Unit: Designing Circuits for Neurodevices

Lesson 2: Circuits vs. the Nervous System

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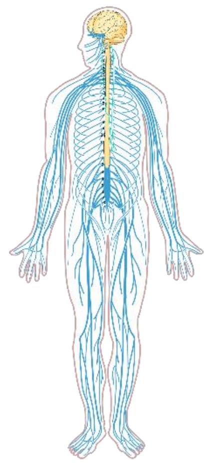

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LESSON OVERVIEW

Activity Time:
One 55 minute class period.

Lesson Plan Summary:
In this lesson, students will compare and contrast the nervous system to what they know already about circuitry and electricity. They will also experiment with their own nervous system and learn about and discuss the concept of plasticity.

STUDENT UNDERSTANDINGS

Big Idea & Enduring Understanding:

- **The Nervous System:** The nervous system can be directly compared to electronic circuitry and it also has an element of plasticity.
- **The Brain**: The brain can be thought of similarly to an electric circuit, where sensory neurons receive input, the brain processes this, and motor neurons instigate a response.

Investigative Phenomenon: The human brain can adapt, organize, and change its neural connections through a process called neuroplasticity.

Driving Question:

- How does the nervous system compare to electronic circuitry?

Learning Objectives:

Students will know…

- How the nervous system works on a macro scale.
- How the brain has plasticity.
- How the nervous system compares to electronic circuitry.

Students will be able to…

- Explain and demonstrate plasticity of the brain with simple experiments.
- Explain to another student the differences and similarities between an electronic circuit and the nervous system.

Vocabulary:

- **Auditory:** Sensory information obtained through your auditory system (e.g., outer/middle/inner ear, cochlear nucleus, auditory cortex in brain).
- **Nervous System:** Consists of the central nervous system (brain and spinal cord) and peripheral nervous system (all nerves throughout the body not part of the brain or spinal cord).
- **Neuroplasticity:** Also known as brain plasticity. The brain's ability to reorganize itself by forming new neural connections throughout life. This happens through learning and memorization. Neuroplasticity occurs during brain development when the brain processes sensory information from infancy through adulthood. Neuroplasticity also occurs as an adaptive mechanism; for example, in the case of the brain injury, the brain may compensate for lost functions or amplify remaining functions.
- **Stimuli/Stimulus:** Something that evokes a functional reaction, for instance visual stimulus that evoke a response in the brain. Some examples of stimuli include visual, tactile, auditory, smell, and motor.
- **Tactile:** Sensory information obtained through your sense of touch (e.g., pressure, temperature, texture).
- **Visual:** Sensory information obtained through your visual system (e.g., eyes, visual cortex in brain).

Next Generation Science Standards:

This lesson builds toward the following Performance Expectation (PE) and its integrated three dimensions of learning. Additional dimensions are denoted with an asterisk (*).

High School Performance Expectations
HS-LS1-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. (Grades 9-12).

HS-PS3-5: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. (Grades 9-12).		
Science and Engineering Practices (SEPs)	**Disciplinary Core Idea(s)**	**Crosscutting Concepts (CCCs)**
Developing and Using Models *Asking Questions and Defining Problems	LS1.A: Structure and Function PS3.C: Relationship between Energy and Forces	Systems and System Models Cause and Effect

TEACHER PREPARATION

Materials

Material	Description	Quantity
Rules or meter sticks	For nervous system reaction time activity. Each pair of students will need two rulers taped together (0 end to 30 end) or a meter stick.	1/pair of students
Calculators	For nervous system reaction time activity.	1/pair of students
Student Handouts	*Student Handout 2.1: How Fast Can You React?*	1/student
Student Handouts	*Student Handout 2.2: Venn Diagram*	1/student or pair
Teacher Resource	*Teacher Resource 2.2: Venn Diagram Answer Key*	1

Preparation

1. Read and learn about neural plasticity if you do not already have an understanding or background. See the *Resources* section at the end of this lesson plan.

2. Make copies of *Student Handouts 2.1* and *2.2.* Cut copies of *Student Handout 2.2* in half.

3. Gather all necessary supplies.

4. Prepare supplies. If using rulers, tape two rulers together end-to-end, with the 0 end of one ruler taped to the 30 end of the other ruler, making one very long ruler.

PROCEDURE

Engage: How Fast Can You React? Intro (5 min)

1. Post the following entry task on the board or in whatever format you use in your classroom:
    a. *Which cue would give you the fastest reaction time: visual (see), auditory (hear), or tactile (touch)? Why? Which would give you the slowest reaction time? Why?*

2. Ask students to complete the first step of *Student Handout 2.1*. They should be making predictions on how fast they think they can react to various cues. You may need to address how long an actual second is with them. Many students do not realize the actual length of a second or that they can answer with fractions of seconds.

3. Have students discuss the predictions they made with their table group.

Explore: How Fast Can You React? Mini Lab (20 min)

4. In pairs, have students complete the rest of *Student Handout 2.1*. They should be completely filling out all of the data tables and answering all of the questions.

Explain: Class Discussion (5-10 min)

5. Engage the class in a discussion about what they did and observed. Make sure to specifically go over their answers to the questions. Lead students into more of a discussion about the last question and what this means for their nervous system.

6. Tell students about plasticity and how it relates to the nervous system. Explain the different causes of neuroplasticity (see *Teacher Background*), and note that they are experiencing it right now, whenever they are engaged in learning and memorization.

7. *Optional:* To help students understand how neuroplasticity works to change, organize, or strengthen the neural connections in the brain, challenge students to a fun memory task. There are many options; here are a few:

    a. **Concentration/Memory:** Use a deck of cards that has pairs of picture cards. Place all cards face down. Take turns choosing two cards, trying to find the pairs.
    b. **Sorting Cup Game:** Get three matching plastic cups. Place a coin or other small object under one cup. Shuffle the cups by sliding and changing their position on the table. Try to keep track of which cup has the object. Slowly increase the amount of moves you make with the cup, seeing how many moves can be easily remembered.
    c. **Number Line:** How big of a number can you remember? The first person says a single-digit number. The second person says that number, followed by a new single-digit number, and so on. Continue until someone forgets a number.
    d. **What's Missing?** Place an assortment of objects on a table or tray, covered with a piece of cloth. Life the cloth and allow a brief amount of time for everyone to look at the objects and memorize them. Cover with the cloth. Discreetly remove one object and rearrange them. Uncover the objects and ask, what's missing? Start with 4 objects, then increase in each round. As you get to larger numbers of objects, you can have students write down a list to see how many objects they can remember.

8. Ask students to decide whether or not their answer to Question #3 on *Student Handout 2.1* relates to this concept and what that means about their own nervous systems.
    a. If students look across their three trials, was there an improvement in reaction time or not? Why may this be?
    b. One kinds of things might affect reaction time?
    c. In particular, you might discuss how the test subjects may develop strategies to improve their reaction time (e.g., eliminating distractions, increasing focus) or that the brain is acquiring a new motor skill (catch the ruler!) by refining a sensory-motor

pathway. In addition, the tester herself might also develop strategies to make the experiment run more smoothly and consistently (e.g., knowing where to hold the ruler when dropping it, making a consistent noise when dropping, etc.).

Elaborate: Comparing and Contrasting (10-15 min)

9. In pairs or table groups, have students fill out *Student Handout 2.2*. Remind them that they can also reflect on what they learned about the nervous system with the jigsaw activity and videos from *Lesson One*.

10. Lead the class in a discussion on what they put on the handout in each category. Make sure that they have come up with examples in at least each category.

11. Students will save this handout to draw from later on in Lesson 5.

12. Post the following exit ticket on the board or in whatever format you use in your classroom:
    a. *Write a one sentence summary of the Venn Diagram we just created.*

STUDENT ASSESSMENT

Assessment Opportunities:

- Teachers can check on student understanding and engagement during the class discussions and while visiting the students as they conduct the experiment.
- The Student Handouts and entry/exit tickets can be used for assessment.

Student Metacognition: Students will have time to work on the handouts collaboratively and discuss the lesson with their partners. Afterwards, they will keep both handouts in their journal or notebook to reference, particularly for Lesson 5.

Scoring Guide: Students will be successful if they complete the lab and complete both of the handouts.

EXTENSION ACTIVITIES

Extension Activities: More time could be spent on neuroplasticity and what it means. Students could potentially do some sort of mini research project associated with it. See the following websites for more information or the possibility of extending the learning.

Video: Neuroplasticity, Khan Academy (9:40 min)
Close captioning and video transcript available
https://www.khanacademy.org/science/health-and-medicine/nervous-system-and-sensory-infor/neural-cells-and-neurotransmitters/v/neuroplasticity

Web Article: Brain Plasticity: What is it?, Neuroscience for Kids
Grade 12 reading level
https://faculty.washington.edu/chudler/plast.html

Adaptations: This lesson can be adapted based on the student pairings for the activity. Younger students could still do the lab activity, with more help/scaffolding during it.

All videos linked in this lesson have closed captioning and transcripts available.

TEACHER BACKGROUND & RESOURCES

Background Information: For this lesson and the one proceeding it, teachers need to have a working understanding of the nervous system. It is also important to understand the scientific concept of neuroplasticity. The resources listed elsewhere in this lesson are helpful for that purpose. In addition, this resource helps explain brain plasticity and neural pruning in more depth.

What is Brain Plasticity and Why is it so Important?
The Conversation 4/4/16
http://theconversation.com/what-is-brain-plasticity-and-why-is-it-so-important-55967

It is also important to understand the difference between the scientific concept of neuroplasticity and the educational psychology concept of growth mindset. **Neuroplasticity** is the brain's ability to reorganize itself by forming new neural connections. Neuroplasticity occurs during brain development when the brain processes sensory information from infancy through adulthood. Neuroplasticity happens throughout the lifetime through learning and memorization processes. Neuroplasticity also occurs as an adaptive mechanism; for example, in the case of the brain injury, the brain may compensate for lost functions or amplify remaining functions. **Growth mindset** is a belief that intelligence is not fixed, but that can be developed. It is inspired by the scientific concept of neuroplasticity, but growth mindset itself is a *behavior* or *strategy* that impacts how people think about themselves, their brain, and their ability to learn.

Resources:
What is Brain Plasticity and Why is it so Important?
The Conversation 4/4/16
Reading level: College level
http://theconversation.com/what-is-brain-plasticity-and-why-is-it-so-important-55967

Video: Neuroplasticity, Khan Academy (9:40 min)
Close captioning and video transcript available

https://www.khanacademy.org/science/health-and-medicine/nervous-system-and-sensory-infor/neural-cells-and-neurotransmitters/v/neuroplasticity

Web Article: Brain Plasticity: What is it?, Neuroscience for Kids
Reading level: Grade 12
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Unit: Designing Circuits for Neurodevices

Student Handout 2.1: How Fast Can You React?

Name:___________________________ Date:______________ Period:__________

INTRO: Make predictions for how fast (in seconds) it will take you to react and grab a ruler based solely on the three cues provided on the data table: Visual (see), Auditory (hear), and Tactile (touch). Each cue will be the only one (for example, if it is auditory, you cannot see the ruler dropping). Make sure to record this in the Predicted Reaction Time column of *Table 2: Data Summary* on the next page.

PROCEDURES:

1. Assign one person to be the catcher and the other to be the dropper.

2. The catcher stands with their dominant hand in front of them in a half open grip, like they are ready to catch a ruler with their pincher grip (thumb and forefinger).

3. The dropper holds the taped rulers or meter stick, 0 side down, just above the catcher's hand so that if the ruler were to drop, it would go between their fingers.

4. **For the visual cue**, the dropper simply drops the ruler and the catcher attempts to catch it as quickly as possible. It is important that the dropper does this silently. Once the ruler is caught, the catcher must not move their hand until the distance dropped is recorded (in cm).

5. Repeat Step #4 two more times.

6. **For the auditory cue**, the setup is the same as Step #4, except that the catcher now closes their eyes. The dropper tells the catcher when they are dropping it instead of being able to see it being dropped, by making a noise ("Go!" or "Drop!"). Again, record the distance dropped (in cm).

7. Repeat Step #6 two more times.

8. **For the tactile cue**, the setup is the same as Step #6, except that instead of telling the grabber when they are dropping the ruler, the dropper gently taps the catcher's foot with their own foot, as they are simultaneously dropping the ruler. Again, record distance dropped (in cm).

9. Repeat Step #8 two more times.

10. Using the distance dropped data, calculate the actual reaction time for each trial using the following equation where *t* is time, *d* is distance, and *g* is gravity (10 m/s^2): $t = d/g$

11. Average each cue's reaction times by adding them up and dividing by three. Record the average reaction time for each cue.

DATA:

Table 1: Data Collection

Cue	**Trial 1: Distance Dropped (cm)**	**Trial 2: Distance Dropped (cm)**	**Trial 3: Distance Dropped (cm)**
Visual			
Auditory			
Touch			

Table 2: Data Summary

Cue	**Predicted Reaction Time (s)**	**Trial 1: Actual Reaction Time (s)**	**Trial 2: Actual Reaction Time (s)**	**Trial 3: Actual Reaction Time (s)**	**Average Reaction Time (s)**
Visual					
Auditory					
Tactile					

QUESTIONS:

1. Were your predictions accurate or not? Why or why not?

2. What was most surprising about this lab? Why?

3. Do you think that you could improve any of your reaction times? Why or why not? How?

4. What is the best/fastest cue for reaction time? Why?

5. Do you think that where you are touched would affect your reaction time? Why?

6. How does this activity affect your view on how different populations react to different stimuli?

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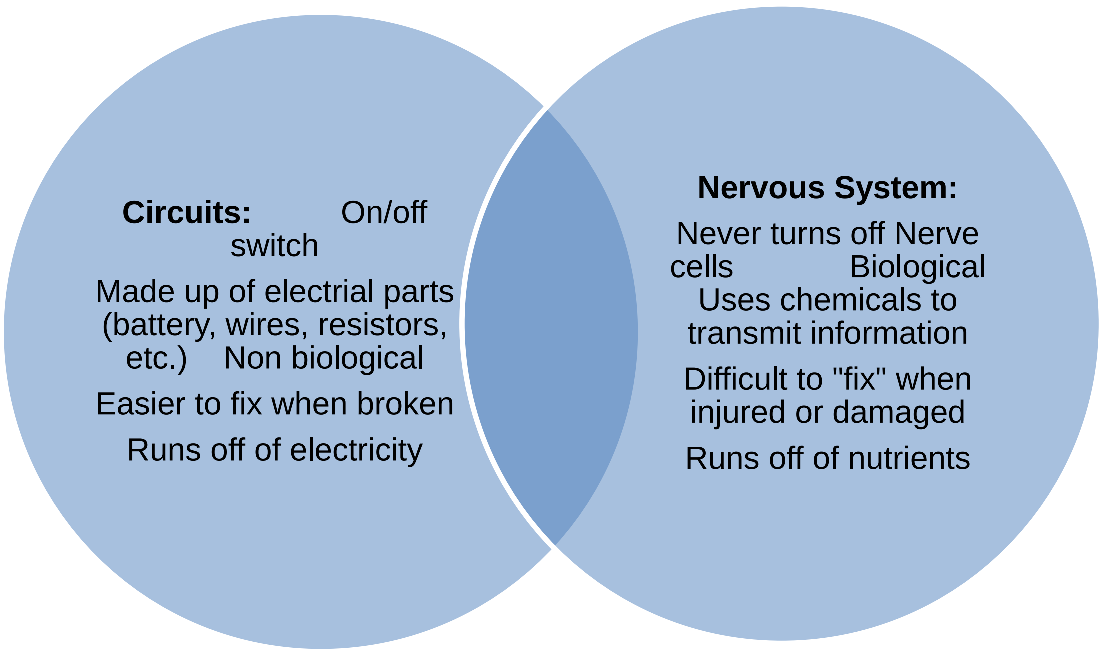
Teacher Resource 2.2: Venn Diagram Answer Key

Some possible student answers are listed below. Note this is not an exhaustive list.



Both:
Electrical/generates electricity
Transmits signals
Receives signals
Communication
Must be connected
Inputs and outputs

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Student Handout 2.2: Venn Diagram

Name:_______________________________ Date:________________ Period:_________