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? 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:
Reading assignments will be drawn from neuroscience texts, and scientific literature. Readings should be done prior to class to preview key themes to be discussed. After class, readings are useful to review topics discussed in class as part of studying.
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. 20% Homework: 4% each-5 homework assignments. Homework problems will primarily relate to material already discussed but will typically also include 1-2 questions related to material in the upcoming class period or related to individual paper.
2. 10% - Quizzes: 3 quizzes, each accounting for 5% of the course grade. The lowest quiz grade will be dropped. Quizzes will be 10 minutes, covering material discussed in class.
3. 30%-Hour-long exams. There will be three non-cumulative hour-long exams. Each will count for 10% of your grade.
4. 15% Comprehensive (Final) exam on the last day of the course (August 2).
5. 20%- 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.
6. 5% In-class work and effort.

Revision policy:
On homework, quizzes, hour-long exams, (#1,2,3 above), you may submit revisions by the next class period to recover up to half of the points you missed. (e.g. If you receive a quiz back with a score of 3/5 on a Tuesday, you may revise and resubmit your work by Thursday of the same week to increase your score to a maximum of 4/5).

Late Work: Assigned work that is turned in late will receive a deduction of 20% of the possible points per day that the assignment is late.

Academic Integrity: Communication is critical to the scientific process. You may discuss ideas and topics with your classmates, but assignments should represent your own, individual work. Suspected Academic Integrity Violations will be reported to University College Academic Integrity Officer: http://bulletin.wustl.edu/grad/ucollege/policies/

Grade Scale
98.0-100%: A+
92.0-97.9%: A
89.5-91.9%: A-
87.5-89.4%: B+
82.0-87.4%: B
79.5-81.9%: B-
77.5-79.4%: C+
72.0-77.4%: C
69.5-71.9%: C-
67.5-69.4%: D+
62.0-67.4%: D
59.5-61.9%: D-
0-59.4%: F

Pass/Fail: Anyone taking this course Pass/Fail must receive 59.5% or better (equivalent to a D-) to receive a Pass.
**Course Schedule**

**June 12:** Course Introduction, Neural signaling, Structure and function of synapses  
**Reading:**
- [https://nba.uth.tmc.edu/neuroscience/s1/introduction.html](https://nba.uth.tmc.edu/neuroscience/s1/introduction.html)  
- [https://nba.uth.tmc.edu/neuroscience/s1/chapter05.html](https://nba.uth.tmc.edu/neuroscience/s1/chapter05.html)

**June 14:** HW1 Due. Discovery of chemical synapses, structure and function of synapses, different classes of neurotransmitters and synapses.  
**Readings:** Kandel, Ch 8, 10  

**June 19:** Quiz 1 (Covers June 12, 14 class material). Chemical modifiers of receptor function.  
**Readings:**  
- [https://nba.uth.tmc.edu/neuroscience/s1/chapter06.html](https://nba.uth.tmc.edu/neuroscience/s1/chapter06.html)

**June 21:** Exam 1 (Covers June 12, 14, 19) Learning and memory 1: Can you teach an old owl (or person) new tricks? Where is memory stored in the brain?  
**No readings**

**June 26:** Defining memory and parts of the brain associated with memory. How *Aplysia* and *Drosophila* help us understand how memory works.  
**Reading:** Kandel Ch 65, Ch 66: only parts BEFORE heading “Memory of Learned Fear in Mammals Involves the Amygdala”

**June 28:** HW 2 Due. Mechanisms of Spatial and Explicit Memory: Prefrontal Cortex and Hippocampus  
**Readings:** Kandel Ch 67  

**July 3:** Quiz 2 (Covers June 21-June 28 Material); Spatial and explicit memory; Mechanisms of implicit memory  
**Readings:** Kandel Ch 66  
- [https://nba.uth.tmc.edu/neuroscience/s3/chapter04.html](https://nba.uth.tmc.edu/neuroscience/s3/chapter04.html)  
- [https://nba.uth.tmc.edu/neuroscience/s4/chapter06.html](https://nba.uth.tmc.edu/neuroscience/s4/chapter06.html)

**July 5:** HW 3 Due. Implicit memory, Bias and errors in memory.  
**Readings:**  
Kandel Ch 65 section on errors in memory  
July 10: Exam 2 (Covers June 21-July 5 material); The discovery of Nerve Growth Factor/early development

Reading:

July 12: Activity-dependent circuit refinement in development: Learning to see, critical periods and Autism.

Readings:
Kandel Ch 55 ONLY section titled “Some synapses are eliminated after birth,” Ch 66

July 17: HW 4 due. The Teen brain, causes of Schizophrenia.

Readings:
Kandel Ch 62

July 19: Quiz 3 (Covers July 10-July 17 class material); The Aging brain and neurodegeneration

Reading:
Kandel Ch 59

July 24: HW 5 due. Pathological memory: PTSD and addiction

Optional deadline for paper drafts.

Readings:
Kandel Ch 63 section on Anxiety Disorders only, Ch 49 section titled Drug abuse and addiction are goal-directed behaviors

July 26: Exam 3 (Covers July 12-July 24 Material); Exercise and the brain

No readings.

July 31. Papers due. Exercise, sleep, and cognition

Readings:

August 2: Final Exam, future of neuroscience