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**Enhancing the Physiological Psychology Course through the Development of  
Neuroanatomy Laboratory Experiences and Integrative Exercises**

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## Introduction

This resource is a guide designed to supplement a typical upper level Physiological Psychology or Behavioral Neuroscience course or to serve as a stand-alone, expandable laboratory experience. The guide includes 10 assignments, answer keys, and references that reinforce and expand upon students' learning and stimulate interesting class discussions. See Table 1 (next page) for a list of the assignments and how they coincide with chapters in Carlson's (2007) text. The first assignment is also based on Vanderwolf and Cooley's (1979) sheep brain atlas. The assignments can be easily adapted for use with other physiological psychology texts or assigned in different orders because they do not depend on each other. The Table of Contents notes specific pages for the start of each segment of the guide. Additional front matter gives advice for the novice instructor on how to design and conduct a neuroanatomy laboratory using biological tissue.

## Texts

Carlson, N. R. (2007). *Physiology of behavior* (9<sup>th</sup> ed.). Boston: Allyn and Bacon.

Vanderwolf, C. H., & Cooley, K. C. (1979). *The sheep brain: A photographic series* (2<sup>nd</sup> ed.). London: A. J. Kirby.

## Overview of Assignments

**1. Sheep Brain Dissection Guide:** This guide not only steps the students through dissection procedures for identification of major central nervous system (CNS) structures, regions, and systems from both a gross and microscopic perspective, but it also contains a set of questions meant to guide students toward a deeper understanding of structure-function relationships. It also serves to introduce students to material and systems that are normally discussed throughout the semester. The student guide and associated questions are listed first to facilitate distribution to students. This is followed by a second copy of the guide and questions, with suggested answers embedded after each question (now available upon request only – please contact the author directly). All of the answers have been italicized for emphasis. Page numbers with each segment of the guide reference Vanderwolf and Cooley's (1979) sheep brain atlas.

**2. – 10. Paper Prompts:** Each of these assignments is a half-page or less prompt suitable for stimulating short (1-2 page) individual student papers and class discussion. Some contain additional references or instruct students to find academic sources. Each is followed by an answer key or description of points students will probably make in their responses.

Assignment	Carlson (2007) Chapter Numbers
1. Sheep Brain Dissection	2 and 3
2. Neurotoxins	2 and 4
3. Neurophysiology	2 and 4
4. Prosopagnosia	6 and 7
5. Mirror Neurons	8, 11, and 13
6. Cranial Nerve Zero	10
7. Sexual Orientation	10
8. Hypothalamic Neurogenesis	10, 12, and 13
9. Addiction	13 and 18
10. Movement Disorders	15

## I. Designing a Neuroanatomy Laboratory

### A. How to Set Up Your Neuroanatomy Laboratory Experience

Below is a list of the scientific supply companies referenced in this manual. Many others exist. To order materials from these companies, you may need to establish an institutional or personal account and provide them with shipping and purchasing information. Most companies will require a purchase order or credit card number before they will ship the items. Each company has its own procedures, so you should contact them directly to determine how to comply. Alternatively, your Materials Management or Purchasing departments may do this for you.

Each company's website can provide additional information concerning the items to be purchased as well as their retail prices. Many companies provide discounted rates for educational purchases and for state institutions (e.g., tax and shipping exemptions). You might also wish to contact your sales representative for that supplier to receive a quote on the items you wish to order. Your representative may be able to provide additional discounts. Make sure to ask for estimated shipping charges, which may not be calculated ahead of time, but which may produce unexpected expenses. Additional hazardous shipping rates may apply for some materials (especially for biological specimens and chemicals). Check with the manufacturer before ordering.

COMPANY	PHONE	FAX	ADDRESS	WEB ADDRESS
Fisher Scientific	1(800) 766-7000	1(800) 926-1166	81 Wyman Street Waltham, MA 02454	<a href="http://www.fishersci.com">www.fishersci.com</a>
Electron Microscopy Sciences	1(800) 523-5874	(215) 646-8931	321 Morris Rd. Box 251 Fort Washington, PA 19034	<a href="http://www.emsdiasum.com">www.emsdiasum.com</a>
Carolina Biological Supply Co.	1(800) 334-5551	1(800) 222-7112	2700 York Road Burlington, NC 27215	<a href="http://www.carosci.com">www.carosci.com</a>
VWR International	1(800) 932-5000		1310 Goshen Parkway West Chester, PA 19380	<a href="http://www.vwr.com">www.vwr.com</a>
Blue Spruce Biological Supply, Inc.	1(800) 825-8522	(303) 688-3428	701 Park St. Castle Rock, CO 80104	<a href="http://www.bluebio.com">www.bluebio.com</a>

Below is a short list of items to support a neuroanatomy laboratory experience. Although all items are included for thoroughness, the list can be pared down based on your specific laboratory goals.

PRODUCT	PRODUCT DESCRIPTION	COMPANY	ORDER No.
Brains	Sheep Brain w/ Hypophysis	Fisher	S9226S
Brains	Sheep Brain Student Grade	Fisher	S92265
Spinal Cord	4" Cow Spinal Cord Portion	Carolina	228920
Spinal Cord	4" Cow Spinal Cord Portion	Fisher	S1711S
Eyes	Sheep Eyes (package/10)	Fisher	S9224S
Histology Slides	Cerebellum	Blue Spruce	HE1-32
Histology Slides	Cerebral Cortex	Blue Spruce	HE1-21
Histology Slides	Spinal Cord cross section	Blue Spruce	HE2-22
Histology Slides	Peripheral Nerve	Blue Spruce	HE3-11
Histology Slides	Motor Nerve Cell	Blue Spruce	HE4-1
Histology Slides	Hypophysis	Blue Spruce	H01-1
Histology Slides	Sensory Organ Detail Set (10 slides)	Fisher	S64950
Histology Slides	Nervous System Detail Set (11 slides)	Fisher	S64949
Preservative	Biofresh Concentrate	Fisher	S6011S
Containers	6 Gallon Pail with Lid	Fisher	S6020
Containers	12qt Buckets	Fisher	S30518A
Dissection Knife	190mm Disposable Autopsy Knife	EMS	63010-01
Scissors	Student Scissors	Fisher	S17310
Trays	Dissecting Pans with Wax	Fisher	09-002-20
Gloves	Fisherbrand Nitrile Gloves (M & L)	Fisher	19-050-221
Dissecting Needles	Dissecting Needles (package/12)	VWR	257778-000
Dissecting Needle	Dissecting Needles (package/12)	Fisher	08-965A
Dissecting Kit	Individual Student Dissecting Kit	Fisher	S17259
Sheep Brain Atlas	The Sheep Brain: A Photographic Series	Amazon.com	920700039

### B. Important Practical Considerations in Developing a Neuroanatomy Laboratory:

All biological specimens are packaged with a preservative and should also be stored in a preservative between uses (e.g., Fisher packages some materials in a non-formaldehyde containing preservative called BioFresh, which can be purchased separately for specimen storage). Precautions should be taken in handling these materials. You should follow your institution's chemical safety regulations regarding the handling, use and disposal of these materials. Additional information can be obtained from the manufacturer in the form of Material Safety Data Sheets (MSDS). MSDSs provide a wealth of information including chemical content information, health risks, emergency procedures, first aid measures, fire fighting measures, accidental release measures, storage and handling information, etc.

You should provide gloves for handling the biological specimens. To avoid issues with possible latex allergies, you may wish to use latex-free gloves. There are many latex-free alternatives on the market (e.g., Nitrile brand gloves). Depending on how the specimens have been preserved and stored, you may also wish to provide surgical masks. Alternatively, instruct students to place the specimen under running water before performing laboratory sessions to help remove excess chemicals and reduce vapors.

Scissors and dissecting knives can be shared, but students should have their own dissecting needle(s) and atlas and each group should have its own trays. Order enough buckets and preservative for short-term and long-term storage. Buy some cheap rags and string. Once the students start sectioning their brains, the string can be used to keep each brain together and separate from other students' in between lab sessions. Instruct the students to avoid letting the specimens dry out during the laboratory sessions. They can use the rags mentioned above dipped

in the preservative to moisten the specimens and to cover those not being used. This should be done frequently during each laboratory session.

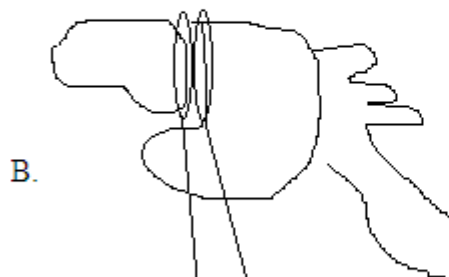
Most students will benefit from a small group experience during the brain anatomy laboratories. This is also a cost efficient strategy. It is my observation that group size should be limited to two or three students per group. Large groups may reduce the level of involvement for some group members. Be sure to instruct students that all members of the group must “get their hands wet.”

Although many of these items will need to be purchased by the institution, some may be a required purchase for the student (e.g., Sheep Brain, Spinal Cords, Sheep Eyes, and Student Dissecting Kits). This can be arranged by contacting your bookstore manager. Many bookstores are experienced at ordering these types of materials for students in Natural Sciences courses.

Each group will be working with one brain for whole brain inspection as well as for midsagittal and several coronal sections. Allow the students to observe all visible whole brain structures before making the midsagittal cut (i.e., dividing the two hemispheres). Instruct the students to keep one half of the brain intact for reviewing midsagittal and whole brain structures and to work exclusively with the other half for the remaining coronal sections. Perform the coronal sections in the order suggested using the landmarks highlighted in the lab book (Vanderwolf & Cooley, 1979) for this half brain. After making each successive coronal section, use that section and the remaining intact half brain to simulate a whole brain section (see figure below).



A. A lateral view of a half sheep brain bisected with a single mid-sagittal cut



B. A coronal section made through the half brain



C. A whole brain section is simulated by opposing the two surfaces from the coronal section

**C. Useful Web Links for Students and Faculty:**

A few of the many excellent web-based resources in neuroanatomy are listed below. If you are considering developing a neuroanatomy lab, but are limited in resources, you might consider utilizing some of these materials as a substitute for real tissue.

1. <http://www.gwc.maricopa.edu/class/bio201/brain/1neuro.htm>

This website contains several pictures of sheep brain sections, including “hard to get to areas.” Students can also test their knowledge of 30 midsagittal structures by completing an on-line quiz.

2. <http://www.exploratorium.edu/memory/braindissection/>

This site is dedicated to the anatomy of memory. It includes a video of a sheep brain dissection.

3. <http://academic.scranton.edu/departement/psych/sheep/>

This excellent sheep brain dissection resource is currently under development. Several of the concepts listed in this guide are reinforced. Check back regularly for regular additions to the site.

4. <http://www.wellesley.edu/Biology/Concepts/Html/sheepbrain.html>

The site includes a digital video of the hippocampus (a hard to reach brain region).

## II. Assignments and Answer Keys (now available upon request only)

### A. Assignment 1: Sheep Brain Dissection Guide and Associated Questions

Use this guide along with your lab book (Vanderwolf & Cooley, 1979) to help you locate structures in the brain, identify the functions of these structures, and identify major functional brain circuits. Answer all of the questions in this lab manual and turn them in as Assignment #1.

#### I. Meninges

1. The brain has a three-layered covering collectively called the meninges.
  - a. What are the names of each layer starting with the inner most layer and moving out?
  - b. Name three major functions of the meninges.
2. Before you remove the meninges, note the cranial nerves emerging mostly from the base of the brain (see V & C, p. 18).
3. Remove the meninges from your sheep brain using scissors and forceps. Be careful not to remove the pituitary gland. Also be very careful in removing the tentorium (the dura that separates the cerebellum and cerebral cortex). Note the thickness and toughness of the two outer layers of the meninges and the fragility of the third layer (which is probably still attached to the brain). Notice how the third layer dips into the sulci, following the contours of the brain.
  - a. Which layers compose the tough stuff?
  - b. Which layer is delicate and most closely associated with the brain's surface structures?
4. Delicately remove the final layer of the meninges, being careful not to disrupt the cranial nerves on the ventral aspect of the brain.
  - a. Which aspect is ventral? Which aspect is dorsal?
  - b. Rostral? Caudal? Anterior? Posterior?

#### II. Surface Features of the Brain (V & C, p. 16-17)

1. Attempt to locate the lobes of the brain and review the human counterparts and functions.
  - a. What will you use as your landmarks? How do they differ from the human brain?
  - b. Name a primary cortical area contained in each of the four lobes of the human brain.
2. What is the difference between a sulcus and a fissure? A sulcus and a gyrus?
3. In the human brain, what is the name of the gyrus that contains the primary motor cortex? The primary somatosensory cortex?
4. Gently lift and pull the cerebellum caudally, being careful not to pull too hard, and gently pull the cerebral cortex rostrally. Observe the corpora quadrigemina.
  - a. What structures compose the corpora quadrigemina?
  - b. What's another name for these structures?
  - c. What lies immediately ventral to these structures?
  - d. What is the function of these structures?

#### III. Ventral View (V & C, p. 18)

1. Identify as many of the cranial nerves as you can see (note: the cranial nerves are delicate and many will not survive your dissection of the meninges).
  - a. What do they do (generally)?
  - b. Name each of the 12 cranial nerves in order starting with cranial nerve I.
2. Mammillary Body (MB)
  - a. What is it connected to?
  - b. Why might Korsakoff's syndrome, which targets the mammillary bodies, result in anterograde amnesia?
3. Infundibulum
  - a. It connects \_\_\_\_\_ to \_\_\_\_\_.
  - b. What is so important about this connection?
4. Optic Tract/Chiasm – this is where part of the visual world decussates (see V & C, pp. 89; 101-103 for additional help).
  - a. What does decussate mean?
  - b. Which parts of the eye decussate?
  - c. How does the fact that some processes decussate and others do not determine the location of the left vs. the right visual fields?
5. Olfactory system (refer to V & C, p. 93 for additional help)
  - a. Where are these sensory projections sent in the brain?
  - b. What is the first major stop of other sensory projections in the brain (Hint: it is part of the diencephalon)?
  - c. What are some implications for the unique projection patten for olfactory sensory fibers?
6. Temporal Lobe
  - a. Name two limbic structures that are located deep within the temporal lobe.

#### IV. Midsagittal View (V & C, pp. 21-22)

1. Spinal Cord, Medulla, and Pons
  - a. These are contiguous structures. How are they similar? How are they different?
  - b. What developmental division of the brain do these structures develop from?
2. Midbrain
  - a. What are the six major nuclei that make up the midbrain?
  - b. What are the major functions of these nuclei?
  - c. In general, what is the overall function of the midbrain?
3. Diencephalon
  - a. The diencephalon is made up of which two major structures?
  - b. The name of one of these diencephalon structures suggests its anatomical position in relation to the other. Which structure? What direction is provided by the name?
  - c. What are the major functions of each of the two structures of the diencephalon?
4. Cerebral Cortex - make sure you can locate the different lobes and surface features of the human brain from pictures in your textbook. Try to locate analogous regions in the sheep brain (see V & C, p. 81 for additional help).
  - a. What primary sensory cortical area is located in the temporal lobe?
  - b. Which lobe is anterior to the parietal lobe? What primary cortex is contained in this lobe and, therefore, what are some of the major functions of this area?



- c. Which lobe contains the primary visual area? What are the functional consequences of damage to the primary visual area compared to the visual association areas?
- 5. Cerebellum
  - a. What happens to an animal when you damage its cerebellum, and what does this suggest about one of the major functions of the cerebellum?
  - b. Cerebellum means small brain – look at its organization and suggest why.
- 6. The Ventricular System
  - a. Identify and name the different ventricles, the regions of the brain they serve and related components. Describe how the different ventricles are interconnected to allow a flow of cerebrospinal fluid (CSF). Be sure to include the following terms in your answer: the Lateral, 3<sup>rd</sup>, and 4<sup>th</sup> ventricles; the septum pellucidum; the interventricular foramen; and the cerebral aqueduct.
  - b. What is so important about the ventricular system and the CSF that it contains?
  - c. Where is the CSF made?
- 7. Cingulate Gyrus
  - a. I am calling your ATTENTION to this structure – Why?
  - b. Which brain system does the Cingulate Gyrus belong to?
  - c. What does this suggest about another of its functions?
- 8. Corpus Callosum (CC)
  - a. It is a commissural system – what does this mean and what does it connect?
  - b. Name the other commissural systems.
- 9. Massa intermedia - what does it connect?
- 10. Hippocampal formation (if you can see it): Hippocampus means sea horse.
  - a. What happened to HM when he lost this structure?
  - b. What does the loss suggest about the function of the hippocampus?
- 11. Tectum (roof)
  - a. What two structures compose the tectum?
  - b. Which sensory systems project to which colliculi?
  - c. Without looking in your book, which colliculus is closer to the dorsal aspect of the brain, the superior or inferior? Explain how you came to your answer.
- 12. Tegmentum (floor)
  - a. Name several nuclei contained in the tegmentum.
  - b. Two of the nuclei in the tegmentum are dopaminergic. Name the nuclei and explain what dopaminergic means.
  - c. Which dopaminergic nucleus in the tegmentum degenerates in Parkinson's disease, and which one is involved in drug addiction?
  - d. Which nucleus is involved in pain perception?
- 13. Anterior Commissure (AC) and Posterior Commissure (PC)
  - a. What good are they?
- 14. Pineal gland
  - a. What is its historical significance?
  - b. What is it now known to do?

#### V. Special Dissections (V & C, pp. 23-26)

Do not try to replicate these dissections, but use the pictures to help understand the 3-D organization of the brain and the following structure-function relationships:

1. Visualize how information from the optic tract flows first to the relay nucleus (thalamus) and specifically to the lateral geniculate nucleus.
  - a. Why is it called the geniculate nucleus? What does it look like?
  - b. These fibers are relayed to three major regions of the brain. Indicate what the information might be used for within these structures:
    - i. Suprachiasmatic nucleus of the hypothalamus
    - ii. The Superior Colliculus
    - iii. The Occipital Lobe
  - c. What is the thalamic division that relays auditory information?
  - d. Name the main destination for auditory information after the leaving the thalamus.
2. Notice the internal capsule which contains fibers coming to the brain and fibers going from the brain. These fibers all converge near the thalamus. Because these projection fibers splay out (diverge) into cortical regions, they are called the optic radiations.

VI. Cross Sections (refer to V & C, p. 28, for help in determining where to section)

1. Coronal section through the optic chiasm (Section E in V & C, on p. 33)
  - a. Gray matter and white matter
    - i. What makes matter gray versus white?
    - ii. What cell type makes the white stuff?
    - iii. What is the physiological significance of the white stuff?
  - b. The Striatum
    - i. Which two nuclei make up the striatum?
  - c. Globus pallidus along with the striatum forms the basal ganglia (BG).
    - i. What is the general function of this brain circuit?
    - ii. Name two neurodegenerative disorders that target this brain circuit.
  - d. Internal/External/Extreme Capsule and corona radiata are all fiber pathways sending information to and from the cerebral cortex.
  - e. Corpus callosum
    - i. What does corpus callosum mean?
    - ii. What is the structure immediately ventral to the corpus callosum?
2. Coronal section through the mammillary body (Section G in V & C, p. 35)
  - a. Thalamus
    - i. Attempt to locate the different divisions of the thalamus discussed at IV. 3.
  - b. Hippocampal formation
    - i. What is the general function of the hippocampus?
    - ii. What does hippocampus mean?
  - c. Amygdala (means almond)- it's all the RAGE
    - i. What might happen if you lesion someone's amygdala?
  - d. Lateral Ventricle
    - i. What number ventricle is this?
  - e. Limbic or Cingulate Cortex (located superior to the cingulum and corpus callosum)
    - i. Name at least one function associated with this structure.
3. Coronal section through the cerebral peduncle (Section H in V & C, p. 36)
  - a. Hippocampus & dentate gyrus

- b. Lateral geniculate nucleus (part of the thalamus)
- c. Substantia nigra
  - i. What neurotransmitter is used by this nucleus?
  - ii. What neurodegenerative disorder targets this structure?
  - iii. What forebrain nuclei does this target project to?
  - iv. What is the function of this nucleus?
- d. Superior Colliculus

VII. Horizontal Brain Sections: (refer to V & C, pp. 29-30):

Horizontal sections demonstrate the three dimensionality of the brain, providing an overview of the location of most structures in relation to one another.

VIII. Spinal Cord Sections: Use V & C (p.105), text book, and lecture notes to help you locate the following portions of the spinal cord:

1. Gray matter, white matter, and central canal
  - a. How is the organization different from the brain's organization?
  - b. What is in the central canal?
  - c. What brain system is the central canal continuous with?
2. Dorsal horn versus ventral horn
  - a. Which way is dorsal and which way is ventral in the spinal cord?
  - b. Why is this different from the orientation of the brain?
  - c. Which horn contains the cell bodies of the motoneurons?
  - d. What type of neuron is a motoneuron (i.e., describe its morphology)?
  - e. Where are the cell bodies of the sensory neurons?
  - f. What type of neurons are these sensory neurons (describe their morphology)?
3. Dorsal root versus ventral root (One of each serves the same basic region of the body and enters/exits the same area of the spinal cord; they are called spinal nerves).
  - a. What type of fibers make up the dorsal root (sensory/motor)?
  - b. What type of fibers make up the ventral root (sensory/motor)?
4. Spinal Nerve (see 3. above). Describe the organization of the spinal cord into functional segments or spinal nerves. How many spinal nerves are there and how are they grouped?
  - a. Would there be a greater deficit after cervical or lumbar spinal cord damage?
  - b. Why?
5. Dorsal Root Ganglion (DRG)
  - a. What's in the DRG?
  - b. Why are there no ventral root ganglia?

**Microscopic Anatomy (Histology of Sensory and CNS Tissue)**

**Make sure to handle these glass microscope slides very carefully – they will break if you mishandle them.**

**I. Spinal Cord Sections (V & C, pp. 50-55):**

- Slide 70812e (Spinal Cord, Human – for general structure)**
- Slide Ma527e (Spinal Cord of Cat – stained for Nissl bodies)**
- Slide HE2-22 (Spinal Cord of Cat – Dorsal Root Ganglion Section)**
- Slide 70825f (Spinal Cord of Cat = light blue stain)**

1. Locate the ventral horn of the spinal cord by first finding the motoneurons. Note: Depending on the tissue preparation that you have, you may only be able to see the soma and short stubs of the multiple processes. This will cause them to appear star shaped. They are clearly confined to one horn of the spinal cord – the ventral horn. Although you may see some nuclear staining in the dorsal horn, these cells are not as large and not multipolar in shape. Once you have found the motoneurons, move to the 10x objective for a closer look.
  - a. What shape do they have?
  - b. How are they different from the sensory neurons in the DRG?
2. Can you see the divisions of the white matter? What is the functional significance of these divisions? Note: Position the slide so that you are viewing the border of the spinal cord. The columns/fasciculi should appear as delicate partitions. In fact they have small membranes that separate them from other surrounding columns/fasciculi, almost like the sections of an orange (refer to V & C, pp.71-73; 77 for additional help).

Make sure you can identify the following structures in these histological preparations:

- a. Gray matter and white matter
- b. Ventral and dorsal horn: Note: The horns contain myelinated fibers (on the inside) and are the white matter with gray matter surrounding.
- c. Dorsal root ganglion in some slides: Note: Position the slide so you are viewing outside of the spinal cord. The dorsal root ganglia may appear as a separate, round tissue structure with many stained nuclei. The DRG contain sensory neurons.
- d. Motoneurons
- e. Central Canal: Note: The central canal is in the very center of the spinal cord and is absent any staining, save the dark staining of the ependymal cells (specialized glia) that line the canal and, occasionally, also the choroid plexus (specialized glia that produce CSF).

## II. Nerves (V & C, pp. 56-57)

**Slide 70818e (Nerve, Human – cross section)**

**Slide HE3-11 (Nerve, Peripheral, Human – cross section)**

**Slide 70817e (Nerve, Human – transverse section)**

1. What is the definition of a nerve?  
Note just how many fibers are contained within a given nerve segment. Many of these axons are myelinated. The myelin is only faintly stained, but the axon is darkly stained and located in the center. Note the segmentation of this tissue and the connective tissue that separates various segments. Some blood vessels can be seen as they course through the connective tissue.
2. The transverse section shows the length of the individual axons. You can still see the myelin sheath around the axon. Under high magnification, notice how the myelin is absent around very small regions of the axon. These are the Nodes of Ranvier.
  - a. What occurs at these Nodes?
  - b. What is the purpose of the myelin sheath?
  - c. Which cells make the myelin in the CNS? In the PNS?
  - d. If myelination is so beneficial, how come all axons are not myelinated?
  - e. What are some types of fibers that are likely to be myelinated? That is, what type of neural signals would likely need a fast reaction?

Make sure you can identify the following objects in these histological preparations:

- a. Axons
- b. Myelin sheaths
- c. Nodes of Ranvier: Note: To see the Nodes, look in the transverse section and use high magnification (greater than a 10x objective may be necessary). You are looking for a thinning and then absence of the myelin sheath around the axon. Spend some time looking for it; it is worth the search.

### III. Cerebellum (V & C, p. 60-61)

**Slide 70803e (Cerebellum, Human)**

**Slide HE1-32 (Cerebellum, Human)**

1. Observe the difference between the cerebral cortex (V & C, p. 58) and the cerebellum. Notice that each structure is made up of diverse cell types organized into layers. Using your text, describe how the cerebellum modulates movements based on the sensory signals received. Which part of the cerebellum receives the sensory signals? How do these sensory signals influence the output of the cerebellum? What is the result of the cerebellar output on the motor cortices
2. Observe the three different layers of the cerebellum. Describe the morphology of each layer. What makes each layer distinct? Are they made up of different cells? If so, describe the morphology of both of the major cell types as observed under the microscope. Do they contain neuronal processes and connections? If so, describe the connections being made.
  - a. Granule cell layer
  - b. Purkinje cell layer
  - c. Molecular cell layer

Make sure you can identify the following objects and regions in these histological preparations:

- a. Granule cells/Granule cell layer
- b. Purkinje cells/Purkinje cell layer
- c. Molecular cell layer

### IV. Cerebral Cortex Golgi Preparation

**Slide 70829f (Cerebrum, Cat – Golgi Stained)**

Note: The Golgi stain is an old, but poorly understood histological method. Pioneered by Golgi and used extensively by Cajal (neuroanatomy pioneers who won the Nobel prize for their work using the Golgi stain). It has the ability to produce a complete stain of a limited number of neurons. Those neurons that take up the stain will do so throughout the entirety of the neuron (including all of its processes). The result is the preservation of the morphology of a single neuron without the interference of neighboring neurons also being stained. This is a great method for studying the morphology of different types of neurons.

1. Look at a Golgi stain of the cerebral cortex under high magnification. Notice the thin, black, wispy lines running throughout the cortex. These are neuronal processes.

- a. How would you compare the complexity of the cerebral cortex to the cerebellar cortex.
- b. Attempt to identify and distinguish axons from dendrites. How would you explain the difference to your lab partner if he or she were struggling to distinguish between them?
- c. Can you see why dendrites are said to arborize? What does that mean?

#### V. Horizontal Section of Mouse Brain

##### Slide Ma521e (Brain of Mouse)

1. Start with low power magnification. Observe the general organization of the brain.
2. Identify the following structures or regions:
  - a. Anterior aspect of the brain and olfactory bulb
  - b. Posterior aspect of the brain and cerebellum. View the cerebellum. Attempt to identify the different layers. Notice the faintly blue stained areas in the white matter of the cerebellum. What are these structures? What is the functional significance of these structures?
  - c. Cerebral cortex. The cerebral cortex is a six-layered structure. Describe the basic inputs/outputs that distinguish the different layers of the cortex.
  - d. Hippocampus (look for the sea horse). What is the functional significance of this region of the brain? Describe how the adult neurogenesis that occurs in the hippocampus might be related to its function.

#### VI. The Retina (V & C, pp. 63-65)

##### Slide 70713f (Retina from Human Eye)

##### Slide 70722f (Entrance of Optic Nerve in the Retina)

1. Each of these slides shows a cross section of the neural part of the back of the eye called the retina. The retina is neural tissue. In fact, it develops from an outcropping of the same tissue that forms the rest of the brain. The retina is a multi-layered structure.
  - a. The most populated layer contains the photoreceptors that transduce light into neural impulses.
  - b. The other layers contain processing cells and output cells (ganglion cells).
2. The axons of the ganglion cells form the optic nerve. They send information from the eye to the brain. The retina appears to have a backwards organization. Light must pass through all of the layers of the retina before reaching the photoreceptors. Once transduced, this information is sent back through the other layers to the ganglion cells on the way to the brain. What advantage does this type of organization afford the photoreceptors?
3. Identify the following structures and describe the function of each:
  - a. The three main layers of the retina
  - b. The photoreceptors
  - c. The optic nerve
  - d. Retinal pigmented epithelium (RPE)

#### VII. The Tongue

##### Slide 70701e (Tongue of Rabbit)

1. Tongue – notice the numerous papillae (like little mountains with valleys in between them).
2. In the valleys are small, rounded, clear objects. These organizations of cells are taste buds. What type of information is transduced by taste buds? In addition to the traditional taste buds, recent evidence supports the existence of two additional taste buds. What type of taste information do these buds convey? Taste is only one component of flavor. What is the other?

***C. Assignment 2: Neurotoxins***

1. Research and describe how the tetraodon pufferfish defends itself. Use your new knowledge of neurophysiology to better explain the phenomenon. Additionally, describe the desired effect of this gourmet meal in Fugu restaurants and the physiological explanation for the effect.
2. Research and describe a different neurotoxin that is produced by another species (e.g., spider, snake) as a weapon or defense mechanism. Describe its physiological mode of action (that is, make sure you come up with a unique example that is not described in your text and make use of your new knowledge of neural communication in your answer).

To thoroughly complete this assignment, you will need to be able to describe neural communication and how these organisms target this process.

**Assignment 2 Answer Key**

Please contact the author directly for a copy of the answer key.



***D. Assignment 3: Neurophysiology***

Ethyl alcohol is found in beer, wine, distillates, etc. It is classified as a Central Nervous System (CNS) depressant. Suppose I tell you that alcohol works on the CNS by facilitating chloride channel gating mechanisms.

1. Using your newfound knowledge of neurophysiology, explain how this mechanism of action leads to its CNS depressant effect. In other words, describe the membrane potential changes that will take place, why they take place, and what result they will have.
2. Provide a possible explanation for why alcohol has biphasic effects (small concentrations produce relaxation and cheerfulness, but large doses produce slurred speech, coordination problems, memory impairments, etc.).

**Assignment 3 Answer Key**

Please contact the author directly for a copy of the answer key.

***E. Assignment 4: Prosopagnosia***

Read the title story from Oliver Sacks' (1985) book *The Man Who Mistook His Wife for a Hat*. Dr. P. obviously had some serious problems, including a disconnection between sensation and perception. Answer the following questions:

1. Based on the information presented in the case study, where do you think Dr. P.'s brain damage was located (generally and specifically)? In localizing the damage, consider that Dr. P. was once able to recognize a student as follows: "That's Karl. I know his movements, his body movements."
2. What additional pieces of information led to your conclusion in question #1 (i.e., what symptoms did he display and what functioning did he maintain versus lose)?
3. Additionally, what role did nonvisual stimuli play in his functioning and what does this suggest about the cross-talk between sensory systems?
4. Why is multi-modal processing so important for our everyday functioning?

**Assignment 4 Answer Key**

Please contact the author directly for a copy of the answer key.

***F. Assignment 5: Mirror Neurons***

Mirror neurons have become all the rage in the neurosciences. Scientists speculate about their role in the evolutionary emergence and development of language as well as the development of a theory of mind and autism. They have also been speculated to be involved in social learning and empathy construction.

What are mirror neurons? What do they do? Where are they located? Make an argument for mirror neuron involvement in each of the above instances.

**Assignment 5 Answer Key**

Please contact the author directly for a copy of the answer key.

**G. Assignment 6: Cranial Nerve Zero**

1. There are many examples of mammalian pheromone effects on sexual reproduction. Describe the following examples: Whitten effect, Vandenberg effect, Lee-Boot effect, Bruce effect, and Coolidge effect.
2. Read the article referenced below concerning the terminal nerve. Are humans capable of using pheromone signaling too? Do some academic internet research and look for supporting evidence and counterevidence. Summarize this evidence and your viewpoint.

Fields, D. F. (2007). Sex and the secret nerve. *Scientific American Mind*, 18(1), 21-27.

**Assignment 6 Answer Key**

Please contact the author directly for a copy of the answer key.

***H. Assignment 7: Sexual Orientation***

Describe the current state of research on the possible biological basis of sexual orientation. In particular, how might neurobiological mechanisms be used to help explain male preferences for male versus female partners or female preferences for female versus male partners? Be sure to include information about organizational and activational hormonal effects, and sexually dimorphic nuclei in your explanation. Be sure to provide a critique of the research you reference.

**Assignment 7 Answer Key:**

*Please contact the author directly for a copy of the answer key.*

### ***I. Assignment 8: Hypothalamic Neurogenesis***

Does adult neurogenesis have a possible role in controlling our appetitive drives?

Read the Kokoeva, Yin, and Flier (2005) article referenced below. Use the following background information and discussions from class to answer the questions provided.

Kokoeva et al.'s report is truly an exciting paper on many levels:

1. If their results prove to be replicable, this is the first demonstration of a physiological effect from the addition of new neurons in the adult brain and their role in pathophysiology.
2. It is another piece in the puzzle in our attempts to understand how to treat a major risk factor for any number of health problems.

Growth factors are thought to control a number of developmentally related processes in the brain including neuron growth, differentiation, migration, and survival, to name a few. Many growth factors have been investigated as treatments for neurological disorders. Ciliary neurotrophic factor (CNTF) has long been recognized as a growth factor capable of keeping neurons alive, and it promotes their differentiation. It was tested in clinical trials as a treatment for Amyotrophic Lateral Sclerosis (ALS or Lou Gehrig's disease) that results in the death of motoneurons. Strangely, the patients lost their appetites and a great deal of weight. More recent studies have shown that CNTF could do the same thing in virtually all experimental mouse models of obesity and led to the development of Axokine as a successful, long-lasting treatment for obesity. But what is CNTF doing? The answer may be of some surprise.

A) In your own words, summarize the major findings of this paper.

B) Explain the rationale for the following experiments in this study and how the results from these studies support the authors' conclusions:

1. BrdU labeling
2. Hu and TUJ1 immunostaining
3. Ara-C treatment
4. pSTAT3 immunostaining
5. ob/ob mice

Kokoeva, M. V., Yin, H., & Flier, J. S. (2005, October 28). Neurogenesis in the hypothalamus of adult mice: Potential role in energy balance. *Science*, *310*, 679-683.

### **Assignment 8 Answer Key:**

Please contact the author directly for a copy of the answer key.

***J. Assignment 9: Addiction***

Some people argue that addiction is an aberrant form of learning, involving motivated behaviors and hedonic responses. In fact, anatomical and biochemical changes like those that occur during other learning paradigms have been noted. Still others support this view by suggesting that both classical conditioning and operant conditioning both maintain drug use and abuse and initiate it.

1. Describe how classical conditioning might establish the formation of drug cues and the development of cravings that are so troublesome to abstinent addicts and that are often the root causes of relapse.
2. Describe how operant conditioning might be involved in the initiation of drug use and the continuation of use even after tolerance to the euphoric effects of the drug has occurred.
3. Finally, speculate as to the neurological bases of these learned events.

**Assignment 9 Answer Key:**

Please contact the author directly for a copy of the answer key.

***K. Assignment 10: Movement Disorders***

Parkinson's Disease (PD) and Huntington's Disease (HD) both produce motor impairments by disrupting brain circuitry involved in movement control. Describe how each of these disorders produces its motor symptoms by describing (a) the region of the brain that degenerates and (b) the role of this brain region in basal ganglia function.

Using what you have learned about neurotransmitter signaling, research and explain a pharmacological treatment strategy for Huntington's Chorea. Be sure to explain how the drug is targeting the dysfunctional basal ganglia circuitry and its mechanism of action (e.g., direct or indirect agonist or antagonist). A complete answer will fully elucidate the treatment strategy being targeted with the use of the drug.

**Assignment 10 Answer Key:**

Please contact the author directly for a copy of the answer key.