PY299: NEUROSCIENCE

Blocks 1-2, 2012: Lori Driscoll, Bob Jacobs
Lecture: Tutt Science Lecture Hall #122
Labs: Quant. Neuromorphology #313
      Behav. Neurotoxicology #307

Office Hours*: MWF: 3:30-4:30
              TTH: 1:00-2:00
*No office hours on lab or test days.

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Course Description

No, nor nowhere else but in your brain.

(Shakespeare, The Merry Wives of Windsor, IV, ii, 139)

Shakespeare was right--there is, in a sense, nothing that exists outside your brain. Almost all areas of psychology require at least a working knowledge of the brain. It is indeed doubtful if one can truly understand behavior without knowledge of the neural substrate that makes all behavior possible. Psychology 299: Neuroscience provides you with an opportunity to learn about the basic structure and function of the human brain. The term neuroscience refers to investigations of the development, organization, and functioning of the nervous system.

In order to provide you a guided tour of the brain, the course follows primarily a lecture format with an extensive laboratory component designed to give you "hands on" experience with human tissue. Emphasis is placed on fundamental neurobiological principles, including an overview of the relevant neurophysiology, neuropharmacology, and especially neuroanatomy (e.g., embryology and histology, sensory processing from the spinal cord/brain stem to thalamo-cortical systems, the cerebral hemispheres, the limbic system, etc.). For most of you, this will be the only course where you can obtain a good foundation in neural structure, and therefore the course is organized neuroanatomically.

Although the course does not assume any specialized scientific knowledge, it remains a challenging course, requiring the same commitment as would any study of a foreign language. Indeed, learning neurobiology means that you must learn the "language of the brain"; there is no getting around this. [see: http://faculty.washington.edu/chudler/neuroroot.html] Without a core knowledge of the neural substrate, any subsequent discussion of function quickly loses contact with reality. As noted recently by Damasio (1994):

...neuroanatomy is the fundamental discipline in neuroscience...There can be no hope of understanding the many levels of brain function if we do not have a detailed knowledge of brain geography at multiple scales (p. 25).
The course should not be viewed as an end to itself, but rather as a window to a new perspective. The knowledge obtained in the course should both guide and constrain future thinking about issues related to the human brain and mind, be they in the linguistic, philosophical, psychological, social, or political domain. The course provides the tools with which you can continue your exploration of psychology, biology, and/or neuroscience. In fact, the knowledge of the brain you gain in this course will profoundly affect your perception and appreciation of everything you do.

The main goal of the course is that you obtain an ACTIVE (rather than passive) knowledge of the brain. To this end, you will be asked to participate in the Elementary School Outreach Program, a program designed for you to share your newly acquired knowledge of the brain with elementary school children.

Lectures will generally begin exactly at 8:45 AM. You will be expected to be available until 3 PM most days for review and any extra sessions not on the syllabus. Cell phones and other portable electronic devices must be turned off during lectures and tests. You may use your laptop during class, but please show respect for your classmates and professors by refraining from using non-class related applications during lecture.

How is this course relevant to Psychology? This course, or its equivalent (e.g., biological psychology, physiological psychology) is required for psychology majors at almost every university/college. This is done for a reason. Along with Research Design, it forms the core of psychological investigations into behavior—all behavior (including everything one studies in the humanities and social sciences) derives from brain function at some level. CC students who have already taken Psychology courses beyond Research Design have often noted how knowledge of the brain has enriched their understanding of the material covered in these courses. However, if you have not taken many Psychology courses yet, here are but a few examples of direct links between this class and other Psychology courses:

- **Clinical/abnormal psychology.** This is probably the area of psychology for which Neuroscience is most relevant. As a clinician, your job is to treat humans. But what in those humans produces the abnormal or maladaptive behavior in the first place? The brain. What do clinicians treat? Whether they are using psychotherapy or drugs or both, they are ultimately attempting to alter maladaptive brain processes. Research shows that psychotherapy produces lasting effects on the brain, and that the magnitude of those brain changes correlate with the patient’s self-reported level of improvement. ALL licensed clinicians are required to know something about brain systems and how they are affected by the therapies that they practice. If you plan to study clinical or abnormal psychology, the neuroscience course will give you a substantial head start.

- **Developmental and educational psychology.** Psychological development and neurobiological development go hand-in-hand. Most developmental disorders (mental retardation syndromes, learning disorders, etc.) have a neurological basis, and you will discuss these neurological bases when you take Lifespan Developmental Psychology (PY374). You will also discuss how children’s brain development corresponds to their cognitive, emotional, and social development. In addition, the neuroscience course will give you a more fundamental understanding of the
substantial brain-environment interactions that shape the brain throughout one’s lifetime.

- **Personality and social psychology.** Modern social and personality psychologists work hand-in-hand with neuroscientists to understand the neural bases of individual differences and interpersonal interactions in psychology. In fact, it is becoming standard for the brightest young psychologists in these fields to be simultaneously trained in neuroimaging techniques, as these techniques are frequently employed in their research. There is, in fact, a new field devoted to such research: Social Neuroscience. If you were to open a social psychology journal, you would see at least one article (and probably several!) per issue that contains brain scans to support the authors’ behavioral findings. You will particularly see research on brain areas involved in making moral decisions, interpreting someone’s actions/intentions, differences in limbic system and cerebral cortex activation between introverts and extroverts, between prejudiced and non-prejudiced individuals, and so on.

- **Emotion.** One can study emotion on several levels, but invariably one has to come back to the underlying brain structures that give rise to emotions. This is an area of research that has grown tremendously in the last 20 years as neuroscientists have mapped out specific circuitry involved in emotion and motivation.

- **Learning/Cognition.** Although one can explore learning and cognition without reference to underlying brain structures, one’s ultimate appreciation of these complex phenomena is greatly enriched by understanding the neural processes that make learning and cognition possible.

### Required Textbooks


The information in DSE, dealing primarily with neuroanatomy, is absolutely essential. The benefit of this book comes from coloring the assigned plates before the lecture in which the material is discussed. Although the act of coloring is quite time consuming (between 30 and 60 minutes per plate—no one ever claimed that learning was quick and easy!), it is the best way to remember the material. In the past, students who avoided coloring found themselves hopelessly lost (and frustrated) after only a short period of time.

You will need approximately 20-30 different colored pencils to color the plates effectively.


Bear et al. (2007) supplements the neuroanatomy in DSE with a broader range of information related to physiology, function, and neuropharmacology. At the beginning of each chapter is an overview outline; at the end of each chapter are key terms and review questions. You should take advantage of these study aids. To learn the material sufficiently well, read each assignment more than once. Many students report that they gain the maximum benefit from Bear when they read each assignment once before lecture and once after.
Haines, D. E. (2012). Neuroanatomy: An atlas of structures, sections, and systems (8th Ed.). Baltimore, MD: Lippincott, Williams & Wilkins. [henceforth Haines]—you can wait to purchase this book—copies of it are available in the lab

This atlas is very helpful for your laboratory sessions, and for most other aspects of the course—study the pages here as they are assigned on the syllabus. The atlas is intended to be a supplement to the other materials in the course; it contains more structural detail than we will cover in class.

In addition, the neuroscience webpage is essential, both for resources and for course downloads:

http://www.coloradocollege.edu/academics/dept/neuroscience/course/

**Study suggestions** (best practices vary by individual needs)

(1) **It is recommended that you form a study group consisting of 3-4 people.** Meet with each other daily to go over the lectures and the readings; quiz each other, help each other, and share your insights. This is the best way to become comfortable with the material, and it will help you to gain an active knowledge of the material. Individuals in previous classes who did not work regularly in study groups had considerably more difficulty in the course than those who regularly participated in a group. Often, it is best to conduct such study groups in the laboratory, where you can get immediate assistance from the professors and tutors if you have questions.

(2) Do the reading and the coloring in DSE before the lecture. Above all, do not get behind. **The path gets cold very quickly!** Work at a consistent and steady pace throughout the course. **You cannot cram for the tests** and be successful—there is simply too much information. To integrate the information requires that you stay on top of everything and that you review constantly as you study new material. If there is something you do not understand, ask another student or the professors. This is a learning experience for everyone. The only stupid question is the one that remains unasked.

(3) You should note that it is **not** sufficient for you to get just the "gist" of the information covered. At this level, you are also expected to **know the details**—and there are a lot of them. If you have not marked up your textbook, or taken copious notes, then you have not read the material thoroughly enough. You should read each Bear chapter at least twice before the tests, and study all of the assigned plates in DSE extensively. Coloring the plates quickly may allow you to finish sooner, but probably at the expense of actually learning the material thoroughly. **Learning takes time!**

(4) Use the **interactive computer programs** to review information covered in lectures, particularly with regards to the slides. Especially useful is the Brainstorm program--it will greatly facilitate your learning of the anatomy. Take advantage of these programs!

(5) **Lecture notes** (and lecture slides) are available on the Neuroscience web page. You should go over the appropriate lecture notes for each day **before** you come to class; **bring these lecture notes with you to class**—they will assist you in taking notes. **These notes should NOT** take the place of your own notes. Many lecture notes also have sample questions attached for
you to quiz each other on—these should help you to determine your relative knowledge of
the material, particularly with regards to the Bear textbook.

(6) There are many useful links on the Neuroscience web page:
http://www.coloradocollege.edu/academics/dept/neuroscience/resources/links.dot

In particular, we suggest the following:

http://library.med.utah.edu/kw/animations/hyperbrain/pathways/index.html, which is good
for reviewing many of the tracts you will learn in this course; and for gross anatomy.

http://www.anatomie-amsterdam.nl/sub_sites/anatomie-zenuwwerking/123_neuro/start.htm,
a collection of beautiful cross-sections through human brain tissue.

(7) Exams will include information covered in the assigned readings, in labs, and in lectures.

(8) When working in labs and going through the wet brain, you will learn the material better if
you use the atlases to guide you.

(9) Please observe professors’ office hours, as these times are specifically set up for you to ask
questions pertaining to the course.

**Grading Procedures**

The grades in this course will be based primarily on scores from four examinations. In addition,
part of your grade will be determined by your participation in the Outreach program. **Note: Your
grade in this course is based only on your mastery of the material, not on your perceived
effort.**

All examinations are comprehensive, but will have a slight emphasis on material covered since
the previous exam. Exams will cover material from the readings, the lectures, and the laboratory.
**SPELLING IS IMPORTANT, AND SPELLING ERRORS WILL COST POINTS.** You should
be aware that not all material in the readings will be covered in lectures. In particular, please do
not underestimate the amount of material in the textbooks that will be covered on the tests (even
if not explicitly discussed in class). If there is something in the reading you do not understand,
please ask in class so we can discuss it.

Each exam will have a variety of question types (e.g., Multiple Choice, True/False,
Identification, Short Answer, and Essay). Each exam will also have a wet-brain and/or a slide
component, which cannot be made up.

Final grades are calculated as follows (of course, "+" and "-" will also be given when
appropriate):

<table>
<thead>
<tr>
<th>Exam</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam 1</td>
<td>10%</td>
</tr>
<tr>
<td>Exam 2</td>
<td>20%</td>
</tr>
</tbody>
</table>
Exam 3  22%
Exam 4  33%
Gross anatomy LAB  3%
Micro anatomy LAB  2%
Finger twitch LAB  2%
Neuropharmacology LAB  3%
Mulligan stain LAB  2%
Outreach program  3%
Total  100%

with the following breakdown:

A = 90-100%
B = 80-89%
C = 70-79%
D = 65-69%
NC = below 65%

A = Excellent work that reflects superior understanding and insight, creativity, or skill.
B = Good work that reflects a high level of understanding and insight, creativity, or skill.
C = Adequate work that indicates readiness to continue study in the field.
D = Marginal work, only minimally adequate, indicating lack of readiness to continue in the field.
NC = Failing work, clearly inadequate and unworthy of credit.

Note 1: No personal listening devices (e.g., IPods, CD players) may be used during the tests.

Note 2: If you have a disability and require accommodations for this course, please speak with the professors as soon as possible (preferably before the block begins) so that your learning needs may be appropriately met. Please keep in mind that due to the intense pace of the Block Plan, it is necessary to request accommodations in a timely manner to allow faculty and staff sufficient time to evaluate your request and implement reasonable accommodations. If you have not already done so, you will need to register with Disability Services (Learning Commons at Tutt Library, Room 152, 227-8285), the office responsible for coordinating accommodations and services for students with disabilities.

Note 3: After tests are handed back, you may not talk to professors about the test for two days (unless the professors have made an obvious mathematical mistake on the scoring of the exam)—go over tests in your groups to figure out what you missed.

**Outreach Program**

The purpose of "Elementary School Outreach Program for Neuroscience Education" is to introduce local elementary school children (Grades 1-6) to basic neuroscience by providing them with hands-on experience with brain tissue at the gross and microscopic level. Often the best way to learn material is by teaching it yourself. Another belief is that a well-rounded education at any
level must include knowledge of how the brain works, and that this knowledge relates directly to how humans interact with each other as social beings. The sooner neuroscience education begins, the better. With this program, neuroscientific information can reach a very broad audience in the Colorado Springs area.

The requirements for this program are straightforward. You will work in groups of two–four as assigned by the professors. Through a series of meetings, you will organize your "presentation" for the elementary school children you will be meeting during near the end of the course. You will write an outline of what you plan to do; you will prepare at least one original poster to take with you for your presentation; you will take digital pictures of your outreach experience and email these to the professors after your outreach experience. Depending on accessibility to the elementary schools, you will meet with 1-4 classrooms.

The following summarizes our efforts since 1993, when the program started:

**Number of classrooms visited:** 658

**Grades visited:** generally, 1st through 6th; and some middle school children

**Number of elementary school students involved:** approximately 16,837

Note: if you do not have or want to use your own vehicle, you can use CC transportation free of charge after taking a training course. See professors well in advance if you would like this option.

More can be found here: [http://www.coloradocollege.edu/academics/dept/neuroscience/outreach-program/](http://www.coloradocollege.edu/academics/dept/neuroscience/outreach-program/)

### Honor System

As is the tradition at Colorado College, examinations in this course are unproctored, but you will be required to take exams in the classroom. Any unauthorized use of materials other than your own brain (e.g., other students, notes) in the taking of exams is considered to be a violation of the Honor Code. Removal of tests from the testing room for any reason is a violation of the Honor Code and will be reported immediately to the Colorado College Honor Council. In addition, any unauthorized copying of an examination used in this course is strictly forbidden, as is use of any such copy to prepare for an examination. You will have access to your old tests to review them, but they must remain in the department.

### Labs

Some laboratory activities are structured and **participation is mandatory**. Most of the time, however, the laboratories will remain open in the afternoons and evenings for you to work in groups and learn the material. Most afternoons, the professors will be available to answer any questions your group might have—don't hesitate to ask if you need assistance during the professors’ office hours. You will have access to at least one plastinated hemisphere from a human brain throughout the block. PLEASE TREAT THE BRAINS GENTLY—if you damage them, you will be asked to replace them (and they are expensive, approximately $1,600/hemisphere). Brain atlases, embedded sections, and slides will be in the lab for your use. The purpose of the laboratory is for you to extend your knowledge beyond the textbook; to this
end, each examination will include a slide and/or wet brain component to test your knowledge of actual tissue. UNDER NO CIRCUMSTANCES WHATSOEVER MAY YOU REMOVE THE BRAINS FROM TUTT SCIENCE 313 OR 307.

There is a lab write up for each of the labs, constituting 12% of your final grade. These write-ups are designed to reinforce material from the labs themselves as well as other relevant material in the course.

**Labs are to be written up individually, not in groups.**
WEEKLY SCHEDULE

Notes: (1) You are responsible for knowing this schedule. Complete all readings by the day and time they are listed.
(2) Plate numbers are provided for DSE; optional plates are within brackets; all other plates are required.
(3) Although topics are broken into rather circumscribed areas, you should realize that, ultimately, they all overlap with each other.
(4) Most afternoons are OPEN LABS, that is, they are for you to study whatever you feel you need to study. Use this time to review material, to work in your study groups, and to ask the professors for help.
(5) There will be review sessions when tests are handed back; these will usually be held in the afternoon. Make note of these sessions in the syllabus.

BLOCK #1, WEEK #1

MONDAY 10:30 AM (following Opening Convocation): Introductions and Overview of the course; overview of the field of neuroscience

Bring this syllabus with you and make sure you have read it thoroughly

TUESDAY: Evolution of the human brain
Historical overview of neuroscience (Jacobs) [26 pages of text]

Bear et al. (2007): Chapter 1: Introduction to neuroscience (pp. 3-21)
Haines: pp. 2-8

PREVIEW: In this lecture, you will be introduced to the phylogeny of the central nervous system (CNS--consisting of the spinal cord and the brain), that is, how the brain has developed through evolution. This is important for understanding functional neuroanatomy and the field of evolutionary psychology.
Today’s lecture also provides a brief overview of the history of thinking about the brain, highlighting some landmarks from antiquity to the present.
WEDNESDAY: Embryology (Jacobs) [9 plates; 53 pages of text]

**DSE:** 3-1 to 3-4; 3-7; 3-11; 9-3; 9-4; 9-11  
**Bear et al. (2007):** Chapter 7: The structure of the nervous system (pp. 167-174; 178-203)  
**Bear et al. (2007):** Chapter 23: Wiring the brain (pp. 690-697)  
**Haines:** pp. 25; 52-63

**PREVIEW:** Here, we will explore the ontogeny of the brain, that is, how it develops within each individual. A great deal happens during the nine-month gestation period. Knowing the complex and critical nature of neural embryogenesis and early brain development will help you to appreciate and understand (1) the basic "components" of the brain, and (2) the relevance of this development for later mental abilities. In addition, a brief overview of gross anatomy is provided. We will also overview general gross anatomy.

THURSDAY: GROSS NEUROANATOMY LAB [7 plates; 43 pages of text]

**DSE:** 1-1 to 1-6; 5-44  
**Bear et al. (2007):** Chapter 7 Appendix: An illustrated guide to human neuroanatomy (pp. 205-217, 232-235; self quizzes: pp. 236-240; 247-248)  
**Haines:** pp. 13-30—focus on those pages with gross anatomy; 38

- **Group #1:** 8:30-10 AM  
- **Group #2:** 10:30AM-12 PM  
- **Group #3:** 1-2:30 PM

**PREVIEW:** The primary purpose of the LAB is to let you see first hand what the brain looks like, and to point out the differences between textbook drawings and reality: there are no dotted lines in nature. Be sure to note the individual variation in the brains you examine. Each person's brain is as different as each person's physiognomy and personality--indeed, each person's brain is his/her personality.  
**Question:** What makes each brain different?  
**Note:** You are not expected to know everything in the lab handout by the end of the session; it will take you several days to have a firm grasp on the material covered in the handout--give yourself time to digest all the information.
**FRIDAY:** Neuromorphology (Jacobs); Intracellular organelles (Driscoll) [5 plates; 27 pages of text]

**DSE:** 2-1 to 2-3; 2-6; 7-2

**Bear et al. (2007):** Chapter 2: Neurons and glia (pp. 23-49)

**PREVIEW:** Neuromorphology is the study of neural structure. As interesting as gross anatomy may be, the real picture lies at the microanatomical level, which is a forest unto itself. Microanatomical structures have important stories to tell because it is at this level that all of the complex processing in the brain takes place. The main purpose of the lecture is to familiarize you with the necessary terminology. The microanatomical structures are important because many cognitive models take the neuron (= nerve cell) as their starting point. The neuron, which consists of dendrites (to bring information into the cell) a soma (the cell body, which integrates all incoming information), and an axon (to carry information away from the cell) is the building block of the brain. Consider how the shapes of neurons might relate to their diverse functions.

Equally important to the functioning of the neuron is the machinery within, the organelles that are responsible for housing and transcribing the cell’s genetic material (the nucleus); synthesizing proteins (the rough endoplasmic reticulum); packaging proteins and neurotransmitters for transport to other parts of the neuron (Golgi apparatus); transporting neurotransmitters to the axon terminals (microtubules and microfilaments); and producing energy (the mitochondria) to fuel most of the cell’s vital processes. Becoming familiar with the functions of these organelles will enrich your understanding of the processes that underlie cellular and synaptic physiology and pharmacology, which we will discuss in detail next week.

**BLOCK #1, WEEK #2**

**MONDAY:** Neurophysiology I (Driscoll) [2 plates; 23 pages of text]

**DSE:** 2-4; 2-5

**Bear et al. (2007):** Chapter 3: The neuronal membrane at rest (pp. 51-73)

**PREVIEW:** Neural structures are not static, nor do they operate in isolation; rather, they work together in highly integrated networks. Neurons communicate with each other in very elaborate and complicated ways. To understand how they communicate, you need to know the basics of neurophysiology, which focuses on the interaction (i.e., function) of the various components of the nervous system and describes how nerve cells respond to input and conduct signals. To begin this journey, we must first understand the forces that operate within a single neuron—the passive and active movement of ions and proteins across concentration gradients and electrochemical gradients that characterize the neuron at rest; and the events that lead up to and produce the sudden burst of energy called the action potential that sets the chain of inter-neuronal communication in motion.

**GROSS NEUROANATOMY LAB WRITE-UP DUE AT BEGINNING OF CLASS**

**NOTE:** LAB WRITE-UPS ARE TO BE DONE INDIVIDUALLY.
TUESDAY: Neurophysiology II (Driscoll) [26 pages of text]

*Bear et al. (2007):* Chapter 4: The action potential (pp. 75-100)

**PREVIEW:** Neurons are designed to respond quickly to stimulation—in the same way a drawn bow is ready to shoot an arrow. An elaborate electrochemical system conducts impulses (known as *action potentials*) throughout the body. Today we will examine the action potential at multiple levels, from the structure and function of ion channels, to the dynamic flow of ions that characterize the phases of the action potential, to the movement of the signal down the axon to the synaptic terminal, to the translation of patterns of action potentials into the language of the brain. Consider the following: how does this singular, “all-or-nothing” signal translate into sensations, thoughts, and actions? How does a neuron “know” when to fire an action potential and when to remain silent? We will begin to answer these questions today, but also keep the questions in mind for next time, when we discuss synaptic transmission.

WEDNESDAY: 1) HISTOLOGY, MICROSTRUCTURE LAB

**Group #3:** 8:30-10 AM  
**Group #2:** 10:30 AM-12 PM  
**Group #1:** 1-2:30 PM

**Preview:** The purpose of this lab is to expose you to some of the morphological variability that typifies neural tissue, and with a couple of the histological techniques for visualizing neural structures. Along with this lab, you should study the associated web pages.

2) FINGER TWITCH LAB—sign up for one hour slots

**Preview:** We will explore the characteristics of the action potentials that culminate at the neuromuscular junction in the human forearm, and manipulate signal strength and signal frequency to see how they contribute to the signal to move and sustain a muscle contraction.

THURSDAY: Neuropharmacology I (Driscoll) [32 pages of text]

*Bear et al. (2007):* Chapter 5: Synaptic Transmission (pp. 101-132)

**PREVIEW:** Neuropharmacology refers to the study of normal chemical synaptic transmission and the effects of drugs on the nervous system and behavior. The synapse (= bridge) is the structure by which neurons often communicate with each other. Although there are several different kinds of synapses, we will concentrate on the most common kind: the chemical synapse. *Neurotransmitters* are chemicals that cross synaptic junctions, thereby allowing two neurons to communicate with each other, that is, to "transmit" information. These substances cross the synaptic cleft and bind to receptors on the postsynaptic neuron. There are many different types of receptors, and often a single neurotransmitter can bind to multiple types of receptors. Remember: it is the receptor, not the neurotransmitter, that determines whether a signal is “excitatory” (i.e., facilitates activity) or “inhibitory” (i.e., reduces or inhibits activity). Do not underestimate the importance of inhibition! A system without inhibition will simply not work because it will self-destruct.

Pharmacology does not end with the binding of transmitters to receptors; some of the most complex and interesting interactions take place inside the postsynaptic cell. *Ionotropic* receptors control the opening and closing of ion channels, while *metabotropic* receptors initiate biochemical cascades that influence the effectiveness of other receptors and can even increase or decrease gene
expression in the nucleus. The latter effects are thought to underlie the formation of long-term memories and neuronal plasticity, both of which we will investigate later in the course.

HISTOLOGY LAB WRITE-UP DUE AT BEGINNING OF CLASS
NOTE: LAB WRITE-UPS ARE TO BE DONE INDIVIDUALLY.

FRIDAY: Neuropharmacology II (Driscoll) [45 pages]

Bear et al. (2007): Chapter 15: Chemical control of the brain and behavior (pp. 498-508)
Bear et al. (2007): Chapter 6: Neurotransmitter systems (pp. 133-166)

PREVIEW: Today we will discuss the anatomical localization of the major neurotransmitter nuclei and their projections, along with some drugs that influence these systems. Some drugs are endogenous, that is, produced within the body; others are exogenous, that is, originating from outside the body. Psychotropics, anesthetics, sedatives, hypnotics, stimulants, and other drugs produce their unique effects through their interactions with specific neurotransmitter systems. In order to appreciate the mechanisms by which drugs alter nervous system function, and diseases and insults impair it, it is important to understand how neurotransmitters and drugs interact with receptors and receptor complexes. For example, what makes one GABA receptor responsive to alcohol while another is responsive to anxiolytics? Why are some cholinergic receptors excitatory and others inhibitory? If glutamate receptors are important for learning and memory, is it possible to engineer “smarter” or “dumber” receptors by changing their composition?

FINGER TWITCH LAB WRITE-UP DUE AT BEGINNING OF CLASS
NOTE: LAB WRITE-UPS ARE TO BE DONE INDIVIDUALLY.

SATURDAY: 10AM: REVIEW SESSION— including a slide review

BLOCK #1, WEEK #3

MONDAY: TEST #1

TUESDAY: Spinal cord (Jacobs) [8 plates; 78 pages of text]

DSE: 2-9 to 2-10; 3-6; 4-1 to 4-4; 4-9
Bear et al. (2007): Chapter 7 Appendix: An illustrated guide to human neuroanatomy (pp. 226-229; self quizzes: p. 246)
Bear et al. (2007): Chapter 12: The somatic sensory system (pp. 387-400; 408-422)
Bear et al. (2007): Chapter 13: Spinal control of movement (pp. 423-432; 437-450)
Bear et al. (2007): Chapter 14: Brain control of movement (pp. 451-461)
Haines: pp. 85-95; 178-181; 184-185; 188-189

TUESDAY: 1 PM: Return and review tests
PREVIEW: Before information from the outside world can be processed in the brain, which sits in the dark cave of the skull, it must reach the brain. Thus, the primary questions today are: How does information get into the brain? What are the major processing steps along the way? All information (except olfaction) flows from the peripheral nervous system (PNS) to the CNS. We will examine one example of an ascending (sensory) pathway through the spinal cord, and one descending (motor) system. These two systems are somewhat more accessible than other types of processing and illustrate the basics very clearly. You will be responsible for following the path of these two tracts through the nervous system; you are also responsible for the names and general functions of other ascending and descending tracts, but you will not have to identify them in cross sections.

As you learn how information is processed, consider how intricate the feedback loops are, and how intertwined sensory and motor systems are. This is especially true for something like language—think about how you are able to hear what you are saying and make very detailed adjustments in your speech based on what you hear and what you perceive the situation to be. Whether the topic is processing somatosensory information from the foot or information of a linguistic nature, the basic principles (e.g., sensory transduction, encoding, feedback, monitoring, updating of information, modifications of output signals) remain the same.

We strongly recommend the following web site:

http://library.med.utah.edu/kw/animations/hyperbrain/pathways/index.html

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WEDNESDAY: NEUROPHARMACOLOGY LAB

**Group #2:** 8:30-10 AM  
**Group #3:** 10:30AM-12 PM  
**Group #1:** 1-2:30 PM

PREVIEW: This lab will introduce you to some of the basic techniques involved in behavioral pharmacology, or the study of the effects of drugs on behavior. Researchers who are interested in the unique influence of particular neurotransmitter systems on behavior can administer a drug that increases or decreases activity of that system, then measure the change in behavior that results as a function of the drug. We will investigate the paradoxical effect of the stimulant drug methylphenidate (Ritalin) on locomotor activity in rats, and discuss the potential mechanisms that underlie the effects we observe.

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THURSDAY: Brainstem I—Gross anatomy and tracts (Jacobs) [8 plates; 35 pages]

**DSE:** 5-1 to 5-4; [5-5]; 5-6; 5-8; 5-9; 5-10  
**Bear et al. (2007):** Chapter 7 Appendix: An illustrated guide to human neuroanatomy (pp. 224-226; self quizzes: pp. 244-245)  
**Haines:** pp. 100-111; 118-125; 128-137

PREVIEW: The brain stem, which is absolutely essential for life, is an extremely complex collection of nuclei (= groups of cells with a shared function) and fibers (= the “telephone wires” carrying signals). It consists of the medulla oblongata, the pons, and the midbrain. We will follow the two tracts we discussed previously (DCML and Corticospinal) as they traverse through the brainstem. In addition, we will briefly cover a couple of the more obvious nuclei, their functions, and other landmarks along the way.
FRIDAY: Brainstem II — Cranial nerves and nuclei (Driscoll) [8 plates; 37 pages]

DSE: 6-1; 6-3; 6-4; 6-11 to 6-13; 6-23; 6-24
Bear et al. (2007): Chapter 7 Appendix: An illustrated guide to human neuroanatomy (pp. 232-233; self quizzes: pp. 247)
Lecture notes: read the lecture notes for this lecture before class
Haines: pp. 24; 50; 104-111; 176-177; 190-191

PREVIEW: A vital part of the brainstem is the cranial nerves, of which there are 12 pairs (I through XII). On many levels, the cranial nerves are to the head what the spinal nerves are to the rest of the body: they transmit a wide variety of (sensory and motor) information to and from the brain. However, the information carried by the cranial nerves is somewhat more detailed and specialized. In addition to learning the basic origins and destinations of these nerves and their brainstem nuclei, we will investigate in detail the pathways of two of these nerves.

NEUROPHARM LAB WRITE-UP DUE AT BEGINNING OF CLASS NOTE: LAB WRITE-UPS ARE TO BE DONE INDIVIDUALLY.

BLOCK #1, WEEK #4

MONDAY: Thalamus (Jacobs); Hypothalamus (Driscoll) [7 plates; 34 pages]

DSE: 5-16 to 5-22
Bear et al. (2007): Chapter 15: Chemical control of the brain and behavior (pp. 481-497)
Haines: pp. 140-155

PREVIEW: With the exception of olfaction, all information coming into the cortex must pass through the thalamus, which serves as the great "portal" to the cortex, and functions as a processing/relay station. The thalamus may be the earliest level at which sensations attain consciousness. This structure is composed of many nuclei, each responsible for a different kind of sensory information or processing function, and each with specific cortical interconnections. There is, in fact, a continual interchange of information between the thalamus and the cortex. The hypothalamus is a favorite structure for psychologists because of its wide-ranging functions. In brief, it controls our body adjustments in relation to our external and internal environment (internal homeostasis). It regulates body temperature, hunger, thirst, sexual activity, goal-seeking behavior, endocrine functions, affective behavior and the activity of the visceral nervous system.

TUESDAY: 10 AM: REVIEW SESSION — including a slide review

WEDNESDAY: TEST #2
Note: We strongly suggest you review material during block break that you are still not completely comfortable with, and that you work ahead with the new material.

BLOCK #2, WEEK #1

MONDAY: Cerebral hemispheres and (neo)cortex (Jacobs) [4 plates; 21 pages of text]

DSE: 5-29 to 5-32
Bear et al. (2007): Chapter 12: The somatic sensory system (pp. 401-408)
Bear et al. (2007): Chapter 14: Brain control of movement (pp. 459-464; 468-472)
Haines: pp. 14-15

PREVIEW: In discussions of so-called “higher” cognitive functions, the cerebral hemispheres, and specifically the (neo)cortex, are the primary focus of attention. Today, you will be (re)introduced to the basic structural, organizational, and functional characteristics of the cortex at both the gross and the microscopic level. We will build on these characteristics when we talk about audition, vision, learning/memory and emotions, so it is important that you understand the fundamentals.

In the cortex, one can distinguish between motor areas (those concerned with muscle movements), sensory areas (those concerned with processing of a specific sensory modality), and association areas (those concerned with integration of different sensory modalities, and/or sensorimotor integration). It is very likely that many of the qualities we most (and least!) "value" as humans [e.g., language, cognition, abstract reasoning, forethought, personality, humor, intelligence, social skills, greed, jealousy] are mediated quite intimately by association cortices.

MONDAY: 1 PM: Return and review tests
**TUESDAY:** Cerebellum (Jacobs) [3 plates; 24 pages]

**DSE:** 5-13 to 5-15  
**Bear et al. (2007):** Chapter 14: Brain control of movement (pp. 472-478)  
**Bear et al. (2007):** Chapter 25: Vertebrate models of learning (pp. 772-776)  
**Haines:** pp. 36-37; 80-83; 222-225; 228-229

**PREVIEW:** Two other structures that work closely with the cerebral cortex are the basal ganglia and the cerebellum, both of which are intimately involved in motor control. Recent research suggests that these structures are also involved in sensory, cognitive, emotional, and learning processes. The cerebellum (= little brain) receives direct somatic sensory information from the periphery, and this input hints at its function: control and coordination of very rapid muscular activities such as running, typing, playing the piano, and even talking. The cerebellum has a very extensive and rapidly acting input and output system. Loss of this area causes almost complete incoordination even though there is no paralysis. We will explore the circuitry of the cerebellum in some detail because it is one of the best understood of all brain structures, and illustrates rather dramatically the importance of inhibition in neuronal networks.

**WEDNESDAY:** MULLIGAN'S STAIN LAB [18 pages]

**Bear et al. (2007):** Chapter 7 Appendix: An illustrated guide to human neuroanatomy (pp. 218-223; self quizzes: pp. 241-243)  
**Haines:** pp. 66-74

- **Group #2:** 8:30-10 AM  
- **Group #1:** 10:30AM-12 PM  
- **Group #3:** 1-2:30 PM

**PREVIEW:** The Mulligan stain is a gray matter stain that allows one to clearly see the demarcation between gray and white matter. We will be staining coronal sections of the cerebrum and brainstem structures. This will allow us to see subcortical structures (e.g., basal ganglia, hippocampus, amygdala) that cannot be seen on surface anatomy.
**THURSDAY:** Basal ganglia (Driscoll) [2 plates; 29 pages]

**DSE:** 5-24 and 5-25  
**Bear et al. (2007):** Chapter 14: Brain control of movement (pp. 464-468)  
**Bear et al. (2007):** Chapter 24: Memory systems (pp. 751-754)  
**Haines:** pp. 146-159; 234-239

**PREVIEW:** The basal ganglia are subcortical structures that are involved in the integration of motor activity and the programming, initiation, and termination of such activity. In general, the basal ganglia inhibit motor tone by transmitting inhibitory signals both to the motor cortex and the lower brain stem. However, both excitatory and inhibitory loops through the basal ganglia act in concert to aid in the initiation and termination of movement. When a plan for an important movement reaches the basal ganglia, the basal ganglia shut down inhibition to allow excitatory signals to travel from the thalamus to the cortex. With widespread destruction of the basal ganglia, muscle rigidity throughout the body results. The basal ganglia also appear to be intimately involved in procedural memory.

**FRIDAY:** Limbic system: amygdala (Jacobs) [1 plate; 23 pages of text]

**DSE:** 5-26  
**Bear et al. (2007):** Chapter 18: Brain mechanisms of emotion (pp. 563-583)  
**Haines:** pp. 258-259

**PREVIEW:** The cortex does not function by itself. In addition to the reciprocal connections with the thalamus and basal ganglia discussed previously, the cortex functions efficiently only because of its complex interconnections with other (subcortical) structures. These structures communicate with each other through an elaborate series of reciprocal connections (loops) that permit constant monitoring and adjusting of the information flow. Input and output are continually compared in these loops to insure that the system runs smoothly. There are three "qualities" without which cognition as we know it could not exist: emotions, motivation, and memory. All of these are intimately linked to what is known as the "limbic system," a rather broad range of interconnected cortical and subcortical structures. One purpose today is to introduce the amygdala, which is crucial to emotions and our affective evaluations of sensory stimulation.

Think about the following: The limbic system leads; the cortex follows.
**BLOCK #2, WEEK #2**

**MONDAY:** Hippocampus (Driscoll) [2 plates; 57 pages]

DSE: 5-27 to 5-28  
**Bear et al. (2007):** Chapter 24: Memory systems (pp. 725-750)  
**Bear et al. (2007):** Chapter 25: Molecular mechanisms of learning and memory  (pp. 761-771; 776-793)  
**Haines:** pp. 256-257

**PREVIEW:** The hippocampus (=sea horse) is another favorite structure of neuroscientific research, due to its purported role in the laying down (consolidation) of declarative memories. For those who sustain damage to this structure, life essentially stops at the time of the insult. Imagine not being able to make new friends or keep track of what you have said or done. However, memories made prior to the damage tend to be spared, suggesting that memories are not stored in the hippocampus. If not here, then where? Today we will explore the molecular, physiological, pharmacological, and anatomical bases of memory. Much of the research that has contributed to our current knowledge of memory formation has been conducted in the hippocampus, although vital contributions have also come from invertebrate sensorimotor circuits.

**TUESDAY:** Visual system (Jacobs) [2 plates; 69 pages of text]

DSE: 6-6 and 6-7  
**Bear et al. (2007):** Chapter 9: The eye (pp. 277-308)  
**Bear et al. (2007):** Chapter 10: The central visual system (pp. 309-341)  
**Haines:** pp. 244-247

**PREVIEW:** Vision has received more attention than any other area of neuroscientific research and, as a result, is one of the more understood areas. In many ways, visual processing serves as the paradigm for all types of sensory processing. Many cognitive models (e.g., connectionism, neural networks, perceptrons) would not be possible without the knowledge that has been gained from the study of the visual system. As you study this area, think how similar processing techniques (e.g., parallel and hierarchical) could be involved in the processing of other types of sensory information.

**WEDNESDAY:** OUTREACH PROGRAM

**YOU NEED TO RESERVE THE ENTIRE DAY FOR THIS**

Note: Your group also needs to make one original, high quality poster for this activity. Also, please take digital photos of your presentation and the children’s participation in the program. Let us know in advance if you need a digital camera.
**THURSDAY:** Neuroplasticity (Driscoll) [1 plate; 31 pages of text]

**DSE:** 3-12  
**Bear et al. (2007):** Chapter 23: Wiring the brain (pp. 689-691; 697-723)  
**Haines:** pp. 243

**PREVIEW:** “Plasticity” refers to the ability of the nervous system to change in response to developmental cues, sensory input, motor activity, learning, and physical or environmental insults. Not all plasticity is growth; neurons, dendrites, synapses, and receptors also die in response to internal or external cues, from prenatal development throughout adulthood. Some “pruning” is, in fact, a necessary part of our nervous system’s ability to refine its connections—a sort of “use it or lose it” process. Although the brain changes throughout our lifespan, “sensitive periods” of increased plasticity in specific regions of the brain are thought to contribute to our learning abilities for certain types of material (such as language) at particular ages.

**MULLIGAN STAIN LAB WRITE-UP DUE AT BEGINNING OF CLASS**  
**NOTE:** LAB WRITE-UPS ARE TO BE DONE INDIVIDUALLY.

**FRIDAY:** Chemical senses (Driscoll) [3 plates; 25 pages of text]

**DSE:** 6-5; 6-16; 6-21  
**Bear et al. (2007):** Chapter 8: The chemical senses (pp. 251-275)

**PREVIEW:** Less is known about gustation (taste) and olfaction (smell) than about vision, audition, or somatosensation. However, this does not mean that there is nothing interesting to learn! For example, approximately 3% of the mammalian genome is devoted to the coding of olfactory receptor types, and thousands of these receptor types have already been identified. In addition, have you ever wondered why odors evoke such strong emotional memories? Both the gustatory and olfactory systems are highly interconnected with the limbic system. Very recently the specific receptor proteins involved in several of the taste transduction mechanisms have been identified, so research in this area is intensifying.

**SATURDAY:** 10 AM: REVIEW SESSION—including a slide review

**BLOCK #2, WEEK #3**

**MONDAY:** TEST # 3
TUESDAY: Auditory system (Jacobs) [2 plates; 35 pages of text]

DSE: 6-17 and 6-18
Bear et al. (2007): Chapter 11: The auditory and vestibular systems (pp. 343-375)
Haines: pp. 250-251

PREVIEW: Today we will discuss the specialized sense of audition. The importance of this sense is obvious: it is the primary (but certainly not the only) sensory mode through which language is normally acquired. In general, we will discuss how sound, in the form of physical waves devoid of any inherent meaning, is transformed in the ear into the electrochemical signals that the brain can interpret. We will trace the flow of information from the brain stem into the primary and secondary auditory cortices. Auditory information is subjected to a great deal of processing before it even reaches the cerebral cortex. It is important to know at least the basics in order to understand psycholinguistic experiments (e.g., dichotic listening). Once the signal reaches the cortex, it receives additional processing (in the primary auditory cortex) and is integrated with previously stored information (in secondary auditory cortices such as Wernicke's area, the angular, and supramarginal gyri).

TUESDAY: 1 PM: Return and review test

WEDNESDAY: OUTREACH PROGRAM

YOU NEED TO RESERVE THE ENTIRE DAY FOR THIS

Note: Your group also needs to make one original, high quality poster for this activity. Also, please take digital photos of your presentation and the children’s participation in the program. Let us know in advance if you need a digital camera.

THURSDAY: Language and Neuroimaging (Jacobs) [40 pages of text]

Bear et al. (2007): Chapter 20: Language (pp. 617-642)
Bear et al. (2007): Chapter 7: The structure of the nervous system (pp. 174-179)
Bear et al. (2007): Chapter 19: Rhythms of the brain (pp. 585-590)
Haines: pp. 76-80

PREVIEW: Perhaps the most human of all characteristics is (human) language, a skill that has certainly received considerable attention in psychology and in the neurosciences. Today, we will explore the classical view of how language functions in the brain (i.e., Broca’s area and Wernicke’s area) along with some more detailed aspects of language as revealed by neuroimaging studies. Language is certainly not confined to the classical language areas; indeed, a very large number of neural structures are probably involved in language in some way. Today, we will also outline some of the basic imaging techniques such as PET and MRI, along with their relative strengths and weaknesses. These techniques have revolutionized our understanding of the living, functional brain.
FRIDAY: Comparative neuroanatomy (Driscoll)

PREVIEW: To date, the majority of neurobiological, neurophysiological, and neurochemical research has been conducted in non-human animals. For example, applied research (research designed to directly benefit the human condition) relies on the use of “animal models” to understand pathological processes that occur in the human nervous system and to test potential therapies. If you attend graduate school in neuroscience or biological psychology, it is very possible that your advisor will do research on non-human animals rather than humans. We will explore the similarities and differences between human and non-human neuroanatomy, with particular attention paid to the rodent, which is one of the preferred model organisms in neuroscience.

BLOCK #2, WEEK #4

MONDAY: 10 AM: REVIEW SESSION—including slide review

TUESDAY: REVIEW DAY—consider this an additional study day

WEDNESDAY: FINAL EXAM
Guide to Interactive Computer Programs

The interactive programs listed below are generally self-explanatory. To open these programs, simply double click the mouse on their icons on the desktop—these programs are on the iMacs in Tutt Science 313, and the Brainstorm program is also on the PCs in Tutt Science 307.

**Brainstorm**

This is simply the best and most appropriate program for the course. **Use it!** You will find it immensely helpful from the 3rd week on, especially with regards to cross sections of the spinal cord and brainstem. The program is self-explanatory; it should be easy for you to navigate.

**Haines Anatomy**

This is basically a computer version of the Haines atlas.

**iPod, iPad, and iPhone users…**

You might find the following of interest: [http://www.sylvius.com/ipod/](http://www.sylvius.com/ipod/)

Student contract
Note: This sheet must be turned in to the professors by the second day of the class.

I have read and understand the requirements of this course with regard to the following (initial each):

_______ All examinations are comprehensive in nature and will thoroughly test my knowledge/understanding of the material (learning just the gist is not enough).

_______ All grading in the course is done blindly; grades are based entirely on my demonstrated knowledge of the material, and not on my perceived effort involved in doing the work.

_______ The Honor System, including that removing tests from the testing area is an honor code violation and will be reported as such.

_______ In studying the brain, a wide variety of behaviors and disorders will be discussed; a few of these topics could make some students uncomfortable (which is different than being challenged). The professors will make every effort to help you understand the material (including classroom demonstrations involving students), but will never purposely do anything to make you uncomfortable. Moreover, the professors are not responsible for the opinions expressed by other students.

_______ I will only put my student ID# (not my name) on all tests.

_______ It is to my advantage to ask questions when I do not understand something; indeed, it is my responsibility to seek out assistance from the professor if needed.

_______ I will respect the professors’ office hours, and limit my questions regarding course material to those times.

_______ Tests cannot be made up except in documented cases of emergency (e.g., death of relative, etc.).

_______ Class begins exactly at 8:45 AM unless specifically noted otherwise. If I am late, I will be locked out until the break.

I have thoroughly read and understand the syllabus and the requirements for this course in their entirety.

Signature: _____________________________    Date: _____________________________

Print name: _____________________________