BIOLOGY 640-001: Cellular Neurophysiology

INSTRUCTOR: Dr. Dirk Bucher  
EMAIL: bucher@njit.edu

OFFICE: 420G Central King Bldg.  
OFFICE HOURS: M, R: 2:00PM - 3:00PM

COURSE SCHEDULE: M, R: 4:00PM – 5:25PM • CKB 212  
COURSE WEBSITE: http://moodle.njit.edu/

COURSE DESCRIPTION: This course will examine the nervous system from a functional perspective. The goal is to understand how ion channels and other components of nerve cells give rise to electrical excitability and synaptic function, and how those properties are then used for coding information and higher order function in the nervous system.

TEXTBOOK:  

LEARNING OUTCOMES:

STUDENTS WILL BE ABLE TO:

- To understand in some detail how electrical and chemical signaling within and between nerve cells works.
- To understand the experimental and theoretical approaches used to study neurophysiology, both for basic research and medical diagnostics.
- To understand fundamental principles of how the nervous system uses electrical activity to encode and decode information about the outside world and internal states.
- To further develop critical thinking and communication skills. This will be measured in the ability to interpret graphs, experimental designs, and problem discussion. Students will be required to participate in instructor-led discussions of the material as they analyze problems and propose possible mechanisms used by neurons to solve them. Weekly quizzes will be used to test some of these goals and reinforce the learning of the material.

IMPORTANT RULES AND COURSE POLICIES:

- **Academic Integrity:** The Academic Integrity Code strictly enforced!
- **Electronic Devices:** The use of cell phones and other electronic devices during class or exam times is prohibited.
- **Make-Up Exams and Quizzes:** If you miss an exam due to a valid medical excuse you need to provide a doctor’s note or other valid and verifiable documentation. The grade of exams missed for a valid reason will be determined on a case-by-case basis.
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Grading Policy: The final grade in this course is determined as follows:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Percentage</th>
<th>Grade Scale</th>
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<tbody>
<tr>
<td>Participation &amp; Weekly Quizzes</td>
<td>25%</td>
<td>A: 88.1-100</td>
</tr>
<tr>
<td>Midterm Exam I:</td>
<td>20%</td>
<td>B+: 80.1-88</td>
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<tr>
<td>Midterm Exam II:</td>
<td>20%</td>
<td>B: 73.1-80</td>
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<tr>
<td>Final Exam:</td>
<td>35%</td>
<td>C+: 66.1-73</td>
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<tr>
<td>Total:</td>
<td>100%</td>
<td>C: 60.1-66</td>
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<td>F: 0-60</td>
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Tentative Course Outline: Class will meet twice every week, unless otherwise noted.

Lecture Topics

Week 1
- Introduction and course overview - What is Neurophysiology?
  
  **Section 1: Intrinsic neuronal properties**

Week 2
- [Sept. 11: last day to Add/Drop a class]
  - Neurons and glia cells: Morphological and molecular diversity.
  - Membrane potential I: Ions, channels, Nernst Equation.

Week 3
- Membrane potential II: GHK equation and equivalent circuit
- Passive properties: Input resistance, capacitance, length constant, time constant.

Week 4
- Action potential I: Ionic mechanisms
- Action potential II: Hodgkin-Huxley formalism, propagation, myelination

Week 5
- Diversity of voltage-gated channels: molecular identities and effect on neuronal firing
- Diversity of voltage-gated channels: molecular identities and effect on neuronal firing

Week 6
- **Section 2: Synaptic signaling**
  - Review, Q&A session

Week 7
- **MIDTERM EXAM I**
  - Electrical and chemical transmission: Gap junctions, crayfish escape system, frog neuromuscular junction.

Week 8
- Central synapses, small molecule transmitters and ionotropic receptors.
- Metabotropic transmission, GPCRs, 2nd messenger signaling.

Week 9
- Transmitter release I: Quantal analysis.
- Transmitter release II: SNARE complex, vesicle pools, postsynaptic receptors.

Week 10
- Transmitter types: Synthesis, transport, release, re-uptake and degradation.
- Types of communication: Transmitters, neuromodulators, neurohormones.

Week 11
- Synaptic plasticity I: Short-term synaptic dynamics
- Synaptic plasticity II: Long-term synaptic dynamics. Aplysia gill withdrawal, LTP, LTD

Week 12
- **MIDTERM EXAM II**
| Week 13 | **Section 3: Sensory transduction mechanisms and simple coding principles**  
|         | Sensory transduction, modalities, coding principles  
|         | Somatosensory and auditory coding |
| Week 14 | Visual and chemosensory coding  
|         | Motor coding: posture and movement control |
| Week 15 | Review, Q&A session  
|         | READING DAY, NO CLASS |

**FINAL EXAM WEEK: DECEMBER 15-21, 2017**