2024-25

# NEUROSCIENCE DOCTORAL PROGRAM

MCW GRADUATE SCHOOL

## Program Description

Neuroscience is a dynamic, rapidly growing field devoted to study of the central and peripheral nervous systems in health and disease. During the past three decades, a group of eminent scientists with research interests in many areas of neuroscience has been assembled in the basic science and clinical departments of the Medical College of Wisconsin. These individuals, who have an impressive record of pre-and post-doctoral training, research, and extramural funding in the neurosciences, form the core faculty for this training program. The research areas of the neuroscience faculty include functional imaging, electrophysiological, biochemical, cellular, and molecular approaches to questions of fundamental and clinical importance.

The Neuroscience Doctoral Program (NDP) is committed to providing a specialized education in neuroscience ranging across molecular and cellular mechanisms, systems neuroscience, and brain imaging. This education is designed to serve the students well as they move on to pursue specialized research projects. During the first year, students take a core curriculum designed to provide a foundation in neuroscience as well as biochemistry, cell biology, genetics, molecular biology, physiology, signaling, laboratory techniques, and biostatistics. Students also take 4-6 credits of elective courses and a summer course on general writing to help with the qualifying exam and professional development.

A novel aspect of the NDP is that students will be provided with a hands-on Techniques in Neuroscience program, an immersive 6-week program designed to create an on-ramp for new students to the major techniques and skills they will need for their careers in Neuroscience. Through hands-on, interactive sessions, first-year NDP students will be introduced to 1) Molecular techniques in neuroscience, 2) Microscopy and image analysis, 3) Electrophysiology in the neurosciences, 4) Animal behavioral models for neuroscientific investigation, 5) Basics of Python for data analysis, and 6) Introduction to Human Subjects Research. This program also offers several opportunities for students to engage directly with NDP faculty instructors. Opportunities include social events, conversation-focused seminars, and shadow opportunities. These relationship-building events were designed to facilitate students' transition into their lab rotations by allowing them to familiarize themselves with potential research programs and build connections with faculty members crucial to their doctoral training. It also provides a platform for increased visibility of NDP faculty and opportunities for faculty members to interact with potential future trainees. Students will shadow a minimum of 9 faculty instructors to assist in choosing laboratories for first-year rotations.

Students will then explore their individual research interests through 3-4 laboratory rotations that emphasize experimental design and integration into a research team. Students are encouraged to take advantage of the diversity of neuroscience research opportunities in the participating departments. Once a student selects a dissertation advisor at the end of their first year, they will become affiliated with one of the following graduate programs: Biochemistry; Biophysics; Cell and Developmental Biology;

Physiology; Microbiology and Immunology; or Pharmacology and Toxicology. In addition, students may also pursue a clinical focus if admitted into the Basic and Translational Science Program. Additional information about individual departmental programs is given elsewhere in this publication.

During the second year of their studies, students will take a course in writing an NIH-style fellowship and prepare and defend a proposal based on their own research that will provide them with valuable experience in mastering a scientific problem, formulating a suitable hypothesis, and drafting a feasible and productive experimental scheme with which to test it. The qualifying exam for NDP students will be administered by the graduate program that their thesis laboratory is affiliated with (e.g., Biochemistry; Biophysics; Cell and Developmental Biology; Physiology; Microbiology and Immunology; or Pharmacology and Toxicology*)*. Successful completion of this qualifying exam is a major step towards being admitted to candidacy for a PhD degree in the thesis department. During their second semester and in subsequent years, students are also expected to successfully complete a number of advanced courses selected with the guidance of their dissertation mentor, dissertation committee, and the Graduate Program Director of their affiliated department. Upper-level students will focus on the development of their research skills, performance of their doctoral research, and completion of their dissertation.

Once affiliated with a particular laboratory and department, students can expect attentive personal mentoring by their dissertation advisor. Throughout their graduate careers, students in the Interdisciplinary Program continue to meet as a group to share ideas, insights, and research accomplishments with each other and with the faculty.

This program prepares students for advanced study in one of the following PhD degree-granting programs: Biochemistry; Biophysics; Cell and Developmental Biology; Microbiology and Immunology; Physiology; and Pharmacology and Toxicology.

### Admission Requirements

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

Successful applicants will show undergraduate achievement in science and mathematics courses and have prior research experience.

### Fields of Study

Faculty participating in the Neuroscience Doctoral Program have diverse research interests such as:

- Neurodegeneration and Neurotrauma

Neurodegenerative diseases including ALS, Parkinson's disease, Alzheimer's disease, and Spinal Cord Injury are studied using stem cells, animal models, and human tissues.

- Neuroimaging, Tissue to Brain

State of the art brain imaging and biomedical engineering technologies are used to study language, vision, hearing, motor control, learning and memory, and brain associated cancers.

- Cellular and Synaptic Communication

Neuronal communication and receptor-ligand binding at the cellular and structural levels are studied using cutting edge genetic, electrophysiological, and computational tools to

dissect mechanisms of development, signaling, and disease associated with vison, learning and memory, and addiction.

- Function of Neural Systems in Normal and Disease states

Sleep disruption, breathing, chronic stress, reward and drug abuse systems, hearing, touch and temperature sensation and chronic pain are studied using diverse model systems and approaches.

## Required Courses

**INBS 16211 Introduction to Biomedical Research.** *1 credit.*
This course reflects student's participation in laboratory research rotations and their attendance at seminars and/or journal clubs.

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

**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 Cell 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 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 will focus 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 will be placed on understanding concepts as well as learning to apply the covered statistical techniques. Students will also learn how to read, interpret, and critically evaluate statistical concepts in the literature.

**INBS 16271 Fundamentals of Neuroscience**. *3.5 credits.*
Fundamentals of Neuroscience follows a multidisciplinary approach to current knowledge about the structural and functional properties of the nervous system. The mechanisms of the nervous system are described at the molecular, cellular, systems and complex brain function levels. The course includes in-class lectures, seminars from prominent scientists (video archives), and written assignments. The purpose of this course is to introduce 1st year graduate students to the structure and function of the human nervous system.

**INBS 16272 Graduate Neuroanatomy**. *0.5 credits.*
Graduate Neuroanatomy is a lab-based course intended to accompany MCW course Fundamentals of Neuroscience. The purpose of this course is to introduce 1st year PhD students to the anatomy of the human nervous system.

**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.*

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.

**INBS 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.

**INBS 16293 Writing an Individual Fellowship**. *2 credits.*
*Prerequisite: 16292 Writing a Scientific Paper*
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).

**NSCI 12298 Journal Club.** *1 credit.*
Weekly readings will be selected from contemporary and historical literature in neuroscience. Informal discussions will include participation from students and faculty.

## Elective Courses

**NSCI 12221 Advanced Systems Neuroscience.** *3 credits.*
*Prerequisite: 16271 Fundamentals of Neuroscience or consent of the course director.*
Readings and discussion in cellular, molecular, and developmental neurobiology. Among the topics covered in this course are ion channels and the ionic basis of potentials; mechanisms of synaptic transmission; neurotransmitter receptors and their receptors; sensory signal transduction and neural development.

**NSCI 12237 Cellular and Molecular Neurobiology.** *3 credits.*
*Prerequisite: 16271 Fundamentals of Neuroscience or consent of the course director.*
Readings and discussion in cellular, molecular, and developmental neurobiology. Among the topics covered in this course are ion channels and the ionic basis of potentials; mechanisms of synaptic transmission; neurotransmitter receptors and their receptors; sensory signal transduction and neural development.

**INBS 16277 Cognitive Neuroscience.** *1 credit.*
Cognitive neuroscience examines human brain information processing at the level of large-scale neurobiological systems. Some examples include information processing that underlies

learning and retrieving concepts, comprehending, and producing language, directing, and maintaining attention, and recognizing sensory objects. Each session in this course will begin with a 1-hour contextual lecture, followed by review and discussion of two relevant landmark papers, sometimes with opposing views. Emphasis will be placed on understanding the processing models central to each domain, the extent to which these models are supported by empirical evidence from neuroimaging, and the relevance of the field to a variety of human brain disorders. There are a number of courses offered by other departments at the Medical College of Wisconsin that can be taken by students in the Neuroscience Doctoral Program depending upon their research interests. The goal is to provide each student with the basics of modern neuroscience and then allow them to customize a program of course work that best meets their needs.