Sowing the Seeds of Neuroscience

Neuroscience 101

Neuroscience 101

Activity Time: Two 50 minute periods.

Lesson Summary:

In this interactive lesson, students will learn the basic anatomy and physiology of the nervous system. Starting with structure of the brain, spinal cord, and nerve cells, students will then learn about neurotransmission, the electrochemical process by which neurons send signals. They will participate in several activities that model the functions of neurons.

STUDENT UNDERSTANDINGS

Big Idea & Enduring Understanding

- **Structure and Function of the Nervous System:** The nervous system influences and is influenced by all other body systems. The nervous system receives signals from the body and the outside world, processes this information, and sends signals to muscles, glands, and organs to ensure the survival of the organism.

Essential Questions

- What is the structure and components of the nervous system?
- How does the brain communicate with the rest of the body?

Neuroscience Core Concepts

- The nervous system controls and responds to body functions and directs behavior.
- The brain is the body's most complex organ.
- The nervous system influences and is influenced by all other body systems (cardiovascular, endocrine, gastrointestinal, immune systems, etc.).
- Neurons communicate using electrical and chemical signals.
- Synapses are chemical or electrical junctions that allow electrical signals to pass from neurons to other cells.
- All thoughts and behaviors result from combinations of signals among neurons.

Learning Objectives

Students will know…

- The nervous system is made up of the brain, spinal cord, and the nerves of the body.
- The nervous system is divided into the central nervous system (CNS) and the peripheral nervous system (PNS).
- Neurons use electrical and chemical signals to transmit information.

Students will be able to…

- Create one metaphor for the human brain and explain how it is similar and/or different to an actual brain.
- Identify the names and functions of the different parts of a neuron.
- Provide evidence for why the brain is the body's most complex organ.
- Define the "all-or-none" concept of action potential.
- Identify ten new things they learned about the nervous system.

Standards Alignment

Washington State Essential Academic Learning Requirements (EALRs): Science
Science EALR 1: Systems • 6-8 SYSA—Subsystems Science EALR 2: Inquiry • 6-8 INQE—Model
Next Generation Science Standards (NGSS)
From Molecules to Organisms: Structures and Processes • MS-LS1-2 • MS-LS1-3 • MS-LS1D-8
Common Core Standards: English Language Arts (ELA)
Language Standard 4c & 6: Vocabulary Acquisition & Use • CCSS.ELA-Literacy.L.6.4c • CCSS.ELA-Literacy.L.6.6

TEACHER PREPARATION

Materials

Classroom Materials

Item	Quantity
Copies of *Neuroscience 101 Background Reading—Student Handout*	1 per student
Optional: Copies of *Neuroanatomy Crossword Puzzle—Student Handout*	1 per student
Student lab notebook	1 per student

Laboratory Materials

One Rope Neuron Model is provided in the *Sowing the Seeds of Neuroscience* classroom kit. The small objects needed for the Pass the Message and Neuron Race activities are not provided in your kit.

Item	Quantity
Small objects, such as stones, coins, buttons, binder clips, etc.	1 object per student
Rope Neuron Model. One model is provided with your kit. If you choose to construct additional models, you will need the following materials (see *Preparation* section for assembly instructions): • Rope (for dendrites and axon) • Plastic containers (for cell body and synaptic terminal) • Pool float (or another object that will slide along the rope; for the action potential) • Plastic balls (for neurotransmitters)	1 model

Lab Safety

- Students must not eat or drink anything in the lab.
- During the Rope Neuron Activity, the pool float will travel very fast! Make sure that the person holding the synaptic terminal keeps his or her hands away from the pool float.

Preparation

- Photocopy the Student Handouts.
- You may choose to assign the background reading on the *Neuroscience 101 Background Reading—Student Handout* to students as homework prior to delivering the lesson.

- Plan your timing: It may work best to deliver this lesson over two days. On Day One, conduct the activities in the *Engage* section of the lesson plan, including a review of the background reading, learning goals, and vocabulary. On Day Two, conduct the activities in the *Explore* section, focusing on the anatomy of neurons and the basics of neurotransmission. Also cover the *Explain*, *Elaborate*, and *Evaluate* sections of this lesson plan.

- To help you understand how to operate the Rope Neuron model, you may want to watch a demonstration of the model and some helpful background information. Check out this clip from the "BrainWorks" video.

  Clip of "BrainWorks: Neuroscience for Kids" Video (3:57 mins)
  uwtv, 2006
  http://www.neuroseeds.org/About-Neuroseeds/Lessons/neuroscience101

TEACHER PROCEDURE

Day One

Engage

1. Explain the purpose of the lesson and review Big Idea, Enduring Understanding, and Essential Questions.

2. **What is a Brain?** Tell students that the brain is the body's most complex organ. It is the control center of the nervous system. Discuss what students already know about the human brain and nervous system and what they want to know. Create a K/W/L chart to record students' responses in the "K" and "W" columns, as shown below.

What I Know About the Brain & Nervous System	**What I Want to Know About the Brain & Nervous System**	**What I Learned About the Brain & Nervous System**

3. **BrainWorks.** Show students a clip from the uwtv production of "BrainWorks: Neuroscience for Kids". The video clip is available at the Sowing the Seeds of Neuroscience website.

Clip of "BrainWorks: Neuroscience for Kids" Video (3:57 mins)
uwtv, 2006
http://www.neuroseeds.org/About-Neuroseeds/Lessons/neuroscience101

4. **Computer vs. Brain.** Ask students how the brain may be similar and different from other objects. Using a computer as an example, discuss: How is the brain similar to a computer? How is it different? You may choose to use a T-chart to record student answers.

   Some prompting questions include:
   - Do they both use energy?
   - Do they store information in the same way?
   - Do they have parts?
   - Do they use electricity?
   - Do they contain chemicals?

   Examples of student answers have been provided on the sample T-chart below:

Computer vs. Brain	
Similarities	**Differences**
Brains and computers both… • Store tons of knowledge. • Process things. • Work automatically. • Are effective. • Need energy to function. • Send messages.	*The brain…* • Can feel emotions. • Can feel pain. • Is faster. • Thinks independently. • Can take shortcuts rather than going through the entire problem. • Doesn't do the same thing every time.

5. Add a summary of students' responses to the "K" column of the K/W/L chart.

6. For more information about the similarities and differences between the human brain and the computer, check out the following website:

   "The Brain vs. the Computer"
   Neuroscience for Kids
   http://faculty.washington.edu/chudler/bvc.html

7. **Brain Metaphors.** Explain to students that saying that "the human brain is a computer" is one example of using a metaphor to describe the brain. Ask students to help develop a definition for "metaphor." Compare students' definition to the definition provided by the Merriam-Webster dictionary:

"***Metaphor:*** *A figure of speech in which a word or phrase literally denoting one kind of object or idea is used in place of another to suggest a likeness or analogy between them."*

8. Students may work alone or in groups for this activity. Give each student or group of students a different object or a picture of an object that represents a Brain Metaphor. These objects can be just about anything, but the following objects work well and are easy to obtain:

- Pencil
- Spring
- Coin
- Paper clip
- Apple
- Book
- Dictionary
- Clock
- Ruler
- Rubber band

9. Tell students to use their lab notebooks or a piece of paper to make a list of similarities and differences between their object and a human brain.

   If students need a few examples to help them get started, some sample Brain Metaphors have been provided below.

The Brain is a…	**Because it…**
Spider web	…is delicate, minimal, hypersensitive, and connects many things. It responds instantly and simultaneously to outside events.
Prism	…breaks white light (seemingly one thing) into many colors.
Lens	…magnifies and concentrates energy to an intense point (focus).
Lamp	…allows you to see things better.
Spaceship	…can orbit the whole world and travel to other worlds (imagination!).
Map	…has different geographical features each with unique characteristics.
Atlas	…is a collection of maps (of all scales and types).
Mirror	…can see things as others see it and see other things and oneself from all angles.
Tree	…has branches that diverge and converge.
River	…has many tributaries that branch.

Bunch of toys	…must be played with to learn all sorts of things.
A friend	…does things together, shares, and compares knowledge.
Factory	…manufactures things.
Toolbox	…can be used in all sorts of ways to make all sorts of things.
Thundercloud	…accumulates and then suddenly and briefly releases great energy.
Snowflake or Crystal	…grows symmetrically from center point to "huge" size.
Cookbook	…contains recipes for making all sorts of things.
Music or Dance	…orchestrates movement of things, ideas, or emotions.

From: "Brain Metaphors." Neuroscience for Kids. http://faculty.washington.edu/chudler/metaphor.html.

10. Tell students that the brain is one component of the nervous system. In this lesson, students will be learning about **neuroanatomy**—the parts and functions of the human nervous system. This will help prepare them for a series of labs investigating the ways that chemicals in plants can affect the nervous system and neurological disorders.

11. Distribute copies of *Neuroscience 101 Background Reading—Student Handout*. Allow time in class for students to read the handout, or assign it as homework.

12. When students have completed the background reading, engage them in a review of neuroanatomy vocabulary, the basics of the central and peripheral nervous system, and the job of the nervous system.

Day Two

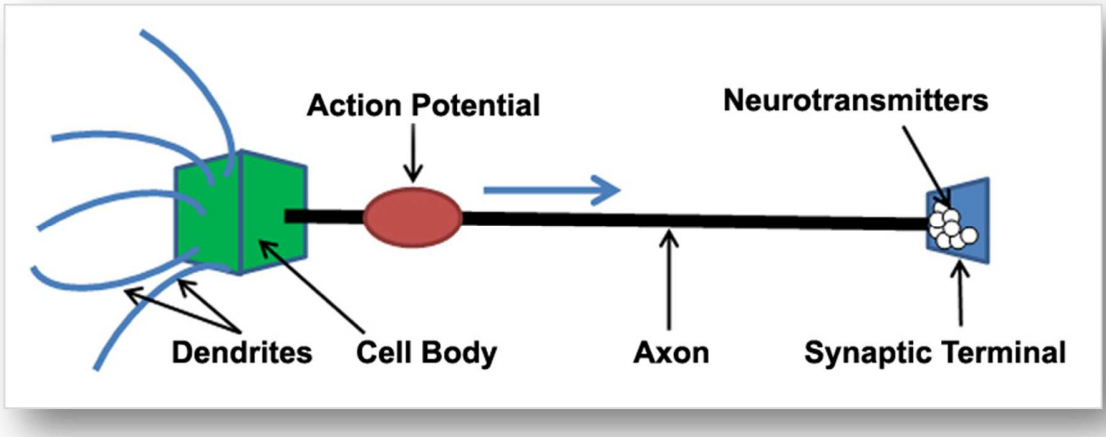
Explore

Rope Neuron Activity

13. Review the section on action potential from the Student Handout. What are the parts of the neuron? What is action potential? What is the "all-or-none" concept?

14. Tell students that they will help operate a giant model of a neuron. The model will illustrate the properties of **chemical transmission** and **action potential**.

15. First, ask for student volunteers to help operate the model:



- Several students are needed to hold the short rope pieces representing the ***dendrites***, one student per rope.
- One student should hold the ***cell body*** (plastic container to which dendrites are attached).
- One student should hold the ***synaptic terminal*** (plastic container with balls). Make sure the person holding the synaptic terminal keeps his or her hands ***away*** from the place the axon attaches.
- One student should hold some ***molecules of neurotransmitter*** (some of the plastic balls) near the students who are the dendrites.
- One student should hold the ***action potential*** (pool float).

16. Now it is time to use the model!

- Have the student holding molecules of neurotransmitter ***toss*** the plastic balls to the people who are dendrites. The "dendrite students" should try to catch the plastic balls.
    - This models the release of neurotransmitters and the attachment (binding) of neurotransmitters to receptors on dendrites.

- When three plastic balls have been caught by dendrites, the person holding the action potential can throw/slide the pool float down the axon.
    - This simulates that a certain amount of neurotransmitter must bind to receptors before an action potential is generated.

- The action potential (pool float) should speed down the axon toward the synaptic terminal where it will slam into the container. This should cause the release of the neurotransmitters (plastic balls) that were being held there.

CAUTION: The pool float will travel very fast! Make sure that the person holding the synaptic terminal keeps his or her fingers and hands ***away*** from the pool float. Also, instruct students not to exert too much force on the model or it may break.

17. If the entire model is stretched tightly, the pool float should travel down to the terminal smoothly. This model can be used to reinforce the ***"all-or-none" concept of the action potential:***

    - Once the action potential starts, it continues without interruption down the length of the axon.
    - The size of the action potential stays the same as it travels down the axon.

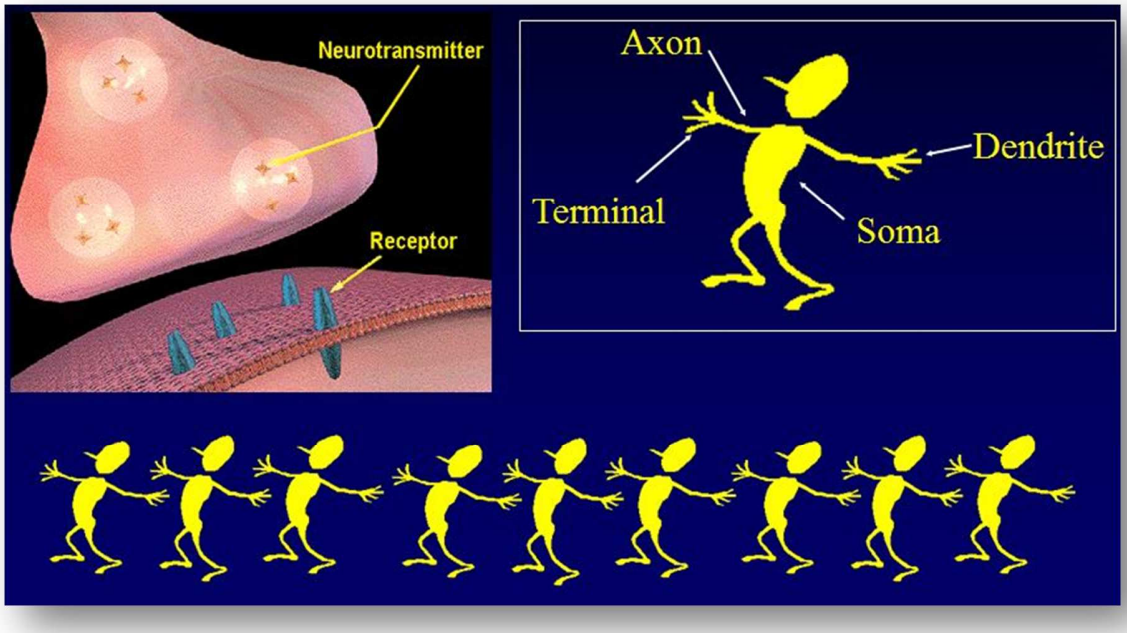
18. Prompt students to consider what new understandings they have gained after participating in the Rope Neuron activity. Add their responses to the "L" column of the K/W/L chart.

Pass the Message & Neuron Race Activities

19. Now that students have modeled the anatomy and function of a neuron, their next challenge is to model the chemical and electrical transmission of messages from neuron to neuron. Share with students this exciting fact: ***Messages can travel in neurons at speeds up to 268 miles per hour! These signals are transmitted from neuron to neuron across synapses***.

20. To illustrate how messages are passed from neuron to neuron using chemical and electrical signals, use students to make a chain of neurons. First, you will have a group of students demonstrate the neuron model in the Pass the Message activity. Then, you will challenge teams of students to a Neuron Race.

21. To demonstrate the Pass the Message activity, ask for five student volunteers. Position the students so that they are standing in a line. Explain to the class that each person in the line is a neuron. Everyone's left hand are the **dendrites** of a neuron; their body is the **cell body**; their right arm is an **axon** and their right hand is the **synaptic terminal** (see the illustration below).



22. Hand a small object (coin, pebble, button, etc.) to each student in the line. Explain that these objects represents each particular neuron's **neurotransmitter**. Each neuron has its own neurotransmitter.

23. Instruct the first student in the line to hold the object in his or her right hand (the synaptic terminal). The four other students should place their objects in their right hands, leaving their left hands empty.

24. Explain that each "neuron" will receive a neurotransmitter in his or her empty left hands (dendrites) and then pass his or her own neurotransmitter from his/her right hand (synaptic terminals) to the empty left hand (dendrites) of the next neuron in line. The exchange of the neurotransmitter causes an electrical signal inside of the neuron that received the neurotransmitter. The entire process is one where a chemical signal ***between*** neurons causes an electrical signal ***inside*** of a signal neuron: the neurotransmitter generates an electrical signal; the electrical signal is passed down the dendrite (left hand), to the cell body (the body of each student), and then down the axon (right arm) to the synaptic terminal (right hand).

25. When you say "Go!" have the student at the beginning of the line start the signal transmission by placing his or her "neurotransmitter" (object) into the hand (dendrite) of the adjacent person. Once this message is received, this second neuron places its neurotransmitter into the dendrite of the next neuron, keeping the neurotransmitter that was just passed to them. The third neuron then places its neurotransmitter into the dendrites of the next neuron and the "signal" travels to the end of the line. The transmission is complete when the "signal" goes all the way to the end of the line.

26. Now it is time for a Neuron Race! Break students up into teams, aiming to have the same number of students on each team. Each team needs to stand in a line, as was demonstrated during the Pass the Message activity. Hand a "neurotransmitter" object to each student.

27. Tell students to imagine that they are neurons inside of a professional baseball player who plays an outfield position. This is the most important game of his life—a World Series game! If his team gets one more out, they win the game. As the batter approaches the plate, our player is tense and alert, ready to spring into action. *Crack!* The batter smacks the ball and it is headed straight for our player. He tracks it with his eyes, raises his mitt, feels the ball whack his palm, and slams his finger shut around the ball. But wait! Oh no, he's dropped the ball. The crowd lets out a collective gasp. The player reaches out and catches the ball just before it hits the ground. The crowd goes wild!

28. When the outfielder drops the ball, the neurons inside his body need to send a message ***quickly*** to the brain that will be processed as "*Oh no! Grab that ball!"* so that the brain can instruct the hand to catch the ball before it hits the ground. In the Neuron Race, students will model the neurons inside our outfielder right as his fingers drop the ball.

29. When you say "Go!" each team will pass their "neurotransmitter" objects as quickly as they can. When it reaches the last person in line, they need to shout "Grab that ball!" and then send their own neurotransmitter back along the line. When the first person in the line receives a neurotransmitter from the neuron next to them, they should lift their hand in the air, signaling that the outfielder has caught the dropped ball, and that his team has won the World Series.

30. Prepare the teams for the Neuron Race. Say "Go!" and then watch to see which student first lifts his or her hand in the air.

Explain

31. Ask for students' observations of the neuron models, either as a class discussion or in small groups.

32. Discuss the following questions:

    - What does it mean if a team drops their "neurotransmitters"? *Those particular neurotransmitter molecules were not absorbed by the receiving neuron, therefore the message was not communicated to the next neuron. The lost neurotransmitters may or may not be reabsorbed (a process called re-uptake) by the sending neuron.*

    - What is the significance of the message traveling quickly or slowly?*The speed of the message being sent, received, processed, and transmitted correlates to how quickly the*

player acts and whether he is able to catch the falling baseball. The speed of the message also says something about the outfielder's motor skills and reflexes.

- Can you think of anything that could cause the outfielder's nervous system to speed up or slow down the sending and receiving of nerve impulses? *Students may provide a variety of responses; key response focuses on chemicals with neuroactive properties that can speed up or slow down the transmission of messages among neurons.*

33. Prompt students to consider what new understandings they have gained after participating in the Pass the Message and Neuron Race activities. Add their responses to the "L" column of the K/W/L chart.

34. You may want to ask students to review the sections of the background reading that are relevant to the Pass the Message and Neuron Race activities; in particular, focus on the *Pass the Message—Catch that Cell Phone!* section and corresponding vocabulary terms.

Elaborate

35. Explain that there are different types of substances that can affect the nervous system and the speed by which nerve impulses are sent and processed. For example, poisons that act on the nervous system are called **neurotoxins**. There are many animals and some plants that produce neurotoxins. Animals include scorpions, poison arrow frogs, some snakes, certain spiders, tarantulas, soft coral, honey bees, wasps, pufferfish, blue-ringed octopus, some marine snails, some mussels, and sea anemones. Plants include some algae and cayenne pepper, to name just a few.

    While plants can produce neurotoxins, they can also produce chemicals that have a beneficial effect on the nervous system. The chemicals in plants that affect the nervous system are called **neuroactive**.

36. Tell students that they will be participating in a series of lab investigations that explore the neuroactive properties of plants. In these investigations, they will discover the fascinating relationships between plants and neurological disorders and diseases. Share with students these teasers:
    - What does a cup of coffee and a bowl of fava beans have in common?
    - Why would a person with depression drink a potion of St. John's wort?
    - How does a forest walk lower your stress levels and boost your mood? The nose knows!
    - Do banana plants have magical healing properties?
    - Is garlic effective at protecting the brain from bacterial infections?

Evaluate

37. Challenge students to reflect on today's neuroscience lesson. In their lab notebooks, students should write down a list of at least ten new things they learned about the nervous system. Then, ask each student to circle their favorite "new thing."

38. As a class, return to the K/W/L chart you created at the beginning of the lesson. Ask for student volunteers to share their favorite "new things" and record any new responses in the "L" column of the class chart.

What I Know About the Brain & Nervous System	**What I Want to Know About the Brain & Nervous System**	**What I Learned About the Brain & Nervous System**

39. Take some time to review the "K" column. Is there anything in this column that students now know to be incorrect? If so, amend the chart so that the statements are scientifically correct.

40. Also review the "W" column of the class chart. Is there anything that students wanted to know about the brain and nervous system that hasn't yet been covered? Let students know if these topics will be addressed by the lab investigations they will be doing as part of the *Sowing the Seeds of Neuroscience* curriculum.

41. ***Optional:*** Assign the *Neuroanatomy Crossword Puzzle—Student Handout* as a vocabulary quiz. The answers are provided in the *Scoring Guide* section of this lesson plan.

SCORING GUIDES

Answer Key for Neuroanatomy Crossword Puzzle

11 possible points.

Across	Down
4. Synapse	1. Electrical transmission
10. Neuroactive chemicals	2. Dendrites
12. Axon	3. Nervous system
13. Neuroanatomy	5. Neurotoxin
14. Synaptic terminal	6. Action potential
15. Peripheral nervous system	7. Glia
16. Central nervous system	8. Neurotransmitter
	9. Cell body
	10. Neuron
	11. Chemical transmission

EXTENSIONS

- Show students "BrainWorks: Neuroscience for Kids". In this video: With the help of five kids, host Eric Chudler takes viewers on a journey inside of the brain. The show begins in the studio with an introduction to the nervous system. The kids then visit laboratories where they learn about automatic functions of the brain and how the electrical activity of the brain is recorded. Back in the studio, the kids see a real human brain and build their own model nerve cells and brains.

  "BrainWorks: Neuroscience for Kids" Video (28:07 mins)
  uwtv, 2006
  http://uwtv.org/watch/16205591/

- This lesson introduces students to number of technical terms; to be successful in the other lessons in this curriculum, it is important that students develop an understanding of these vocabulary terms. One strategy for developing student understanding of these new terms is to assign a vocabulary word to each student. Challenge the students to dissect each word by determining: syllables, pronunciation, part of speech, and meaning. Next, challenge each student to provide an example of the word's use in a sentence both verbally and in writing. Also, you may want to ask students to search online for an image or video that can be used to teach other students about the term and its meaning. In addition, the *Neuroanatomy Crossword Puzzle—Student Handout* can be assigned as a vocabulary quiz to be completed individually or in small groups.

- Challenge student groups to model a component of the nervous system. Check out the "Modeling the Nervous System" page on the Neuroscience for Kids website (http://faculty.washington.edu/chudler/chmodel.html) for instructions on creating models from clay, beads, pipe cleaners, string, hats, food, and more!

- Check out the "Experiment" menu on the Neuroscience for Kids website (http://faculty.washington.edu/chudler/experi.html). You will find games, worksheets, neuroanatomy coloring sheets, background readings, demos, experiments, and more.

- Challenge students to choose one of the careers listed in the *Career Connections* section of this lesson plan and to consider how a person in that career might study or use plants with neuroactive properties.

TEACHER BACKGROUND & RESOURCES

Neuroanatomy Resources

Neurobiology Basics
Kid-friendly information from Sowing the Seeds of Neuroscience's Information Center
http://www.neuroseeds.org/links

General Neuroscience Information
A wealth of information from Neuroscience for Kids. Check out the "Explore" section.
http://faculty.washington.edu/chudler/neurok.html

The Synapse
Kid-friendly information from Neuroscience for Kids.
http://faculty.washington.edu/chudler/synapse.html.

Types of Neurons (Nerve Cells)
Kid-friendly information from Neuroscience for Kids.
http://faculty.washington.edu/chudler/cells.html.

A Computer in Your Head
A reading about the human brain from Neuroscience for Kids.
http://faculty.washington.edu/chudler/computer.html.

Neuroscience Career Resources

A Career in Neuroscience: A Game of "Survivor?"
A kid-friendly career essay from Neuroscience for Kids.
http://faculty.washington.edu/chudler/survive.html.

Another Day, Another Neuron
A kid-friendly career essay from Neuroscience for Kids.
http://faculty.washington.edu/chudler/csem.html.

Career Connections

Neurologist: A physician who has specialized in neurology, the study of the brain and nervous system. Neurologists are trained to diagnose and treat neurological disorders**.**

Neuropharmacologist: A scientific researcher who studies the action of drugs on the nervous system and/or behavior.

Neuroscientist: A scientist that studies the brain and nervous system. Neuroscientists are primarily concerned with research. Areas of specialty include neuroanatomy, neurobiology, neurochemistry, neurophysiology, neuropsychology, and more.

Illustrations and Photograph Credits

Skull and Brain Illustration. Courtesy of Wikimedia Commons, Dcoetzee. 5 August 2010. Patrick J. Lynch, medical illustrator; C. Carl Jaffe, MD, cardiologist. Medical Illustrations by Patrick Lynch, generated for multimedia teaching projects by the Yale University School of Medicine, Center for Advanced Instructional Media, 1987-2000.

Rope Neuron Diagram. Courtesy of Eric Chudler, University of Washington.

Nervous System Diagram. Courtesy of Wikimedia Commons, Interiot. 19 December 2006. From the US Federal (public domain) (Nerve Tissue, retrieved March 2007), redrawn by User: Dhp1080 in Illustrator. Source: "Anatomy and Physiology" by the US National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) Program.

Diagram of a Neuron. Courtesy Eric Chudler. 3 September 2013.

Diagram of a Synapse. Courtesy of Wikimedia Commons, Edk006. 26 November 2011.

Bibliographic Credits

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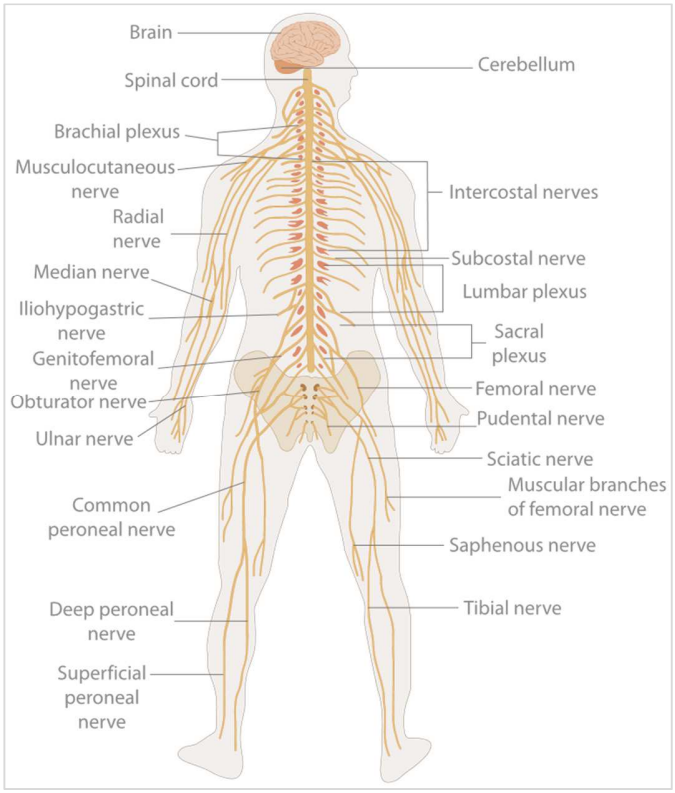
NEUROSCIENCE 101 BACKGROUND READING
STUDENT HANDOUT

Name:_____ **Date:**_____ **Period:**_____

The Body's Control Center

What are you doing right now? Your eyeballs are moving as you read and make sense of these words. You are breathing and your heart is pumping blood and oxygen throughout your blood vessels. You are sitting upright in your chair, contracting some muscles and relaxing others so that you don't tumble to the floor. Can you hear anything? What kind of mood are you in?



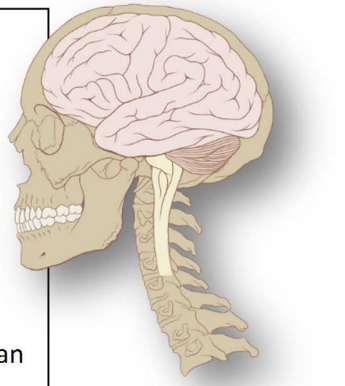
Your nervous system is working twenty-four hours a day, seven days a week to allow you to do these marvelous tasks, from digesting your breakfast to texting a friend.

The nervous system is made up of the brain, spinal cord, and the nerves of the body (there's a lot of them!). It is the body's control center: it controls and responds to body functions and directs behavior. The nervous system is responsible for everything from automatic responses (such as heart rate and breathing) to sensing and perceiving (seeing, hearing, smelling, tasting, touching), to emoting, moving, thinking, and talking. The nervous system influences and is influenced by all other body systems, such as the cardiovascular, endocrine, and immune systems. Because specific parts of the brain are specialized to perform certain functions, damage to a particular area of the brain can disrupt specific activities.

The human nervous system is divided in two parts. The **central nervous system (CNS)** is composed of the brain and the spinal cord. The **peripheral nervous system (PNS)** includes the nerves extending out of and into the brain and spinal cord. The major nerves of the PNS are shown on the diagram above.

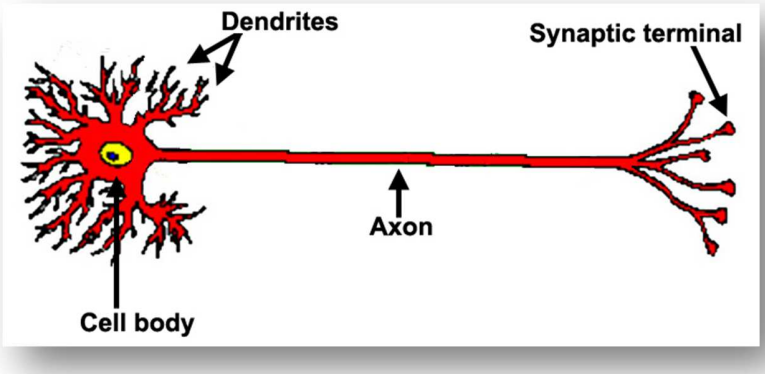
Brainiac-Facts

- The brain is the body's most complex organ.
- The adult human brain weighs approximately 1.4 kg (3 pounds) and contains about 100 billion **neurons** (nerve cells) and trillions of "support cells" called **glia**.
- The spinal cord is about 43 to 45 cm long (17-18 inches) in adult humans and weighs about 35-40 grams (1.2-1.4 ounces).
- The backbone that houses and protects the spinal cord is much longer than the spinal cord—about 70 cm (27 inches) long.



Pass the Message—Catch that Cell Phone!

Neurons (nerve cells) are cells that are specialized for communication. Each neuron communicates with many other neurons to share information.



Neurons send messages electrochemically. This means that neurons communicate using both electrical and chemical signals.

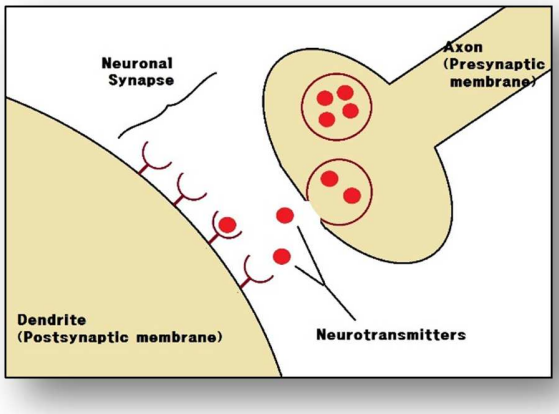
Imagine you are talking on your cell phone while walking the family dog in a park. Just as you are crossing a wooden bridge over a creek, your dog spots a squirrel and yanks hard on his leash. You are thrown off balance as your phone fumbles out of your hand and flies into the air. You reach out and catch the phone before it falls over the side of the bridge. *Phew!*

What happened within your nervous system to help you catch your phone? A message was sent electrochemically from neuron to neuron, from your fingertips all the way to the brain where it was processed. Since a response was needed (*Grab it! Quick!),* the brain then passed a message back through the neurons to cause muscle impulses and movement. At lightning speed, your brain processed an astounding amount of information and sent a message back through your neurons to your hand. Your quick-acting nervous system saved your phone from a swim in the creek below.

Here's how a message gets relayed from neuron to neuron (remember, this all occurs at an amazingly fast speed): Neurons have specialized cell parts called **dendrites** and **axons**. Dendrites bring electrical signals ***to*** the cell body. Axons take information ***away*** from the cell body.

The Synapse

Information from one neuron flows to another neuron across a **synapse**. The synapse is a small gap separating neurons. At the end of the axon, before the synapse is the **synaptic terminal**: a bulge in the axon that stores and releases neurotransmitters. At the dendrite side of the synapse has receptor sites for neurotransmitters.



Special chemicals called **neurotransmitters** send information from one neuron to another. These chemicals are stored and released from the **synaptic terminal** of a neuron. They are released by the first neuron into a space between two neurons called a **synaptic gap**. The neurotransmitter is taken up by the dendrites of the second neuron. If enough neurotransmitters are taken up by the dendrites, the second neuron may fire and pass its own neurotransmitter to another neuron.

When a chemical neurotransmitter is passed from one neuron to another, it can cause an electric signal (or impulse) to be carried along the receiving neuron—and that electrical signal may cause the cell to pass its own chemical neurotransmitters to another neuron.

The electrical signals carried along neurons are called **action potentials**. Within each neuron, it is an ***"all-or-none"*** impulse:

- Once the action potential starts, it continues without interruption down the length of the axon.
- The size of the action potential stays the same as it travels down the axon.

The message of *Grab it! Quick!* is sent to the brain, processed, and the brain then sends a message back along the neurons causing movement among the muscles in the hand. The cell phone is saved from a plunge in the creek.

Every single one of your thoughts, behaviors, and movements result from combinations of signals passed along your neurons. The action potentials in your muscles cause contractions and movement, allowing you to hold this piece of paper, breathe, move your eyeballs to read these words, listen to music, and stay upright in your chair.

Many drugs and **neurotoxins** can change the ways that neurotransmitters are released and taken up by neurons. The plant extracts you'll work with in the *Sowing the Seeds of Neuroscience* curriculum may do these very same things!

Neuron Trivia

Q: How many neurons are there in the human brain?

- There are at least one hundred billion neurons in the human brain and we use them all.

Q: How big is a neuron?

- Neurons come in many different shapes and sizes. The smallest neurons have **cell bodies** that are only 4 microns wide while the biggest neurons have cell bodies that are 100 microns wide—about the width of a human hair.

Q: How fast does a message travel through the nervous system?

- Messages can travel in neurons at speeds up to 268 miles per hour! That's faster than a high-speed bullet train.

Q: How many other neurons is each neuron connected to?

- Each neuron may be connected to and able to communicate with 1,000 to 10,000 other neurons. That's quite a neural network!

Neuroscience 101: Vocabulary List

Action potential: An electrical signal carried along the axon of a neuron. It is an "all-or-none" impulse that transmits information within the nervous system. The action potential is sometimes called a spike.

Axon: The part of the neuron that takes information ***away*** from the cell body.

Cell body: Also called the soma; the part of the cell that contains the nucleus.

Central Nervous System (CNS): The brain and spinal cord.

Chemical transmission: Neurons communicate using both electrical and chemical signals. Chemical transmission is when a neurotransmitter is received by a dendrite, increasing or decreasing the likelihood that an action potential will occur in that cell.

Dendrites: Extensions from the neuron cell body that bring information ***to*** the cell body.

Electrical transmission: Neurons communicate using both electrical and chemical signals. Electrical transmission is the electrical signal that is carried along the receiving neuron after a chemical neurotransmitter is passed from one neuron to another. The response received by the dendrite increases or decreases the chances that the receiving neuron will generate an action potential.

Glia: Non-neural support cells of the nervous system.

Nervous system: An organ system that controls and responds to body functions and directs behavior.

Neuroactive chemicals: Chemicals that interact with or affect the brain or other nervous system cells in animals.

Neuroanatomy: The structure of the nervous system.

Neuron: A nerve cell.

Neurotoxin: Poison that affects the nervous system.

Neurotransmitter: Chemical that transmits information across the synapse to communicate from one neuron to another.

Peripheral Nervous System (PNS): The part of the nervous system containing all of the nerves outside of the brain and spinal cord.

Synapse: Chemical or electrical junctions that allow electrical signals to pass from neurons to other cells. A synapse includes the synaptic terminal, synaptic gap, and dendrite.

Synaptic gap: The area between neurons that allows neurotransmitters to pass between neurons**.** It is the functional connection between an axon of one neuron and a dendrite of another.

Synaptic terminal: A bulge in the axon that stores and releases neurotransmitters.

NEUROANATOMY CROSSWORD PUZZLE—STUDENT HANDOUT

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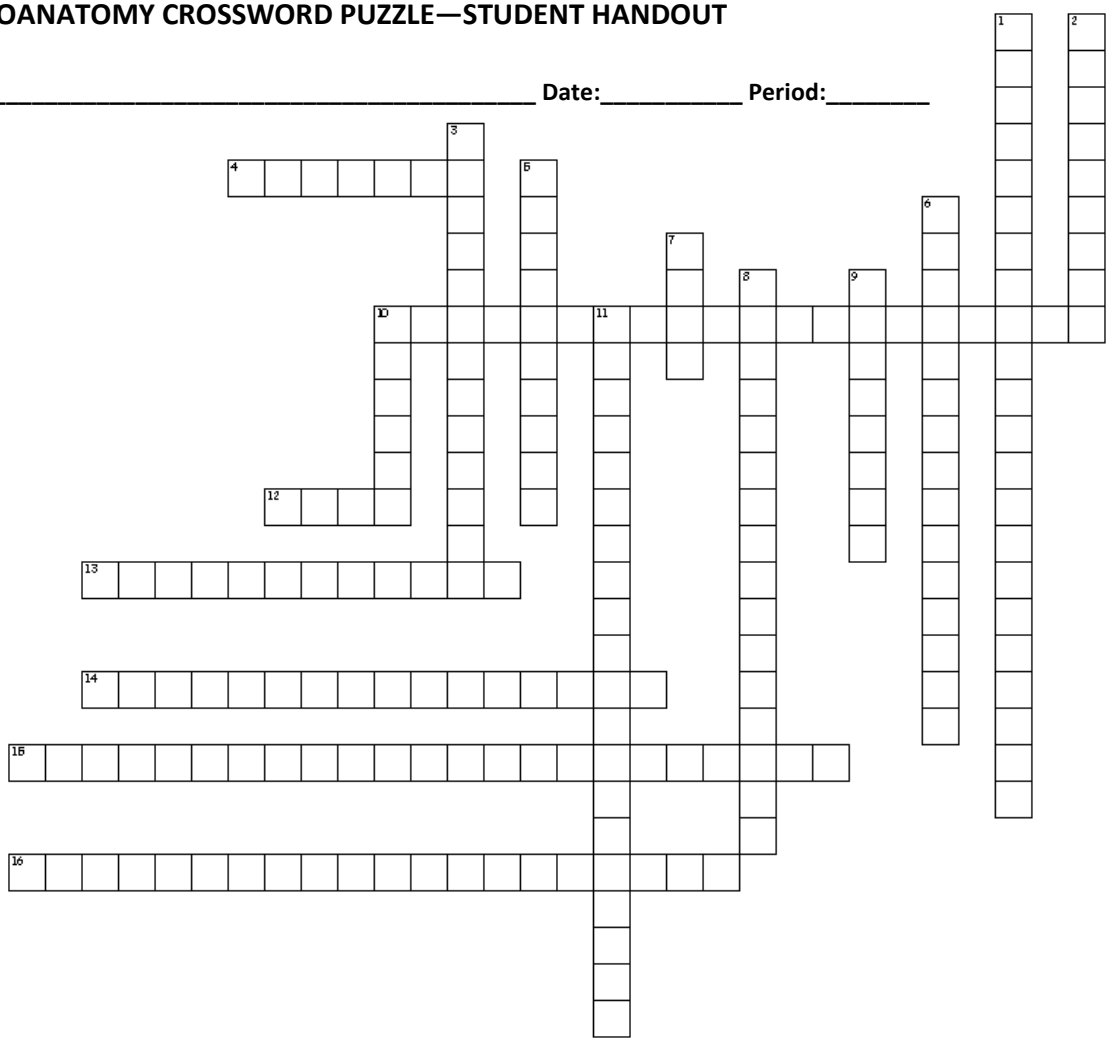

Across

4. A small gap between neurons that allows neurotransmitters to pass between neurons. It is the functional connection between an axon of one neuron and a dendrite of another.

10. Chemicals that interact with or affect the brain or other nervous system cells in animals. (2 words)

12. The part of the neuron that takes information away from the cell body.

13. The structure of the nervous system.

14. A bulge in the axon that stores and releases neurotransmitters. (2 words)

15. The part of the nervous system containing all of the nerves outside of the brain and spinal cord. (3 words)

Across (continued)

16. The brain and spinal cord. (3 words)

Down

1. The electrical signal that is carried along the receiving neuron after a chemical neurotransmitter is passed from one neuron to another. (2 words)

2. Extensions from the neuron cell body that bring information to the cell body.

3. An organ system that controls and responds to body functions and directs behavior. (2 words)

5. Poison that affects the nervous system.

6. An electrical “all-or-none” signal that transmits information along the axon of a neuron. (2 words)

7. Non-neural support cells of the nervous system.

8. Chemical that transmits information across the synapse to communicate from one neuron to another.

9. Also called the soma; the part of the cell that contains the nucleus. (2 words)

10. A nerve cell.

11. When a neurotransmitter is received by a dendrite, increasing or decreasing the likelihood that an action potential will occur in that cell. (2 words)