How do we learn? How do our genes and environment come together to shape our brains? Why is it so hard to recover from addiction? How is neurodevelopment altered in developmental disorders such as Autism? Can we actually teach old dogs (or people) new tricks? A dizzying number of unanswered questions show that understanding the biology of the brain is one of the great scientific challenges of our time. At the core of many of these open questions is the neuronal synapse. In this course, we will focus on the structure and function of synapses, and how they are modified through experience. Specific topics include the impact of different types of synapses on neural function, their wiring and modification during development, and in learning and memory. We will analyze synaptic function and change with aging, as well as how synaptic change in different circuits in the brain are linked to different types of learning. We will discuss how learning and memory are altered in mood disorders and addiction, as well as how they are affected by sleep and exercise.

The course will emphasize analysis of scientific evidence as well as core content. We will draw on work done in a variety of organisms, and discuss key classical studies as well as emerging research. This will involve consistent inclusion of research papers and review articles into class discussion, and a 3-5 page paper that students will write on a question not directly covered in class. As the course will involve in class discussion and work as well as lecture, attendance and participation are important.

Course Objectives:
By completing this course, students will
1. Understand what synapses are and how they function in cell-cell communication in the nervous system.
2. Describe the roles of experience dependent change in synaptic function as it relates to
   a. Wiring of the nervous system
   b. Learning and memory in a variety of functional and behavioral contexts
3. Analyze scientific evidence linking changes in synaptic strength to neuronal function and learning in a variety of organisms.
4. Analyze the role of synaptic function and dysfunction in health and disease states.

Readings:
Readings should be done prior to class. Reading assignments will be drawn from neuroscience texts, and scientific literature.
Primary Text: Kandel, et al, Principles of Neural Science (2013), accessible as an e-text via the WUSTL library, or as a hard copy.
Grade:
1. 10% - Quizzes: 3 quizzes, each accounting for 5% of the course grade. The lowest quiz grade will be dropped. Quizzes will be approximately 15 minutes, covering material discussed in class.
2. 30% - Hour-long exams. There will be two non-cumulative hour-long exams. Your highest exam score will count for 20% of your grade. Your lowest will count for 10%.
3. 25% - Comprehensive (Final) exam on the last day of the course, 90 minutes in length.
4. 15% - 3-5 page paper. Students will explore a scientific question in depth related to class material not directly covered in class time. Students must cite primary research papers.
5. 16% - Homework: 4% each-5 homework assignments. Lowest Homework grade dropped.
6. 4% - Attendance and participation

*Note: Quizzes and tests will feature short answer and essay questions.

Grade Scale

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<tr>
<th>Percentage</th>
<th>Grade</th>
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<tbody>
<tr>
<td>98.0-100%</td>
<td>A+</td>
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<tr>
<td>92.0-97.9%</td>
<td>A</td>
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<tr>
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<td>87.5-89.4%</td>
<td>B+</td>
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</tbody>
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Pass/Fail: Anyone taking this course Pass/Fail must receive 69.5% or better (equivalent to a C-) to receive a Pass.

Course Schedule

**July 18:** Course Introduction, Overview of neural signaling and synaptic function
Case Study: The discovery of chemical synaptic transmission

Reading: [http://neuroscience.uth.tmc.edu/s1/introduction.html](http://neuroscience.uth.tmc.edu/s1/introduction.html)


**July 20:** Structure and function of synapses;
Case Study: The effects of mimicking or blocking neurotransmitters.

Readings:
Kandel, Ch 8, 13

HW1 Due
July 22: Quiz 1 (Covers July 18, 20 class material); How is the nervous system wired? How is it refined?
Case Study: Learning to See: How light exposure shapes visual cortex development
Readings:
http://neuroscience.uth.tmc.edu/s1/chapter09.html
Kandel, Ch 56

July 25: Nervous system wiring throughout the brain.
Case Study: Nervous system development in adolescence and early adulthood
Case Study: Synaptic refinement and Autism
Readings:
HW 2 Due

July 27: Exam 1 (Covers July 18-July 25 Material); The famous patient HM, different types of memory.

July 29: Key features of synaptic plasticity and memory: short and long term storage, associativity
Case Study: Insights from Aplysia: short and long term habituation and sensitization
Reading: Kandel Ch 65

Aug 1: Mechanisms of Spatial and Explicit Memory: Prefrontal Cortex and Hippocampus; Adult neurogenesis in the hippocampus
Readings: Kandel Ch 67
HW 3 Due

Aug 3: Quiz 2 (Covers July 27-August 1 Material); Implicit Memory: Fear and emotional memory
Case study: Manipulating emotional content of memory
Readings:
Kandel Ch 66

Aug 5: Implicit Memory 2: learning, memory, and motor function
Readings:
Kandel Ch 66
HW 4 due

Aug 8: Exam 2 (Covers July 27-August 5 material); Understanding errors in memory
Aug 10: Pathological Learning: Learning and memory in mood disorders and addictive states
Readings:
Kandel Ch 49, 63
HW 5; Optional Deadline for Paper Drafts

Aug 12: Quiz 3 (Covers Aug 8-10 class material); The Aging brain
Reading:
Kandel Ch 59

Aug 15: How do sleep and exercise impact learning and memory performance?
Readings:
Papers due

Aug 17: Exam 3 (Covers July 18-Aug 15 Material); Special topic: TBD