# NEUROSCIENCE (NEURODPT)

**NEURODPT/NTP 610 – CELLULAR AND MOLECULAR NEUROSCIENCE**
4 credits.

Study of original papers leading to an understanding of the molecular basis of electrical activity in neurons. Topics include voltage-sensitive currents, molecular biology of neuronal receptorrs, synaptic transmission and sensory transduction.
**Requisites:** ZOOLOGY/PSYCH 523 and (PHYSICS 202, 208, or 248), or graduate/professional standing
**Course Designation:** Breadth - Biological Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
**Repeatable for Credit:** No
**Last Taught:** Fall 2024
**Learning Outcomes:** 1. Identify the major anatomical parts of a neuron and summarize their functions
Audience: Both Grad & Undergrad

2. Name the major classes of voltage-gated ion channels responsible for the resting potential and action potential. Describe their functional roles in generating those potentials, with respect to concepts such as voltage-dependence, activation, inactivation and propagation. Identify the structural motifs in these proteins that permit their function
Audience: Both Grad & Undergrad

3. Summarize the sequence of events in the presynaptic terminal that lead from depolarization to neurotransmitter release, including the role of calcium. Explain the quantal hypothesis of neurotransmitter release and the experimental evidence that supports it. Describe the exocytosis/endocytosis cycle
Audience: Both Grad & Undergrad

4. Summarize basic principles of ligand/receptor interactions. Interpret the meaning of quantities such as the dissociation constant (Kd) and the maximum response (Vmax). Explain the experimental evidence that led to the equations (e.g., Hill Equation) that describe these principles
Audience: Both Grad & Undergrad

5. Name the major classes of ligand-gated ion channels that support fast synaptic transmission and differentiate their functions with respect to excitation versus inhibition. Identify the structural motifs in these proteins that permit their specific functions. Solve equations that describe the behavior of simple chemical and electrical systems as a function of time
Audience: Both Grad & Undergrad

6. Explain what second messengers and signaling cascades are and how they participate in regulating neuronal function. Describe the major processes leading from DNA to RNA to the production of proteins and explain how these processes are regulated with respect to the structure of chromatin and the action of transcriptional activators and repressors
Audience: Both Grad & Undergrad

7. Define the concept of sensory transduction. Describe the key components of transduction and their interactions in the following systems: vision, olfaction, touch and hearing. Explain how sensory cells can be "tuned" to respond to specific aspects of a stimulus (e.g., color, frequency, etc)

**NEURODPT/NTP/PSYCH 611 – SYSTEMS NEUROSCIENCE**
4 credits.

Introduction to the anatomy and physiology of the mammalian nervous system. Lectures will cover the neuroanatomy of the major subdivisions of the human brain, the major sensory and motor systems, and higher order functions. Lab/discussion sections will emphasize readings from the primary literature and hands-on dissections.
**Requisites:** NEURODPT/NTP 610 or graduate/professional standing
**Course Designation:** Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
**Repeatable for Credit:** No
**Last Taught:** Spring 2025
**Learning Outcomes:** 1. Describe the organization and structure of mammalian nervous system, including the spinal cord, brainstem, thalamus, cerebral cortex, cerebellum, basal ganglia, limbic system, and their interconnections on a systems leve
Audience: Both Grad & Undergrad

2. Demonstrate a solid understanding of the functions of the sensory and motor systems that underlie perception and action
Audience: Both Grad & Undergrad

3. Demonstrate a solid understanding of higher brain functions and behavior, including learning and memory and executive function
Audience: Both Grad & Undergrad

4. Demonstrate knowledge about approaches of modern neuroscience research including neuroanatomy, neurophysiology, functional brain imaging, behavioral assays, and quantitative data analysis methods
Audience: Both Grad & Undergrad

5. Develop and apply critical thinking to evaluate original neuroscience research
Audience: Graduate

6. Develop ability to formulate hypotheses and to apply knowledge learned from the course to design experiments for hypothesis testing
Audience: Graduate

**NEURODPT/ZOOLOGY 616 – LAB COURSE IN NEUROBIOLOGY AND BEHAVIOR**
4 credits.

Independent experimental modules exploring neurophysiology and behavior will be completed in groups. Learn techniques and develop investigations into three separate areas of neurobiology.
**Requisites:** ZOOLOGY/PSYCH 523 and PSYCH 454
**Course Designation:** Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
**Repeatable for Credit:** No
**Last Taught:** Spring 2017

**NEURODPT/NTP 629 – MOLECULAR AND CELLULAR MECHANISMS OF MEMORY**
3 credits.

Focuses on the cell signaling and the resulting structural changes that occur at neuronal synapses during memory formation. The aim is to understand how the synaptic changes underlying memory occur.
**Requisites:** Graduate/professional standing or ANAT&PHY 335, 435, PHYSIOL 335, 435 or ZOOLOGY/PSYCH 523
**Course Designation:** Breadth - Biological Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
**Repeatable for Credit:** No
**Last Taught:** Fall 2023
**Learning Outcomes:** 1. Describe how the neural activity at the synapse which occurs during a memory-inducing event (a memorable event) leads to the ability to recall that event, when the animal or person does recall that event, either spontaneously or by prompting.
Audience: Both Grad & Undergrad

2. Apply a variety of biological techniques to understand the biochemical processes that are involved in memory. Learn the principles of these advanced techniqes and apply them appropriately to work out mechanisms.
Audience: Both Grad & Undergrad

3. Formulate why alterations in synaptic strength between neurons in an autoassociative network lead to the ability to recall an event which involved the activation of neurons in that network. This is the concept of pattern completion, which is the core of memory formation and is an incredibly important overall concept.
Audience: Both Grad & Undergrad

4. Succinctly present research proposals that are students' extensions of work that has been published, including a strong component of originality on the part of the student.
Audience: Both Grad & Undergrad

5. Formulate the basics of synaptic transmission mechanisms including presynaptic release of neurotransmitter and effects of neurotransmitter interactions with the post synaptic membrane on biochemistry and electrophysiology of the dendritic spine. These include unique properties of the dendritic spine including anatomy,biochemical composition.
Audience: Both Grad & Undergrad

6. Formulate the concept of neural plasticity, the strengthening and weakening of transmission between presynaptic terminals and post synaptic dendritic spines. The realization that this occurs as the result of interaction between a large number of proteins. Describe the structure of the synapse in detail that includes the roles played by structural proteins and protein kinases and phosphatases in affecting synaptic strength.
Audience: Both Grad & Undergrad

7. Describe the application of the use of advanced optical approaches such as FRET (fluorescence resonance energy transfer) and several others. Formulate how they reveal detailed information about the movements and alterations in properties of the key macromolecules that comprise the synaptic region. Formulate how information is derived from these measurements to explain events of synaptic plasticity.
Audience: Both Grad & Undergrad

8. Formulate an approach using one or more of these techniques to answer an unresolved question regarding the mechanisms of plasticity.
Audience: Graduate

**NEURODPT/NTP 640 – COMPUTATIONAL NEUROSCIENCE: FROM SINGLE CELLS TO WHOLE BRAIN MODELS**
3 credits.

Theory and application of methods in computational neuroscience across various levels of organization from single cells to global brain dynamics and cognition. Computational neuroscience is an approach to understanding the development and function of nervous systems in mechanistic terms at many different structural scales. Topics include biophysical properties of neurons and synapses, neural plasticity, sensory systems, neural circuits, whole brain analysis and modeling, and different views on brain function. Includes primers on relevant computational techniques (ICA, information theoretical approaches, dynamical systems) and a computational problem set. Starts with an introduction to MATLAB (used for problem sets).
**Requisites:** PSYCH/ZOOLOGY 523, PSYCH 454, MATH 221, and (PHYSICS 104, 202, 208, or 248); or graduate/professional standing and NEURODPT/NTP 610 and PSYCH/NEURODPT/NTP 611
**Course Designation:** Breadth - Biological Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
**Repeatable for Credit:** No
**Last Taught:** Spring 2025
**Learning Outcomes:** 1. Explain the basic functioning of a neuron in biophysical terms (including how action potentials are generated, the role of dendrites, and postsynaptic integration).
Audience: Both Grad & Undergrad

2. Summarize the computational properties of sensory neurons reacting to sensory stimuli (tuning curves, receptive fields, feature selectivity).
Audience: Both Grad & Undergrad

3. Demonstrate technical familiarity in evaluating the statistical and information theoretical properties of neuronal activity (basics of signal detection theory, spike train statistics, firing rate models, PCA/ICA analysis).
Audience: Both Grad & Undergrad

4. Name various types of neural circuit models and their areas of application.
Audience: Both Grad & Undergrad

5. List the main differences between artificial neural networks as developed in computer science and computational models of biological neural networks.
Audience: Both Grad & Undergrad

6. Demonstrate how to characterize the dynamical properties of neurons and neural networks.
Audience: Both Grad & Undergrad

7. Summarize the hierarchical organization of the brain in computational terms (canonical microcircuit, mini-columns, functional brain networks).
Audience: Both Grad & Undergrad

8. Distinguish between anatomical, functional, and effective cortical connectivity.
Audience: Both Grad & Undergrad

9. Summarize main theoretical approaches to understanding brain functioning (graph theory, dynamical systems, information processing, decoding, whole-brain computational models).
Audience: Both Grad & Undergrad

10. Run and adapt MATLAB scripts for building and simulating neural

**NEURODPT/PSYCH/ZOOLOGY 674 – BEHAVIORAL NEUROENDOCRINOLOGY SEMINAR**
2 credits.

Behavior results from a complex interplay among hormones, the brain, and environmental factors. Behaviors and their underlying neural substrates have evolved in response to specific environmental conditions, resulting in vast species diversity in behavioral and neuroendocrine solutions to environmental problems. Designed to explore the primary literature on the neuroendocrine underpinnings of behavior spanning from feeding to sex differences in complex social behaviors. A range of taxonomic groups will be discussed, including (but not limited to) mammals, birds, and fish.
**Requisites:** ZOOLOGY/BIOLOGY 101, ZOOLOGY/BIOLOGY/BOTANY 151, BIOCORE 383 or graduate/professional standing
**Course Designation:** Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
**Repeatable for Credit:** No
**Last Taught:** Fall 2021
**Learning Outcomes:** 1. Identify how behaviors and their underlying neural substrates have evolved in response to specific environmental conditions
Audience: Both Grad & Undergrad

2. Discuss and explore the primary literature on the neuroendocrine underpinnings of behavior spanning from feeding to sex differences in complex social behaviors
Audience: Both Grad & Undergrad

3. Identify and discuss hormones, the brain, and environmental factors as they relate to behavioral evolution and biological diversity
Audience: Both Grad & Undergrad

4. Develop and apply critical thinking to evaluate neuroendocrinological research
Audience: Graduate

5. Communicate effectively about concepts, theories and approaches of neuroendocrinology and behavioral research
Audience: Graduate

**NEURODPT 675 – SELECTED TOPICS IN PHYSIOLOGY**
1-3 credits.

Topics include: advanced cardiovascular physiology, advanced respiratory physiology, advanced endocrinology, membrane transport physiology and neurobiology.
**Requisites:** None
**Course Designation:** Breadth - Biological Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
**Repeatable for Credit:** Yes, unlimited number of completions
**Last Taught:** Fall 2019
**Learning Outcomes:** 1. Apply, analyze, or evaluate advanced theories, concepts, or methods in Neuroscience and Physiology, including but not limited to: ion channels, advanced cardiovascular physiology, advanced respiratory physiology, advanced endocrinology, membrane transport physiology and neurobiology
Audience: Both Grad & Undergrad

2. Identify and describe key theories, concepts, and methods in Physiology and Neuroscience, including but not limited to: ion channels, advanced cardiovascular physiology, advanced respiratory physiology, advanced endocrinology, membrane transport physiology and neurobiology and apply the knowledge gained to research in the field
Audience: Graduate

**NEURODPT 699 – DIRECTED STUDY**
1-4 credits.

Independent work.
**Requisites:** Consent of instructor
**Repeatable for Credit:** Yes, unlimited number of completions
**Last Taught:** Spring 2025
**Learning Outcomes:** 1. Apply concepts learned in coursework to real life situations
Audience: Undergraduate

2. Read and effectively search scientific literature
Audience: Undergraduate

3. Develop critical, analytical, and independent thinking skills
Audience: Undergraduate

**NEURODPT 747 – SENSORY AND MOTOR SYSTEMS**
2 credits.

Overview of the basic science principles of sensory and motor systems in the central and peripheral nervous system, with clinicians providing complementary presentations on their relevant experiences in the clinic. Topics include Somatosensory pathways in spinal cord, brainstem and cerebrum, Motor neurons in spinal cord and brainstem and the descending systems that control them, Blood Supply of the CNS and affiliated vascular syndromes, Cerebellum, Basal Ganglia and associated pathways, Eye Movement control, Vestibular, Auditory, and Visual systems and organization of Cerebral Cortex.
**Requisites:** MED SC-M 810, 811, 812, and 813
**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement
**Repeatable for Credit:** No
**Last Taught:** Spring 2025
**Learning Outcomes:** 1. Identify and summarize the main sensory and motor structures within the nervous system.
Audience: Graduate

2. Explain how elements in the nervous system interact to enable specific sensory and motor functions.
Audience: Graduate

3. Describe how pathology in specific neural pathways leads to particular clinical neurological signs and symptoms (e.g., ischemic stroke syndromes).
Audience: Graduate

4. Predict the location of damage in the nervous system based on symptoms and signs.
Audience: Graduate

**NEURODPT/NTP/ZOOLOGY 765 – DEVELOPMENTAL NEUROSCIENCE**
3 credits.

Analysis of neural development with emphasis on experimental approaches. Combination of lectures and discussions of primary literature. Topics include neural induction, patterning, mechanisms of axon guidance, neural crest cell migration and differentiation, cortical development, and synapse formation and elimination.
**Requisites:** Graduate/professional standing
**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement
**Repeatable for Credit:** No
**Last Taught:** Spring 2025
**Learning Outcomes:** 1. Gain an extensive understanding of mechanisms of neural development
Audience: Graduate

2. Acquire the ability to critically analyze current studies in neural development
Audience: Graduate

**NEURODPT 990 – RESEARCH AND THESIS**
1-9 credits.

Research supervised by individual faculty members.
**Requisites:** Consent of instructor
**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement
**Repeatable for Credit:** Yes, unlimited number of completions
**Last Taught:** Spring 2025
**Learning Outcomes:** 1. Exhibit a broad understanding of general Neuroscience principles
Audience: Graduate

2. Conduct independent research using a variety of approaches
Audience: Graduate

3. Think critically to address research challenges
Audience: Graduate

4. Exhibit and foster professional and ethical conduct in their research
Audience: Graduate

5. Collaborate with other investigators within or outside the thesis lab
Audience: Graduate