Goals of course:

- To examine the biophysical concepts of neural function with the emphasis on neural signal processing at synapses and elementary circuits.
- To study modern biophysical/engineering approaches to investigate neural function.
- To learn critical analysis and presentation of primary research literature

Coursemaster:

Vitaly Klyachko  
Whitaker 390D  
Office hours: Mon: 11:30am-1:30pm  
Phone: 935-8538(BME), 262-5517 (Med School)  
Email: klyachko@wustl.edu

Credit: 3 units

Prerequisites:

Introductory Neuroscience, Mathematical analysis, or permission of instructor

Suggested Text:

"Foundations of Cellular Neurophysiology" by Johnston and Wu, The MIT Press.

Lectures and Discussions:

The course will combine lectures and weekly discussions of primary research literature.

Lectures will be held in Whitaker Hall, Rm 216 on Mondays from 10:00am-11:30am.

The primary literature presentations and discussions will be held in Whitaker Hall, Rm 216 on Wednesdays from 10:00am-11:30am.

In class presentations:

Each student will make two PowerPoint presentations of primary research papers during the semester.  
Each presentation will count towards 1/4 of the class grade.

Sign up for 2 half-class presentation dates: 
http://www.doodle.com/zsh2ch2fn8b6x69f

Presentation evaluation:

Evaluation will be based on the following criteria: understanding and presentation of techniques used, understanding and presentation of background information, ability to present and synthesize ideas described in the papers, clarity of presentation.

Exams:

There will be two take-home tests. The first will be held during the semester. The second will be given during the final exam period for this course.
Grading:
Exam #1 – 1/4 of the grade.
Exam #2 – 1/4 of the grade.
Presentation – 1/4 of the grade.

The final grade will not be curved-graded.

**Cellular Neurophysiology**

**Schedule**

Whitaker Hall (BME, Rm 216)

**Wednesday, January 19**
10:00 Lecture 1: Neuronal communication: synaptic/dendritic structure and function  
Reading: “Foundations of Cellular Neurophysiology” by Johnston and Wu, Chapters 1, 2

**Monday, January 24**
10:00 Lecture 2: Functional diversity of voltage-gated ionic conductances, stochastic channel mechanisms  
Reading: “Foundations of Cellular Neurophysiology” Ch. 7, 9

**Wednesday, January 26**
10:00 Discussion 1-2: Voltage-gated ion channels in synaptic function  
http://jp.physoc.org/content/333/1/619.long
http://www.jstor.org/stable/2886703

**Monday, January 31**
10:00 Lecture 3: Linear and non-linear properties of excitable membranes  
Reading: “Foundations of Cellular Neurophysiology”, Ch. 2, 6

**Wednesday, February 2**
10:00 Discussion 3: Action potential: initiation and propagation  
http://www.nature.com/nature/journal/v440/n7087/full/nature04610.html

http://www.jneurosci.org/cgi/reprint/28/29/7260

**Monday, February 7** 
10:00 Lecture 4: **Functional properties of dendrites**  
*Klyachko*

Reading: “Foundations of Cellular Neurophysiology”, Chapter 4

**Wednesday, February 9** 
10:00 Discussion 4: **Dendritic signaling mechanisms**  
*Klyachko*

http://www.jneurosci.org/cgi/reprint/26/7/2088

http://www.nature.com/nature/journal/v375/n6533/pdf/375682a0.pdf

**Monday, February 14** 
10:00 Lecture 5: **Synaptic transmission I, quantal analysis**  
*Guest lecture: Wilkinson*

Reading: “Foundations of Cellular Neurophysiology”, Ch. 11

**Wednesday, February 16** 
10:00 Discussion 5: **Foundations of quantal analysis**  
*Klyachko/Wilkinson*

http://jp.physoc.org/content/124/3/560.long  
see also: http://jp.physoc.org/content/117/1/109.long

http://jn.physiology.org/cgi/reprint/73/3/1145

**Monday, February 21** 
10:00 Lecture 6: **Synaptic transmission II: Calcium and neurotransmitter release; molecular mechanisms of release**  
*Guest lecture: Wilkinson*

Reading: Foundations of Cellular Neurophysiology”, Ch. 12
Wednesday, February 23
10:00  Discussion 6:  The role of calcium in neurotransmitter release  

Papers:  
See also: http://jp.physoc.org/content/189/3/535.long

http://jp.physoc.org/content/193/2/419.long

Monday, February 28
10:00  Lecture 7:  Excitatory vs. inhibitory synaptic transmission, Feed-forward/feedback inhibition  

Reading:  
Foundations of Cellular Neurophysiology”, Ch. 13

Wednesday, March 2
10:00  Discussion 7:  Mechanisms of inhibitory synaptic transmission  

Papers:  
http://jp.physoc.org/content/130/2/326.full.pdf

http://www.sciencemag.org/cgi/content/full/311/5758/233 
See also: http://www.nature.com/neuro/journal/v12/n1/pdf/nn.2230.pdf

Take-home Exam 1

March 7 – March 11: Spring Break

Monday, March 14  
10:00  Lecture 8:  Synaptic vesicle cycling 

Reading:  
“Foundations of Cellular Neurophysiology”, Ch. 12

Wednesday, March 16  
10:00  Discussion 8:  Debate on vesicle recycling mechanisms 

Papers:  
http://jcb.rupress.org/cgi/reprint/57/2/315 
See also: http://jcb.rupress.org/cgi/reprint/57/2/499

Monday, March 21
10:00 Lecture 9

Short-Term synaptic plasticity: presynaptic mechanisms

Klyachko

Reading:

"Foundations of Cellular Neurophysiology", Ch 11, 12

Wednesday, March 23
10:00 Discussion 9:

Short-term synaptic plasticity and information processing

Klyachko

Papers:

http://jn.physiology.org/cgi/reprint/97/4/2863

http://www.nature.com/nature/journal/v421/n6918/pdf/nature01248.pdf

Monday, March 28
10:00 Lecture 10:

Postsynaptic mechanisms, spatial and temporal summation, dendritic attenuation

Guest Lecture: Huettner

Reading:

Foundations of Cellular Neurophysiology”, Ch 13

Wednesday, March 30
10:00 Discussion 10:

Postsynaptic mechanisms

Klyachko/Huettner

Papers:

http://www.nature.com/nature/journal/v346/n6284/pdf/346565a0.pdf

See also: http://www.nature.com/neuro/journal/v2/n6/pdf/nn0699_508.pdf

Monday, April 4
10:00 Lecture 11:

Long-term Plasticity, learning and memory

Guest Lecture: Huettner

Reading:

Foundations of Cellular Neurophysiology”, Ch 14, 15

Wednesday, April 6
10:00 Discussion 11:

Papers:

Long-term plasticity, learning and memory

Klyachko/Huettner

Isaac, Nicoll, Malenka (1995) Evidence for silent synapses:
implications for the expression of LTP. *Neuron* 15:427-434.


### Monday, April 11

10:00 Lecture 12:

**Electrophysiological methods to study synaptic mechanisms.**  
*Klyachko*

Reading:

Foundations of Cellular Neurophysiology”, Ch 8, 14

### Wednesday, April 13

10:00 Discussion 12:

**Modern Electrophysiological techniques**  
*Klyachko*

Papers:

- Neher and Sakmann (1976) Single-channel currents recorded from membrane of denervated frog muscle fibres.  

- Neher and Marty (1982) Discrete changes of cell membrane capacitance observed under conditions of enhanced secretion in bovine adrenal chromaffin cells.  
  *Proc Natl Acad Sci U S A.* 79:6712-6.  

### Monday, April 18

10:00 Lecture 13:

**Optical techniques to study synaptic mechanisms**  
*Guest Lecture: Holy*

Reading:

Foundations of Cellular Neurophysiology”, Ch B

### Wednesday, April 20

10:00 Discussion 13:

**High-resolution imaging techniques for in vivo and in vitro studies of neuronal function**  
*Klyachko/Holy*

  http://www.sciencemag.org/cgi/reprint/248/4951/73

  http://www.nature.com/nature/journal/v440/n7086/pdf/nature04592.pdf

### Monday, April 25

10:00 Lecture 14:

**Role of synapses in higher order processing:**  
*Guest Lecture: Burkhalter*

**synaptic integration in cortical networks**

Reading:

The Synaptic Organization of the Brain by G. Shepherd,  
Oxford Univ. Press, Ch. 12
Wednesday, April 27

10:00 Discussion 14: Synaptic function in cortical networks

Papers:


Take-home Exam 2