Exploring Cellular Function

Companion Lesson to X-STEM All Access Episode "Science That Saves Lives"

Grade/ Grade Band 6-12	**Topic:** Neuroscience	

Brief Lesson Description: Dr. Greg Gage is a neuroscientist, and he believes that neuroscience is for everyone. In this lesson, students create a model of a neuron to illustrate how the nervous system sends messages around the body.

Performance Expectation(s):
MS-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.

MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved

Specific Learning Outcomes:
Students will create a model of a neuron to illustrate how the cell transmits messages in one direction and that one neuron can activate the next.

Narrative / Background Information

Prior Student Knowledge:
Students should know the structures of the nervous system.
Students should be able to describe simple machines and how they are used to modify motion.

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
Developing and Using Models Constructing explanations and designing Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. ● Develop a model to describe phenomena. (MS-LS1-2) ● Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4)	**LS1.A: Structure and Function** Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (MS-LS1-2) **ETS1.C: Optimizing the Design Solution** The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	**Structure and Function** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS1-2)

Possible Preconceptions/Misconceptions: The brain being " hard-wired" is a misconception most people have. We are illustrating with the model that the brain is organized in a way with neurons creating neural pathways like wires and they communicate by releasing a pulse of electricity through ions. And while that is a true description of how neurons function, we need to emphasize that the nervous system is less rigid and more plastic and can change its wiring. An example is when someone is practicing a new skill, like learning to play the violin, the system "rewires" parts of the brain that are responsible for fine motor control. Or how people with brain injuries can recruit other parts of the brain to compensate for the damage. This would not be possible if the nervous system was "hard-wired". This activity does not dispel the misconception. As the educator, you need to highlight how change and adjustments are possible in the nervous system such as learning something new or recovering from an injury.

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:
Ask the students to organize themselves to complete the wave like they were at a sporting event. After the organize themselves have them write down what happened and was their role in making sure the wave was executed accurately.

Show the students the video: Science That Saves Lives with Dr. Greg Gage and ask them to record 2-3 facts that they believe would relate to the wave.

Lead a discussion about the experiment Dr. Gage shared about how you know to turn around when someone taps you on the shoulder. Highlight: using an animal model (similar nervous system to humans), neuron cell structure and function (axon transmits communication, note he mentions electricity), and ethics of experimenting with animals or on yourself, and the brain machine interface.

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:
Prior to the lesson procure as much as you can of the following materials:

- Dominos
- String
- Tape
- Rubber bands
- Clamp stands
- Recyclable materials (from the cafeteria like paper towel tubes, milk containers (crates or cartons), paper bags, cardboard boxes)
- Buckets
- Marbles
- Legos
- Tennis ball/ baseball/ golf ball
- Dixie Cups
- Balloons
- Matchbox cars

You need an assortment of materials that will allow students to get creative. Ask students to bring in items from home.
Students are going to build a Rube Goldberg machine /mousetrap machine to model how neurons send messages.

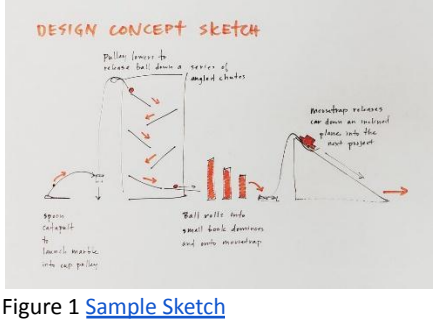

Figure 1 Sample Sketch

In teams of 4, ask students to sketch a plan to create a machine that will pop a balloon in no more than 5 steps.
Once the sketch has been approved (you're looking for 5 or less steps, realistic use of materials based on simple machines: levers, pulleys, inclined plane, wedge, wheel and axle, and screw) the team can build their machine and test it.

EXPLAIN: Concepts Explained and Vocabulary Defined:
Ask students if they've ever wondered why they feel sleepy after the sun sets? Explain that when the sun goes down the pineal gland in the brain secretes the hormone, melatonin, which makes you feel tired. This is just one example of how the brain uses chemical signals and electrical signals through the nervous system to transmit or send messages to other parts of the body. Neurons are composed of 3 parts: cell body, an axon, and dendrites. The cell body is where the nucleus is located; the axon is the long narrow appendage that extends from the cell body to send electrical impulses to the other neurons; the dendrites also extend from the cell body however they are responsible for receiving messages from other neurons at the contact point call a synapse.

Neurons work by sending neurotransmitters (chemicals) across the synapses between the axon of one neuron to the dendrite of another neuron.

Have students label their sketches with the structures of the neuron.

Vocabulary:
Neuron- the cell of the nervous system whose function is to receive sensory inputs from the external environment and sending motor commands to the muscles and transforming and relaying the electrical signals throughout the body.
Cell Body- contains the nucleus and genetic information of the neuron.
Axon- long branch that extends from the cell body carrying information via electrical impulses to the next neuron
Dendrites-short branches extending from the cell body that receives messages from other neurons.
Synapse- the space between neurons when the dendrites of one neuron meets up with the axon of another neuron.

ELABORATE: Applications and Extensions:

Tell students they are going to connect their neurons with the rest of the class to simulate the nervous system. Allow teams to align their "neuron" machines to travel through the classroom and eventually pop a balloon.

Students should be allowed to revise their design however they should not increase the number of steps in each team's design.

After 15 mins and at least 3 tests to pop the balloon, ask students to write a paragraph explaining how the model simulates the nervous system. If the signal failed to travel around the room and pop the balloon, tell students to diagnose the potential issues and propose solutions.

Lead a discussion using the following questions as a guide: What worked well? What would you do differently next time? What were some of the limitations?

EVALUATE:

Formative Monitoring (Questioning / Discussion): The sketch of the machine assesses student understanding of developing a model to generate data

Summative Assessment (Quiz / Project / Report): Students write a summary about the model and how it illustrates a neuron and the nervous system

Elaborate Further / Reflect: Enrichment: Students will investigate the nervous system of a leech in a virtual lab. They will have the opportunity to observe the response to stimuli and map how the leech's nervous systems responds to touch.

SOCIAL EMOTIONAL LEARNING ACTIVITY

CASEL Competency: Self Awareness
The abilities to understand one's own emotions, thoughts, and values and how they influence behavior is extremely valuable to understand. In this activity *Circle of Control* students discuss what things they can control (i.e. things I say, helping people) and what things they cannot control (i.e. other people's reactions, the weather). On chart paper create a graphic organizer drawing 2 large concentric circles, label the inner circle **WHAT I CAN CONTROL** and the outer circle **WHAT I CANNOT CONTROL.** Give students 4-6 Post It notes and ask them to write one example per Post It note. Encourage them to have an equal amount of can vs cannot. When they have written their statements, they can place them on the graphic organizer in the appropriate section. Read aloud the examples and challenge students to focus on the things they can control.

INTERDISCIPLINARY CONNECTIONS/IDEAS

RST.6-8.1 – Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and interest, (MS-ETS1-4)

Materials Required for This Lesson/Activity

Quantity	Description
	Dominos
3 rolls	String
3 rolls	Tape
100	Rubber bands (various sizes)
6-8	Clamp stands
	Recyclable materials (from the cafeteria like paper towel tubes, milk containers (crates or cartons), paper bags, cardboard boxes)
2	Buckets
20	Marbles
	Legos
3	Tennis ball/ baseball/ golf ball
20	Dixie Cups
15-30	Balloons
5	Matchbox cars
10	Wooden dowels
Per student	laptops