

PSYC 437 Neurobiology of Learning and Memory  
Department of Psychology & Neuroscience

**Prerequisite:** PSYC 220 or 315. BIOL 101 is recommended.

**Target audience:** This course focuses on the current state of our knowledge about the neurobiological basis of learning and memory using a combination of lectures and student-led discussions. This course is intended for undergraduates interested in molecular, cellular, computational and systems level analysis of learning and memory from a behavioral and neural perspective.

**Course Goals and Key Learning Objectives:**

- Describe, and be able to explain, the major terminology, theories, and research methods used when studying learning and memory.
- Read, present, discuss, and critically evaluate empirical learning and memory research.
- Provide a critical analysis of the literature through written and oral forms of communication that includes a synthesis of findings with concepts discussed in the literature and in class.

**Required reading**

1. Neurobiology of Learning and Memory by J.W. Rudy.
2. Primary literature (see below). You will find these readings via Pubmed and access them through the UNC library.

**WHAT YOU SHOULD BRING TO CLASS EVERY DAY:**

1. A laptop or notebook for note taking. Note: educational research shows that students learn more by handwriting notes, despite how convenient we all feel a laptop is!
2. Extra blank paper for drawings, notes, activities etc. (or tablet computer for drawing)
3. 3 x 5 index cards to turn in to me during activities (with or without lines, preferably white).
4. A smart-device: either your laptop/ipad/smartphone enabled for UNC wi-fi access (don't rely on cellular service)

**Course Requirements**

1. **Quizzes:** Online quizzes will be used as a study tool and to assess your learning. These quizzes will help you keep abreast of your reading for the class, and will help you determine if you took away key concepts from the reading. Quizzes are due *prior* to the relevant class, closing 1 hour before class begins. Quizzes will include ~5 multiple choice and/or fill-in-the-blank questions. Your lowest quiz score will be dropped. Make up quizzes will not be administered.
2. **Class participation** is an important part of this class and will contribute significantly to your learning experience. Participation will count for 10% of the final grade. Active participation requires being present for the entire class period and taking part in the discussion. Participating in seminars and discussions involves developing a particular skill set. Therefore, you should expect to improve at discussion over time just like you would in other

skills like reading, writing, or learning another language. Focus on improving your skills. This is an active learning process! I am more interested in your willingness to explore ideas - out loud - than your "getting it right". In class participation will be scored as: 0 (no participation/no notes), 0.5 (minimal contribution), 1 (insightful comments/questions). On lecture days, PollEverywhere may be used to facilitate discussion (PollEv.com/neurons), and additional in-class exercises will count toward your participation grade.

3. **Reading questions:** Over the course of the semester, you will read a number of primary research papers. To facilitate your understanding of these papers, you'll submit answers to a set of reading questions. You should write your answers in complete sentences, but using bullet points is fine. Your responses should be relatively short – in many cases a couple of sentences is all that's needed. Answers to these reading questions should be submitted via Sakai by no later than 10pm the night before we discuss the primary paper. Late submissions will not be accepted. These questions should address the following (1 point for each):
  - i. What is the hypothesis?
  - ii. What predictions are tested?
  - iii. What kinds of techniques and methods are used to test the predictions?
  - iv. What are the main findings of the research?
  - v. Why are these findings important for everyday life?
  
4. **Student-led Discussion:** For each of the primary papers we will read in class, 2 students will be responsible for leading a discussion period on the assigned primary paper. You should: 1) use visual aids, 2) do *additional* research on your own to enrich the discussion, 3) summarize the work in YOUR OWN WORDS, and 4) bring several pre-prepared questions to facilitate discussion. You will post these questions on Sakai, in the resources folder "Discussion questions" 48 hours before your discussion. I encourage you to start working on your discussions early so that you have sufficient time to meet with me with your questions. Meeting with me is not required, but I encourage you to do so if anything is unclear to you, or if you just want to talk about how awesome your paper is! This assignment constitutes a large proportion of your grade for the semester – you should expect to put in significant effort. You will be graded on:
  - i. How well you summarize the **main findings** of the paper – not necessarily the entirety of the paper (5 points)
  - ii. Your visual aids – don't just load a bunch of slides with text! (3 points)
  - iii. Your own research that goes beyond the paper you are discussing (3 points)
  - iv. Your discussion questions (3 points)
  - v. How well you convey why the research is important in everyday life, or how/why it's applicable to you, your grandma, your neighbor... (5 points)
  - vi. Your ability to work well with your partner, as assessed by a peer evaluation (1 point)

Students who are not leading the discussion should look at the discussion questions posted on Sakai by the discussion leaders and be prepared to discuss them in class. For discussion classes, you will spend the first 15 minutes of the class working in small groups going over the paper together. Bring a copy of the paper and your reading questions with you to class to make notes on. I may also provide you with additional activities to complete in your groups. The remainder of the class will be spent discussing the paper as a class, with the discussion leaders facilitating.

5. **Exams:** There will be 4 exams in total over the course of the semester, 3 will take place in class, and one will take place during the final examination period. Your best 3 test scores will go toward your final grade (i.e. you will be

able to drop your lowest test score). Exams will be a combination of multiple choice and short answer/essay type questions. Note that study questions are available on Sakai under 'resources' and are exactly the kinds of questions that will appear on your exams. **Final Exam Schedule:** We are required to have our final exam on **December 11th at 8am**. If you have two exams at the same time or three exams within 24 hours and you want to reschedule the exam, then see an academic advisor for an exam excuse form. Please give me the pink copy of your exam excuse form on or before our last lecture meeting. When you turn in your form, you will be provided with the date, time and location of the alternate exam.

6. **Summary paper:** You will submit one 5-6 page paper that summarizes one of the primary papers we discussed in class. These papers give you the opportunity to express your ideas about how neuroscience is relevant to everyday life, as well as develop critical thinking and writing skills. Because you have 3 opportunities to submit critical analysis papers (\*see due dates below), late papers will not be accepted/graded. The overall goal of this paper to summarize the primary paper for someone who has not read the paper, and tell them how the main findings apply to everyday life. Your paper should include the following:

- 1) A concise statement of the problem(s) that the paper addresses (1 point)
- 2) A summary of the main findings and conclusions (2.0 points)
- 3) Why the findings are important in everyday life (i.e., to the lay person) (2.5 points)
- 4) An **original** figure that highlights the main findings, ideas, or themes of the work contained within the paper (3 points)
- 5) Reference materials used to prepare the paper should be listed at the end. Include all works cited, including any additional research you did to enhance your paper. (0.5 point)
- 6) Clarity of the paper as a whole – the paper is well edited, language is clear and concise, and is free of unnecessary jargon. (1 point)

\*\*Please note: your paper must be written in your OWN words. Quoting passages from your sources (yes, even in quotation marks) will result in a grade of 0.

### Course Grading Criteria

- Quizzes (drop lowest score) (5%)
- Participation (10%)
- Reading questions (drop lowest score) (15%)
- Student-led discussion (20% of grade)
- Exams (best 3 of 4) (30% of grade)
- Critical analysis paper (20% of grade)

### Letter Grade Assignments

A = 94-100	C+ = 77-79	F = 0-59
A- = 90-93	C = 74-76	
B+ = 87-89	C- = 70-73	
B = 84-86	D+ = 67-69	
B- = 80-83	D = 60-66	

\* Final grades are rounded (.4 down and .5 up). For example 89.4 = 89/B+; 89.5 = 90/A-.

**Note on attendance:** Regular attendance and class participation are expected. You are responsible for your attendance and for any information you miss by not attending class. This includes, but is not limited to: lecture material,

assignments, exams. Note that much of the class is centered around discussion, so regularly missing classes will significantly impact your grade. If you know that you will not be able to attend class, please let me know prior to the class you will miss.

**Digital etiquette:** It will sometimes be necessary to use a digital device during class time. Please be respectful of your classmates and restrict your use to course content. If you choose to buy a new sweater or surf Facebook anyway, I may ask you to put your device away for the rest of the class, and you will forfeit your participation points for that day. It's likely that there will be times in class when you have completed your work, but your classmates have not – use this time to review your notes before we move on. We are all working as a learning team in class, and we're only as awesome as our weakest link! Don't let it be you!

**Accessibility Resources & Service:** If you have accommodations to take exams at the Office of Accessibility Resources, please let me know as soon as possible (and well before the first exam).

**ACADEMIC INTEGRITY:** As in all Carolina courses, the Honor Code is in effect. The Instrument of Student Judicial Governance requires that you sign a pledge on all written work that says “On my honor, I have neither given nor received unauthorized aid on this assignment.” This Code applies to all exams and class projects. Although you may study together for exams, all exams are to be taken without the assistance of other people, books, or notes. Ideas or information in your written work and class presentations must be appropriately referenced, whether the original source is written or verbal. Five or more words taken verbatim from any source must be placed in quotation marks with the source appropriately referenced. If you have not done so previously, please review the academic code at UNC at [http://integrity.unc.edu/hc\\_handout.html](http://integrity.unc.edu/hc_handout.html). Suspected cases of academic misconduct must be reported to the Office of the Dean of Students.

## SCHEDULE

**Changes to the Syllabus:** If a change to the syllabus becomes necessary, I will announce this in class or by email. It is your responsibility to check it and your UNC email account regularly.

\* Due dates for critical analysis papers; **Bolded dates** indicate quizzes are due before class

Date	Topic	Reading
08-19	Introduction to class	
<b>08-21 Quiz 1</b>	Fundamental Concepts and Historical Foundations	Chapter 1
<b>08-24</b>	Neuroanatomy review (in-class quiz)	LECTURE SLIDES
08-26	Neurophysiology review (in-class quiz)	LECTURE SLIDES
08-28	Experimental design	Reading on Sakai
08-31	Anatomy of an empirical paper; using search engines effectively (e.g., Pubmed)	LECTURE SLIDES
<b>09-02 Quiz 2</b>	Mechanisms of Synaptic Plasticity	Chapter 2

<b>09-04 Quiz 3</b>	Modifying Synapses: Central Concepts	Chapter 3
09-07	No Class	
<b>09-09 Quiz 4</b>	Making Memories: Conceptual Issues and Methods	Chapter 9
09-11	Making Memories: Conceptual Issues and Methods	TBA
09-14	EXAM 1	
<b>09-16 Quiz 5</b>	Memory Formation: Early Stages	Chapter 10
09-18	<b>Practice Discussion:</b> Tang YP, Shimizu E, Dube GR, Rampon C, Kerchner GA, Zhuo M, Liu G, Tsien JZ (1999) Genetic enhancement of learning and memory in mice. Nature 401: 63-69.	
<b>09-21 Quiz 6</b>	Memory Consolidation	Chapter 11
09-23	<u>Discussion 1:</u> Borota D, Murray E, Keceli G, Chang A, Watabe JM, Ly M, Toscano JP, Yassa MA. (2014) Post-study caffeine administration enhances memory consolidation in humans. Nat Neurosci: 201-203.	
<b>09-25 Quiz 7</b>	Memory Maintenance and Forgetting	Chapter 12
09-28	<u>Discussion 2:</u> Shema R, Haramati S, Ron S, Hazvi S, Chen A, Sacktor TC, Dudai Y (2011) Enhancement of consolidated long-term memory by overexpression of protein kinase M zeta in the neocortex. Science 331:1207-10.	
09-30	<u>Discussion 3:</u> Lee AM, Kanter BR, Wang D, Lim JP, Zou ME, Qiu C, McMahon T, Dadgar J, Fischbach-Weiss SC, Messing RO (2013). Prkcz null mice show normal learning and memory. Nature. 493: 416-419.	
<b>10-02 Quiz 8</b>	Memory Modulation Systems	Chapter 13
10-05	<u>Discussion 4:</u> de Quervain DJ, Roozendaal B, McGaugh JL. (1998) Stress and glucocorticoids impair retrieval of long-term spatial memory. Nature. 394:787-90.	
<b>10-07 Quiz 9</b>	The Fate of Retrieved Memories	Chapter 14
10-09	<u>Discussion 5:</u> Otis JM, Mueller D. (2011) Inhibition of $\beta$ -adrenergic receptors induces a persistent deficit in retrieval of a cocaine-associated memory providing protection against reinstatement. Neuropsychopharmacology. 36:1912-20.	
10-12	<u>Discussion 6:</u> Schwabe L, Nader K, Wolf OT, Beaudry T, Pruessner JC (2012) Neural signature of reconsolidation impairments by propranolol in humans. Biol Psychiatry 71:380-386.	
10-14	<b>EXAM 2</b>	
10-16	No class	
<b>10-19 Quiz 10</b>	Memory Systems and the Hippocampus	Chapter 15
<b>10-21 Quiz 11</b>	The Hippocampus Index and Episodic Memory	Chapter 16
10-23*	<u>Discussion 7:</u> Bakker A, Kirwan CB, Miller M, Stark CE. (2008) Pattern separation in the human hippocampal CA3 and dentate gyrus. Science. 319:1640-2.	
10-26	<u>Discussion 8:</u> Wimmer GE, Shohamy D (2012) Preference by association: how memory mechanisms in the hippocampus bias decisions. Science. 2012 Oct 12;338(6104):270-273.	
<b>10-28</b>	The MTH System: Episodic Memory, Semantic Memory, and Ribot's Law	Chapter 17

<b>Quiz 12</b>		
10-30	<u>Discussion 9</u> : Wang SH, Teixeira CM, Wheeler AL, Frankland PW. (2009) The precision of remote context memories does not require the hippocampus. Nat Neurosci. 12:253-5.	
11-02	<b>EXAM 3</b>	
<b>11-04 Quiz 13</b>	Action, Habits, and the Cortico-Striatal System	Chapter 18 – to the end of p 365
<b>11-06 Quiz 14</b>	Action, Habits, and the Cortico-Striatal System	Chapter 18 – remainder of the chapter
11-09	<u>Discussion 10</u> : Smith KS, Virkud A, Deisseroth K, Graybiel AM. (2012) Reversible online control of habitual behavior by optogenetic perturbation of medial prefrontal cortex. Proc Natl Acad Sci U S A. 109:18932-7.	
11-11*	<u>Discussion 11</u> : Flagel SB, Clark JJ, Robinson TE, Mayo L, Czuj A, Willuhn I, Akers CA, Clinton SM, Phillips PE, Akil H. (2011) A selective role for dopamine in stimulus-reward learning. Nature. 469:53-7.	
11-13	<u>Discussion 12</u> : Nasrallah NA, Clark JJ, Collins AL, Akers CA, Phillips PE, Bernstein IL. (2011) Risk preference following adolescent alcohol use is associated with corrupted encoding of costs but not rewards by mesolimbic dopamine. Proc Natl Acad Sci U S A. 108:5466-71.	
<b>11-16 Quiz 15</b>	Learning about Danger: The Neurobiology of Fear Memories	Chapter 19
11-18	<u>Discussion 13</u> : Choi J-S., Kim JJ (2010) Amygdala regulates risk of predation in rats foraging in a dynamic fear environment. Proc Natl Acad Sci 107: 21773-21777.	
11-20	<u>Discussion 14</u> : Hauner KK, Howard JD, Zelano C, Gottfried JA (2013) Stimulus-specific enhancement of fear extinction during slow-wave sleep. Nat Neurosci 16:1553-5.	
<b>11-23 Quiz 16</b>	The Role of Replay and Sleep in Learning and Memory: Diekelmann S, Born J (2010) The memory function of sleep. Nat Rev Neurosci 11:114-126.	
11-25	No class	
11-27	No class	
11-30*	<u>Discussion 15</u> : Rolls A, Colas D, Adamantidis A, Carter M, Lanre-Amos T, Heller HC, de Lecea L (2011) Optogenetic disruption of sleep continuity impairs memory consolidation. Proc Natl Acad Sci U S A 108:13305-13310.	
12-02	<u>Discussion 16</u> : Wilhelm I, Diekelmann S, Molzow I, Ayoub A, Mölle M, Born J (2011) Sleep selectively enhances memory expected to be of future relevance. J Neurosci 31:1563-1569.	

**Final Exam:** Friday December 11<sup>th</sup>, 8am ☹