It Takes a Lot of Nerve

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Grade Level:
High School

It Takes a Lot of Nerve

Purpose:
To engage students in testing their memory capabilities.

Target audience:
Grades 9 – 12

Objectives:
Students will be able to:

- engage in active memorization of visual observations.
- recall and record visual observations.
- demonstrate current level of understanding of the structure and function of nerves and the brain.

Materials:

- scene of the crime handouts

Preparation and Procedure:

1. Give the following instructions to the class **before** you give them their handout.
    - When I say "go", turn over your paper.
    - Study this picture carefully for three minutes. Then you will be asked 20 questions by the police. Observe carefully since you will be relying solely on your memory!
2. Handout the paper entitled "At the Scene of the Crime: Part 1".
3. Hand it out upside down and do not allow the students to look at it until you are ready.
4. When all students have their papers, have them turn them over and begin timing.
5. At the end of three minutes, they must turn over their paper.
6. Then tell them "In the rather busy street scene on the previous page, you were witness to one robbery, four misdemeanors, and an approaching calamity. The police would like your firsthand account of what happened, so please answer the following questions as precisely as possible."
    - The person who gets the most questions right **rules** and of course gets a prize!

Safety Issues: None

Questions to Ask:

1. What senses were you using in this activity?
2. How does a message travel from your eyes to your brain?

Discussion:
The brain and its associated nervous system are amazing circuitries that work with phenomenal speed and accuracy in transmitting signals. Many signals that are transmitted

are stored in our memory. Other signals from our neurons lead us to immediate action. The brain can process large amounts of information in an extremely short time. This amazing nervous system allows us to think, move, feel, recall, taste, smell and it also controls activities of our body that we never think about: breathing and your heart rate, to name a few.

Recall that cells work together to form tissues, tissues form organs, organs form organ systems, and organ systems form organisms. Communication and control are the keys that unlock the secret of integration of all the parts of an organism.

That is the role of the nervous system, to communicate and control. But the whole organism **is** dependent upon the part. The cell of the nervous system is called a neuron. In the next few lessons, we will focus on the structure and function of these amazing cells.

References and Resources

1. Carruba, Richard. *At the Scene of the Crime: Part I and Part II*. Brackenridge High School, San Antonio, Texas. 1999.
2. Textbooks on Anatomy and Physiology.

Suggestion for Assessment

It is not recommended that the students receive a grade for their answers on the worksheet; it is intended to grab their attention. However, bonus points could be given on their test for each correct answer.

It Takes a Lot of Nerve
At The Scene of the Crime

In the rather busy street scene on the previous page, you were witness to one robbery, four Misdemeanors and an approaching calamity. The police would like your firsthand account of what happened, so please answer the following questions as precisely as possible.

1. What time was it by the bank clock?
2. What day of the week was it?
3. What was the name of the outdoor café?
4. On what street was the entrance of the outdoor café?
5. How many thieves were staging the holdup?
6. Were the thieves armed?
7. How many bags of loot were they carrying?
8. Was the thief in the street wearing a hat?
9. How many people, besides you and the holdup men, were at the scene of the robbery?
10. What were the initials of the man in the business suit?
11. What immediate danger was he in?
12. Was the onlooker from the second floor a man or a woman?
13. What was the name of the store next door to the café?
14. On what street was the entrance to the store?
15. What was the shopper stealing?
16. What was the license number of the car parked in front of the store?
17. Why was the car illegally parked?
18. What part of the car was being vandalized?
19. What offense was being committed against the lady diner?
20. Was there a police phone at the corner?

It Takes A Lot of Nerve!
Building a Model Neuron

Teacher's Guide

Purpose:
To allow students to explore the anatomy of a neuron.

Objectives:
Students will be able to:

- construct a model of a neuron using felt, pipe cleaners, beads, and styrofoam balls.
- use textbooks or other sources to determine the components of a neuron.
- explore the various types of neurons by creating sensory, motor and interneurons using different color felt.

Materials (per group):

- pieces of felt or foam sheets (Some groups will have blue, only one or two groups will have yellow, and the rest should be pink.)
- scissors (one pair per group)
- pipe cleaners (six per group)
- beads--the kind that can be strung on a pipe cleaner (approximately 10 – 12 per group)
- styrofoam balls (one per group)

Preparation and Procedure:

1. The materials for this lab can be purchased at a craft store. Total cost for materials is about $10.00 for supplying 60 students (working in groups of three).
2. Have the students build a neuron, following the instructions on their handout.
3. Assign several groups to make blue cell bodies, one or two groups to make yellow cell bodies and several groups to make pink cell bodies. Blue neurons represent sensory neurons, yellow represents interneurons and pink represents motor neurons. Don't tell them why they are assigned different colors.
4. After completion, have them show their models to the class.
5. Students need to be able to create the neurons on their own, however, I have found that for the next activity, they need to have used the pipe cleaners as dendrites and some of the beads as neurotransmitters. Neurotransmitters need to be placed on the axon terminals but not on dendrites at first.

Safety: Use caution with sharp scissors.

Note: To prevent students from jabbing themselves with scissors, demonstrate how to fold felt or foam sheets, and then make a small snip in the fold with the scissors to make a hole.

Questions to Ask:

1. What is the importance of the nucleus to the neuron?
2. Why is it necessary for the axons to have a great deal of length?
3. How many dendrites does a neuron have? Axons?
4. Why should neurotransmitter be on the axon terminals and not the dendrites?

Where to go from Here:

The next section of this activity will emphasize transmission of a signal through sensory, motor and interneurons.

References and Resources

None

Suggestions for Assessment

1. Assess answers from student guide page 2.
2. Suggested Rubric for model:

100 – All 7 items are included; they are places correctly; neuron is exceptionally neat and creative.
90 - All 7 items are included but one is placed incorrectly; neuron is neat and creative.
80 - All 7 items are included but two or more are placed incorrectly; neuron could be neater and more creative.
70 - Not all 7 items are included; neuron could be neater and more creative.

It Takes A Lot of Nerve!
Building a Model Neuron

Student's Guide

Purpose:
To explore the anatomy of a neuron.

Objectives
Students will be able to:

- create a model of a neuron using felt, pipe cleaners, beads, and Styrofoam balls.
- use textbooks or other sources to determine the components of a neuron.
- explore the various types of neurons.

Materials (per group):

- pieces of felt or foam sheets (Your instructor will assign a specific color)
- scissors
- pipe cleaners (6)
- beads (15)
- styrofoam ball (1)

Safety:
Use caution with sharp scissors.

Procedure

1. Using the materials at your desk, design and build a neuron. You have creative license but it must be structurally correct.
2. You may use any books that are available.
3. You must include the following components:
    a. Nucleus
    b. Cell body
    c. Axon
    d. Dendrites
    e. Myelin
    f. Nodes
    g. Neurotransmitters – Make sure these are mobile!

4. Once you have built your model, relate structure to function. List below the functions of the following:

a. Nucleus - _____
_____
b. Cell body - _____
_____
c. Axon - _____
_____

d. Dendrites - _____
_____
e. Myelin - _____
_____
f. Nodes - _____
_____
g. Neurotransmitters - _____
_____

It Takes A Lot of Nerve!
Sending the Signal

Teacher's Guide

Purpose:
The purpose of this activity is to simulate actual transmission of a signal from a sensory neuron to a motor neuron, using the models that you made in Part 2.

Objectives:
Students will be able to:

- review what is known about the physiology of the neuron.
- collaborate to predict the sequence of events that will occur when a stimulus is applied and an impulse is transmitted.
- communicate their understanding of the nervous system and how it works.

Materials:

1. neurons from Module #2
2. picture of a spider
3. picture of an eye
4. picture of a leg
5. picture of the CNS

Preparation and Procedure:

1. Begin a KWL Poster (what I know, what I want to know, and what I learned).
2. Go over the information section of the lab.
3. Answer any questions regarding the CNS and its structure and function.
4. Explain the rules for the role-playing activity.
5. Step back and let the students collaborate and work out the sequence of events. They may use any text or resources, **except yo**u!
6. If they make mistakes in their sequence, don't tell them what was wrong, just how many corrections that they need to make and let them collaborate again and re-present their role-playing to you until they get it right!

Safety: None

Correct sequence for Sending the Signal Activity:

1. Spider
2. Eye
3. Sensory neurons (however many you have) (neurotransmitters have to be transferred from axon to dendrite each time)
4. Interneurons and CNS
5. Motor neurons (however many you have)
6. Leg muscle
7. Student should run or step on the spider!

Questions to ask:

1. Why are neurons classified as sensory, motor and interneurons?
2. What is each of their functions?
3. What would happen if the neurotransmitter quit working?
4. What happens if a signal gets to the brain, but the cells there have been impaired because of drugs or head injuries?

Analysis and Conclusion Answers

1. What is a neuron?
   A neuron is a cell that carries impulses throughout the nervous system; it consists of a cell body, dendrites and an axon.
2. Explain the difference in a sensory neuron and a motor neuron.
   A sensory neuron is a cell that receives information from the internal and external environments and transmits the signals to the CNS. A motor neuron is a nerve cell that transmits signals from the brain or spinal cord to muscles or glands.
3. Describe the advantage of having an axon covered with myelin.
   It is advantageous to have an axon covered with myelin because when an impulse travels down an axon, the action potential jumps from one node to the next. This happens because electrical current flows from one node to the next, which greatly speeds up the rate at which the impulse moves.
4. Sequence the events as a nerve impulse moves through a neuron.
   Impulses move through the dendrites toward the cell body, and then away from the cell body through the axon.
5. What factors would affect the rate at which impulses are transmitted along an axon?
   Two factors that would affect the rate at which impulses are transmitted along an axon would be the diameter of the axon and the presence or absence of a myelin sheath around the axon.
6. What is the CNS? What are the two parts of the CNS?
   The CNS is the Central nervous system and it consists of the brain and the spinal cord.
7. How does an axon with nodes differ from one without nodes?
   An axon with nodes is sheathed with myelin; an axon without nodes is not.
8. If some of a person's myelin were destroyed, how do you think the person would be affected?
   When myelin is destroyed, the transmission of electrical impulses is impaired. This may cause paralysis, poor coordination, slurred speech, blurred vision and tremor.

Where to Go from Here:

1. Action potentials and how they work are not introduced in this lab but it would be a good idea to cover that topic after the students have completed this lab.
2. Also, these activities could lead into discussion of different neurotransmitters and their role in impulse transmission.

References and Resources

1. Anthony, Catherine and Gary Thiboudeau. (1979). *Textbook of Anatomy and*
2. *Physiology*. St. Louis. C. V. Mosby Company.
3. Miller, Ken and Joe Levine. (1998). *Biology: The Living Science*. Prentice Hall.

Suggestions for Assessment

See student instructions.

It Takes A Lot of Nerve!
Sending the Signal

Student's Guide

Purpose: The purpose of this activity is to simulate actual transmission of a signal from a sensory neuron to a motor neuron, using the models that you made in Part 2.

Objectives:
Students will be able to:

- review what is known about the physiology of the neuron.
- collaborate to predict the sequence of events that will occur when a stimulus is applied and an impulse is transmitted.
- communicate your understanding of the nervous system and how it works.

Information:
The telephone is a way to transmit information from one location to the next. To understand how a telephone works, you start with the basics – electricity, telephone wires, telephones, etc. With time, you could learn how thousands of parts work together to fulfill a common goal of communicating across a distance.
The same can hold true with the nervous system. The basic units of the nervous system are cells called **neuron**s. These cells carry messages throughout your body in the form of **impulses**.

A neuron is made up of a **cell bod**y, **dendrites** and an **axon**. The largest part of the neuron is its **cell body**. Most of the metabolic activity of the cell takes place there. This is where the **nucleus** is found. In addition, the cell body collects information from the **dendrites** – small branched extensions that spread out from the cell body. Dendrites carry impulses toward the cell body. The long branch that carries impulses away from the cell body is called an **axon**. At the end of the axon is a **synapse**. When an impulse reaches the end of the axon of one neuron, **neurotransmitters** bind to the receptors on the membrane of an adjacent neuron at the dendrite. As a result, the nerve impulse continues to the next neuron. A neuron may have many dendrites, but it usually has only one axon.
In most animals, neurons are clustered into bundles of fibers called **nerves.** Some nerves contain only a few neurons, but many others have hundreds or even thousands of neurons.

There are three general types of neurons, distinguished by the directions in which they carry impulses. The **sensory neurons** carry impulses from the sense organs to the brain and the spinal cord (Central Nervous System or CNS). **Motor neurons** carry impulses in the opposite direction, from the CNS to muscles or other organs. **Interneurons** connect sensory and motor neurons and carry impulses between them.

As you know, most electrical wires are insulated, that is, they are covered with rubber or plastic to prevent a short circuit. The nervous system has a kind of insulation, too. In some nerve cells, **Schwann cells** grow around an axon, and wrap it in layers of their own cell membrane, forming a material known as **myelin**. The Schwann cells that surround a

single long axon leave many gaps between themselves where the axon membrane is exposed. These gaps are called **nodes**.

When an impulse moves down an axon covered with myelin, an action potential or rapid change in voltage, jumps from one node to the next. This jumping of electrical current from one node to the next speeds up the rate at which the impulse moves. A large axon with myelin can carry messages at speeds as great as 200 meters per second.

Materials needed for the whole class:

- motor neurons made in activity one (blue)
- sensory neurons made in activity one (pink)
- interneurons made in activity one (yellow)
- picture of a spider
- picture of an eyeball
- picture of the CNS
- picture of a leg muscle

Procedure:

1. One student holds a picture of the CNS.
2. One student holds the picture of an extremely deadly spider.
3. One student holds the picture of an eyeball.
4. One student holds a picture of a leg muscle.
5. One student is in charge of telling the students how to act out the impulse.
6. The rest of the students hold the neuron that they constructed.
7. It is your job as a class to act out an impulse from stimulus (spider) to reaction (running). Each student must hold their assigned model neuron and stand in a formation that correctly sequences the events that occur in the nervous system when a person sees a dangerous spider directly in front of them - obviously you run away from the spider or step on it! The person in *charge* of the simulation must talk the class through what happens each step of the way, correctly explaining the sequence to the teacher.
   You must include **neurotransmitters** in your sequence of events.
   If the class gets all the information correct the first time through, everyone get a grade of 100. For each time that you have to make corrections, the instructor will count off five points for each student until it is done correctly.
   Get started and inform your instructor when you are ready!!!

Analysis and Conclusions. Answer in complete sentences.

1. What is a neuron?

_____
_____
_____

2. Explain the difference in a sensory neuron and a motor neuron.

_____

_____
_____

3. Describe the advantage of having an axon covered with myelin.

_____
_____

4. Sequence the events as a nerve impulse moves through a neuron.

_____
_____
_____
_____

5. What would be a factor that would affect the rate at which impulses are transmitted along an axon?

_____
_____

6. What is the CNS? What are the two parts of the CNS?

_____

7. How does an axon with nodes behave differently from one without nodes?

_____
_____
_____

8. If some of a person's myelin were destroyed, how do you think the person would be affected?

_____
_____
_____

9. Draw a picture of your model neuron. Label the following: dendrites, axon, nodes, myelin, cell body, and nucleus. Color the dendrites red, the axon green, the myelin yellow, the cell body blue, and the nucleus orange.

It Takes A Lot of Nerve!
Interfering with the Signal

Teacher's Guide

Purpose:
To understand how neurotoxins interfere with transmission of signals.

Objectives:
Students will apply knowledge of neurotransmission to new situations.

Materials:
- synapse Handout
- map colors

Preparation and Procedures:
1. Go over the excitatory and inhibitory neurotransmission information.
2. Have them complete the handout.
3. The sequence of events in Illustration I should show neurotransmitter binding to receptors. The students should indicate that when the inhibitory transmitter binds to the receptors, it should control the firing of the neuron, which would stop contraction of a muscle.

Answer to "Who Am I?" Game
The bacteria in the electron micrograph is *Clostridium tetani*. This bacillus is an obligate anaerobe which causes tetanus by interfering with the inhibitory synapses on motor neurons.

Questions to Ask
1. What happens when an excitatory neurotransmitter doesn't cross the synapse when it's supposed to?
   The impulse is not triggered in the second cell.
2. What happens when an inhibitory neurotransmitter doesn't cross the synapse when it's supposed to?
   The impulse is not stopped or slowed down and this leads to excessive contraction of the neuron.
3. Most drugs act on the nervous system by altering synaptic mechanisms and thus synaptic effectiveness. An example is **antihistamines.** Histamine is a neurotransmitter that is secreted by tissues as part of the inflammatory response. What would be the role of antihistamines?
   Antihistamines act as antagonists and block the neurotransmission of histamine and reduces inflammation.

More information
Good websites with answers about tetanus:
- http://www.nevdgp.org.au/geninf/nyhd/ny_tetanus.htm

- http://www.emedicine.com/emerg/topic574.htm
- http://www.bact.wisc.edu/microtextbook/disease/botulism.html

References and Resources

1. http://faculty.washington.edu/chudler/colorb3.html
2. http://bact.wisc.edu/microtextbook/disease/botulism.html
3. Vander, Arthur, James Sherman and Dorothy Luciano. *Human Physiology*. Sixth
4. Ed. McGraw-Hill. New York. 1994.

Suggestions for Assessment

Judge drawing for accuracy.

It Takes A Lot of Nerve!
Interfering with the Signal

Student's Guide

Purpose:
To understand how neurotoxins interfere with transmission of signals.

Objective:
Apply knowledge of neurotransmission to new situations.

Introduction:
As you know, neurotransmission is important in sending signals. When an impulse moves down the axon and arrives at the axon terminal, dozens of vesicles fuse with the cell membrane and discharge the neurotransmitter into the small gap between the two cells. The molecules of the neurotransmitter diffuse across the gap and attach themselves to special receptors on the membrane of the neuron receiving the impulse.

When the neurotransmitter becomes attached to the cell membrane of the adjacent nerve cell, it changes the permeability of that membrane. As a result, Na^+ ions diffuse through the membrane into the cell. This process continues for only a few milliseconds, stopping when the neurotransmitter detaches from the membrane. However, if enough neurotransmitter is released by the axon terminal, so many Na^+ ions diffuse into the neuron that the neuron becomes depolarized. A threshold is reached and an impulse begins in the second cell.

The release of neurotransmitters at a synapse can either trigger an impulse (action potential) or inhibit an impulse. If it triggers an impulse, it is called **excitatory**. If it stops or slows down an impulse, it is called **inhibitory**. Inhibitory neurotransmitters are important because they keep the system in check.

Materials:
- synapse Handout
- map colors

Procedure

1. In illustration I, draw an inhibitory neurotransmitters' normal pathway across the synaptonemal complex.

2. Beneath the picture, describe the sequence of events that occur when that inhibitory transmitter crosses the complex.

3. What would be the end result of this action if this were a motor neuron?
   _____

Look at the electron micrograph above. Let's play "Who Am I?"
I:

- am a Gram-positive, anaerobic, rod-shaped bacteria.
- am resistant to heat, desiccation and disinfectants.
- am unable to live in the presence of oxygen.
- release a neurotoxin when an organism is infected with me.
- am found in soil, house dust, animal intestines and human feces.
- am able to interfere with inhibitory synapses on motor neurons.
- cause an unbalance of excitation of muscle cells, causing excessive contraction.
- result in spastic paralysis, lockjaw and even death

Who am I?_____

Most cases of this disease result from small puncture wounds that become contaminated with spores from the bacteria that germinate and produce a toxin.
The toxin can travel to motor neurons of the CNS and then interfere with inhibitory neurotransmission. Other symptoms besides lockjaw include stiffness of the neck, difficulty swallowing, spasms, sweating, and fever.

It Takes A Lot of Nerve!
Extra, Extra, Read All About It

Teacher's Guide

Purpose:
To assess the students' understanding about the anatomy and physiology of a neuron.

Materials
Paper and pen

Preparation and Procedure:
Give these instructions to your students:

> *Pretend that you're an unemployed neuron. You **must** get a job soon or you will die a slow death due to lack of exercise. You want to put an advertisement in the Classified Ads of your local newspaper extolling your values.*
> *It is your job to describe fully all your attributes and how valuable they would be to any CNS. Don't be shy; include everything!*

Good websites for Neurophysiology in general include:

- http://faculty.washington.edu/chudler/experi.html