Section A: Intro to Nervous System
The Nervous System regulates and coordinates activities within the body. It detects, interprets and responds to changes that occur internally and externally. Sensory receptors gather information and send electrical impulses to the Central Nervous System (CNS – spinal cord and brain). Electrical impulses are processed and generate appropriate reactions by sending electrical impulses via nerves to effector organs such as muscle and glands. The diagram illustrates the divisions of the nervous system.

1. The CNS is composed of the ____________________________.
2. What is the function of the brain? _________________________________________________________
3. What is the function of the spinal cord? _____________________________________________________
4. The PNS has two divisions – the sensory and motor division.
   a. What is the function of the sensory division? ____________________________________________
   b. What is the function of the motor division? ____________________________________________
5. The motor division is composed of the ____________________________________________________
6. What does the somatic nervous system control? ____________________________________________
7. What does the autonomic nervous system control? __________________________________________
8. The autonomic nervous system (ANS) is further divided into two divisions – sympathetic and parasympathetic division. What’s the difference between these two subdivisions? __________________________________________

Section B: Divisions & Functions
1. The Nervous System has 3 major functions. Identify the function based on its description.
   a. _____________________: receives the stimuli and then takes the information to the brain/central nervous system.
   b. _____________________: make decisions/process information.
   c. _____________________: the act of carrying a response to a gland or muscle.
2. The sensory pathway is also referred to as the (afferent/efferent) pathway. ________________
3. The motor pathway is also referred to as the (afferent/efferent) pathway. ________________
4. The motor pathway carries information (to / away from) the central nervous system. ________________
5. The sensory pathway carries information (to / away from) the central nervous system. ________________
6. What does the CNS stand for? _____________________________
7. What does the PNS stand for? _____________________________
8. What does the ANS stand for? _____________________________
9. The (CNS/PNS) is made up of the brain and spinal cord. _______
10. The (CNS/PNS) is made up of the nerves that lead to and from the brain and spinal cord. _______
11. Which sensory division carries information from the skin, skeletal muscles and joints to the CNS? _____________________________
12. Which sensory division carries information from the visceral organs within the ventral body cavity to the CNS? _____________________________
13. Which motor division conducts information from the CNS to the skeletal system? _____________________________
14. The ANS is further divided into the _____________________________. What is another name for this division? _____________________________. This division is commonly referred to as the involuntary division – why would it be called this? _____________________________.
15. The (parasympathetic/sympathetic) division of the nervous system mobilizes the body in emergency situations making someone more alert. It is this portion of the nervous system that causes a person to get the adrenaline rush in times of anxiety, anger, excitement resulting in an increased respiration rate, increased heart rate, increased perspiration, etc… _____________________________.
16. The (parasympathetic/sympathetic) division of the nervous system regulates your body’s activities under “normal”/stable conditions i.e. times when your emotional state is normal without any mood swings associated to anger, excitement, etc… _____________________________.
17. Identify which division and function of the nervous system. Put a check in the appropriate boxes.

<table>
<thead>
<tr>
<th>Division of the Nervous System</th>
<th>Nervous System Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNS</td>
<td>PNS</td>
</tr>
<tr>
<td>A. Brain</td>
<td></td>
</tr>
<tr>
<td>B. Decision Making</td>
<td></td>
</tr>
<tr>
<td>C. Getting “chill bumps”</td>
<td></td>
</tr>
<tr>
<td>D. Hearing a noise</td>
<td></td>
</tr>
<tr>
<td>E. Processing</td>
<td></td>
</tr>
<tr>
<td>F. Sweating</td>
<td></td>
</tr>
<tr>
<td>G. Spinal Cord</td>
<td></td>
</tr>
<tr>
<td>H. Glands secrete substances</td>
<td></td>
</tr>
<tr>
<td>I. Thinking</td>
<td></td>
</tr>
<tr>
<td>J. Tasting something</td>
<td></td>
</tr>
<tr>
<td>K. Meissner’s Corpuscles, Pacinian Corpuscles, and Free Nerve Endings</td>
<td></td>
</tr>
<tr>
<td>L. Picking up an object</td>
<td></td>
</tr>
<tr>
<td>M. Feeling Something</td>
<td></td>
</tr>
</tbody>
</table>
**Section C: Neuroglia**

1. What are the two types of cells that make up nervous tissue? __________________________________________

2. What are the functions of neuroglia cells?
   _____________________________________________________
   _____________________________________________________

3. List 2 characteristics of neuroglia cells. _____________________________________________________

**Match the neuroglia cell with the correct function:**

- astrocytes
- microglia
- ependymal
- schwann cells
- satellite cells

4. ___________________ Cells that produce the myelin in the PNS.
5. ___________________ Cells that produce the myelin in the CNS.
6. ___________________ Phagocytes that dispose of debris such as dead brain cells and bacteria.
7. ___________________ Anchors and braces neurons with cellular projections.
8. ___________________ Cells have cilia that help circulate the cerebrospinal fluid.
9. ___________________ Cells help cushion and protect neurons in the PNS.
10. _________________ Cells serve as a medium for diffusion between capillaries and neurons.
11. _________________ Cells line cavities of the brain and spinal cord.

12. Which glial cells are found only in the PNS? ___________________________________________________

13. Color the glial cells in the diagram.
Section D: Neurons
1. What is the function(s) of neurons? ____________________________________________

2. Sam was diagnosed with a brain tumor. Which type of cells would be dividing uncontrollably to form the tumor – neuroglia or neurons? __________________________

Match the parts of a neuron with the correct function.

<table>
<thead>
<tr>
<th>nodes of ranvier</th>
<th>axon terminals</th>
<th>axon hillock</th>
</tr>
</thead>
<tbody>
<tr>
<td>axon</td>
<td>dendrites</td>
<td>synapse</td>
</tr>
<tr>
<td>myelin</td>
<td>soma</td>
<td>synaptic cleft</td>
</tr>
</tbody>
</table>

3. ________________ Contains the nucleus and is the metabolic center of cell
4. ________________ Slender fibers that conduct impulses toward the soma
5. ________________ Junction of two neurons
6. ________________ Space between the axon terminal of one neuron & the dendrites of another neuron
7. ________________ Long fiber that extends from soma and conducts impulses away from soma
8. ________________ End branches that contain neurotransmitter storage vesicles
9. ________________ Gaps found between the myelin sheaths
10. ________________ Fatty material that protects fibers and speeds up impulse transmission
11. ________________ Part of the soma that connects to the axon

Did you know? Synapses change as we learn from our experiences. The brain forms new synapses when we are learning and removes unneeded synapses. Our brain is constantly adapting to reflect our lives. http://www.healthybrainforlife.com/

12. Label the neuron.
A. __________________________
B. __________________________
C. __________________________
D. __________________________
E. __________________________

13. Explain how an impulse is transmitted through a neuron starting at the sensory receptors.
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

Section E: Types of Neurons
Neurons are divided into afferent, efferent, and interneuron. In sensory (afferent) neurons, the dendrites are connected to sensory receptors and the axons are connected to other neurons. The receptors change information from external sources, such as light waves or sound vibrations, into electrical impulses. In motor neurons, the dendrites are connected to other neurons, and the axons to effectors (muscles and glands). Interneurons connect afferent and efferent neurons allowing them to communicate. Interneurons are located entirely within the CNS and conduct signals between other nerve cells. In interneurons, the dendrites are connected to the sensory fiber axons and the axons are connected to the motor fiber dendrites.
Sensory neurons conduct impulses from the sense organs to the spinal cord where interneurons form ascending tracts that transmit sensory impulse to the brain for integration. Impulses are transmitted from the brain by interneurons that form descending tracts in the spinal cord. Motor neurons conduct impulses from the spinal cord to effector organs.

1. What are the 3 types of neurons? ______________________________________________________
2. What is the function of the afferent neurons? ____________________________________________
3. What is the function of interneurons? ___________________________________________________
4. What is the function of efferent neurons? ________________________________________________
5. Which neurons have sensory receptors? ____________________________
6. Where are the sensory receptors located on a neuron? ________________________________
7. Which neurons cause movement or action in an organ? ________________________________
8. What are ganglia? ___________________________________________________________________
9. Which neuron has ganglia in the PNS? __________

Section F: Neuron Physiology
1. Nervous tissue possesses two distinctive properties – irritability and conductivity. Define these terms.
   a. Irritability - _______________________________________________________________________
   b. Conductivity - _______________________________________________________________________

2. Using the diagram, compare the conduction rate in an unmyelinated fiber and a myelinated fiber. Which fiber conducts an impulse faster? Explain your answer. ______________________________________
   ____________________________________________________________________________________
   ____________________________________________________________
3. An inactive neuron is polarized. What is meant by polarized? ________________________________________________

4. What causes depolarization? ____________________________________________________________

5. What causes repolarization? ____________________________________________________________

6. What happens to create an action potential? ______________________________________________

7. What is the function of the Na+/K+ pump? _______________________________________________

8. Put the following steps in order - Stimulation of a Neuron...
   1. Ca+ causes vesicles to release neurotransmitter.
   2. K+ diffuses out of the cell
   3. Stimulus activates neuron at the dendrite sensory receptors.
   4. Stimulus changes permeability of neuron.
   5. Na+/K+ pump restores resting position of ions.
   6. Na+ diffuses into cell
   7. Impulse reaches terminal, causing Ca+ to be released.
   8. Action potential is created.
   9. Neurotransmitter binds to receptors of next neuron.
   10. Events and impulse continue to spread across the membrane.

Use the diagram to help with question #8.

Section G: Neurotransmitters
Neurotransmitters are chemicals which carry the impulse from one neuron to the next neuron. These chemicals allow the transmission of signals across the synapse. Some neurotransmitters are excitatory or inhibitory. Here are a few examples of common neurotransmitters.

- Acetylcholine – stimulates muscle contractions, causes glands to secrete hormones and plays a role in memory. (Alzheimer’s disease is associated with a shortage of Ach.)
- GABA (gamma-aminobutyric acid) – an inhibitory neurotransmitter because it causes cells to be less excitable. (Low levels of GABA cause anxiety disorders.)
- Serotonin – an inhibitory neurotransmitter involved in mood and emotion. It brings about a sense of emotional well-being and helps to regulate sleep. (Low levels lead to depression and trouble sleeping. – Interesting fact: Warm milk before bedtime increases the levels of serotonin.)
- Dopamine – controls mood and motivation. Drives our internal feelings of reward and pleasure. It has an important role in learning. (Drugs such as cocaine and alcohol increase the levels of...
dopamine. Schizophrenia is associated with increased levels of dopamine. Parkinson’s disease is
associated with decreased levels of dopamine.)

- Norepinephrine – is released to stimulate our sympathetic nervous system and put our body into
‘high alert’. It’s important in forming memories. (Exercise increases the release of norepinephrine
and stress decreases it.)
- Glutamate – an excitatory neurotransmitter which plays a role in memory. (Excessive amounts of
  glutamate due to a stroke or brain damage will kill neurons. ALS results from excessive glutamate
  production.)
- Endorphins – an inhibitory neurotransmitter involved in pain reduction and pleasure.

http://webspace.ship.edu/cgboer/genpsyneurotransmitters.html

Section H: Reaction Time Lab
Reaction time is a measure of how quickly you can respond to a given stimulus. It is more complex than a
reflex. It requires information to be sent to the brain to be interpreted and back to cause an action.

Materials: Reaction Time Card with fractions of seconds printed on it. The numbers on the edge of the card
are fractions of a second as the card falls from bottom to top.

Procedure:
SIGHT:
1. Have your partner hold the card at the top.
2. Place your thumb and forefinger just below either side of the bottom of the card. Use the same hand
every trial.
3. Watch the card. When your partner drops it, catch it as fast as you can.
4. Record the reaction time. Repeat steps 1 through 3 for a total of 5 trials.

SOUND:
1. Follow the same procedure as above, but close your eyes. Your partner will say “go” when he/she drops
the card. Catch the card as fast as you can.

TOUCH:
1. Follow the same procedure as above, but close your eyes. Your partner will tap your shoulder as he/she
drops the card. Catch the card as fast as you can.

<table>
<thead>
<tr>
<th>Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Seconds)</td>
</tr>
<tr>
<td>Trial</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>

Conclusions:
✓ Describe the path of a stimulus from sensory receptor to motor neuron. How can the differing paths for
each stimulus account for the difference in reaction time?
Section I: CNS - Cerebrum

1. Label the 4 parts of the brain.
   a. _______________________
   b. _______________________
   c. _______________________
   d. _______________________

2. What are the elevated ridges of tissue on the cerebrum called? __________________________

3. The ridges are separated by shallow grooves called ________________________

4. What are the deeper grooves called? ________________________

5. What fissure separates the cerebrum into left and right hemispheres? _______________________

6. What fissure separates the frontal and the parietal lobes? ________________________

7. What fissure separates the frontal and the temporal lobe? ________________________

8. What is the bundle of myelinated fibers that allow the left and right cerebral hemisphere to
   communicate? _______________________

9. Label the lobes of the cerebrum.
   a. _______________________
   b. _______________________
   c. _______________________
   d. _______________________

Speech, memory, logical and emotional response, consciousness, interpretation of sensation and voluntary movement are all functions of the cerebrum. Identify which lobe controls the following activities:

10. Primary motor area that allows us to consciously move our skeletal muscles. __________________

11. Somatic sensory area - recognize pain, temperature or touch from the skin. __________________

12. Primary visual area. __________________

13. Primary auditory area. __________________

14. Primary olfactory area. __________________

15. Ability to speak – Broca’s area. __________________

16. Higher intellectual reasoning. __________________

Did you know? The right primary motor area controls the left side of the body and the left primary motor areas control the right side of the body. The right somatic sensory area receives input from the left side of the body and the left somatic sensory area receives input from the right side of the body.

17. Cerebral Cortex
   a. What is the outermost cerebral cortex consists of? ________________________
   b. What is the function of the cerebral cortex? ________________________
   c. Describe what the fibers in this area. ________________________

18. Cerebral Medulla
   a. What is the innermost cerebral medulla consists of? ________________________
   b. What is the function of the cerebral medulla? ________________________
   c. Describe the fibers in this area. ________________________

19. What is the function of basal nuclei? ________________________
Section J: Broca’s & Wernicke’s Area
Identifying the parts of the brain that are involved in language began in 1861, when Paul Broca, a French neurosurgeon, examined the brain of a recently deceased patient who had had an unusual disorder. Though he had been able to understand spoken language and did not have any motor impairments of the mouth or tongue that might have affected his ability to speak, he could neither speak a complete sentence nor express his thoughts in writing. When Broca autopsied the brain, he found a sizable lesion in the left inferior frontal cortex. Subsequently, this led to the identification of a “language centre” in the posterior portion of the frontal lobe of the left hemisphere - now known as Broca’s area.
Ten years later, Carl Wernicke, a German neurologist, discovered another part, this one involved in understanding language, in the posterior portion of the left temporal lobe. People who had a lesion at this location could speak, but their speech was often incoherent and made no sense. Neuroscientists now agree that running around the lateral sulcus in the left hemisphere of the brain, there is a sort of neural loop that is involved both in understanding and in producing spoken language. At the frontal end of this loop lies Broca's area, which is usually associated with the production of language. At the other end, lies Wernicke's area, which is associated with the processing of words that we hear being spoken. Broca's area and Wernicke's area are connected by a large bundle of nerve fibers called the arcuate fasciculus.

1. What's the function of the Broca’s area? __________________________________________________
2. What’s the function of the Wernicke’s area? _______________________________________________
3. In which hemisphere do you find these areas? _______________________
4. Do the lobes work independently of each other? Explain your answer. _______________________

Section K: Stroop Effect Lab (adapted from http://faculty.washington.edu/chudler/words.html)
Psychologist John Stroop studied the processing of words and how these thought processes affected other mental tasks. He found that the brain must override an automatic response when it receives conflicting information or inference. This is called the Stroop Effect. In this lab, you will complete a task that demonstrates the Stroop Effect.

Procedure:
1. Use the cards that have the words in their own color.
2. Have a partner time and record how long it takes for you to say the color of the word. Give your response as quickly as possible. Record your data. Repeat this step.
3. Use the cards that have the words in different colors.
4. Have a partner time and record how long it takes for you to say the color of the word. Give your response as quickly as possible. Record your data. Repeat this step.

Why?
The words themselves have a strong influence over your ability to say the color. The interference between the different information causes a problem. There are two theories that may explain the Stroop effect:
Speed of Processing Theory: the interference occurs because words are read faster than colors are named.
Selective Attention Theory: the interference occurs because naming colors requires more attention than reading words.

<table>
<thead>
<tr>
<th>Words in their own color</th>
<th>Time (sec)</th>
<th>Correct (c) or Incorrect (i)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Total incorrect responses:
Words in a different color

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Correct (c) or Incorrect (i)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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</tbody>
</table>

Total incorrect responses:
Section L: CNS – Diencephalon, Cerebellum & Brainstem

Diencephalon -- Identify the parts of the diencephalon based on description.
1. Maintains homeostasis. Control centers for regulating hunger, sleep, thirst, body temperature, water balance and blood pressure. Control pituitary gland. ________________________
2. Central relay station for sensory impulses traveling from everywhere else to the cerebrum. Receives all sensory impulses except smell and sends them to correct region of the cerebral cortex to be interpreted. __________________________________________
3. Contains the pineal gland which secretes the hormone melatonin – which regulates daily rhythms (sleep patterns). _______________________________
4. Reflex centers for olfaction. __________________________________________
5. System of pathways connects frontal lobes, temporal lobes, thalamus and hypothalamus – involved in emotions and memory. ______________________
6. Responsible for feelings of anger, fear, sorry, pleasure, affection and sexual interest. ______________________________
7. Parts of the limbic system involved in learning and memory – links emotion to stored memories. ___________________________
8. Knot of capillaries that form the cerebrospinal fluid. ___________________________

Cerebellum & Brainstem – Identify the parts of the brainstem and cerebellum based on description.
9. Part of Brainstem: Centers for regulating heartbeat, breathing and blood pressure. Reflex centers for vomiting, coughing, sneezing and swallowing. Ascending and descending tracts between higher brain centers and spinal cord. ___________________________
10. Part of Brainstem: Relay station for tracts that run between cerebrum, spinal cord and cerebellum. Reflex centers for visual, auditory and tactile responses. ___________________________
11. Coordinates muscles – integrates impulses from higher centers to produce smooth and graceful motion. Maintains normal muscle tone and posture. Receives information about body position in inner ear and sends impulses to muscles to maintain or restore balance. ___________________________
12. Part of Brainstem: Contains tracts between cerebellum and rest of CNS. Coordinates with medulla to regulate breathing. Reflex centers for head movements in response to visual and auditory stimuli. ________________
13. System of loosely clustered neurons extending through brainstem. Functions to arouse brain – receives sensory inputs from all ascending sensory tracts and sends impulses to cerebral cortex through thalamic relays. Maintains cortex in alert conscious state – enhances excitability. __________________________

Section M: 3-D Brain Anatomy & Dissection
1. Click on ‘3-D Brain Anatomy’ and fill in the chart.

<table>
<thead>
<tr>
<th>Function</th>
<th>Structure or Lobe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sight</td>
<td></td>
</tr>
<tr>
<td>Long-term memory</td>
<td></td>
</tr>
<tr>
<td>Short-term memory</td>
<td></td>
</tr>
<tr>
<td>Brain’s relay station</td>
<td></td>
</tr>
<tr>
<td>Cycling sex hormones</td>
<td></td>
</tr>
<tr>
<td>Speech perception</td>
<td></td>
</tr>
<tr>
<td>Emotions</td>
<td></td>
</tr>
<tr>
<td>Balance and coordination</td>
<td></td>
</tr>
<tr>
<td>Connect the right and left hemisphere</td>
<td></td>
</tr>
<tr>
<td>Breathing and heartbeat</td>
<td></td>
</tr>
<tr>
<td>Hearing</td>
<td></td>
</tr>
<tr>
<td>Reasoning</td>
<td></td>
</tr>
<tr>
<td>Touch and sensation</td>
<td></td>
</tr>
</tbody>
</table>

2. Click on ‘Brain Dissection’ and go through the tutorial.
Section N: PNS – Spinal Cord

1. The spinal cord provides a two way conduction pathway to and from the brain. What is the other function? ____________________________________________

2. Ascending tracts take _________________ nerve impulses up to the brain.

3. Descending tracts take _________________ nerve impulses down and out to effectors.

4. What tracts are found in the gray matter of the spinal cord? ____________________________________________

5. What is the function of the gray matter in the spinal cord? ____________________________________________

6. Where is the gray matter in the spinal cord? ____________________________________________

7. What tracts are found in the white matter of the spinal cord? ____________________________________________

8. What is the function of the white matter in the spinal cord? ____________________________________________

9. Where is the white matter in the spinal cord? ____________________________________________

10. Where is the CSF located? ____________________________________________

11. Which neurons are found in the dorsal root? ____________________________________________

12. What is a dorsal root ganglion? ____________________________________________

13. Which neurons are found in the ventral root? ____________________________________________

14. What happens to the body if the dorsal root or ganglion is damaged? __________________________

15. What happens to the body if the ventral root or ganglion is damaged? __________________________

16. What type of fiber tracts are found in a spinal nerve or mixed nerve? __________________________

17. Label the parts of the spinal cord using these terms --- dorsal root, ventral root, dorsal horn, ventral horn, spinal nerve, dorsal root ganglion

   1. __________________________
   2. __________________________
   3. __________________________
   4. __________________________
   5. __________________________
   6. __________________________

Section O: Protection of CNS

1. The meninges are a connective tissue membranes composed of three layers. Identify the layer.
   a. Tough double-layered membrane is attached to the skull and forms the outermost covering of the brain and spinal cord. Forms channels called dural sinuses that collect and return venous blood to circulation. ____________________________________________
   b. The middle layer has threadlike extension spanning the space to attach it the innermost membrane. The space is filled with CSF. ____________________________________________
   c. The innermost layer clings tightly to the surface of the brain and spinal cord following every fold. ____________________________________________
   d. Label the meninges in the spinal cord.
      # 3. __________________________
      # 4. __________________________
      # 5. __________________________

2. What is the cerebrospinal fluid and what are the components of ‘this fluid’? ____________________________________________

3. What forms the cerebrospinal fluid? ____________________________________________
4. What is the function of the CSF? ______________________________________________________

5. CSF circulates through ventricles, into the central canal of spinal cord, into the subarachnoid spaces and returns to veins of the brain where it drains into the dural sinuses and returns to the blood. If the production and drainage is blocked, what happens? ______________________________________________________

6. If the composition of the CSF changes, what could this indicate? ______________________

7. What is the blood-brain barrier? ______________________________________________________

8. What can pass easily through the walls of the capillaries? ______________________________

9. What is prevented to pass through the walls of the capillaries? __________________________

Section P: PNS - Nerves
1. What is a nerve? ____________________________

2. This figure shows the anatomy of a nerve.
   a. What does #3 represent? ____________________________
   b. What does #2 represent? ____________________________
   c. What does #6 represent? ____________________________

3. How many pairs of cranial nerves are found in the body? ____________________________

4. How many pairs of spinal nerves are found in the body? ____________________________

5. Label the diagram. Use the wordbank – CNS, PNS, spinal cord, brain, cranial nerves, spinal nerves
   a. ______________________________________
   b. ______________________________________
   c. ______________________________________
   d. ______________________________________
   e. ______________________________________
   f. ______________________________________