Proposed Curriculum Revision for MCB Neurobiology Emphasis

November 12, 2014

The MCB department would like to apply for a change in curriculum for its Neurobiology emphasis. This proposal was adopted unanimously by MCB Neurobiology faculty, and approved by the MCB Undergraduate Advising Committee and the MCB Committee of Chairs and Division Heads (CCDH).

Summary
The Neurobiology emphasis is the most popular undergraduate emphasis within the Molecular & Cell Biology (MCB) major, with 120 majors per year. The current curriculum was established in 1986. It is built around a single core survey of Neuroscience, MCB 160 (Introduction to Neurobiology), followed by a choice of 2 neuroscience-related electives and a lab. Tremendous growth in knowledge in the past 30 years has made it impossible to teach a single-semester survey at a level appropriate for UC Berkeley MCB majors. We propose to replace MCB 160 with a required 2-course Core Neuroscience sequence (160: Cellular & Molecular Neuroscience, and 161: Circuits, Systems & Behavioral Neuroscience), followed by choice of a single elective course and a lab. This parallels the structure of two other MCB emphases (Biochemistry & Molecular Biology Track 1, and Immunology). We will also re-focus one of our popular elective courses, MCB 165, to become a course on Neurobiology of Disease.

Background and Need for Curriculum Revision
Growth in Neuroscience knowledge (facts, concepts, experimental paradigms) makes it no longer feasible to survey the field of Neuroscience in a single semester in MCB 160. This central problem creates a rippling effect in our elective classes: because 160 cannot adequately cover most topics, these are re-taught and extended in higher classes, leading to duplicative coverage. A related problem is that many majors delay 160 until senior year, so elective classes cannot generally require 160 as prerequisite, and must include even more remedial 160 material to bring all students up to basic level. These factors undermine the quality of the Neurobiology curriculum.

Curriculum Proposal
To remedy these problems, we propose to replace the single-semester MCB 160 survey with a required 2-semester sequence (MCB 160 FA + MCB 161 SP), while relaxing MCB 160 prerequisites to allow nearly all majors to take this class in Fall of Junior year. To offset the additional required course, we will only require choice of one elective class, instead of the current two. The choice of labs is unchanged. Two additional course requirements that are common for most MCB emphases are also unchanged (MCB 102: Biochemistry & Molecular Biology, and MCB 104: Genetics, Genomics & Cell Biology).

This reorganization will allow most students to take a comprehensive survey of Neuroscience in the Junior year, and to take the elective and lab class as Seniors.
Summary of course changes (to take effect in 2015-2016)

1. The current MCB 160 will be split into a new MCB 160, Cellular & Molecular Neuroscience, and MCB 161, Neural Circuits, Systems & Behavior. This will be a required 2-course sequence (160: Fall, 161: Spring). Each is 4 units (MWF lecture + required discussion section). To enable students to take MCB 160 in FA of junior year, the prerequisite of MCB 102 will be removed, and Physics 8B will be a co-requisite (instead of prerequisite). Bio 1A will remain a prerequisite.

2. MCB 165 will be re-focused from its current topic of Molecular Neuroscience to a course on Neurobiology of Disease. Offered Spring. 3 units. (TTh lecture + required discussion section). Prerequisite: 160.

3. MCB 167 will be eliminated. 167 is an elective class on Circuits, Systems & Behavioral Neuroscience, and is taken by about half the Neurobiology majors. Its content will be shifted into 161. In reality, the creation of the required 160-161 sequence is simply a rebranding of the (required) 160 – (elective) 167 sequence that many majors already take. Reorganizing material between these courses, and requiring both, allows us to provide a modern, comprehensive survey of neuroscience for all our majors.

The MCB 166 elective (Biophysical Neurobiology) remains unchanged. The laboratory classes MCB 160L and MCB 163 remain unchanged. The requirement for MCB 102 and 104 remains unchanged.

Existing Curriculum – 6 Required Courses

1. MCB 102 Biochemistry & Molecular Biology
2. MCB 104 Genetics, Genomics & Cell Biology
3. MCB 160 Introduction to Neurobiology
4. MCB 160L or 163 Neurobiology Lab or Mammalian Neuroanatomy Lab (choose one)
5. Elective B Chosen from MB 165 (Molecular Neurobiology), MCB 166 (Biophysical Neurobiology), or MCB 167 (Physiological and Genetic Basis of Behavior)
6. Elective A or B Chosen from Elective B, or a long list of approved classes in other MCB divisions and other departments.

Schedule of MCB Neurobiology Classes (current, including 2014-2015)

<table>
<thead>
<tr>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>160 (required survey of Neurobiology)</td>
<td>160</td>
</tr>
<tr>
<td>163 (lab)</td>
<td>160L (lab)</td>
</tr>
<tr>
<td>166 (elective)</td>
<td>165 (elective)</td>
</tr>
<tr>
<td></td>
<td>167 (elective)</td>
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MCB 102 and 104 are offered in both semesters.

Proposed New Curriculum – 6 Required Courses

1. MCB 102 Biochemistry & Molecular Biology
2. MCB 104 Genetics, Genomics & Cell Biology
3. MCB 160 Cellular & Molecular Neuroscience *
4. MCB 161 Circuits, Systems & Behavioral Neuroscience *
5. MCB 160L or 163 Neurobiology Lab or Mammalian Neuroanatomy Lab (choose one)
6. One elective From a list of MCB Neurobiology and approved outside classes” (choose one)

* Required 2-course sequence, offered FA-SP each year.
The elective list merges all Elective A and Elective B classes from the existing curriculum. The second lab can also be taken as an elective (as in the current curriculum). The full elective list is in Appendix 1.

Schedule of MCB Neurobiology Courses (to begin 2015-2016)

<table>
<thead>
<tr>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>revised 160 (Cellular/Molecular Neurobiology)*</td>
<td>new 161 (Circuits/Systems/Behavioral Neurobiology)*</td>
</tr>
<tr>
<td>163 (lab)</td>
<td>160L (lab)</td>
</tr>
<tr>
<td>166 (elective)</td>
<td>revised 165 (elective, Neurobiology of Disease)</td>
</tr>
</tbody>
</table>

* required 2-course sequence. 102 and 104 are still offered in both semesters.

Syllabi for the modified courses (160, 161, 165) are attached.

We will strongly recommend that students take the 160-161 sequence as Juniors, and then take the lab and elective in Senior year. However, there are workable progressions through the major for students who cannot take 160-161 until senior year. See Appendix 2 for details.

Implications for course enrollment

MCB 160 currently enrolls 220 students per year (90 FA, 130 SP). This includes both Neuro majors (120 per year) and students in other MCB divisions and departments who want a survey course in Neuroscience. In the new organization, 160 and 161 will each be offered only once per year (160 FA, 161 SP). Thus, 160 class size will increase. Because the new 160-161 sequence may be less attractive to students outside the major seeking a 1-semester Neuroscience survey, we anticipate that 160 enrollment may drop to ~180 students per year. We speculate that 161 enrollment may be ~150 students per year. These are large courses but are feasible given the lecture + required discussion format.

Implementation Plan for 2015-2016

We propose to implement this plan in 2015-2016. We would offer the revised 160 in FA 2015, and the new 161 in SP 2016. We would offer the updated 165 (Neurobiology of Disease) in SP 2016. We would NOT offer 160 or 167 in SP 2016.

This transition is rapid, but will work smoothly for our current majors and upcoming majors. All current students who have taken 160 (juniors and seniors) will be unaffected, and will graduate under the old curriculum. Current juniors who have not yet taken 160 could either take it in SP 2015, and graduate fulfilling the old requirements, or could take 160-161 in 2015-2016 and graduate fulfilling the new requirements. Current sophomores will use the new requirements. The MCB undergraduate advising office concurs that this time frame is feasible, because the new curriculum is a relatively modest change from the old.

Sincerely,

Marla B. Feller, Ph. D.
Professor of Neurobiology
Head of Neurobiology Division
David Raulet  
CH Li Professor of Immunology and Pathogenesis  
Co-Chair, Department of Molecular and Cell Biology  

Richard Harland  
CH Li Professor of Genetics, Genomics and Development  
Co-Chair, Department of Molecular and Cell Biology
Appendix 1: Neurobiology Elective List

MCB Neurobiology Courses (formerly Elective List B)
Molecular and Cell Biology
- 160L Neurobiology Lab (Sp; 4 units) (allowed only if MCB 163 is used as lab requirement)
- 163 Mammalian Neuroanatomy (F; 4 units) (allowed only if MCB 160L is used as lab requirement)
- 165 Molecular Neurobiology/Neurochemistry (Sp; 3 units)
- 166 Biophysical Neurobiology (F; 3 units)

Courses from Other MCB Divisions and Departments (formerly Elective List A)
Bioengineering
- 121 Introduction to Micro and Nanobiotechnology: MioMEMS (F, Sp; 3 units)
- BioEng 143 Computational Methods in Biology

Cognitive Science
- C127 Cognitive Neuroscience (F; 3 units)

Integrative Biology
- 131 Human Anatomy (F, Su; 3 units)
- C139 The Biology of Stress (Alt F, 3 units)
- C143A Biological Clocks: Physiology & Behavior (Alt F; 3 units)
- C143B Hormones & Behavior (Sp; 3 units)
- 144 Animal Behavior (F; 4 units)

Mathematics
- 110 Linear Algebra (F, Sp, Su; 4 units)
- 127 Mathematical and Computational Methods in Molecular Biology (F; 4 units)
- 128A Numerical Analysis (F; 4 units)
- 128B Numerical Analysis (Sp; 4 units)

Molecular and Cell Biology
- C100A Biophysical Chemistry (F, Sp; 4 units)
- 130A Cell and Systems Biology (Sp; 4 units)
- 132 Biology of Cancer (F; 4 units)
- 135A Molecular Endocrinology (F; 3 units)
- 136 Physiology (F; 4 units)
- 137 Computer Simulation in Biology (Sp; 3 units)
- 141 Developmental Biology (Sp; 4 units)
- MCB C145 Genomics
- 150 Molecular Immunology (F, Sp; 4 units)

Physics
- 112 Introduction to Statistical and Thermal Physics (F, Sp; 4 units)
- Physics 132 Contemporary Physics

Psychology
- C112 The Biology of Stress (Alt F; 3 units)
- C113 Biological Clocks: Physiology and Behavior (Alt F; 3 units)
- C116 Hormones and Behavior (Sp; 3 units)
- 117 Human Neuropsychology (Sp, Su; 3 units)
- C127 Cognitive Neuroscience (F; 4 units)

Public Health
- 141 Introduction to Biostatistics (Su; 5 units)
- 142 Introduction to Probability and Statistics in Biology & Public Health (F, Sp; 4 units)

Statistics
- 131A Statistical Inferences for Social and Life Scientists (F, Sp; 4 units)
Appendix 2: Anticipated Progress through the Neurobiology Emphasis

Complete prior to FA Jr year:
  Bio 1A
  Bio 1AL
  Physics 8B (most students take this in FA of Junior year, which will still work)

Recommended progression:
  FA Jr:  160 (and Physics 8B for many students)
  SP Jr:  161 and 102
  FA Sr:  163* and/or Elective. 104. * Choose one. This is the lab.
  SP Sr:  160L* and/or Elective. 104.

Progression for students who cannot take 160 until senior year
  FA Jr:  163 and Physics 8B.
  FA Sr:  160. Elective if needed. 104.
  SP Sr:  161 and/or Elective and/or 160L.

Progression for students who join emphasis in Spring of Junior year
  FA Jr:  None.
  FA Sr:  160. 163 or 104.
  SP Sr:  161. 160L or 104.
**Syllabi for Proposed Courses**

**MCB 160: Cellular & Molecular Neuroscience (MWF lecture + required discussion, 4 units)**

<p>| | |</p>
<table>
<thead>
<tr>
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**Cellular neurophysiology**  
2 | The plasma membrane  
3 | Passive electrical properties of neurons  
4 | Origin of the membrane potential  
5 | Selective permeability of ion channels  
6 | Gating of ion channels  
7 | The action potential  
8 | Propagation of action potentials  
   | **The synapse**  
9 | Physiology of synaptic transmission  
10 | Molecular mechanisms of exocytosis and endocytosis  
11 | Postsynaptic receptors (ionotropic)  
12 | Synaptic excitation, inhibition, and integration  
13 | Neurotransmitters  
   | **MIDTERM 1**  
14 | Metabotropic receptors, intracellular messengers and neuromodulation  
15 | Dendrites, spines, and dendritic excitability  
   | **Synaptic plasticity**  
17 | Synaptic plasticity and learning: Aplysia as case study  
18 | Short-term plasticity  
19 | LTP  
20 | LTD, STDP, and structural synaptic plasticity  
   | **Sensory transduction**  
21 | Phototransduction in rods & cones  
22 | Retinal processing of vision (*illustrates synaptic integration, inhibition)  
23 | Evolution of color vision (or maybe melanopsin and circadian rhythms)  
24 | Transduction for taste & olfaction  
25 | Olfactory processing (*illustrates synaptic target selection, circuit construction)  
26 | Pain and temperature transduction  
   | **MIDTERM 2**  
27 | Motor neurons and muscle  
   | **Neural development**  
28 | Neural differentiation  
29 | Axon guidance |
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<tbody>
<tr>
<td>30</td>
<td>Synapse formation</td>
</tr>
<tr>
<td>31</td>
<td>Activity-dependent synaptic refinement</td>
</tr>
<tr>
<td>32</td>
<td>Neural repair and aging; stem cells and adult neurogenesis</td>
</tr>
<tr>
<td>33</td>
<td>Regeneration in PNS and CNS</td>
</tr>
<tr>
<td>34</td>
<td>Molecular basis of behavior and disease</td>
</tr>
<tr>
<td>35</td>
<td>Genes, circuits &amp; behavior (Drosophila courtship or C. elegans escape)</td>
</tr>
<tr>
<td>36</td>
<td>Genes, circuits &amp; behavior (Social behavior in prairie voles)</td>
</tr>
<tr>
<td>37</td>
<td>Traumatic brain injury and epilepsy</td>
</tr>
<tr>
<td>38</td>
<td>Neurodevelopmental and neurodegenerative diseases</td>
</tr>
<tr>
<td>39</td>
<td>Optical methods in neurobiology</td>
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</tbody>
</table>

MCB 161: Circuit, Systems & Behavioral Neuroscience. (MWF lecture + required discussion, 4 units)


Vision
2. Retina, receptive fields, computation of local contrast
3. Retinal computation of motion
4. Central vision to V1: local feature detectors
5. Extrastriate cortex: object and face cells, motion
6. Quantitative approaches to vision: reverse correlation, LNP models, population coding.

Somatic sensation
7. Touch: Pathways, maps, place coding and texture/form coding in S1
8. Pain and Temperature: Pathways and coding
10. Canonical cortical circuits

Chemical senses
11. Taste & olfactory pathways: circuits for innate vs. learned behavior
12. Olfaction: gain control
13. Olfaction: pheromones

MIDTERM 1

Auditory system
14. Cochlea, hair cells, and auditory transduction
15. Molecular mechanisms for mechanotransduction
16. Sound localization: circuits and computation
17. Central auditory processing
18. Bat echolocation
19. Vestibular system
## Motor Systems
20 Spinal cord, motor neurons, control of muscle force
21 Voluntary control of movement: M1 and motor pathways
22 Central Pattern Generators
23 Basal Ganglia. Parkinson's and Huntington's Disease.
24 Cerebellum, coordination and motor learning.
25 Hypothalamus and autonomic nervous system

### MIDTERM 2

## Neurobiology of Learning
26 Memory systems of the brain. Working memory. Cortical plasticity and critical periods
27 Cortical plasticity II (mechanisms, restoring plasticity in adults)
28 Hippocampal learning I (space)
29 Hippocampal learning II (memory)
30 Sensorimotor learning: Bird song learning I
31 Sensorimotor learning: Bird song learning II

## Higher functions
32 Emotion and mood: dopamine and serotonin
33 Amygdala and fear
34 Reward and drugs of abuse
35 Sleep and brain state
36 Higher functions: value, decision, attention
37 Brain Evolution
38 Review, principles, challenges
MCB 165: Neurobiology of Disease. Designed to be taken as an elective after 160-161 sequence.

TTh lectures + required discussion. 3 units.

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<thead>
<tr>
<th></th>
<th>Introduction.</th>
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<tbody>
<tr>
<td>1</td>
<td>Neurochemistry and Its Disorders</td>
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<tr>
<td>2</td>
<td>Neurotransmitters: synthesis, receptors, degradation, uptake</td>
</tr>
<tr>
<td>3</td>
<td>Neuromodulators: peptides, catecholamines</td>
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<tr>
<td>4</td>
<td>Glia in health and disease</td>
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<tr>
<td>5</td>
<td>The mysterious enteric nervous system</td>
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<tr>
<td>6</td>
<td>Presynaptic modulators: cannabinoids, adenosine</td>
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<tr>
<td>7</td>
<td>Synaptic Plasticity</td>
</tr>
<tr>
<td>8</td>
<td>Psychoactive drugs and reward systems: VTA, nucleus accumbens</td>
</tr>
<tr>
<td>9</td>
<td>Addiction</td>
</tr>
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**Midterm I**

**Neurodevelopmental and Neurodegenerative Disorders and CNS Injury**

| 10 | Review of Development and Synaptogenesis |
| 11 | Autism |
| 12 | Fragile X |
| 13 | Other developmental disorders: Down Syndrome and ADHD |
| 14 | Prion Diseases |
| 15 | Parkinson and Huntington Disease |
| 16 | The Aging Brain |
| 17 | Spinal cord organization and injury. |
| 18 | Stem cells, regeneration, and repair. |

**Midterm II**

**Neurobiology of Psychiatric Disorders**

| 19 | Overview of Mood and Psychotic Disorders |
| 20 | Depression and Manic Disorder: Symptoms, Etiology and Neuropathology |
| 21 | Depression Manic Disorder: Monoamine, corticoid and neurotrophic hypothesis |
| 22 | Anxiety Disorder, PTSD and the Amygdala |
| 23 | Schizophrenia: Symptoms and Neuropathology (Developmental Disorder?) |
| 24 | Schizophrenia: Glutamate and Dopamine Hypothesis |
| 25 | Dementia and Alzheimer’s Disease |
| 26 | Epilepsy |