model systems, functional genomics, proteomics, bioinformatics, computational biology, and a growing strength in neuroscience. Didactic coursework covers a broad interdisciplinary foundation complemented with several integrative systems physiology courses. Trainees develop critical thinking skills and other professional skills through performance of cutting-edge research to prepare the next generation of scientists in the Physiological Sciences.

Admission Requirements

In addition to the general Graduate School admission requirements, this program has additional specific requirements.

Students with a major in the Biological or Physical Sciences who have demonstrated above- average scholastic ability are eligible to apply. Preferred undergraduate course work should include Biology (8 credits), General Chemistry (8 credits), Organic chemistry (8 credits), Physics (8 credits), Algebra (3-4 credits), and Calculus (3-4 credits).

Fields of Study

There are six general areas of Physiology in which students may conduct research. Both human and animal models are studied.

Circulatory

- Overall control of the cardiovascular system with emphasis on the neurohumoral control of arterial pressure and the interactions of the renal body fluid volume system.
- Ongoing projects relate to the role of circulatory smooth muscle in hypertension.
- Projects related to regeneration of the heart and vasculature

Endocrinology

- Renin-angiotensin-aldosterone system, vasopressin, and prostaglandin with emphasis on the role of these systems on the control of body fluids, electrolytes, arterial pressure regulation and basal metabolic rate determination in the context of obesity.
- Role of environmental exposure on endocrine systems

Renal and Excretory

- The importance of autocrine, paracrine, and hormonal factors in the regulation of renal tubular and vascular function.
- Elucidation of the factors important in the development of renal failure and hypertensive disease.
- Neural mechanisms regulating bladder function and bladder pain

Respiratory

- The role of the carotid chemoreceptors and medullary, pontine, and cerebellar nuclei in the control of breathing.
- Specific emphasis is on respiratory rhythm and pattern generation and chemosensitivity.
- Studies are targeted to gain insight into Sleep Disordered Breathing, the Sudden Unexpected Death in Epilepsy, and Central Congenital Hypoventilation Syndrome.

Genetics

- Identification and characterization of gene(s) involved in the development of complex disorders in humans and rat models.
- CRISPR/Cas9 gene editing in cells, including inducible pluripotent stem cells, and whole animal models

Molecular and Cell Biology

- Cell signaling in renal, respiratory, and cardiovascular diseases
- DNA binding proteins and their role in health and models of disease
- Development of novel gene editing strategies

Credits Required to Graduate

60 credits minimum

Program Credit Requirements

The emphasis of our PhD program is to provide training in molecular and physiology and/or whole-animal integrative Physiology complemented by training in cellular and molecular Physiology. To achieve this objective, all PhD students are required to complete a sequence of required courses in addition to any elective courses.

For a complete listing of all courses and their timing of enrollment throughout the Physiology PhD program, see the Physiology Student and Faculty Handbook (requests sent to Matt Hodges, PhD (mhodges@mcw.edu). The requirements are summarized below:

Year 1

Fall 2021			Spring 2022		Summer 2022
FBS1 (3cr)	FBS2 (3cr)	FBS3 (3cr)	FBS4 (3cr)	Intro to Organ Systems (2cr)	Ethics (1 cr)
			Statistics	Elective/Functional Genomics (3cr)	Scientific Writing (1cr)
Techniques in Molecular and Cell Biol (1cr)				Professional Development (1cr)	
Rotation 1	Rotation 2	Rotation 3	Rotation 4	Join lab (Feb)	

Year 2

Fall 2022	Spring 2023	Summer 2023
Advanced Human Physiology (3cr)	Electives with permission	Seminar (1 cr)
Writing an Individual Fellowship (1cr)	Special Topics (1cr)	
Qualifying Exam (Dec)	Full-time physiological research	

All students enter through the Interdisciplinary Doctoral Program (IDP), Neuroscience Doctoral Program (NDP), and/or the Medical Scientist Training Program (MSTP). In addition to the course requirements of these programs, there are additional required courses in the Physiology program (highlighted in yellow above). For those entering through IDP and NDP, one additional course must be completed in Spring of Year 1

(Organ Systems Physiology). Students are then required to also enroll in the Seminar course in the Summer semester. Additional required courses in the Physiology program prior to the Qualifying Exam include a grant writing course and Advanced Human Physiology (see descriptions below), which should be completed in the Fall semester of Year 2. Additional required courses that may be completed before or after completion of the Qualifying Exam include Functional Genomics [Spring Offering], Seminar (each Summer semester beginning in Year 2), and Special Problems in Physiology (each Spring semester beginning in Year 2).

Advanced Physiology: This 3-credit course provides the foundation for physiological concepts and integrative thinking and covers 4 major physiological systems: 1) endocrinology and reproduction, 2) cardiovascular physiology, 3) respiratory physiology, 4) renal physiology. Material will be covered by completing assigned pre-work (recorded lectures and primary literature) which are complemented by in-person condensed review sessions/lectures and presentation of classical and cutting-edge research publications within each discipline.

Students complete a written and oral Qualifying Examination after completing courses in the Fall of the second year in the program. This examination is administered by the Physiology Program Faculty. The written component is a grant-style proposal on a topic chosen by the student, and it usually is derived from didactic course materials, work conducted in laboratory rotations, and/or research that potentially will become part of the student's dissertation. The proposal and performance in the oral component of the Qualifying Exam will be evaluated by the examination committee and if acceptable the student will reach advanced degree status.

In each spring semester following the Qualifying Exam, physiology students enroll in Special Problems in Physiology course which is a journal club discussion of manuscripts. Another requirement of all MCW PhD programs is to fulfill two credits in Bioethics by completing Courses on Ethics and Integrity in Science and Research Ethics Discussion Series which are usually completed in the first two years. Students may choose to enroll in elective courses to complement their academic and research interests. Graduate students in other programs may choose to also enroll in this physiology course. Physiology students can also enroll in courses taught by other basic science departments. The student and their advisor choose elective courses that best meet the students career needs. Course selection can be specific to Physiology (see below) or from other MCW departments or other institutions in Milwaukee.

Required Courses Offered by Physiology

PHYS 08205 Advanced Physiology. *3 credits.*
Integrative and systems physiology fosters breakthroughs in all areas of life sciences, and a complete understanding of physiology requires an in-depth understanding of normal biological processes to understand how these processes breakdown in cardiovascular, circulatory, respiratory, renal, endocrine and other diseases. In this advanced physiology course, students gain knowledge through mastery of fundamental physiological concepts and principles as a foundation for advanced study at the graduate level and to build a firm foundation for cutting edge research skills in physiology and related disciplines. A major focus of this course is to learn fundamental physiological principles and gain skills in presentation and critical reading/reasoning of primary literature through a combination of self-directed

learning (pre-work) and presenting published papers.

PHYS 08208 Current Topics in Physiology. *1 credit*.
The course is designed to give enrolled students a window into current advances and techniques in modern physiological research. Students will be required to attend and be graded upon attendance at weekly lectures/seminars sponsored by the Dept. of Physiology and their evaluations of each presentation. This course is offered in Fall and Spring semesters. But is only required beginning in the second year of graduate school until the final semester of their thesis work.

PHYS 08275 Special Problems in Physiology. *1 credit.*
Readings and/or research under direction of a faculty member in a specialized field of physiology. Under specific circumstances, may be substituted for formal courses.

PHYS 08295 Reading and Research. *1-9 credit(s)*.
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.

PHYS 08301 Graduate Student Seminar. *1 credit.*
This course is designed to provide Physiology Graduate students the opportunity to gain experience in presenting their scientific work as part of either the IDP student symposium or the Department of Physiology Seminar series, to gain useful scientific feedback from the audience during and upon the completion of their presentation, and to gain experience in participating in discussion during the presentations of their peers. It is taken each summer during Graduate School.

PHYS 08399 Doctoral Dissertation. *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.

Required Courses Offered by IDP and others

BIOE 10222 Ethics and Integrity in Science. *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.

BIOE 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, 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 the 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.

INBS 16215 Foundations in Biomedical Sciences I. *3 credits.*
This new course will be 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.

INBS 16216 Foundations in Biomedical Sciences II. *3 credits.*
An interdisciplinary course that provides students with a foundation in the areas of gene expression, and basic and contemporary issues in cell biology. The material is primarily presented in lecture format, but a significant number of paper discussion sessions are also included.

INBS 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.

INBS 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.

INBS 16242 Techniques in Molecular & 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 respectively 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.

INBS 16265 Organ Systems Physiology. *2 credits.*
Introduction to Organ Systems Physiology is a first-year elective course that focuses on the classic topics in physiology – the science of regulation and control systems – including the Physiology of Cells, Muscle, Cardiovascular, Pulmonary, Renal, GI, Endocrine, and Reproduction. It will also introduce the students to animal models in physiological research appropriate for the topic at hand. It will follow and build on the first year first semester Graduate School (FBS) course that runs from August-February.

INBS 16278 Functional Genomics. *3 credits.*
This course will use a variety of didactic lecture, paper discussions, and hands on bioinformatics learning to provide students with fundamentals in genomics, transcriptomics, proteomics, genetic manipulation, epigenetics, protein modeling and molecular simulation. Theory, practical applications, and analysis methods will be taught.

INBS 16278 Functional Genomics. *3 credits.*
This course will use a variety of didactic lecture, paper discussions, and hands on bioinformatics learning to provide students with fundamentals in genomics, transcriptomics, proteomics, genetic manipulation, epigenetics, protein modeling and molecular simulation. Theory, practical applications, and analysis methods will be taught.

INBS 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.

INBS 16291 Professional Development II. *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.

INBS 16292 Writing a Scientific Paper. 1 credit.
This course is offered in the Summer between years 1 and 2. The goal is to enhance specific skill sets related to scientific writing and presentation. The course will focus on the processes important for the preparation of scientific manuscripts and an NIH F-type research proposal. This course will include didactic components, and will require students to work individually, or in small groups. Students will also engage in peer review activities to improve interpersonal, professionalism, and leadership skills.

Required Courses as Needed

PHYS 08002 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.

PHYS 08003 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.

PHYS 08299 Master's Thesis. *1-9 credit(s)*.
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 in Physiology

PHYS 08270 Current Concepts in Cardiovascular Biology. *3 credits*.
This lecture course explores the pathogenic mechanisms that underlie cardiovascular disease the leading cause of death in the United States and other industrialized countries. This course covers foundational principles of cardiovascular physiology and pathophysiology with special emphasis on topics related to the CVCs Signature Programs and Affinity Groups. Unique features of the course include the integration of basic and clinical research intentional pairing of pre-doctoral students with post-doctoral fellows' presentations by students and fellows on selected topics and a section on Current Topics in Cardiovascular Sciences such as racial inequity COVID19 and social determinants of health. In addition to advancing education in cardiovascular biology and pathophysiology major goals are to increase knowledge in translational medicine and enhance peer-to-peer mentoring.

Notes

Summary of explicit expectations and timelines for trainees
Students are expected to: 1) complete four 6-week research rotations, 2) choose a laboratory for their PhD research by March of the first year in graduate school, 3) complete the core didactic IDP and Physiology course curriculum by the end of the second year in graduate school, 4) fulfill the requirements for the PhD Qualifying Examination by the end of the second year in graduate school, 5) form an approved

dissertation committee before the start of the Fall semester in Year 2, 6) provide an approved dissertation outline within 6 months after completing the Qualifying Exam, 7) attend and present research at regional or national meetings each year beginning at the end of the second year in graduate school, 8) complete the PhD within 5 years after matriculation, and 9) publish two (2) or more peer-reviewed, first-authored manuscripts with a minimum of at least one accepted at the time of graduation.