Chapter Eight
Nerves

Day One:

Today, your child should complete their reading and practice problems for the week.

Below are the supplies for this week's lab:

One large plastic baggie
One small plastic baggie
33 black beans*
31 red beans*
26 pinto beans*
20 lima beans*

*Any small objects may be used in place of beans as long as they are uniform in appearance.

National Science Education Standards covered this week:

12CLS6.1 Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules.

Definitions

action potential	a series of actions during a nerve impulse in which a large amount of sodium ions enter the cell after the dendrites receive a stimulus
axons	special structures within a nerve cell which move nerve impulses towards the CNS
Central Nervous System (CNS)	control center of the nervous system; consisting of the brain and spinal cord
dendrites	special structures extending from the surface of nerve cells which receive a stimulus
depolarization	period of time during a nerve impulse when waves of positively-charged sodium ions enters the neuron; this causes the neuron to become more positively charged
electrochemical process	method of communication between neurons in which chemicals are released thereby triggering a nerve impulse
electron	negatively-charged particle within an atom; 1800+ times smaller than a proton
gap junctions	areas between synapses in which an electrochemical system can jump from one neuron to another
hyperpolarized	period of time after repolarization when an excess of potassium ions have left the neuron causing it to become more negative
integration	the sorting and directing of signals to other areas of the body
ion	an element which has lost or gained one or more electrons
motor (efferent) nerves	send information AWAY from the central nervous system to the effectors (e.g. muscles or glands)
nerves	a long cable-like bundle of nerve cell axons
neurotransmitters	chemical which allow for neurons to communicate with other neurons

perception	the receiving of signals concerning what is going on inside and outside the body
polarization	stage of a neuron in which the electrical charge on the outside of the neuron is positive while the electrical charge on the inside of the membrane is negative
postsynaptic neuron	the cell that receives the message from the presynaptic neuron
presynaptic neuron	the cell which sends a message
proton	proton-charged particle within an atom
refractory period	period of time during a nerve impulse in which a neuron can no longer send any more signals along its neuron before its resting potential is reached once again
repolarization	stage within a nerve impulse when the movement of positively-charged ions from the inside of the cell begins to lower the positively-charged cell back to a more negative charge
resting potential	electrically negative charge of all neurons
sensory (afferent) nerves	send information from sensory receivers (e.g., in skin, eyes, nose, tongue, ears) TOWARD the central nervous system
sodium/potassium pumps	active transport system which uses energy to move three sodium ions out of the neuron for every two potassium ions it allows in
soma	cell body of a nerve cell
synapses	the location where two nerve cells meet and transmit signals to each other

Sample questions to ask your child after completing the weekly reading.

What is the difference between "nerves" and "nerve cells?"

Nerve cells are individual cells which may be up to 3 feet in length. Nerves are bundles of nerve cells.

How are nerves classified?

Nerves are classified by the direction in which they send information. Sensory nerves send information from receivers to the CNS while motor nerves send nerve impulses from the CNS towards the effectors.

While at rest, what relative charge does a neuron maintain when compared to its extracellular fluid? What causes this charge?

At rest, there are relatively more sodium ions outside the neuron and more potassium ions inside a neuron. If you were to calculate all of the ion charges that exist on both sides of the cell membrane of a neuron, you would find that the internal environment of a neuron is more electrically negative than its surroundings.

What physical structure regulates the speed of a nerve impulse?

The presence of gaps within a myelin covering which surrounds an axon significantly increases the speed of a nerve impulse. Unmyelinated neurons conduct nerve impulses much slower.

Day Two:

Your child should check their work on the practice worksheets today with the answer key on the next page.

In addition, your child should read the lab activity and start collecting all of the necessary materials!

Answer Key for Practice Problems

Vocabulary Review

1) nerves
2) action potential
3) sodium/potassium pumps
4) ion
5) gap junctions
6) soma
7) neurotransmitters
8) Central Nervous System (CNS)
9) resting potential
10) electrochemical process
11) electron
12) hyperpolarized
13) refractory period
14) depolarization
15) proton
16) motor (efferent) nerves
17) sensory (afferent) nerves
18) dendrites
19) axons
20) polarization
21) repolarization
22) postsynaptic neuron
23) presynaptic neuron
24) synapses
25) perception
26) integration

Multiple Choice

1) B
2) A
3) E
4) D
5) B
6) C

Application Questions

A normal stimulus causes Na^+ channels to open along neurons, allowing Na^+ to diffuse into the cell, thus resulting in depolarization. Because lithium ions reduce the permeability of sodium ions (Na^+) through cell membranes, the Na^+ channels in the membrane tend to remain closed. Therefore cell is less sensitive to stimuli because the membrane is less permeable to Na^+.

Day Three: Lab Activity

Your child should have already read through this lab and has been reviewing all of this week's vocabulary words.

Collect your supplies for the lab:

One large plastic baggie
One small plastic baggie
33 black beans*
31 red beans*
26 pinto beans*
20 lima beans*

*Any small objects may be used in place of beans as long as they are uniform in appearance.

You've got some nerve!

I didn't think a nerve impulse took this long…

A model for the five stages of a nerve impulse will be explored.

Materials:

One large plastic baggie
One small plastic baggie
33 black beans*
31 red beans*
26 pinto beans*
20 lima beans*
*Any small objects may be used in place of beans as long as they are uniform in appearance.

Procedure: (for parents)

Within a small baggie place 3 black beans, 30 red beans, 2 pinto beans, and 20 lima beans. Within the large baggie place 30 black beans, 1 red bean, and 24 pinto beans. Place the small baggie within the large baggie and seal both. The chart below is an answer key for the results of this activity:

		Resting Stage		Depolarization		Repolarization	
	Ion	# of ions	Total charge	# of ions	Total charge	# of ions	Total charge
Inside the cell	A^{-2}	20	-40	20	-40	20	-40
	Na^{+1}	3	+18	18	+18	18	+18
	K^{+1}	20	+30	30	+30	15	+15
	Cl^{-1}	2	-2	2	-2	2	-2
Sum of charges			-9		+6		-9
Outside the cell	A^{-2}	0	0	0	0	0	0
	Na^{+1}	30	+30	15	+15	15	+15
	K^{+1}	1	+1	1	+1	16	+16
	Cl^{-1}	24	-24	24	-24	24	-24
Sum of charges			+7		-8		+7
Membrane Potential			-16		+14		-16

Procedure: (for kids)

The beans within the small baggie represent the ions found within a typical nerve cell; and, the beans within the large baggie represent ions found in the area surrounding a nerve cell. Combined, these baggies symbolize a nerve cell at rest.

Each of the beans represents a particular type of ion:

Bean	Ion	Charge
Lima	any large anion (A^{-2})	-2
Black	Sodium (Na^{+1})	+1
Red	Potassium (K^{+1})	+1
Pinto	Chloride (Cl^{-1})	-1

The purpose of this lab is to model the movement of "ions" through a nerve cell and to calculate the charge that occurs both within and outside of a nerve cell during an impulse. The attached table will help you to calculate the membrane potentials at the resting, depolarization, and repolarization stages.

Complete the following steps to simulate a nerve impulse within a neuron:

1) Count the number of each "ion" within both the large and small baggies. Place these numbers within the "# of ions" column under the Resting Stage column.
2) Multiply these numbers by the ion's charge and record this number within the "Total charge" column in the Resting Stage area.
3) Add all of the total charges found inside the cell and place this sum in the "Sum of charges" box. Repeat this with the total charges found outside of the cell as well.
4) Calculate the Membrane Potential charge within the Resting Stage of the neuron by finding the range between both numbers within the "Sum of charges" boxes. *For example, if the sum of charges inside the cell is -4 and is 7 outside the cell, the membrane potential would be 11.*

5) If the sum of charges inside the cell is lower than the sum of charges outside of the cell, the membrane potential charge will be negative. It will be positive if the sum of charges inside the cell is greater than the sum of charges outside of the cell. *Using the same example as above, if the sum of charges inside the cell is -4 and is 7 outside the cell, the membrane potential would be -11.*

This Resting Membrane Potential charge is the charge found in a neuron when it is not going through a nerve impulse. At this time, we are going to simulate the transmission of an impulse along a nerve cell by moving some of these beans in and out of the cell.

6) Move 15 black beans (sodium ions) from outside of the neuron (the large bag) into the neuron (small bag).

This movement symbolizes the action potential within a neuron as sodium ions are allowed to flow into the nerve cell. This flow of ions depolarizes a small portion of the neuron.

7) Calculate the Depolarization Membrane Potential by following the same procedure from #1-5.
8) Move 15 of the red beans (potassium ions) from the inside of the neuron to the outside.

This movement represents the next stage of a nerve impulse – the opening of potassium channels and closing of sodium channels. The flow of potassium ions from the neuron shifts the membrane potential once again as it becomes repolarized.

9) Calculate the Repolarization Membrane Potential by following the same procedure from #1-5

10) Move 15 sodium ions (black beans) from the inside to the outside of the neuron; and, move 15 potassium ions (red beans) from the outside back into the neuron.

This final action should place all of the beans back to their resting position, much like that of the sodium/potassium pump during the refractory period.

Data chart for "You've got some nerve!"

		Resting Stage			Depolarization			Repolarization	
	Ion	# of ions	Total charge		# of ions	Total charge		# of ions	Total charge
Inside the cell	A^{-2}								
	Na^{+1}								
	K^{+1}								
	Cl^{-1}								
Sum of charges									
Outside the cell	A^{-2}								
	Na^{+1}								
	K^{+1}								
	Cl^{-1}								
Sum of charges									
Membrane Potential									

Explanation:

The five stages of a nerve impulse can be visible in this activity:

Polarization occurs at the resting stage in which the outside environment is more positively charged than the internal environment of the neuron. This can be attributed to the excessive amount of the positively charged sodium ions outside of the neuron itself.

The response to a stimulus triggers an **action potential** to occur in which sodium ions are allowed to enter the neuron rapidly.

The influx of positively charged sodium ions generates the **depolarization** of the neuron. The internal environment becomes more positively charged with the excessive presence of sodium ions.

As a result of the increased amount of sodium ions within the neurons, potassium ions begin to flow out of the cell. As more and more potassium ions flow from the neuron, the internal charge begins to decrease rapidly. This process is known as **repolarization**.

This stage actually causes too many potassium ions to flow out of the neuron, causing the neuron to become **hyperpolarized**. This can be observed within the activity as the uneven total charge of potassium ions inside and outside of the neuron during the repolarization stage. Hyperpolarization is resolved through the actions of the sodium/potassium pump which actively transports three sodium ions out of the cell for every two potassium ions in brings back in. The actions of the pump continue during this **refractory period.** No nerve impulses can continue within this period until the neuron can arrive at its resting membrane potential once again.