

Neurobiology 134 Spring 2005

Course Instructor:	Dr. Barry A. Trimmer
Time	Monday, Wednesday and Friday at 10:30-11:20 (Block E)
Room	Barnum 114
Office hours (Dana 304)	Monday 2:00 p.m. to 3:30 p.m. Thursday 3:30 p.m. to 5:00 p.m.

Course Synopsis and Outline

Neuroscience is 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, complex brains 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. 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 (Blackboard).

<http://blackboard.tufts.edu/>

Please make sure that you log onto this site regularly for updates and general communications. All students registered in this course can access the site using their surname and ID# .

There will be three exams contributing to the final grade:

- 1) February 11th Friday. Progress test (20%)**
- 2) March 16th Wednesday. Midterm (30%)**
- 3) May 9th Monday 3:30-5:30 p.m. Final exam (50%)**

You are also encouraged to attend the annual Kenneth Roeder Memorial Lecture on **April 14th at 7:30pm in Barnum 008**. This year's lecture will be by Prof. Michael Land (University of Sussex, UK) who will talk about visual processing and attention.

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.

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 additional reading. I will also post directions to appropriate web resources on the Blackboard site.

These topics are not strictly separate; an understanding of each topic is best achieved by pulling together information from many other topics. Towards the end of the course we will cover material that is not included in the textbook but will be put on reserve at the library. 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.

Topics

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. Complexity/Simple model systems. Chemical/electrical synapses. Recording/monitoring techniques. (First lecture). [*Neuroscience. Purves, D., et al. Chapter 1, p 1-10. How the mind works Pinker, Chapter 1. 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. A distinguishing characteristic of neurons, is their 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. (2 lectures). [*Neuroscience. Purves, D., et al. Chapter 2, p 29-42. 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, molecular techniques can now tell us how they work. (4 lectures). [*Neuroscience. Purves, D., et al. Chapters 2, 3, 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, or cable properties, of the cell. Both morphology and composition determine these properties. The insulation provided by myelin results in fast saltatory conduction of action potentials. Passive properties and specialized channels combine in some neurons to act as signal integrators. (2 lectures). [*Neuroscience. Purves, D., et al. Chapter 3 p 58-67, Box C p 60-61. 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 11th 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. (3 lectures). [*Neuroscience. Purves, D., et al. Chapters 5 and 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. (3 lectures). [*Neuroscience. Purves, D., et al. 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 (4 lectures). [*Neuroscience. Purves, D., et al. Chapter 13 Box D (p 332-3), Chapter 15 Box A (p 384-5) Box B (p 388). How the mind works, Pinker Chapter 2. Delcomyn Chapters 16-21. From Neuron to Brain, Chapter 13. and additional material posted to Blackboard*].

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. (3+ lectures). [*Neuroscience. Purves, D., et al. Chapters 24, 30. How the mind works, Pinker Chapter 2. Delcomyn, Chapter 24. Essentials of Neural Science and Behavior, Chapters 14, 36. From Neuron to Brain, Chapter 13*].

Midterm exam March 16th about here.

Building a nervous system. Part I; differentiation and induction of brain regions. Of all cell types, neurons are unique in their diversity and specificity. How does this diversity arise, how do neurons find and make appropriate connections? Nerves may also exhibit plasticity in their growth and repair and in finding targets. (2 lectures). [*Neuroscience. Purves, D., et al. Chapter 21. Delcomyn, Chapters 22 and 23. Essentials of Neural Science and Behavior, Chapters 4, 6. From Neuron to Brain, Chapter 11*].

Building a nervous system. Part II; pathfinding, synaptic connections, selective cell death. What regulates a neuron's ability to find its target and what are the roles of hormones and trophic factors in the process of neuronal selection? (2 lecture). [*Neuroscience. Purves, D., et al. Chapter 22. Delcomyn, Chapters 22 and 23. Essentials of Neural Science and Behavior, Chapter 6. From Neuron to Brain, Chapter 11 and Chapter 12*].

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? (3 lectures). [*Neuroscience. Purves, D., et al. Chapter 8 p 192-199, Chapters 13, 14. Delcomyn, Chapters 9 and 10. Essentials of Neural Science and Behavior, Chapters 20, 22 From Neuron to Brain, Chapter 16*].

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 some detail the neurobiology of vision and olfaction (4 lectures). [*Neuroscience. Purves, D., et al. Chapters 10, 11 and 12 .How the mind works, Pinker Chapter 4. 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. Ultimately, one of the chief 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 *i.e.*, *Neuroethology*. We will look at several model system, electrolocation and communication in weakly electric (eclectic?) fish and/or escape behavior in insects (2 lectures). [*Delcomyn, Chapters 20 and 21. How the mind works Chapter. 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. (2 lectures). [*Neuroscience. Purves, D., et al. Chapter 1 Box A. From Neuron to Brain, Chapter 19. How the mind works, Pinker Chapter 8. Original papers*].

COURSE BOOKS

Essential reading (*required texts):

***Neuroscience.** Purves, D., Augustine, G.J., Fitzpatrick, D., Katz, L.C., LaMantia, A-S., McNameamara, J.O., and Williams, S.M. 3rd edition Sinauer (2003)

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

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

Supplementary reading (helpful alternative texts):

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? 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.].

Receptors, Restak, R.M., Bantam Books (1994)

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 Course Info site and follow “External Links”

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