

Neurobiology 134 Spring 2012

Course Instructor:	Dr. Barry A. Trimmer
Time	Tuesday and Thursday at 1:30-2:45 (Block H+)
Room	Barnum 104
Office hours	Monday 2:30 p.m. to 3:30 p.m. At 200 Boston Av, 2613 Thursday 3:00 p.m. to 4:00 p.m. In Barnum

Course Synopsis and Outline

Neuroscience continues to be one of the fastest growing areas of biology and is at the cutting edge of technical and conceptual advances in the life sciences. If you want to know how animals (including humans) touch, hear, see, smell, and remember things then you need a firm background in Neurobiology (the study of nervous systems). You will need to study ions, molecules, cells, neural networks, brain structure and behavior. This class will provide you with the fundamentals of neural function at all these levels.

Neurobiology (Biology 134) will proceed from the basic biophysical properties of neurons and glia, to the physiological basis of learning, memory, and sensory processing. These topics will then be brought together in case studies taken from the field of *neuroethology* (the neural basis of behavior under natural conditions). Throughout the course stress will be placed on methods and concepts rather than facts alone. Examples will be taken from invertebrate and vertebrate studies. ***This course does not cover general vertebrate neuroanatomy or experimental psychology, although some lectures include such material where it is relevant.*** Active discussion during the lectures is generally encouraged. It is also recommended that students take advantage of my office hours to discuss course material. The syllabus and additional resources are available at the University Course Information Site on Trunk.

Please make sure that you log onto this site regularly for updates and general communications. Also, there are many resources available (including animations, study guides and quizzes) at the text book website <http://sites.sinauer.com/neuroscience5e/index.html>.

There will be three exams contributing to the final grade:

- 1) February 16th Thursday class time Progress test (20%)**
- 2) March 15th Thursday class time Midterm (30%)**
- 3) May 4th Friday 3:30-5:30 p.m. Final exam (50%)**

I will not give “make-up” exams except in the case of an emergency (medical etc.), evidence for which must be obtained from the Dean’s Office. You are also required to attend the annual Kenneth Roeder Memorial Lecture on April 12 at 5:00pm. This year, Professor Kiisa Nishikawa (Northern Arizona University) (<http://www2.nau.edu/~froggy-p/index.html>) will talk about her work on the biomechanics of muscle and the control of prey-capture in amphibians. We will also be covering some of his work in the class. These lectures (and this one in particular) are fun and informative - your chance to see top research in action.

The following interrelated topics will be covered in succession, although the exact number of lectures devoted to a topic may vary from that stated. For each topic I have indicated the main chapters of the primary text books that are relevant ***in bold text***, together with alternative or additional reading. I will also post directions to appropriate web resources on the Trunk site.

These topics are not strictly separate; an understanding of each topic is best achieved by pulling together information from other topics. Towards the end of the course we will cover material that is not included in the textbook but will be made available on the course website. I also expect to cover advances in our knowledge that are too recent to be included in the textbooks and will give you references to this material.

Syllabus

What is Neurobiology? What are neurons? General course outline. The structure and distinguishing features of neurons, how is a neuron recognized? The architecture of nervous systems. Invertebrate model systems. Chemical/electrical synapses. Recording/monitoring techniques. (First lecture). [*Neuroscience. Purves, D., et al. Chapter 1, p1-13. Delcomyn, Chapters 1-3. Essentials of Neural Science and Behavior, Chapters 2 and 3. From Neuron to Brain, Chapter 1*].

Ionic basis of the resting potential. Unlike most cells, neurons function by making extensive use of electrical activity. Basic to this property is the establishment and maintenance of a resting potential. This is achieved through passive and active mechanisms, channels and pumps. (1 lecture). [*Neuroscience. Purves, D., et al. Chapter 2, p25-37. Delcomyn, Chapter 4. Essentials of Neural Science and Behavior, Chapters 7 and 8. From Neuron to Brain, Chapter 3. APSim software*].

Action potentials and ion channels. Many neurons (although not all of them), generate active electrical signals by controlling ionic permeability. The discovery (or more accurately the inference) of voltage sensitive ion channels was a major factor in developing the new discipline of Neurobiology. These ion channels generate and control action potentials. Ion channels are proteins with distinctive structures and distributions within cells, molecular techniques can now tell us how they work. (3 lectures). [*Neuroscience. Purves, D., et al. Chapter 2, p37-40 and Chapters 3 and 4. Delcomyn, Chapter 5. Essentials of Neural Science and Behavior, Chapter 10. From Neuron to Brain, Chapter 2 (pages 27-43 and 56-65), and Chapter 4. APSim software*].

Cable properties of neurons. The ability of neurons to transmit electrical signals also depends on the passive electrical (“cable”) properties. Morphology and composition determine these properties and both are exploited for diverse functions in different cells. The insulation provided by myelin results in fast saltatory conduction of action potentials. Passive properties and specialized channels combine in most neurons to act as signal integrators. (1 lecture). [*Neuroscience. Purves, D., et al. Chapter 2 p 27-32, Box 2A p30-31. Delcomyn, Chapter 8 p185-197. Essentials of Neural Science and Behavior, Chapter 9. From Neuron to Brain, Chapter 5, Chapter 6 (page 171) and Appendix A. Principles of Neural Science, Chapter 8 and Appendix A p1250*].

Progress test February 16th here (more or less)

Synapses and neurotransmitters. Part I; presynaptic mechanisms. Individual neurons communicate with one another predominantly via synapses. These are junctions between cells that have certain specializations. Signals are passed between neurons either electrically or by releasing neurotransmitters. (2 lectures). [*Neuroscience. Purves, D., et al. Chapters 5 p 78-96, and Chapter 6. Delcomyn, Chapters 6-7. Essentials of Neural Science and Behavior, Chapters 11, 15 and 16. From Neuron to Brain, Chapter 7, Chapter 9 (pages 269-300), Chapter 10 (pages 327-338) and Appendix B. Chapter 2 from “Beyond Neurotransmission” p. 29-82.*].

Synapses and neurotransmitters. Part II; postsynaptic mechanisms. These chemical signals are detected by proteins called receptors which then influence the activity or metabolism of the receptive neuron. (2 lectures). [*Neuroscience. Purves, D., et al. Chapter 5 p96-107 and Chapters 6 and 7. Delcomyn, Chapters 7-8. Essentials of Neural Science and Behavior, Chapters 11, 12, 13 and 14. From Neuron to Brain, Chapter 2 (pages 42-56), Chapter 7 (pages 198-211) Chapter 8, and Chapter 9 (pages 301-306)*].

Neural networks and behavior. Information is integrated by neurons. Interactions between neurons, together with their specific circuit connections, form Networks. Circuits and Networks are capable of producing behaviors. Examples include central pattern generators, reflex arcs and patterned sequences (2 lectures). [*Neuroscience. Purves, D., et al. Chapter 14, Box 14D p316-317. Chapter 16 Boxes 16B and 16C Kristan, W. B., Calabrese, R. L. and Friesen, W. O. (2005). Neuronal control of leech behavior. Progress in Neurobiology 76, 279-327. Marder, E. and*

Bucher, D. (2007). *Understanding circuit dynamics using the stomatogastric nervous system of lobsters and crabs. Annu. Rev. Physiol.* 69, 291-316]. Review papers available on Trunk.

Synaptic plasticity, learning, memory and genes. Studies on simple networks suggest that behavior emerges largely from the pattern of interconnections made between neurons. However, a dramatic feature of neural systems is that they are remarkably “plastic”. This plasticity may underlay memory and non-associative and associative learning. Simple invertebrate models reveal much about the probable cellular basis of some of these phenomena. (2 lectures). [*Neuroscience. Purves, D., et al. Chapter 8. Barco, A., Bailey, C. H. and Kandel, E. R. (2006). Common molecular mechanisms in explicit and implicit memory. J. Neurochem.* 97, 1520] Review paper available on Trunk.

Midterm exam March 15th about here

Sensory systems. How are physical events turned into information? Given that nervous systems can generate patterns and respond to simple inputs, how do they interact with the outside world? Sensory neurons must detect and transduce physical events into a form the nervous system can process. How is this achieved for forces, chemicals and light? (2 lectures). [*Neuroscience. Purves, D., et al. Chapters 9, 11, 13, 14, and 15. Review papers provided on Backboard].*

Central processing of information: reception to perception. Once a signal is encoded how is it processed by the central nervous system? We will examine in detail the neurobiology of vision and olfaction (2 lectures). [*Neuroscience. Purves, D., et al. Chapters 12 and 15, p321-340. Delcomyn, Chapter 11 and 13 (olfaction). Essentials of Neural Science and Behavior, Chapters 21, 23, 24. From Neuron to Brain, Chapter 16 and Chapter 17].*

Examples of neural processing in a behavioral context. Part I, Flight control in insects. One of the ultimate goals of neurobiology is to understand how animals achieve the capacity to behave. To bring neurobiology into this realm we have to study the cellular and systems basis of complicated behavior a field known as *Neuroethology*. The control of insect flight is an excellent case study. (2 lectures) [*Delcomyn, Chapter 17, Frye and Dickinson 2004, Dickinson et al., 2000].*

Kenneth Roeder Memorial Lecture on April 12 at 5:00pm.

**Professor Kiisa Nishikawa (Northern Arizona University)
Biomechanics of Muscle and the Control of Prey-capture in Amphibians**

Examples of neural processing in a behavioral context. Part II. Electric Fish and biorobotics. Not only can we learn about how brains work, studying animal behavior can teach us about new worlds and provide useful insights; some of these findings might help to control devices and machines. We will look at several model system, electrolocation and communication in weakly electric (eclectic?) fish, vocal signaling by frogs and new types of biologically inspired robots (2 lectures). [*Delcomyn, Chapters 20 and 21. Original research papers].*

Neurobiology of the future: problems and perspectives. Lastly, (if we have enough time) we will talk about future directions and techniques in neurobiology; computer modeling of neural networks, the role of molecular biology, optical recording methods, human diseases, and the use of animals in research. (1 lectures). [*Neuroscience. Purves, D., et al. Chapter 1 Box 1B. From Neuron to Brain, Chapter 19. Original papers].*

Final Exam May 4th, 3:30-5:30pm

COURSE BOOKS AND PAPERS

Essential reading (*required texts):

***Neuroscience**, Edited by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, and Leonard E. White. Sinauer (2012) Fifth Edition.

*Marder, E. and Bucher, D. (2007). Understanding circuit dynamics using the stomatogastric nervous system of lobsters and crabs. *Annual Rev. Physiol.* **69**, 291-316

***Frye, M. A.** Multisensory systems integration for high-performance motor control in flies. *Current opinion in Neurobiology* **20**, 347-352.

*Dickinson, M.H., et al., *How animals move: an integrative view*. Science, 2000. **288**(5463): p. 100-6.

Supplementary reading (helpful alternative texts):

Foundations of Neurobiology, Delcomyn, F. 1st edition W. H. Freeman and Company (1998)

From Neuron to Brain, Nicholls, J.G., Martin, A.R and Wallace B.G. 3rd edition, Sinauer and Assoc. (1992)

Essentials of Neural Science and Behavior, Kandel, E.R. and Schwartz, J.H. and Jessell, T.M. 1st edition, Appleton and Lange (1995)

The messenger is not the message; or is it? Trimmer, B.A. from **Beyond Neurotransmission: The role of modulation in information flow and neuronal circuit flexibility**. P. Katz, Editor. (1999), Oxford University Press: Oxford, UK. p. 29-82.

How the Mind Works, Steven Pinker, W.W. Norton and Company (1999)

Behavioral Neurobiology: An Integrative Approach, Zupanc, G. K. H. Oxford University Press. 2nd edition (2010)

Other text books: These three text books are more directed at vertebrate brain function than comparative CNS or general principles

Principles of Neural Science, Kandel, E.R. and Schwartz, J.H. and Jessell, T.M. 4th edition (2000).

Neurobiology: molecules cells and systems Gary G. Mathews 2nd edition. Blackwell Science Inc. (2001).

Neuroscience: exploring the brain. Bear, M., Connors, B.W. and Paradiso, M.A. 2nd edition Lippincott, Williams and Wilkins (2001)

For Web Sites of Interest to Neurobiologists got to the Trunk site and follow “External Links”

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