3

Anatomy of the Nervous System: Systems, Structures, and Cells That Make Up Your Nervous System

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CHAPTER-AT-A-GLANCE

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LEARNING OBJECTIVES

After completion of this chapter, the student should be able to:

LO 3.1 List and describe the major divisions of the nervous system.
LO 3.2 Describe the three meninges and explain their functional role.
LO 3.3 Explain where cerebrospinal fluid is produced and where it flows.
LO 3.4 Explains what the blood-brain barrier is and what functional role it serves.
LO 3.5 Draw, label, and define the major features of a multipolar neuron.
LO 3.6 Describe four kinds of glial cells.
LO 3.7 Compare several neuroanatomical research techniques.
LO 3.8 Illustrate the neuroanatomical directions.
LO 3.9 Draw and label a cross section of the spinal cord.
LO 3.10 List and discuss the five major divisions of the human brain.
LO 3.11 List and describe the components of the myelencephalon.
LO 3.12 List and describe the components of the metencephalon.
LO 3.13 List and describe the components of the mesencephalon.
LO 3.14 List and describe the components of the diencephalon.
LO 3.15 List and describe the components of the telencephalon.
LO 3.16 List and describe the components of the limbic system and of the basal ganglia.

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BRIEF CHAPTER OUTLINE

Lecture Launcher 3.1: *Get Your Bearings: Relating the Nervous System to the Rest of the Body*
Lecture Launcher 3.2: *The Latex Neuron*

1. General Layout of the Nervous System
- **a.** Divisions of the Nervous System
- **b.** Meninges
- **c.** Ventricles and Cerebrospinal Fluid
- **d.** Blood-Brain Barrier

Lecture Launcher 3.3: *Name That Neuron Part*

2. Cells of the Nervous System
- a. Anatomy of Neurons
- b. Glial: The Forgotten Cells

Lecture Launcher 3.4: *Jigsaw Brain*

3. Neuroanatomical Techniques and Directions
- a. Neuroanatomical Techniques
- b. Directions in the Vertebrate Nervous System

4. Anatomy of the Central Nervous System
- a. Spinal Cord
- b. Five Major Divisions of the Brain
- c. Myelencephalon
- d. Metencephalon
- e. Mesencephalon
- f. Diencephalon
- g. Telencephalon
- h. Limbic System and the Basal Ganglia

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TEACHING OUTLINE

1. General Layout of the Nervous System (see Figures 3.1 and 3.2 in ***Biopsychology***)

a. Divisions of the Nervous System
LO 3.1 List and describe the major divisions of the nervous system.

- The nervous system can be divided into **two divisions** using several criteria:
  - **CNS vs. PNS:** the CNS lies within the **bony skull** and **vertebral column**.
  - **Brain vs. Spinal Cord:** comprise the two parts of the CNS.
  - **Somatic vs. Autonomic:** comprise the two parts of the PNS. The somatic branch interacts with the **external environment**; the autonomic branch interacts with the **internal environment**.
  - **Efferent vs. Afferent:** refers to whether nerves bring **sensory information** into the CNS (***afferent***) or carry **motor commands** away from the CNS (***efferent***).
  - **Sympathetic vs. Parasympathetic:** the two branches of the autonomic division of the PNS. Convention suggests that the sympathetic branch **activates** an organism while the parasympathetic branch acts to **conserve energy**. Each autonomic target organ is innervated by both branches and sympathetic activation indicates **arousal**, while parasympathetic activation indicates **relaxation**.
- The **cranial nerves** (see Appendix III in ***Biopsychology***) are a special group of nerves that leave the CNS from the brain through the skull, rather than from the spinal cord. These have specific sensory and/or motor functions (see Appendix IV in ***Biopsychology***); disruption of these functions allows neurologists to accurately determine the location and size of tumors and other kinds of brain pathology.

b. The Meninges (see Figure 3.4 in ***Biopsychology***)
LO 3.2 Describe the three meninges and explain their functional role.

- The brain and spinal cord are well-protected by the skull and vertebrae, and by three membranes called the **meninges**: the **dura mater** (*tough mother;* outside), the **arachnoid mater** (*spidery mother;* middle), and the **pia mater** (*gentle mother;* inside).

c. Ventricles and Cerebrospinal Fluid (see Figure 3.3 in ***Biopsychology*****)**
LO 3.3 Explain where cerebrospinal fluid is produced and where it flows.

- **Cerebrospinal fluid (CSF)** is manufactured by the **choroid plexuses**—capillary networks that protrude into the ventricles. CSF circulates through the **ventricular system** of the brain, the **central canal** of the spinal cord, and the **subarachnoid space**, and is absorbed into large channels called **sinuses** in the dura mater and then into the blood stream (see Figure 3.4 in ***Biopsychology***).
- When the flow of CSF is blocked, **hydrocephalus** results.

d. Blood-Brain Barrier
LO 3.4 Explains what the blood-brain barrier is and what functional role it serves.

- Most blood vessels of the brain do not readily allow compounds to pass from the general circulation into the brain; this protection, called the **blood-brain barrier**, is due to the tightly-packed nature of the cells of these blood vessels.

- Some large molecules (e.g., glucose) are actively transported through blood vessel walls and there are some areas of the brain that allow large molecules to pass through unimpeded.

2. Cells of the Nervous System (see Figures 3.5–3.10 from ***Biopsychology***)
The gross structures of the nervous system are made up of hundreds of billions of different cells that are either **neurons** or **glia**.

a. Anatomy of Neurons
LO 3.5 Draw, label, and define the major features of a multipolar neuron.

i. External Anatomy of Neurons
ii. Internal Anatomy of Neurons
iii. Neuron Cell Membrane

- These are the fundamental functional units of the nervous system; cells that are specialized for the reception, conduction, and transmission of electrochemical signals.
- Most of you have seen a schematic drawing of a multipolar motor neuron; don't be misled by its familiar shape, as neurons come in a wide variety of sizes and shapes. The following are its nine parts (see Figure 3.5 in ***Biopsychology***):
  - A **semipermeable** cell membrane: The cell membrane is semipermeable because of special proteins that allow chemicals to cross the membrane. This semipermeability is critical to the normal activity of the neuron. The inside of the cell is filled with **cytoplasm**.
  - A **cell body** (soma), which is the metabolic center of the cell. The soma also contains the **nucleus** of the neuron, which contains the cell's DNA.
  - **Dendrites** are shorter processes that emanate from the cell body and receive input from synaptic contacts with other neurons.
  - A single **axon** that projects away from the cell body; this process may be as long as a meter.
  - **Axon hillock**, the junction between cell body and axon, is a critical structure in the conveyance of electrical signals by the neuron.
  - Multiple **myelin sheaths**: These are formed by **oligodendroglia** in the CNS and **Schwann** cells in the PNS; they insulate the axon and assist in the conduction of electrical signals.
  - **Nodes of Ranvier** are the small spaces between adjacent myelin sheaths.
  - **Buttons** are the branched endings of the axon that release chemicals that allow the neuron to communicate with other cells.
  - **Synapses** are the points of communication between the neuron and other cells (neurons, muscle fibers).

iv. Classes of Neurons

- The type of neuron usually drawn in textbooks is called a **multipolar neuron** because it has multiple dendrites and an axon extending from soma. There are also **unipolar neurons** (one process that combines both axon and dendrites), **bipolar neurons** (two processes: a single axon and a single dendrite), and **interneurons** that have no axons.

v. Neurons and Neuroanatomical Structure

- Clusters of cell bodies in the central nervous system are called **nuclei;** while clusters of cell bodies in the peripheral nervous system are called **ganglia**.
- In the central nervous system bundles of axons are called **tracts**; in the peripheral nervous system, they are called **nerves**.

b. Glia: The Forgotten Cells
LO 3.6 Briefly describe four kinds of glial cells.

- The most common type of cells in the nervous system are **glia.**

- There are four major types of glia with an expanding list of newly discovered subtypes.
- One of the earliest recognized responsibilities of glia cells is to provide physical and functional support to neurons.
- The glial cells that form the myelin sheaths of axons in the CNS and PNS are **oligodendrocytes** and **Schwann cells** respectively.
- **Microglia** have immune system-like responsibilities in the brain, and they play a role in the regulation of cell death, synapse formation, and synapse elimination.
- **Astroglia** are the largest of the glial cells; they support and provide nourishment for neurons and form part of the blood brain barrier. They also have the ability to contract or relax blood vessels throughout the brain.
- Researchers are beginning to appreciate that astroglia play a key role in the function of the nervous system. They help send chemical signals between neurons, and **establish and maintain connections** between neurons.

3. Neuroanatomical Techniques and Directions (see Figures 3.11–3.13 in ***Biopsychology***)
Research on the anatomy of the nervous system depends upon a variety of techniques that permit a clear view of different aspects of neural structure.

a. Neuroanatomical Techniques
LO 3.7 Compare several neuroanatomical research techniques.

- **Golgi Stain:** permitted **individual neurons** to be studied for the first time (see Figure 3.11).
- **Nissl Stain:** highlights **cell bodies of all neurons**; allowed estimation of cell density in tissue (see Figure 3.12).
- **Electron Microscopy:** allows visualization of the neuronal ultrastructure (see Figure 3.13).
- **Neuroanatomical Tracing Techniques:** highlights **individual axons**; may be **retrograde** (trace back from terminal fields) or **anterograde** (trace from soma to terminal fields).

b. Directions in the Vertebrate Nervous System (see Figures 3.14–3.15 in ***Biopsychology***)
LO 3.8 Illustrate the neuroanatomical directions.

- First axis: **anterior** means toward the nose or front; **posterior** means toward the tail or back.
- Second axis: **dorsal** is toward the surface of the back or top of the head (as in dorsal fin); **ventral** indicates the surface of the chest or bottom of the head.
- Third axis: **medial** is toward the midline of the body; **lateral** indicates outside or away from the midline.

4. Anatomy of the Central Nervous System

a. Spinal Cord (see Figure 3.16 in ***Biopsychology***)
LO 3.9 Draw and label a cross section of the spinal cord.

- In cross section, the **gray matter** (cell bodies) forms a butterfly inside of the **white matter** (myelinated axons).
- The subcortical myelin gives the white matter its glossy white sheen.
- The upper (dorsal; posterior) wings of the butterfly are called the **dorsal horns**; the lower (ventral; anterior) wings are called the **ventral horns**.
- 31 pairs of nerves are attached to the spinal cord. As they near the cord, they split into **dorsal roots** (sensory axons; cell bodies lie just outside the spinal cord in the **dorsal root ganglia**) or **ventral roots** (motor axons; cell bodies lie inside the ventral horns).

b. The Five Major Divisions of the Brain (a brain model is useful for teaching this section; see Figures 3.17 and 3.18 in ***Biopsychology***)
LO 3.10 List and discuss the five major-divisions of the human brain.

- There are **five divisions** of the mammalian brain; in general, higher structures are less reflexive and perform more complex functions, and they are also more recently evolved.
- The nervous system is first recognizable in the developing embryo as the **neural tube**.
- The brain develops from three swellings at one end of the neural tube: the **hindbrain**, the **midbrain (mesencephalon)**, and the **forebrain**.
- The hind brain develops into the **myelencephalon** and the **metencephalon**; the forebrain develops into the **diencephalon** and the **telencephalon** (also called the **cerebral hemispheres**).
- The term "**brain stem**" refers to the stem on which the cerebral hemispheres rest (myelencephalon + metencephalon + mesencephalon + diencephalon = brain stem).

5. Major Structures of the Brain

a. Myelencephalon (see Figure 3.19 in ***Biopsychology***)
LO 3.11 List and describe the components of the myelencephalon.

- The myelencephalon is commonly called the **medulla**; it is composed of major ascending and descending tracts and a network of small nuclei involved in sleep, attention, muscle tone, cardiac function, and respiration.
- The core network of nuclei is the **reticular formation**; the reticular formation also composes the core of the hindbrain and midbrain. It is thought to be an arousal system and is sometimes called the **reticular activating system** (reticulum means "little net").

b. Metencephalon (see Figure 3.19 in ***Biopsychology***)
LO 3.12 List and describe the components of the metencephalon.

- The metencephalon has two parts: the **cerebellum** (little brain) and **pons** (bridge).
- The cerebellum has both **sensorimotor** and **cognitive functions**. The pons is visible as a swelling on the inferior surface and also contains the **reticular formation**.
- Neural tracts ascend and descend through this area.

c. Mesencephalon (see Figure 3.20 in ***Biopsychology***)
LO 3.13 List and describe the components of the mesencephalon.

- The mesencephalon is composed of the **tectum** and **tegmentum**.
- In mammals, the tectum consists of the **superior colliculi** (visual relay) and the **inferior colliculi** (auditory relay); in lower vertebrates, there is simply a single **optic tectum**.
- The tegmentum contains the reticular formation, the **red nucleus** (sensorimotor), the **substantia nigra** (sensorimotor cell bodies here die in patients with Parkinson's disease); and the **periaqueductal gray** (mediates analgesia).

d. Diencephalon (see Figures 3.21 and 3.22 and Appendix V in ***Biopsychology***)
LO 3.14 List and describe the components of the diencephalon.

- The **thalamus** and **hypothalamus** are the two main structures of the diencephalon.
- The thalamus is the top of the brain stem; it is comprised of many different nuclei, most of which project to the cortex.

- Some thalamic nuclei are **sensory relay nuclei** (e.g., **lateral geniculate nuclei**, vision; **medial geniculate nuclei**, audition; **ventral posterior nuclei**, touch).
- There exists a reciprocal connection between the thalamic nuclei and the neocortex (new cortex).
- The above sensory relay nuclei are not one-way streets. They all receive feedback from the very areas of the cortex to which they project.
- The **hypothalamus** is just below the thalamus ("hypo" means below) and the **pituitary gland** (snot gland) is suspended from the hypothalamus. Together, the hypothalamus and pituitary play key roles in endocrine function and many motivated behaviors.
- The **mammillary bodies** are two small bumps visible on the inferior surface, just behind the hypothalamus.
- The **optic chiasm** is the X-shaped part of the optic nerves that lies just in front of the pituitary; it is the spot where axons that originate from the nasal half of each retina cross over **(decussate)** to the opposite side of the brain.

e. Telencephalon (see Figures 3.23–3.25 in ***Biopsychology***)
LO 3.15 List and describe the components of the telencephalon.

- Also called the cerebral hemispheres; characterized by the cortex (bark) with its many convolutions, which are referred to as **gyri** (like hills) or **fissures** (like valleys).
- The telencephalon is the largest division of human brain. Large tracts called **commissures** connect the two hemispheres and the **corpus callosum** is the largest commissure.
- The telencephalon mediates most **complex cognitive functions**.
- About 90% of human cortex is **neocortex**, comprised of **six cell layers** of **pyramidal cells** and **stellate cells**.
- The hippocampus is not neocortex; instead, it is a three-layer cortical area that lies in the medial temporal lobe.
- The **four lobes** of the cerebral hemispheres are defined by the fissures of the cerebral cortex. The four lobes are:
  - **frontal lobe:** superior to **lateral fissure** and anterior to **central fissure**.
  - **temporal lobe:** inferior to lateral fissure.
  - **parietal lobe:** posterior to central fissure.
  - **occipital lobe:** posterior to temporal lobe and to parietal lobe.
- Note the following useful neocortical landmarks: **longitudinal fissure** (between the hemispheres), precentral gyri (in frontal lobe; primary motor cortex), **postcentral gyri** (in parietal lobe; primary somatosensory cortex), **superior temporal gyri** (in the temporal lobe, auditory cortex), and **prefrontal cortex** (the nonmotor portion of the frontal lobe)

f. Limbic System and the Basal Ganglia
LO 3.16 List and describe the components of the limbic system and of the basal ganglia.

- Most of the subcortical parts of the telencephalon are axonal pathways; however, two subcortical systems exist that play important roles in determining our behavior. These are:
  - **The Limbic System** (see Figure 3.26 in ***Biopsychology***): Involved in **regulation of motivated behaviors** (including the "Four F's!"); includes the **mammillary bodies**, **hippocampus**, **amygdala**, **fornix**, **cingulate cortex**, and **septum**.
  - **The Basal Ganglia** (see Figure 3.27 in ***Biopsychology***): Involved in **movement**; include the **amygdala** (again); the **caudate** and **putamen** (collectively called the **striatum**), and the **globus pallidus**.

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LECTURE LAUNCHERS

Lecture Launcher 3.1: Get Your Bearings: Relating the Nervous System to the Rest of the Body

If you have such a model available, bring a rack-mounted skeleton to class and ask your students what such a bony artifact might tell them about neuroanatomy. If you have a model of the vertebral column with the spinal cord in situ, bring that along, too. During this discussion, note that the skeleton can be used to define the difference between the CNS and the PNS, between the brain and spinal cord, and between the somatic and autonomic nervous system. (Here you will have to ask them to visualize the internal organs, muscles, and skin of the skeleton.) Depending on the level of detail you would like to go into, you can have your students palpate landmarks on their own bodies that will help them get oriented (e.g., external occipital protuberance, spinous process of C-7 vertebrae, temporal bones of skull).

Lecture Launcher 3.2: The Latex Neuron

To help students learn neuroanatomy, bring an elbow-length latex glove to class (or better yet, a box of latex gloves so you can hand out gloves to each of your students). Inflate the latex glove and then use it as a model to help students visualize different parts of the neuron. The latex represents the neural membrane, the fingers represent the dendrites, the palm represents the soma, the wrist represents the axon hillock, the arm represents the axon, and the open end of the glove represents the terminal buttons. If you want to be more detailed, throw a colored marble into the glove to represent the nucleus. Want something even trickier? Add some packing popcorn, cut into small pieces, into the glove before you inflate it. Shake the chips to the end of the "axon," then allow some air to escape the glove. The chips that blow out can represent neurotransmitter being released during exocytosis (though caution students that terminal buttons don't actually "spit out" the transmitter).

Lecture Launcher 3.3: Name That Neuron Part

Use the "Neural Structure Quiz" available from Dr. John Krantz at the University of Hanover. Go to http://psych.hanover.edu/ and place "Krantz Neuron" in the search box. Once there, page down to a link that will be labeled "Neural Structure Quiz" to begin the quiz on your own. Ask your class to identify the eight different parts of the neuron shown in the quiz. After each part is named, ask your students to assign a function to the named part. Using the neuron, you can also illustrate the general flow of neural information (somato-dendritic to terminal button) in the cell, preparing your students for material in the next chapter.

Lecture Launcher 3.4: Brain Games

Here is a fun diversion you can use in class to test your students' neuroanatomical proficiency—a brain anatomy matching game, at http://anatomyarcade.com/. On the left hand side of the page, click on the "nervous" link. At the top of the page will be a link for the Match-a-Brain game.

At some point in your class, ask for volunteers to come to the front of the class and take a turn at matching anatomical terms to the diagrams.

Lecture Launcher 3.5: Why Is It Important to Learn Biological Terminology?

Discuss the importance of consistency in communication across languages and specialties. This is why many Latin and Greek terms remain in the sciences.

Handouts
3.1 Concept Maps of the Nervous System
3.2 Vocabulary Crossword Puzzle
3.6 Learning Medical Terms

Lecture Launcher 3.6: What Are the Roots of the Names of Biological Structures?

Most biological names are not random. They tell where the structure is located relative to other structures, what the structure looks like, and sometimes hints at the function of the structure.

Web Links
3.8 Medical Mnemonics
3.9 Medical Mnemonics.com

Lecture Launcher 3.7: Brain Animations

Brain animations are available from several Websites and in video format. There are also software packages that allow interaction with brain diagrams from various points of view.

The Secret Life of the Brain is a companion site to the PBS series revealing the fascinating processes involved in brain development across a lifetime.

Web Links
3.5 The Secret Life of the Brain
3.6 Movies

Lecture Launcher 3.8: 3-D Diagrams and Models

The textbook is flat, yet the structures that are studied are three-dimensional.

- Sometimes it is difficult to make the transition between a flat diagram and a diagram from another point of view or a three-dimensional model. The student may have not been taught this skill and some coaching at the beginning can make it easier for everyone in the class.
- Making your own models, looking for animations that rotate brain diagrams or models, and looking at diagrams from different points of view, are all good ways to make sense out of the diagrams.
- One way to make your own model is to go to one of the Websites that has photos of a brain, either stained and sliced, or from MRI images.
- Print out the series of images. You can print them onto heavy paper such as card stock, or glue
- The sections to foam core or other stiff material.
- You can also use multiple colors of clay or Play-Doh to represent the central nuclei, cortex, and brainstem.
- Either stack the series or arrange them in a slotted piece of folded paper so that they form a "brain."

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ACTIVITIES

Activity 3.1: Digital Anatomist

There are many digital anatomy Websites such as (www9.biostr.washington.edu/). Click the button for the neuroanatomy atlas. Select a specific part or orientation of the brain and quiz students on the parts by point them out with your hand. You could form teams and have them compete or call up several student contestants to play the game against each other. If possible, have them compete for a small prize that you bring to class (e.g., a small model of the human brain).

Activity 3.2: Bring Real Nervous Systems to Class

Get a Real Brain, (Whole or Sectioned)

If your department does not have a human brain, the biology department may have one you can borrow. Seeing a real human brain does a great deal to disabuse students of many misconceptions about the characteristics of the brain, such as size or color.

Contact local butchers or slaughterhouses and request fresh cow or sheep brains. This is effective in helping the students understand the fragile nature of nervous system structures that preserved tissue disguises.

Activity 3.3: Use Metaphors to Create Mental Models

Slice Fruit

Students may have a great deal of difficulty with the orientation terms. Getting them comfortable with these terms will pay off as they refer to brain areas later in the course.

Bring apples and knives to class. (You can draw a face on one side with a permanent marker if you wish.) Have the students work in groups to divide their apples sagitally, frontally, or horizontally. Then have the groups share the different views discussing how the slices look with different orientations. If you have maintained reasonable cleanliness in this process, you can encourage the students to eat the sectioned apples.

Bring in a Jell-O Brain

Molds for making brains from Jell-O are available from anatomical model companies and novelty catalogs. One will make a model of the top of the two hemispheres and the other makes a sagittal view. With the proper Jell-O flavor and food coloring, the brain looks good from a distance. The softness of the Jell-O reminds the students that brains are not hard like the models or preserved brains. This helps them understand the potential for injury to the nervous system. After the lecture you can pass out plastic spoons and cups and share the brain with the class. (Brain molds are available from a variety of sources, including http://www.partycity.com/. Once on the Party City Website, just search for the "Brain Gelatin Mold" to get you to the page you need.

Activity 3.4: Diagrams of the Nervous System

An important part of understanding the nervous system is to be able to look at a diagram, x-ray, or model, and identify a structure. This is made more complicated by the lack of differences in the look of nervous system tissue that has different functions.

Even looking at diagrams can be confusing because they can be from many different points of view and may not look like the diagrams in the text, models you have used in class, or even dissections of real brains.

This makes a good in-class activity done in small groups of two to five students.

Handout

3.4 Diagrams of the Nervous System

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DEMONSTRATIONS

Demonstration 3.1: Nervous System Tissue

Preserved and fresh nervous system tissue is a valuable teaching tool. Brains are available both preserved in formalin or sectioned and embedded in plastic.

You can also use fresh nervous system tissue from domestic animals. This is effective in helping the students understand the fragile nature of nervous system structures that preserved tissue disguises.

Demonstration 3.2: Bring Real Nervous Systems to Class

In-class Dissection of the Sheep Brain

Purchase two sheep brains. Using a brain knife, section one brain along the midsagittal plane and cut the other brain using a series of coronal sections. Label the prominent features of the gross anatomy of the sheep brain using paper labels and pins.

The brains are packed in formaldehyde: be sure to thoroughly wash the brains prior to use and use gloves during handling.

For a pictorial guide to sheep brain dissection, consult Cooley and Vanderwoolf (1990), *A Brief Manual Sheep Brain Dissection: The Anatomy of Memory*, which is available at the Exploratorium Site. Go to http://www.exploratorium.edu/ and place "Sheep brain dissection" in the search box. Click on the first link labeled "sheep brain dissection" to start your tutorial.

Brains (and many other demonstration preparations) can be ordered from:
Carolina Biological Supply Company: http://www.carolina.com

Ward's Natural Science: http://wardsci.com/

The Sheep Brain: A Basic Guide, is available from:
A.J. Kirby Co.
301 Oxford Street West
Box 24107, London, Ontario , Canada N6A 3Y6
ajkirbyco@pobox.com
http://www3.sympatico.ca/ajkirbyco/

] *The Sheep Brain: A Basic Guide*, by Richard K. Cooley and C. H. Vanderwolf, is an excellent manual that is used in many student laboratories. Purchase preserved brains that are complete, including the meninges and cranial nerves.

Web Links
3.10 Atlas of the Sheep Brain

Demonstration 3.3: A "Handy" Model of the Human Brain

This metaphor can be used to assist students with the three-dimensional aspect of the brain. If you are short on models or real brains for examination, having a brain model "at hand" can be very "handy."

Handout
3.3 A "Handy" Model of the Human Brain

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ASSIGNMENTS

Assignment 3.1: Vocabulary Crossword Puzzle

This is one of the most vocabulary-rich chapters in your text, as well as within the discipline as a whole. This can be a challenge.

Part of the assignment will require that the student knows the terminology used in describing the nervous system. I have created a crossword puzzle for this assignment. Crosswords provide cues in the length of the words and in letters determined from easier clues.

This can be used as an assignment, a test, or an in-class activity done in small groups of two to five students.

ANSWERS:

ACROSS

1. **SPINAL_CORD** - Rope-like structure carrying information from the brain to the body
3. **SUBSTANTIA_NIGRA** - Name means "black stuff"
5. **MEDULLA** - You would have trouble breathing after damage to this area
6. **CORTEX** - Outer layers of brain or adrenal glands
9. **PARIETAL** - Lobe of cortex behind the central sulcus
10. **LIMBIC** - "System" involved in emotions
11. **SENSORYMOTOR** - Part of the nervous system responsible for sensory and motor functions
13. **FRONTAL** - Area of cortex responsible for decision making
14. **SOMATOSENSORY** - Area of cortex in the parietal lobe responsible for information from skin, muscles, and tendons
15. **PARASYMPATHETIC** - Digestion is controlled by this part of the peripheral nervous system

DOWN

2. **CORPUS_CALLOSUM** - Contains fibers that connect the two halves of the cerebellum
4. **TEMPORAL** - Name of this area of cortex may remind you of a religious building
7. **HIPPOCAMPUS** - Involved in memory and part of the limbic system
8. **STRIATUM** - Striped part of the basal ganglia
12. **AUTONOMIC** - Part of peripheral nervous system that reacts "automatically

Assignment 3.2: Labeling Diagrams of the Nervous System

This handout provides a series of diagrams of nervous system structures to label. Some are very detailed and some are rough sketches. The student must look at the diagram carefully and determine if there are structures that he or she recognizes. From these it is possible to find and label other structures. This can be an in-class assignment done in groups.

Handout
3.4 Diagrams of the Nervous System

Assignment 3.3: Fill in the Nervous System

A hierarchical diagram provides spaces for the various parts of the nervous system. A few items are filled in for guidance.

Handout

3.5 Organizational Chart: Structure of the Nervous System

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WEB LINKS

Web Link 3.1: *Gray's Anatomy*
Go to http://www.bartleby.com/ and use the left search bar to select Gray's Anatomy. In the search bar located on the right of the homepage, search for "neurology structure." Click on the first link titled "IX. Neurology. 1. Structure of the Nervous System." *Gray's Anatomy* is available both in print and online. A classic text with many black and white illustrations of structures and cell types. Makes an adequate coloring book.

Web Link 3.2: Nervous System
Go to http://www.kumc.edu/ and place "nervous system" in the search bar at the top of the page. Select the first result titled "nervous system."

Copyright © 1996, University of Kansas Medical Center. This document has pictures taken under a microscope of details of the nervous system structures. It is in more detail than you need but you might find it interesting.

Web Link 3.3: The Comparative Mammalian Brain Collections
http://brainmuseum.org/The Comparative Mammalian Brain Collections is a good source for images of sectioned brains.

Web Link 3.4: The Whole Brain Atlas
Place "The Whole Brain Atlas" in your search engine and click on the link associated with Harvard Medical School.

Web Link 3.5: The Secret Life of the Brain
Place "Secret Life of the Brain" in your search engine. Select the clickable link for http://www.pbs.org. The Secret Life of the Brain is a companion site to the PBS series revealing the fascinating processes involved in brain development across a lifetime. If you have Macromedia Flash installed, you can see a 3D brain model and rotate it.

Web Link 3.6: Movies
Go to http://hendrix.imm.dtu.dk/and click on the "movies" link. This site has movies illustrating brain structures and activation.

Web Link 3.7: Brain Model Tutorial
Go to http://www.ucf.edu and type "brain tutorial" into the search bar. Click on the link titled "brain model tutorial" to go to the site where you can search for many images of the whole brain. The brain stem section is particularly useful, as it is unusual. There is also a set of images that you might find useful that includes diagrams, MRI, and brain sections, etc.

Web Link 3.8: Medical Mnemonics.com
http://www.medicalmnemonics.com/ Download a database for your PDA with Palm OS or download a PDF file of the mnemonics.

Web Link 3.9 Atlas of the Sheep Brain
Go to http://www.msu.edu/ and place "sheep brain atlas" in the search bar. Click on the matching link.

Web Link 3.10 Brain Development
Go to http://www.brainfacts.org/ and click on the "Brain Basics" tab at the top of the page. Click the secondary link labeled "Brain Development" to get to the page you need.

A brief overview of brain development from the Brain Facts.org sponsored by the Society for Neuroscience.

Web Link 3.11 Brain Development
Go to http://faculty.washington.edu/ and place "Neuroscience for Kids Brain Development" in the search bar on the main page. Click on the first link about brain development.

Although this page is titled "Neuroscience for Kids," it is a great and accessible overview of brain development.

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HANDOUT DESCRIPTIONS

Handout 3.1: Concept Maps of the Nervous System
You may find these concept maps a useful way to help students organize the terms that they are learning.

Handout 3.2: Vocabulary Crossword Puzzle

Handout 3.3: A "Handy" Model of the Human Brain
This metaphor can be used to assist students with the three-dimensional aspect of the brain. If you are short on models or real brains for examination, having a brain model "at hand" can be very "handy."

Handout 3.4: Diagrams of the Nervous System
This handout provides a series of diagrams of nervous system structures to label. Some are very detailed and some are rough sketches. The student must look at the diagram carefully and determine if there are structures that he or she recognizes. From these, it is possible to find and label other structures.

Handout 3.5: Organizational Chart: Structure of the Nervous System
This Assignment Sheet provides the structure for a hierarchical map of the nervous system. It is a good way for students to test their understanding of relationships in the nervous system There are several correct versions, so try not to just give one set of correct answers for grades.

Handout 3.6: Learning Medical Terms
A handout of medical terminology.

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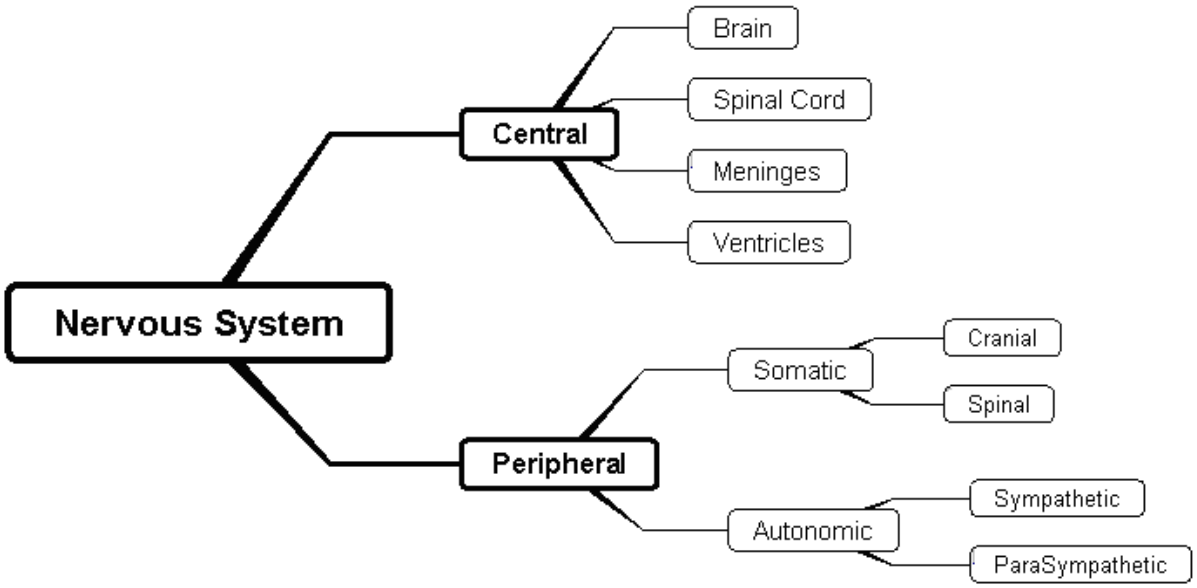
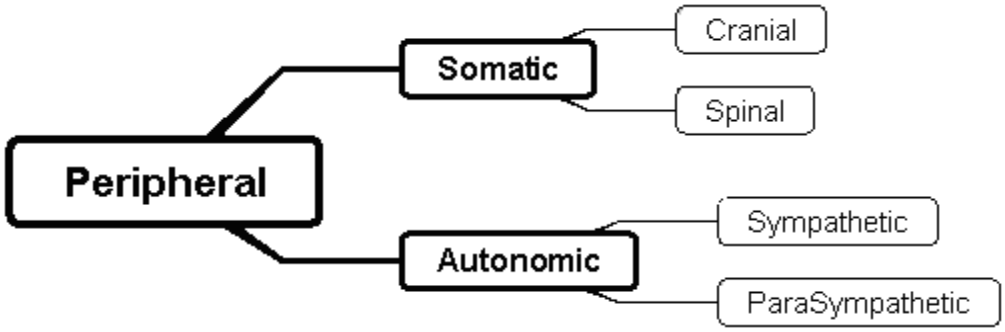
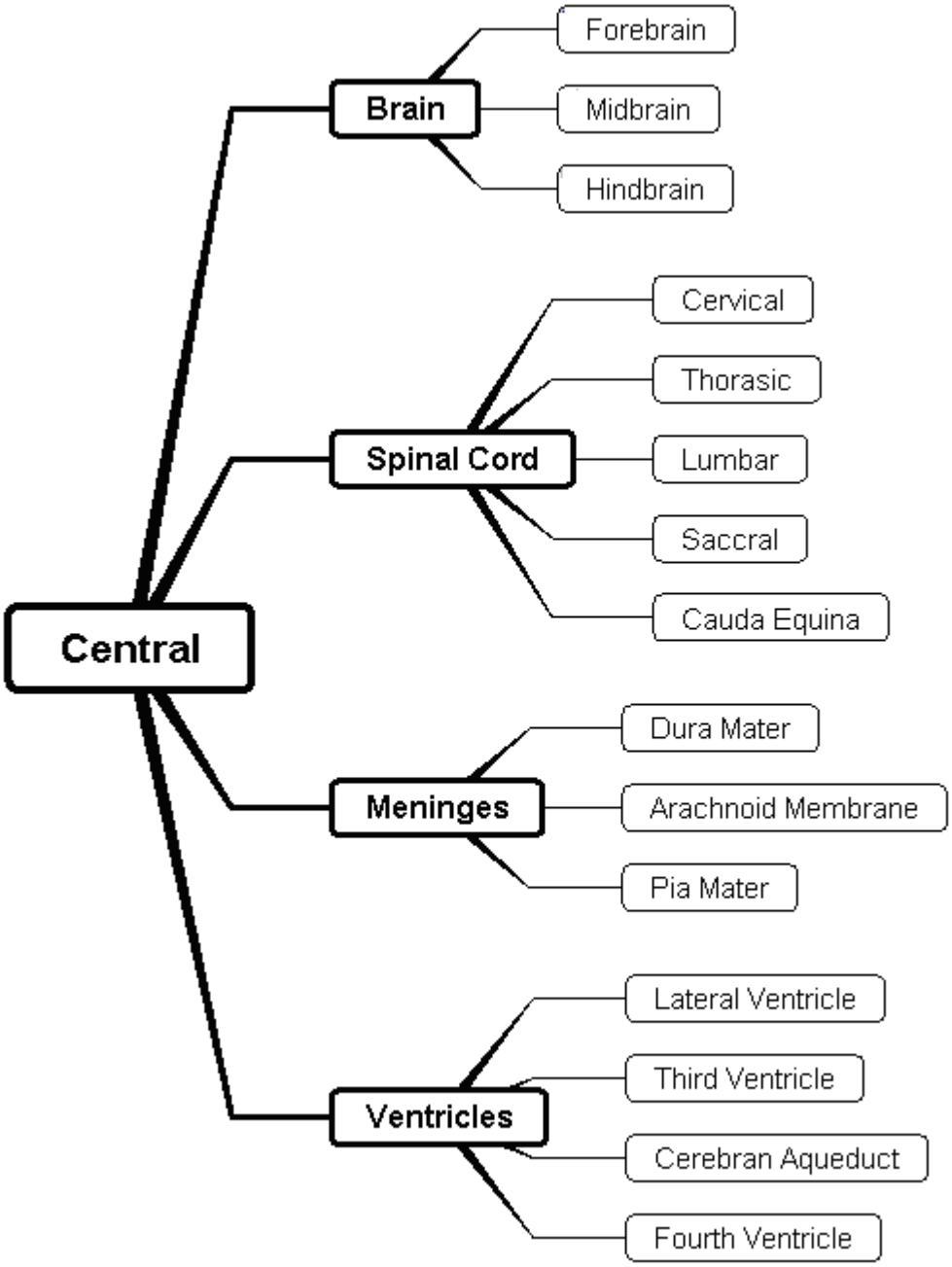
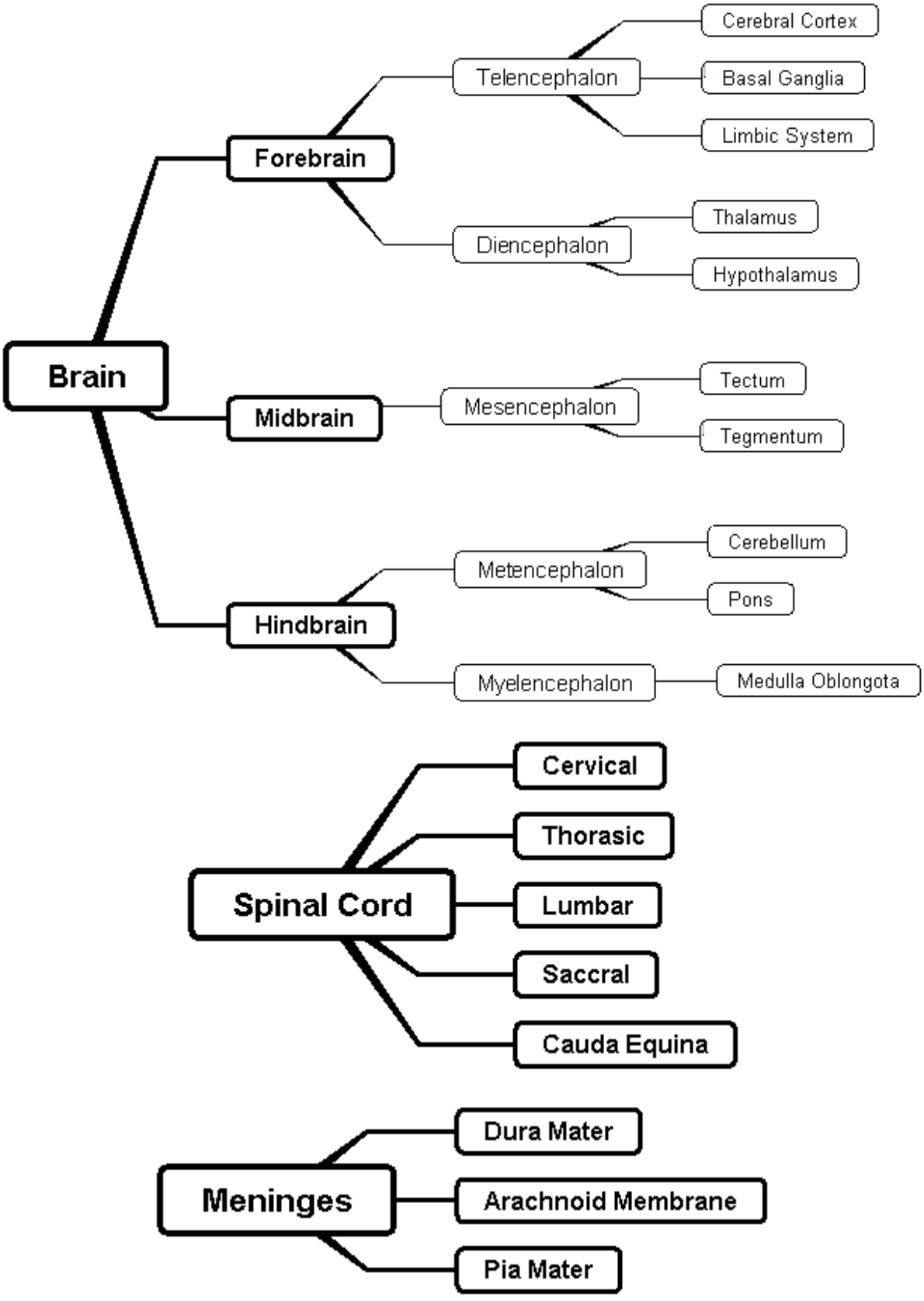
HANDOUTS

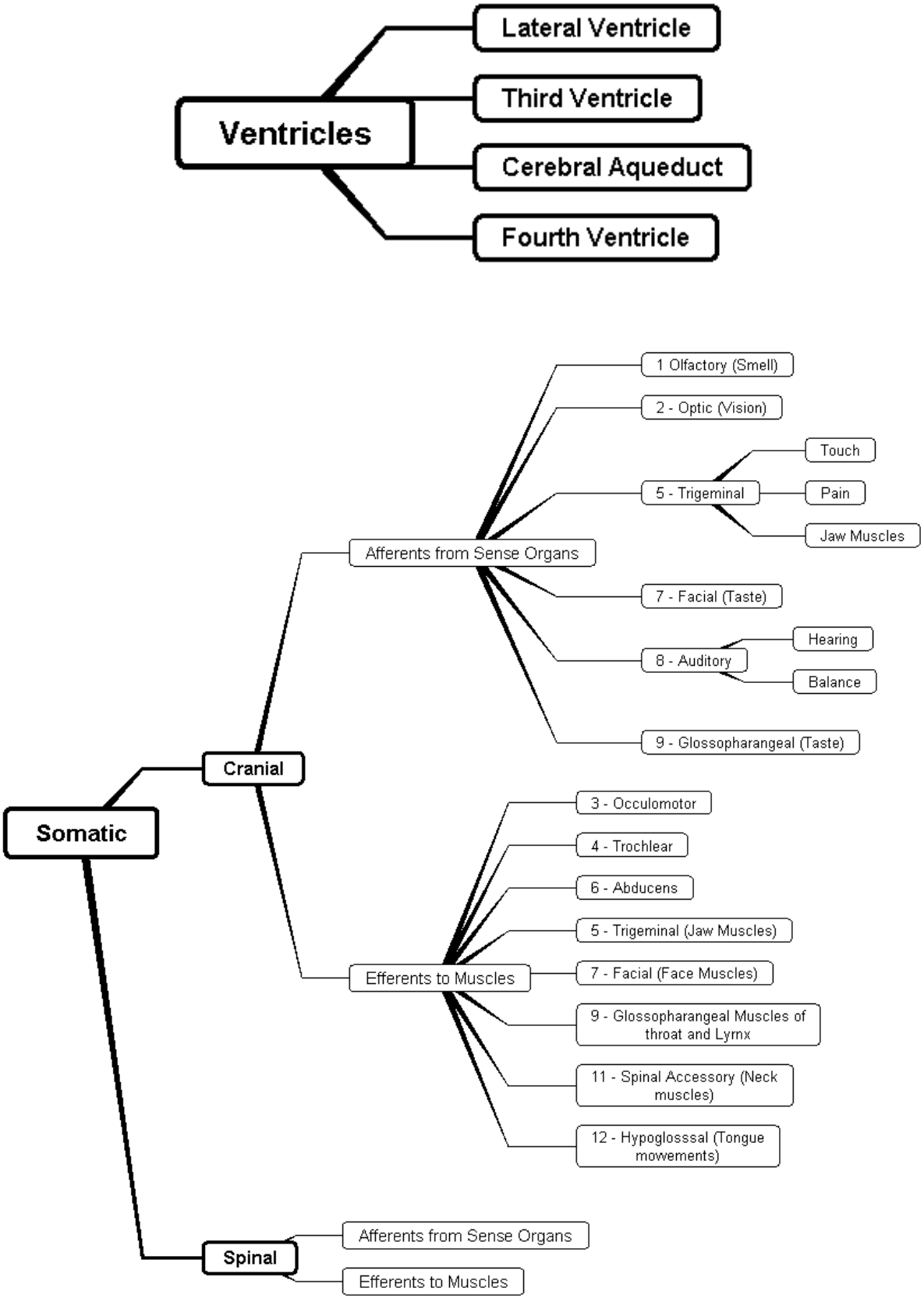
Handout 3.1 Concept Maps of the Nervous System

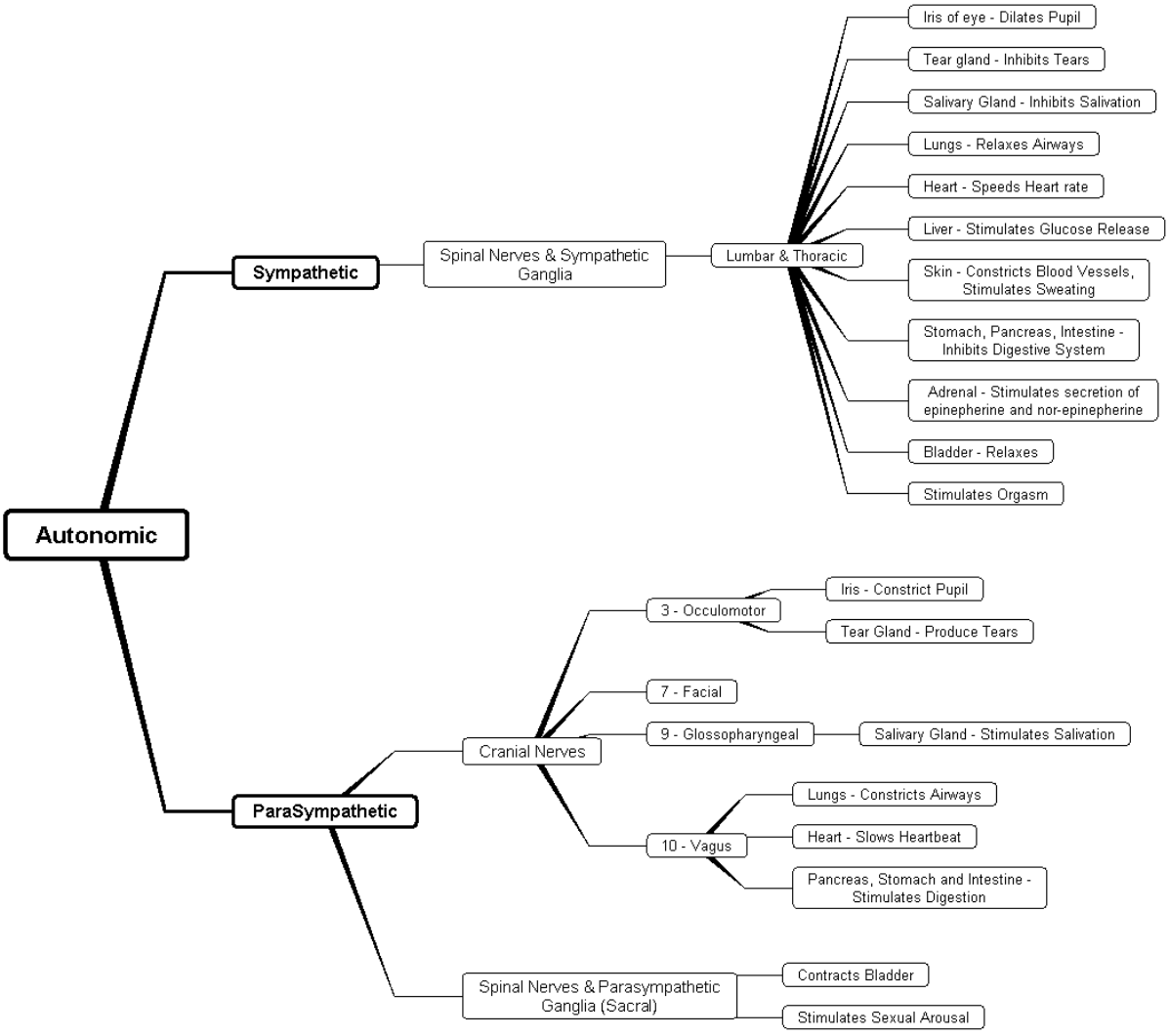












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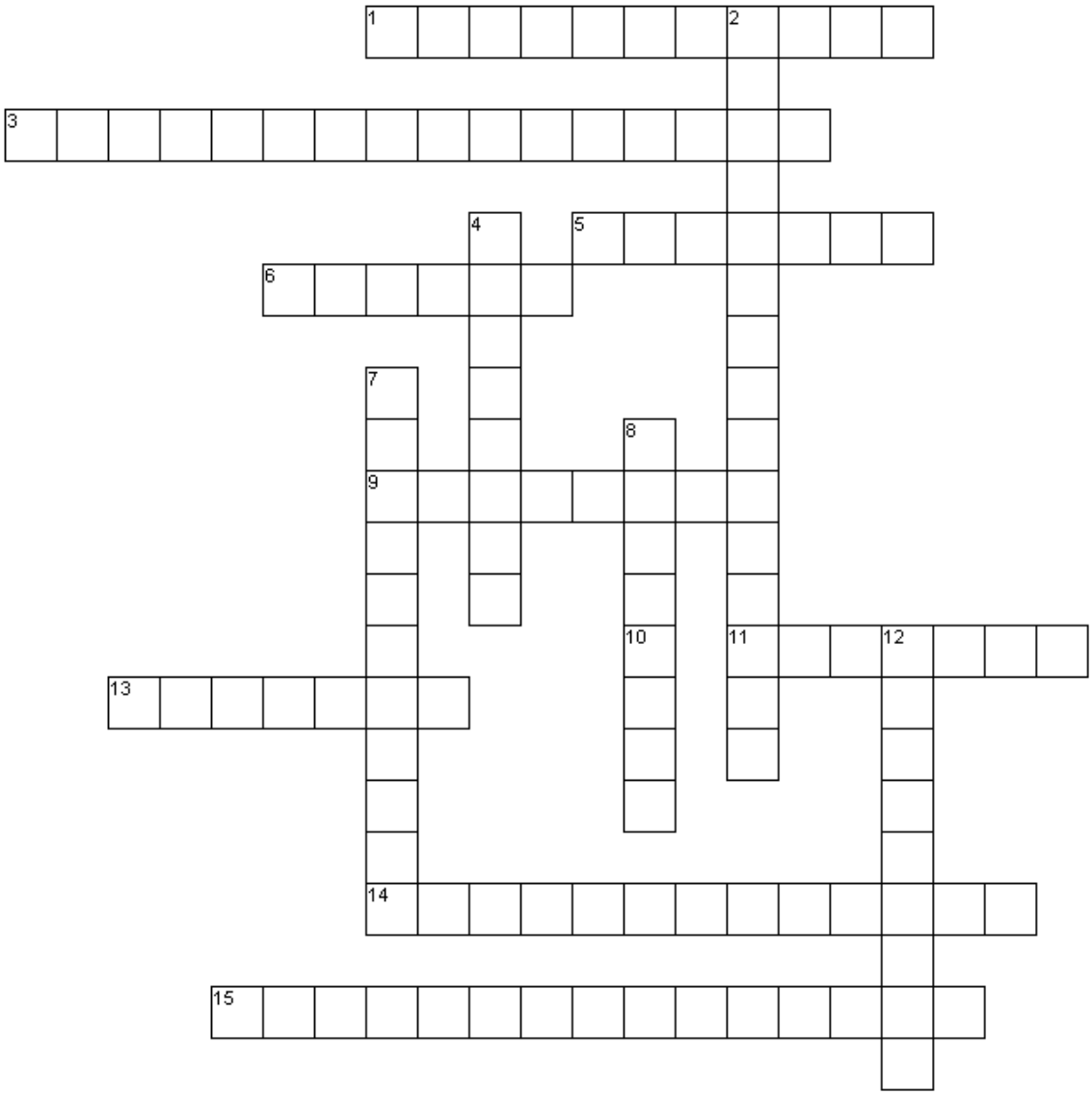
Handout 3.2: Vocabulary Crossword Puzzle

Name:

Section:

Date:

The Nervous System



Across

1. Rope-like structure carrying information from the brain to the body
3. Name means “black stuff”
5. You would have trouble breathing after damage to this area
6. Outer layers of brain or adrenal glands
9. Lobe of cortex behind the central sulcus
10. “System” involved in emotions
11. Part of the nervous system responsible for sensory and motor functions
13. Area of cortex responsible for decision making
14. Area of cortex in the parietal lobe responsible for information from skin, muscles, and tendons.
15. Digestion is controlled by this part of the peripheral nervous system

Down

2. Contains fibers that connect the two halves of the cerebellum
4. Name of this area of cortex may remind you of a religious building
7. Involved in memory and part of the limbic system
8. Striped part of the basal ganglia
12. Part of peripheral nervous system that reacts “automatically”

Puzzle created with Puzzlemaker at DiscoverySchool.com.

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Handout 3.3: A Handy Model of the Human Brain

Sometimes it is difficult to remember the major structures of the human brain and to understand their three-dimensional relationship. Here are some ideas that might be helpful to you in your studies.

Mnemonic Devices
Mnemonic devices have traditionally been the most effective tool for a student trying to put unfamiliar information into memory. Mnemonic devices build associations between the familiar and the new. These associations can then be used to cue memory.

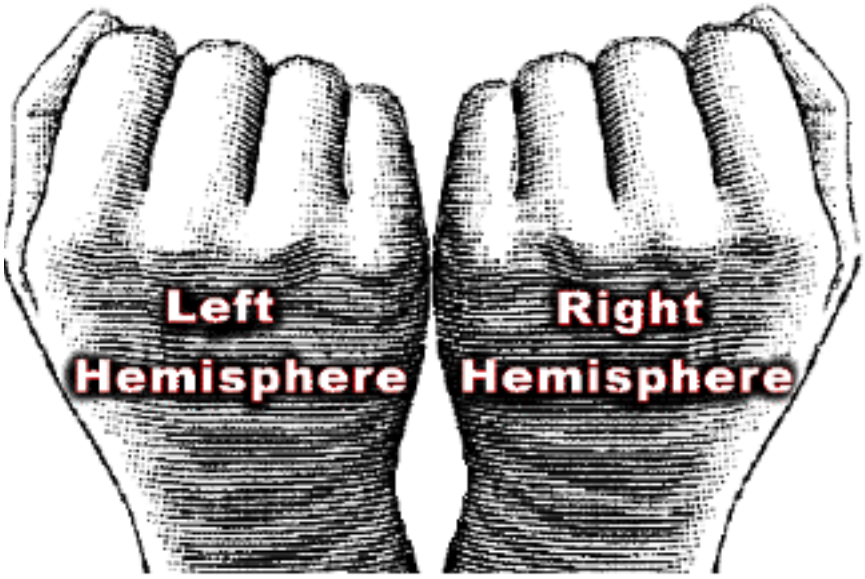
Did your father always know when you were up to some type of mischief? Did he appear to have "eyes in the back of his head"? In one way, he did. The cortical area responsible for vision is at the back of the brain.

In Ancient Greece, the priestesses, called Oracles, would hear voices giving them important information about people and events. Most of the Oracles lived (or worked) in a temple. Under your temples (at the side of your head, under the temple of your glasses) is the temporal lobe. This part of the brain has cortex responsible for audition (or hearing).

Here is another mnemonic device to assist you in remembering the location of brain structures.

A Brain Model

The Two Hemispheres



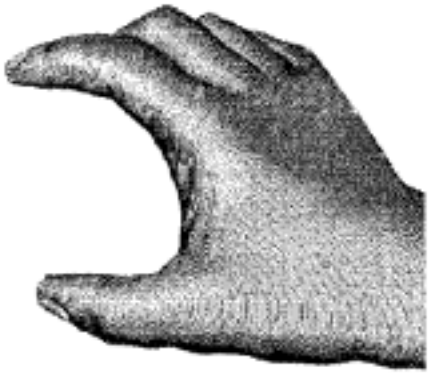
First, imagine that each of your hands represents one of the two hemispheres of your brain. Fold your hands into fists and hold your hands in front of you with the thumbs on the outside. The place where your hands touch represents the corpus callosum, where the two halves of the brain are connected.

The right hand represents the left hemisphere and the left hand represents the right hemisphere.

This will help you to remember that the opposite side of the brain controls the movement and sensation from the body. The neurons cross at a level in the brain stem represented by your wrists.

This is called the decussation (or crossing) of the pyramids.

Why did you curl your hands into a fist?



Some of the structures inside the skull of a human being are curved in a "C" shape. This probably evolved through preference for infants with smaller skulls who still had the same density of neurons to support future learning. (Ask any mother if a small skull at birth is a good idea.) The more surface area a brain has on the cortex, or skin of the brain, the more neurons it can support. The C-shape of the cortex makes more surface area. So does the wrinkled surface of the brain.

The cortex has many wrinkles. The high part of each wrinkle is called a gyrus. The valley between two wrinkles is called a sulcus. If the valley is deep and long and divides major areas of the cortex, it may be called a fissure.

Different areas on the skin of your hand can represent the different lobes of the cortex.

The fingers represent the **Frontal Lobe**. This part of the cortex is involved in complex thought and problem solving as well as emotional control.

The area at base of the fingers that is still within the frontal lobe represents that motor cortex. This area is responsible for voluntary movement below the neck.

The thumb represents the **Temporal Lobe**. Like the thumb, this area can be lifted away from the rest of the hand/brain, though it remains attached at the base, part of the C-shaped curve of the structures. This area has cells responsible for hearing and taste.

At the back of the hand is an area that represents the **Occipital Lobe**. The occipital lobe is responsible for basic vision.

The area remaining, the **Parietal Lobe**, appears to have cells responsible for complex relationships between other areas.

Underneath the occipital lobe at the back of the brain, is the **Cerebellum**, or little brain. (The large, main-brain is referred to as the cerebrum.) You might imagine it as a bracelet around your wrist. The top of the bracelet is very detailed. The band going around your wrist can represent the fibers of the neurons in the cerebellum connecting the two hemispheres of the cerebellum at the front of the brain stem in two lumps called the **Pons**.

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Handout 3.4: Diagrams of the Nervous System

Name:

Section:

Date:

An important part of understanding the nervous system is to be able to look at a diagram, x-ray, or model, and find a structure. This is made more complicated by the lack of differences in the look of nervous system tissue with different functions.

Even looking at diagrams can be confusing because they are from different points of view and may not look like the diagrams in the text, models you have used in class, or even dissections of real brains.

I will give you a series of diagrams of the nervous system to label. Some will be very detailed and some are rough sketches. You will need to look at the diagram carefully and determine if there are structures that you recognize. From these you can find and label other structures.

__ __ __ __ __ __ View

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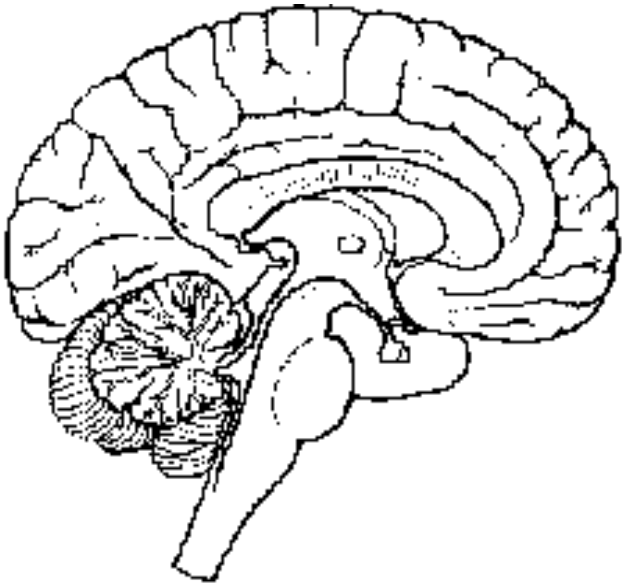

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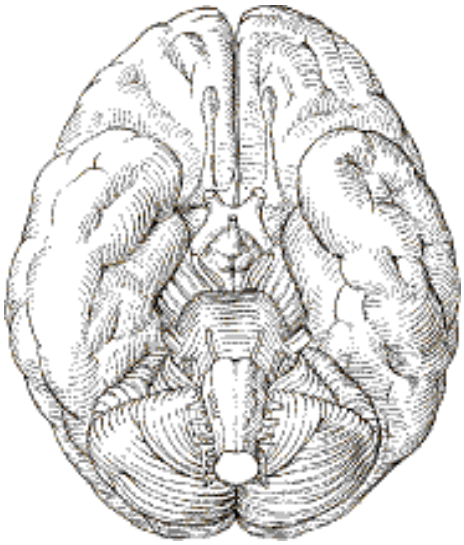

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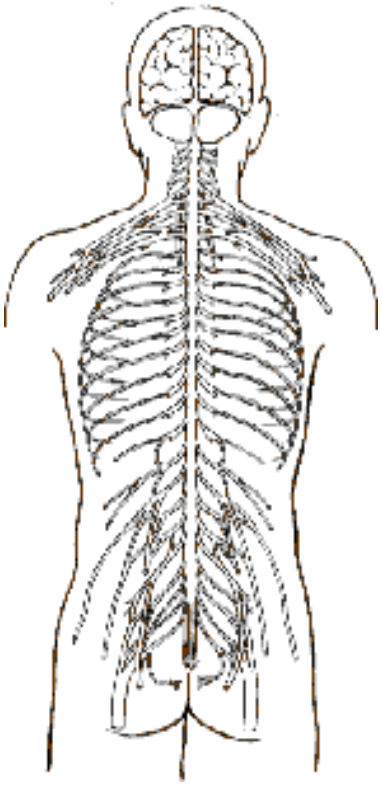

_ _ _ _ _ _ _ _ _ _ _ Nervous System

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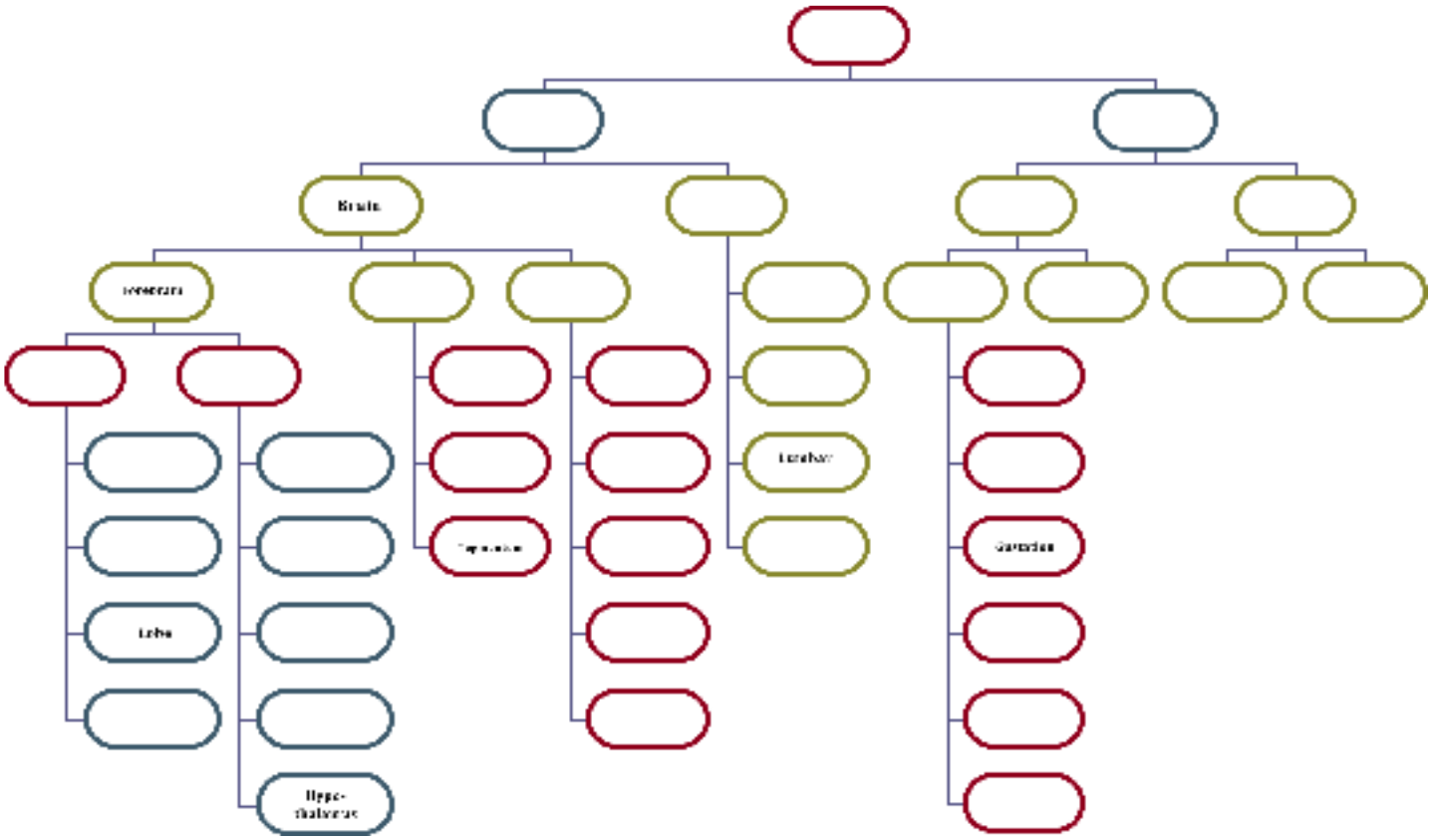
Handout 3.5: Structure of the Nervous System

Name:

Section:

Date:



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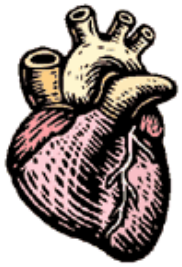
Handout 3.6: Learning Medical Terms

Capit – head
Cephalo – head
Cerebello – cerebellum (part of brain); "small brain"
Cerebro – cerebrum (part of brain)
Cranio – head
Encephalo – brain
Neuro – nerve



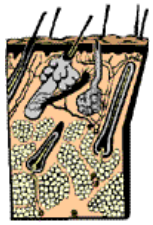
Cardi or cardio – heart

Glosso – tongue
Laryngo – larynx
Linguo – tongue
Stoma – mouth
Os – bone; or mouth

Arthro – joint
Carpo – wrist
Genu – knee (Latin)
Osteo – bone

Naso – nose
Rhino – nose

Orchio, orchido – testis
Ovario – ovary



Meningo – meninges (coverings of the brain and spinal cord)
Derma – skin
Pilo – hair
Cilia – hair (Latin)
Fibro – fibers

Ped – foot

Adeno – gland
Adreno – adrenal gland

Myelo – bone marrow and spinal cord
(Note: The use of this term will determine which tissue is meant.)
Myo – muscle
(Note: The Latin word for muscle is mus.*)*
Chordo or Cordo – cord or string

Oto – ear

Oculo – eye

Hippo – horse; hippocampus (seahorse-shaped)

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