NEUROSCIENCE TRAINING PROGRAM (NTP)

NTP/NEURODPT 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 receptors, 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 2023

**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 respond to specific stimuli and how these responses are integrated into central nervous system function
   Audience: Both Grad & Undergrad

NTP/NEURODPT/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 2024

**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 level
   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

NTP/ANTHRO/PSYCH/ZOOLOGY 619 – BIOLOGY OF MIND
3 credits.


**Requisites:** Junior standing

**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

**Repeatable for Credit:** No

**Last Taught:** Fall 2023
**NTP/ZOOLOGY 620 – NEUROETHOLOGY SEMINAR**  
2 credits.  
A group discussion of primary literature articles relevant to the neural basis of behavior with a purpose to understand the neural basis of behavior in animals, to learn to read papers critically and improve discussion leading skills.  
**Requisites:** PSYCH/ZOOLOGY 523 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:** Yes, unlimited number of completions  
**Last Taught:** Spring 2024

**NTP/NEURODPT 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 techniques 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
NTP/NEURODPT 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 2024
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

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

Audience: Both Grad & Undergrad

NTP/MED PHYS 651 – METHODS FOR NEUROIMAGING RESEARCH
3 credits.

Provides a practical foundation for neuroimaging research studies with statistical image analysis. Specific imaging methods include functional BOLD MRI, structural MRI morphometry, and diffusion tensor imaging. Lectures and associated in-class computer exercises will cover the physics and methods of image acquisition, steps and tools for image analyses, the basis for statistical image analyses and interpretation of the results.

Requisites: Graduate/professional standing or (PHYSICS 104, 202 or 208)
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 2023
Learning Outcomes:
1. Develop a basic understanding of magnetic resonance imaging, anatomical imaging methods, functional BOLD MRI (fMRI), and diffusion tensor imaging (DTI).
Audience: Both Grad & Undergrad

2. Learn and apply basic methods for statistical image analyses.
Audience: Both Grad & Undergrad

3. Gain hands-on experience with tools for processing and analyses of fMRI, DTI and anatomic brain images.
Audience: Both Grad & Undergrad

4. Develop and demonstrate skills to independently process, analyze, troubleshoot and interpret MRI neuroimaging data
Audience: Graduate
NTP 660 – NEUROSCIENCE & PUBLIC POLICY SEMINAR
1-2 credits.

Covers various topics in neuroscience and in the related sciences that demonstrate the interaction between science and public policy.

**Requisites:** BIOCORE 485, ZOOLOGY/PSYCH 523, PSYCH/NEURODPT/NTP 611, or declared in Neuroscience graduate program

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** Yes, unlimited number of completions

**Last Taught:** Spring 2024

**Learning Outcomes:**
1. Integrate knowledge from multiple sources and reflect on how science informs policies and society, and how policies impact the conduct of science.
   Audience: Both Grad & Undergrad

2. Demonstrate ability to consider multiple viewpoints on complex topics and engage in respectful and enriching discussion.
   Audience: Both Grad & Undergrad

3. Summarize content knowledge on current topics in policy, law, and neuroscience.
   Audience: Both Grad & Undergrad

4. Develop critical thinking skills to identify and dissect societal issues that are informed by science and reflect on potential solutions and next steps.
   Audience: Both Grad & Undergrad

5. Demonstrate knowledge of career paths at the intersection of science and policy (e.g. academic, non-profit, industry, government).
   Audience: Both Grad & Undergrad

6. Demonstrate ability to lead an inclusive discussion on topics at the intersection of science and policy.
   Audience: Graduate

NTP 666 – NEUROSCIENCE OF CONSCIOUSNESS AND ITS DISORDERS
3 credits.

Outlines contemporary strategies to study consciousness and current knowledge of the neural correlates of consciousness and their alterations during sleep, parasomnia, anesthesia, coma, stroke, seizures, meditative and psychedelic states. Reviews recent work studying the neural correlates of conscious contents and their interactions with cognitive processes.

Outlines contemporary theories of consciousness, illustrate how they can be empirically tested, and discuss their implications for the presence vs. absence of consciousness in artificial intelligent systems.

**Requisites:** (PSYCH 454 and ZOOLOGY/PSYCH 523) 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 2024

**Learning Outcomes:**
1. Understand approaches used to distinguish between consciousness and its pre-requisites or consequences, and the importance of arousal systems for enabling consciousness.
   Audience: Both Grad & Undergrad

2. Describe current knowledge about cortical structures involved in specific conscious contents.
   Audience: Both Grad & Undergrad

3. Understand the complementarity of animal vs. human models to study consciousness.
   Audience: Both Grad & Undergrad

4. Describe the spectrum of alterations of consciousness present during sleep, parasomnia, anesthesia, coma, seizures, stroke, meditative and psychedelic states, and their neural correlates.
   Audience: Both Grad & Undergrad

5. Understand possible interactions and dissociations between consciousness, attention and memory.
   Audience: Both Grad & Undergrad

6. Describe the variety of current theoretical approaches to consciousness and their relevance to infer the presence of consciousness in artificial intelligent systems.
   Audience: Both Grad & Undergrad

7. Discuss a selection of recent studies - identified shortly before class as providing significant advances and/or reflecting current directions in the consciousness research field – and learn to critically analyze the methodological strengths and limitations of these studies.
   Audience: Graduate

8. Understand how to design an experiment probing the neural correlates of consciousness while accounting for its pre-requisites and consequences.
   Audience: Graduate
NTP 670 – STEM CELLS AND THE CENTRAL NERVOUS SYSTEM
2-3 credits.

Among the topics that will be included in the course are: embryonic stem cells, adult stem cells, and the transplantation of embryonic and adult stem cell to the developing and adult CNS for experimental and therapeutic purposes.

Requisites: BIOCHEM 501 or graduate/professional standing

Course Designation: Breadth - Biological Sci. Counts toward the Natural Sci req

Level - Advanced

L&S Credit - Counts toward the Natural Sci req

Grad 50% - Counts toward 50% graduate coursework requirement

Repeatable for Credit: No

Last Taught: Fall 2021

Learning Outcomes:
1. Describe how neural stem cells function during development and in the adult, and the regulation of these processes
   Audience: Both Grad & Undergrad

2. Describe how neural stem cells can be obtained from reprogramming and can be differentiated into different types of cells, and methods and concerns for their use in modeling disease
   Audience: Both Grad & Undergrad

3. Retrieve, evaluate, and interpret literature related to their scientific question
   Audience: Both Grad & Undergrad

4. Participate and discuss strengths and weaknesses of literature
   Audience: Both Grad & Undergrad

5. Identify, formulate and solve problems using appropriate information and approaches
   Audience: Both Grad & Undergrad

6. Propose original research and develop ability to write Specific Aims page
   Audience: Graduate

7. Communicate effectively through written reports, oral presentations, and discussion
   Audience: Graduate

NTP 675 – SPECIAL TOPICS
1-3 credits.

Requisites: None

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: Yes, unlimited number of completions

Last Taught: Spring 2024

Learning Outcomes:
1. Apply, analyze, or evaluate advanced theories, concepts, or methods in neuroscience and neurobiology
   Audience: Both Grad & Undergrad

2. Identify and describe key theories, concepts, and methods in neurobiology
   Audience: Both Grad & Undergrad

3. Explore a new phenomenon or modality in the neuroscience area and apply the knowledge gained to research in the field
   Audience: Graduate
NTP 677 – BASIC SLEEP MECHANISMS AND SLEEP DISORDERS: FROM NEUROBIOLOGY TO SLEEP MEDICINE
3 credits.

Sleep occupies a third of our life, is found in all animal species carefully studied so far, and loss of sleep has both acute and long-term negative consequences on the brain and the body. Still, why we sleep remains unclear, and hypotheses on the role of sleep for synaptic homeostasis, learning and memory are being tested. Focuses on the neurobiology of sleep, with detailed review of the brain structures involved in controlling wake and sleep, as well as the circadian and homeostatic regulation of sleep. Other topics include changes in sleep need with age, animal models to study sleep, sleep disorders, and genetics of sleep.

Requisites: PSYCH 454 and ZOOLOGY/PSYCH 523 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 2023
Learning Outcomes:
1. Outline the physiology and definitions used to define sleep and wake
Audience: Both Grad & Undergrad
2. Detail the brain structures and systems involved in the control of sleep and wake
Audience: Both Grad & Undergrad
3. Describe circadian and homeostatic regulation of sleep and wakefulness
Audience: Both Grad & Undergrad
4. Describe recent evidence linking sleep, memory, and synaptic plasticity
Audience: Both Grad & Undergrad
5. Describe animal models used to study sleep
Audience: Both Grad & Undergrad
6. Describe molecular and genetic approaches to the study of sleep
Audience: Both Grad & Undergrad
7. Recognize how sleep changes across the lifespan
Audience: Both Grad & Undergrad
8. Explain how sleep affects endocrine, metabolic, and cognitive functions
Audience: Both Grad & Undergrad
9. Outline the importance of sleep for the individual and society, including negative consequences of sleep deprivation and sleep disorders
Audience: Both Grad & Undergrad
10. List the symptoms, pathological mechanisms, epidemiology, and treatments of sleep disorders (including insomnia, sleep apnea, central nervous system hypersomnias, circadian rhythm disorders, parasomnias, and sleep-related movement disorders)
Audience: Both Grad & Undergrad
11. Discuss additional very recent studies (selected shortly before class to reflect pertinence and current direction in the field) on sleep topics and learn how to recognize strengths and limitations of these studies relative to prior knowledge on sleep research
Audience: Graduate
12. Describe how to design a sleep experiment and recognize the many confounding factors often associated with sleep studies

NTP 700 – PROFESSIONAL DEVELOPMENT FOR BIOMEDICAL GRADUATE STUDENTS
1 credit.

Provides graduate students with the skills and knowledge necessary to succeed in science. Topics which are covered include choosing a thesis advisor, grant writing, preparing a seminar presentation, etc.

Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2023
Learning Outcomes:
1. Define the concepts of mentorship, mentor-mentee relationships and choosing a thesis advisor, mentor, and thesis committee members
Audience: Graduate
2. Write compelling publications for peer-reviewed journals, authorship responsibilities
Audience: Graduate
3. Critically evaluate a peer-reviewed scientific article
Audience: Graduate
4. Demonstrate knowledge of the concepts of grant writing, specific aims, preparing a seminar presentation, etc.
Audience: Graduate
5. Participate in various types of research collaborations, team science
Audience: Graduate
6. Provide instruction in the responsible conduct of research (RCR) for students; animal and human subject research and ethics
Audience: Graduate
NTP 701 – EXPERIMENTAL DESIGN AND STATISTICAL METHODOLOGY
1 credit.

Application of the scientific method and experimental design, with a focus on experimental neuroscience. Topics include best practices that underlie robust and unbiased experimental approaches, methods, analyses, data interpretation and transparent reporting of results.

**Requisites:** Graduate/professional standing

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Summer 2023

**Learning Outcomes:**
1. Identify appropriate experimental designs relevant to contemporary neuroscience research
   Audience: Graduate

2. Recognize well-designed, well-controlled experiments
   Audience: Graduate

3. Consider experimental design and analysis principles in their own research
   Audience: Graduate

4. Describe appropriate quantitative approaches used in a variety of experimental systems
   Audience: Graduate

5. Recognize (in)appropriate uses of statistics in neuroscience data analysis, interpreting results, and forming appropriate conclusions
   Audience: Graduate

6. Select appropriate application of statistics to neuroscience data in different experimental paradigms
   Audience: Graduate

NTP 735 – NEUROBIOLOGY OF DISEASE
2 credits.

Seminar course relating major categories of human neurological and ophthalmological disease to fundamental topics in neurobiology.

**Requisites:** Graduate/professional standing and NTP/NEURODPT 610

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** No

**Last Taught:** Spring 2022

**Learning Outcomes:**
1. Recognize the clinical aspects (diagnosis and available treatments) for a number of neurological diseases
   Audience: Graduate

2. Critically discuss current papers in the neurobiology of disease literature
   Audience: Graduate

3. Demonstrate understanding of the latest findings and treatments for a number of neurological disorders
   Audience: Graduate

4. Sharpen communication skills by presenting the scientific papers and leading discussion
   Audience: Graduate

NTP/NEURODPT/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 2023

**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

NTP 900 – NEUROSCIENCE SEMINAR: CURRENT TOPICS IN NEUROBIOLOGY
1 credit.

Critical review of selected topics in neurobiology.

**Requisites:** Declared in Neuroscience graduate program

**Course Designation:** Grad 50% - Counts toward 50% graduate coursework requirement

**Repeatable for Credit:** Yes, unlimited number of completions

**Last Taught:** Spring 2024
NTP 990 – RESEARCH AND THESIS
1-12 credits.

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 2024

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. Demonstrate knowledge by critically addressing 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