Neurobiology for Undergraduates at a Large Public University

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Arizona Research Laboratories
Division of Neurobiology

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University of Arizona, Tucson
University of Arizona

- AAU, Research-1 public land-grant university

- among top 25 US universities in NSF’s rankings (based on research funding)

- ~37,000 students (~27,000 undergraduates)

- 18 Colleges, including:
  > Science
  > Agriculture & Life Sciences
  > Medicine
  > Social & Behavioral Sciences
  > Pharmacy
  > Nursing
  > Optical Sciences
  > Public Health

- one of only 3 (public) universities in the state
Undergraduates in the UA College of Science

- ~ 3,000 students
  > out of ~ 27,000 undergraduates
  > 43% of incoming first-year students declare themselves to be premeds

- diverse, including many non-traditional students

- mentored, independent research is emphasized
  > 65% of all undergraduates with majors in the College of Science do independent research
  > 75% of Molecular & Cellular Biology majors
  > 100% of Biochemistry & Molecular Biophysics majors

out of ~ 27,000 undergraduates
Challenges

- Currently mandated to admit top 50% of in-state HS graduates

- Wide range of student preparedness
  - academic
  - attitudinal

- Diverse student goals
  - pre-professional (premed, etc.)
  - pre-graduate school (Ph.D., etc.)
  - pre-business, etc.

- Limited resources
  - Offering a lab course or section has not been feasible
  - No GTAships
Two examples of neurobiology courses

First-year colloquium

Upper-division neurobiology course
Freshman Honors Seminar – *The Brain*

- 1-unit course
- ≤ 20 students (i.e. very small for a freshman class)
- writing-intensive

- reading assignments, student-led in-class discussions
  > textbook: Bloom, Nelson & Lazerson
    *Brain, Mind, and Behavior*
    (based on Annenberg CPB Project)

  > PBS videos (1988 *The Brain*, et seq.)

- key goals:
  > early experience for freshmen with a field of interest
  > personal contact with a professor early in college
  > small-class experience at a time of big-class overload
  > help introduce students to college-level work
Upper-division lecture course – Neurobiology

- interdisciplinary elective with multiple prerequisites
- cross-listed in, and recommended by, multiple departments
- capstone experience for motivated, well-prepared students
- 35-65 students each year
- 1-semester, 4-unit course
- in-class discussions and group problem-solving
- use on-line videos, simulations, anatomical images, etc.
- reading assignments linked to each lecture
- weekly study questions (including many quantitative problems)
- weekly section meeting (led by GTA) required
- weekly quiz (14 per semester) in place of mid-term exams
- comprehensive final exam based on questions distributed in advance
**Course Syllabus**

**MCB/BIOC/NRSC 407 – NEUROBIOLOGY – 2005**

**Course Description**

**Course Content**
This course is an introduction to neurobiology, emphasizing cellular, molecular, and physiological aspects. The course builds upon a foundation of cellular neurobiology to introduce topics in the organization, function, development, and disorders of neural systems.

**Prerequisites**
Introductory biology (e.g. MCB/BIOC/EEB/MICR 181 & 182), general college chemistry, elementary quantitative reasoning and problem solving at an advanced college level. College-level courses in organic chemistry and cell biology or biochemistry are strongly recommended.

**Semester/Units**
Fall semester / 4 units

**Recommended Text**

**Optional Additional Textbook & Software**

**Course Format**
2 Lectures (Tuesday and Thursday each week, 5:30-6:45 p.m.) in FCS Room 101
1 Discussion Section meeting (Thursdays 4-4:50 or 7-7:50 pm)
Required reading assignments drawn primarily from the recommended textbooks. Most reading assignments are included in the accompanying list. Assignments should be read before the class with which they are associated. **Students are responsible for knowing and understanding the content of the readings.**
| Lectures and Readings | Lectures and reading assignments are **important** in this course. Lectures will emphasize and seek to clarify important concepts, but readings will include essential material not covered in class. Students are responsible for the content of lectures and reading assignments. Reading assignments are shown on the course Website:  
http://www.blc.arizona.edu/courses/mcb407/  
**Attendance at lectures and timely completion of reading assignments are essential and expected of all students.** |
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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Absences</td>
<td>Attendance at lectures is mandatory. All holidays or special events observed by organized religions will be honored for those students who show affiliation with that particular religion. Absences pre-approved by the UA Dean of Students will also be honored.</td>
</tr>
<tr>
<td>Problems &amp; Sections</td>
<td>Students will be assigned to a section meeting on Thursdays at 4:00 or 7:00 p.m. <strong>Participation in section meetings is required of all students.</strong> A set of study questions will be given out each week, usually on Tuesday. These homework assignments will be discussed at the section meetings in the following week.</td>
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Exams & Grades

There will be a quiz almost every Tuesday (14 in all, indicated by “Q” on the course schedule) during the first 15 min. of the class, as well as a final examination during exam period. For each “Q” on the course schedule, the (H) or (N) indicates which instructor will prepare the quiz. Each quiz will emphasize course material covered through the week before the quiz. The quizzes will involve quantitative problem solving as well as analysis and explanation of phenomena in clear, coherent, written English. Only 10 quiz grades will count toward the final course grade, and the top 10 quiz grades will be used if more than 10 quizzes are taken. No make-up quizzes will be offered.
This course ordinarily may not be taken Pass/Fail; the final course grade is determined as follows:

1. the quizzes and the final exam will count 45% and 40% (respectively) in the computation of the final course grade;
2. attendance at, and participation and performance in, the section meetings will constitute 15% of the final grade;
3. active participation in group exercises during lectures will earn extra-credit points; and
4. final, composite numerical grades will be “curved” to generate final letter grades (A,B,C,D,E).

Grades of Incomplete (“I”) will be awarded only at the end of the semester and not on account of disappointing performance. Students who are doing poorly in the course should drop it or withdraw (taking a grade of “W”) before the UA deadlines for those actions.

Students requiring accommodation in testing and note-taking must notify Dr. Nighorn and must provide the Disability Resource Center faculty letter within the first two lectures of the course.
Instructors
John G. Hildebrand, Ph.D., Regents Professor
tel: 621-6626; email <jgh@neurobio.arizona.edu>;
office hour: Wednesday 2:00-3:00 pm (most weeks – call ahead to verify), or by appointment
603 Gould-Simpson Building

Alan Nighorn, Ph.D., Associate Professor
tel: 621-9720; email <nighorn@neurobio.arizona.edu>
office hour: Monday 3:00-4:00 pm, or by appointment
626 Gould-Simpson

GTAs
Penny Letts
Section 002 (Thursday 7:00-7:50 pm, PAS 414)
tel: 626-8387; email <pletts@email.arizona.edu>
office hour: Monday 4:00-5:00 pm, Gould-Simpson 401

Jeff Lochhead
Section 003 (Thursday 4:00-4:50 pm, S SCI 132)
626-2173 or 602-316-6914; email <lochhead@email.arizona.edu>
office hour: Wednesday 4:00-5:00 pm, Gould-Simpson 401 (or check 409 if not in 401)

Josh Martin
Section 001 (Thursday 4:00-4:50 pm, CHEM 126)
626-8118 or 621-8381; email <jpmartin@email.arizona.edu>
office hour: Thursday 2:30-3:30 pm, Gould-Simpson 401 (check 409 if not in 401)

Office Contact
Jennifer Lawrence
tel: 621-6627; email <jll@neurobio.arizona.edu>
office: 603 Gould-Simpson

Expected Classroom Behavior
No cell phones, pagers, or disruptive behavior will be tolerated. This course will adhere to the student code of academic integrity (http://studpubs.web.arizona.edu/policies/academic.htm). The University of Arizona policy about threatening behavior (http://policy.web.arizona.edu/~policy/threaten.shtml) will be enforced.
## MCB/BIOC/NRSC 407
### NEUROBIOLOGY

#### 2005 LECTURE SCHEDULE

Lectures Tuesdays and Thursdays, 5:30-6:45 p.m., Biosciences West, Room 208  
Weekly 1-hr Discussion Section (Thu. or Fri. 4:00 or 7:00 p.m., TBA)

<table>
<thead>
<tr>
<th>Aug.</th>
<th>23</th>
<th>Tu</th>
<th>Introduction and overview</th>
<th>Hildebrand</th>
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</thead>
<tbody>
<tr>
<td>25</td>
<td>Th</td>
<td></td>
<td>Electrical and chemical signaling in nervous systems; monosynaptic reflex</td>
<td>Hildebrand</td>
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<tr>
<td></td>
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<td>Discussion Section (review some principles of electricity)</td>
<td>Hildebrand</td>
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<tr>
<td>30</td>
<td>Tu</td>
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<td>Passive electrical properties of cell membranes; ion channels</td>
<td>Hildebrand</td>
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<tr>
<td>Sept.</td>
<td>1</td>
<td>Th</td>
<td>Ionic basis of the resting potential</td>
<td>Hildebrand</td>
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<td>6</td>
<td>Tu</td>
<td>Q1(H) Ionic basis of the action potential</td>
<td>Hildebrand</td>
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<tr>
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<td>8</td>
<td>Th</td>
<td>Ionic basis of the action potential II</td>
<td>Hildebrand</td>
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<td></td>
<td>Discussion Section (discuss Study Questions 1)</td>
<td>Hildebrand</td>
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<tr>
<td>13</td>
<td>Tu</td>
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<td>Q2(H) Cable properties; propagation of the action potential; function of myelin</td>
<td>Hildebrand</td>
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<tr>
<td>15</td>
<td>Th</td>
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<td>Synaptic communication I – excitation &amp; inhibition; electrical &amp; chemical</td>
<td>Hildebrand</td>
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<td>Discussion Section (discuss Q2 &amp; Study Questions 2)</td>
<td>Hildebrand</td>
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<td>20</td>
<td>Tu</td>
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<td>Q3(H) Synaptic communication II – postsynaptic mechanisms</td>
<td>Hildebrand</td>
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<td>22</td>
<td>Th</td>
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<td>Q4(H) Synaptic communication III – presynaptic mechanisms</td>
<td>Hildebrand</td>
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<td>Discussion Section (discuss Q3 &amp; Study Questions 4)</td>
<td>Hildebrand</td>
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<tr>
<td>27</td>
<td>Tu</td>
<td></td>
<td>Molecular biology of ion channels and receptors</td>
<td>Nighorn</td>
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<tr>
<td>29</td>
<td>Th</td>
<td></td>
<td>Integrating Molecular and Electrical Views of Action Potential</td>
<td>Nighorn</td>
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<td>Discussion Section (discuss Q4 &amp; Study Questions 5)</td>
<td>Nighorn</td>
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<td>Oct.</td>
<td>4</td>
<td>Tu</td>
<td>Q5(H) Synaptic communication IV – neurotransmitters</td>
<td>Hildebrand</td>
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<td>6</td>
<td>Th</td>
<td>Synaptic communication V – synaptic integration</td>
<td>Hildebrand</td>
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<td>Discussion Section (discuss Q5 &amp; Study Questions 6)</td>
<td>Hildebrand</td>
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11 Tu  Q6(N)  Intracellular messengers and modulation
13 Th  Sensory signal transduction
   Discussion Section (discuss Q6 & Study Questions 7)
18 Tu  Q7(H)  Learning and memory I – sensitization & classical conditioning
20 Th  Learning and memory II – LTP & NMDA receptors
   Discussion Section (discuss Q7 & Study Questions 8)
25 Tu  Q8(N)  Sensory systems – introduction, principles, and somatosensation
27 Th  Vision I – the eye and retina
   Discussion Section (discuss Q8 & Study Questions 9)

Nov.
1 Tu  Q9(N)  Vision II – lateral geniculate and visual cortex
3 Th  Vision III – visual cortex
   Discussion Section (discuss Q9 & Study Questions 10)
8 Tu  Q10(H)  Vision IV – higher processing
10 Th  Hearing
   Discussion Section (discuss Q10 & Study Questions 11)
15 Tu  Q11(H)  Olfaction
17 Th  Motor Control
   Discussion Section (discuss Q11 & Study Questions 12)
22 Tu  Q12(N)  Pain
24 Th  No class – Thanksgiving Day
   Holiday – NO SECTION MEETINGS

Dec.
29 Tu  Q13(N)  Development I
   Development II
   Discussion Section (discuss Q12, Q13 & Study Questions 13)
6 Tu  Q14(N)  Development III
8 Th  SPECIAL OPTIONAL MEETING – Course review (and discuss Q14 and
   Study Questions 14) staff
13 Tu  Final Examination (covering entire course) – 5:00-7:00 p.m.

READING ASSIGNMENTS ARE ON THE COURSE WEBSITE:  http://www.blc.arizona.edu/courses/mcb407
Example of in-class demonstration for discussion
David Hubel & Torsten Wiesel

characterizing receptive fields of LGN neurons in cats

off-center cell

http://www.physiology.wisc.edu/yin/public/
Example of in-class group problem-solving
On the basis of receptive-field properties of neurons in retina, LGN or V1, explain the dark “smudges” that are seen at the “street” crossings outside the center of gaze.
1. Why do we see the dark smudges?
See the diagram at left; assume an on-center retinal ganglion cell. Its receptive field is indicated by the large reddish disk. For a ganglion cell with its center ('+') positioned at a crossing (left-top), there are 4 bright patches in the inhibitory surround. A ganglion cell with its center on a “street” (left-bottom), however, gets only 2 inhibitory patches, so it will respond with a higher rate of spiking than one at a crossing.
[This was measured by Baumgartner (1960) in Freiburg -- see picture on the right.]

2. Why don’t we see the smudge when we look right at a crossing?
Because then we direct the fovea at the crossing, and in the fovea the receptive fields are much smaller (small reddish disks on the right of the left figure). With such small receptive fields it doesn’t matter whether they are at the crossings or not.

http://www.michaelbach.de/ot/lum_herGrid/index.html#
This explanation, as plausible as it sounds – and it is in many textbooks – is not the full story!

see:

http://www.michaelbach.de/ot/lum_herGridCurved/index.html

When the grid lines are straight, dark smudges appear in the “street” crossings, except the ones you are directly looking at. When the “streets” are curving, the smudges vanish!

For a great analysis of what is probably going on, see:

Tips – some learned the hard way

_ try to get to know the students
  > even in big classes
  > learn names

_ be accessible
  > before and/or after class
  > office hours

_ provide access to all graphics used in class
  > password-protected Website (for copyrighted material)

_ teaching evaluations
  > learn from them but don’t be discouraged!
Goals underlying and motivating the capstone course

- challenge students
- build on previous science experience – stress the connectedness of all the science and math the students have studied previously
- emphasize critical thinking, reasoning from data, problem-solving
- minimize memorization & use of objective testing
- encourage team-work
- urge students to take responsibility for their own education
- prepare students for what will be expected of them in graduate or professional school – indeed, in life in general
- convey our own love of science, learning & discovery, and Nature
- help (possibly jaded) students discover that thinking about science is fun!