Course syllabus 03-365 & 03-765

Neural Correlates of Learning and Memory, Spring 2016
Instructors: Sandra Kuhlman, Ph.D. and DJ Brasier, Ph.D.

Course Description: This course will examine the biological substrates of learning, memory, and behavioral adaptation. The focus will be on addressing how neural circuits change during new skill acquisition and adapt to variations in the environment. An introduction to experience-dependent changes in neural structure and function, in addition to behavioral learning paradigms, will be provided. Then we will consider the ways in which specific changes in biological substrates give rise to the emergent properties that drive behavioral adaptation, followed by in depth coverage of deciphering which biological substrates constitute a lasting memory trace. Finally, the concept of age-dependent learning will be examined. Concepts and specific examples will come through reading of primary literature and selected readings from advanced texts.

Pre-requisites: 03-161 or 03-240 or 42-202 or 85-219

Learning objectives: Students should demonstrate understanding of major methods to study the biological underpinnings of learning and memory. To do this, students should develop the ability to read, understand, and discuss original research. In addition, students should be able to propose follow-up experiments that would significantly further our understanding of learning and memory. Finally, students should demonstrate proficient understanding of the following topics:

• Paradigms used to study learning
• Behavioral adaptation
• Structural and functional plasticity of individual neurons
• Learning-induced changes in emergent circuit properties
• Balance of excitation/inhibition during learning
• Substrates of learning vulnerable to disease
• Critical period plasticity

Class times: 03-363: TR 9:00 – 10:20 SH 125
03-763: TR 9:00 – 10:20 SH 125 & R 4:30 – 5:50 MI 355

Textbook (not required): The Neurobiology of learning and memory by Jerry Rudy.

Office hours Thursdays 1:30 to 2:30 pm
Kuhlman: MI 159B, email: skuhlman@cmu.edu
Brasier: WEH 4624, email: dbrasier@cmu.edu

If Thursdays from 1:30 to 2:30 do not work, please email us to schedule a meeting time.
Grading (03-365):
Exam 1: ~15% (100 points)
Exam 2: ~15% (100 points)
Final: ~30% (200 points)
Top 5 of 6 quizzes: ~15% (20 points per quiz, 100 total)
Oral Presentation: ~10% (70 points)
Homework, class participation, including review questions: ~15% (100 points total)

Total grade is out of 670 points.

- **Exams.** We only give make up exams with documented illness or in accordance with other CMU exam policies (http://www.cmu.edu/policies/documents/Exams.htm). The mid-term exams will only explicitly test material in that unit of the course (they are not cumulative). However, many of the questions will assume a basic understanding of the concepts from earlier units.

- **The final.** The final is cumulative for the entire course. It will be during finals week. Last year it was on the last day of finals, do not book travel for before May 11th!

- **Exam re-grades.** We are committed to grading as fairly as possible. If you think a mistake was made in grading your exam, you can submit your exam and a written explanation of why you think you deserve more points than you were given and your exam will be re-graded. Re-grades must be submitted no more than one week after exams have been returned. The instructors reserve the right to re-grade the entire exam in addition to the disputed question, and add or subtract points.

- **Homework.** For many class periods, you will be required to bring a summary and/or questions about assigned readings.

- **Class participation.** Students are expected to participate actively in class discussions. Your participation in small group and class-wide discussions during the semester is required. Additionally, at the end of some class periods, you will be required to submit a written summary of main points from the class and also questions you have.

- **Quizzes.** There will be occasional quizzes at the beginning of class that. The purpose of this is to ensure students stay on top of the course material and to encourage reviewing material regularly as well as to prepare you for exams.

- **Presentation.** More details will be given out during the second week of classes.

Grading (03-765):
In addition to all the above, students enrolled in the graduate course will have two individual projects to complete (both will require students to draw from existing experiments and literature, and design a new follow-up experiment) and two group projects (one will be a group presentation of recent advances in understanding of neural plasticity and the other will be a meta-analysis of data from several individual publications in the field in which students will have to develop a cohesive model of different levels of analysis (e.g. molecular, cellular, circuits). See supplemental syllabus for details.
<table>
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<tr>
<th>Date</th>
<th>Topic</th>
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<tbody>
<tr>
<td>Jan 12 (t)</td>
<td>Fundamental concepts and historical foundations of memory storage. Material from: Jerry Rudy textbook.</td>
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<tr>
<td>Jan 14 (th)</td>
<td>Modifying synapses: molecular components and principles. Material from: Jerry Rudy textbook and one classic research article.</td>
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| Jan 19 (t) | *Quiz*  
Instrumental learning and cholinergic neuromodulators. Material from one research article.                                       |
| Jan 21 (th)| Defining three biological substrates of plasticity: synaptic connection, strength, and intrinsic excitability. Material from one review article [Linden]. |
| Jan 26 (t) | Intrinsic excitability plasticity in the cerebellum and brain stem. (DJB)                                                               |
| Jan 28 (th)| *Quiz*  
Assaying behavior in animals: device design and signal acquisition.                                                                  |
| Feb 02 (t) | Dendritic spine dynamics and associative learning. Material from two research articles.                                                 |
| Feb 04 (th)| Gene transcription, epi-genetics, and persistent changes across generations. Material from Jerry Rudy textbook and one research article. Submit review & questions by end of class. |
| Feb 09 (t) | Context-dependent behavior: role of hippocampus. Material from one research article.                                                   |
| Feb 11 (th)| *Quiz*  
| Feb 16 (t) | Neurobiology of forgetting (e.g. fear). Material from: Jerry Rudy textbook.                                                              |
| Feb 18 (th)| **Exam**                                                                                                                                 |
| Feb 23 (t) | Seasonal memory and circadian rhythms: role of spontaneous oscillations in activity. Material from one review article.                  |
| Feb 25 (th)| Fear memories, Part 2a. Oral presentations (7 minutes each) and class discussion.                                                        |
Mar 01 (t)  Fear memories, Part 2b. Oral presentations (7 minutes each) and class discussion.

Mar 03 (th) Fear memories, Part 2c. Oral presentations (7 minutes each) and class discussion.

Mar 08 (t)  Spring Break

Mar 10 (th) Spring Break

Mar 15 (t)  Memory systems and hippocampus, Rudy chapter 15

Mar 17 (th) Memory systems and hippocampus, research articles

Mar 22 (t)  Consolidation of memory, Rudy chapter 11

Mar 24 (th) Quiz
Reconsolidation theory, Rudy chapter 14

Mar 29 (t)  Dopamine and other neuromodulators in memory, Rudy chapter 13

Mar 31 (th) Quiz
Cortico-striatal system and habit learning, Rudy chapter 19

Apr 05 (t)  Cortico-striatal system and habit learning, research articles

Apr 07 (th) Exam

Apr 12 (t)  Perceptual & sensory learning: review article

Apr 14 (th) No Classes, carnival

Apr 19 (t)  Behavioral methods for studying working memory. Material from: Jerry Rudy textbook.

April 21 (th) Changing the rules: cingulate cortex and the biological basis of flexible behavior. Material from one review article.

April 26 (t) Quiz
Impact of early maternal separation on cognitive flexibility. Material from one research article. Submit review & questions by end of class.

April 28 (th) Emergence of anticipatory signals during learning: role of cortical feedback. Material from two research articles.

Final exam (cumulative, date TBA)