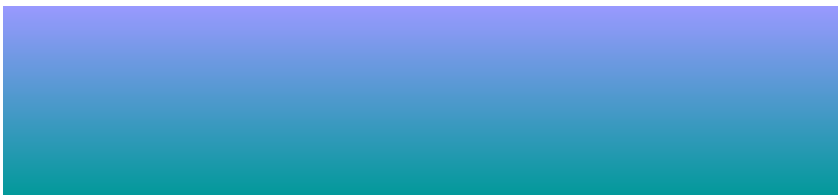


Name _____

Period _____

AP Biology

Date _____



INTRODUCTION:

In this activity, you will set up a model to simulate how a neuron processes information. The model will include such items as peas, beans, and construction paper. You will need to know the following facts.

FACT 1: Black-eyed peas represent sodium ions. There are more sodium ions outside the nerve cell than inside, so there are more peas in the “outside” pan. Lima beans represent potassium ions, black beans represent chloride ions, and the wads of construction paper represent proteins. In a real cell, there would be millions of ions, but there is not enough room for that many peas and beans on your poster board. Sodium and potassium ions have a positive charge, while chloride ions and proteins carry a negative charge.

FACT 2: A positive charge attracts a negative charge, and vice versa. However, positive charges repel each other, and so do negative charges.

FACT 3: Electrical charge (resting membrane potential) is the result of excess ions on one side of the cell membrane.

FACT 4: One force acting on the ions is for them to move from areas of higher concentration to lower concentration.

FACT 5: The facts above describe all cells, even plant cells. However, nerve cells are unique. They have specialized proteins in their membranes called channels or gates. Nerve cells have channels for sodium, potassium, chloride, and other ions, that will only recognize one ion. If a sodium channel opens, sodium ions, but no other ions, can pass through. Channels are very narrow and ions must line up one at a time to pass through the channel, no matter which direction they go. Proteins are too big to fit through any of these channels and must stay inside the cell. In a nerve cell without any channels (gates) open, the charge inside the cell relative to the outside is negative (-70mV).

MATERIALS PER GROUP:

- 900 mg of the following:
 - dried black-eyed peas
 - dried baby lima beans (or Navy beans)
 - dried black beans
- metric ruler
- 2 aluminum pie pans
- 2 Post-it™ notes
- posterboard
- toothpicks
- magic marker

****Safety Note:** Do not eat the peas or beans used in this activity. Avoid hand-to-mouth contact while handling the beans and peas. Commercially prepared beans may have been treated with pesticides. Wash your hands with soap and water at the end of the activity.

PROCEDURE:

Follow the teacher's directions as you set up your nerve cell model. You will use your model cell to answer questions. It may help to take the beans and peas (ions) out of the pans and move them around to visualize the answer to your question. The bean mover in your group can move the beans and peas, and the data recorder can record the results.

QUESTIONS:

1. Look at the numbers of black-eyed peas representing the sodium ions in the pans inside and outside the cell. If the sodium channel were suddenly opened so that sodium ions could move across the cell membrane:
 - a. Which direction would they tend to move based on their concentration: into or out of the cell? Explain. (2 points)
 - b. Which direction would they tend to move based on their charge: into or out of the cell? Explain. (2 points)
2. A sodium channel opens for about one millisecond. Each group's timekeeper will time the opening of the sodium channel for 10 seconds, representing one millisecond. Before he/she begins timing, decide which direction the sodium ions will move based on your answers to questions 1a and 1b. When the teacher gives the signal, the timekeeper will begin timing for 10 seconds. Immediately have the gatekeeper open the sodium channel by moving the toothpick as shown by the teacher. Then the bean mover should take the peas out of the pan and drag them through the sodium channel one at a time in the direction you think they will go until the timekeeper stops timing.

Note: Leave the sodium ions where they are now as you answer questions 3-8, but close the sodium channel. If you used Post-it™ notes to mark "negative" and "positive" remove these notes now.

3. Look at the numbers of sodium ions on each side of the cell membrane now. Compared to the number in each pan at rest, are there: (circle one) (1 point)
 - a. More sodium ions inside the cell now than there were before, or
 - b. Fewer sodium ions inside the cell now than there were before?
4. Based on your answer to question 3, do you think the internal medium of the cell is: (circle one)
 - a. More negative than it was before, or
 - b. More positive than it was before?

Explain. (2 points)

5. Look at the numbers of lima beans in the pans, both inside and outside the cell. If the potassium channel was suddenly opened so that potassium ions could move across the cell membrane:
 - a. Which direction would they tend to move based on their concentration: into or out of the cell? Explain. (2 points)
 - b. Which direction would they tend to move based on their charge: into or out of the cell? Explain. (2 points)

6. A potassium channel opens for one to three milliseconds. Follow the directions in number 2 above, except now you must open the potassium channel. Remember to decide which direction the potassium will move based on your answers to questions 5a and 5b before the teacher gives the signal for the timing to begin.
7. Look at the numbers of potassium ions on each side of the cell membrane now. Compared to the number in each pan at rest, are there: (circle one) (1 point)
 - a. More potassium ions inside the cell now than there were before, or
 - b. Fewer potassium ions inside the cell now than there were before?
8. Based on your answer to question 7, do you think the internal medium of the cell is: (circle one)
 - a. More negative than it was before you had opened the potassium channel (but after you had opened the sodium channel and moved the peas), or
 - b. More positive than it was before you had opened the potassium channel (but after you had opened the sodium channel and moved the peas)?

Explain. (2 points)

9. In the nerve cell axon, something happens called **sodium channel inactivation**. This means that after the sodium gates open and close, they cannot open again for a few milliseconds. (3 points)
 - a. What is this period of time called?
 - b. If you were to line up a number of your models to represent a longer stretch of a nerve cell axon, what effect would this have on the action potential? (LET'S TRY IT!)

- c. Does it make a difference if you start at one end of the long line, or in the middle? Explain.
10. After a lot of action potentials have occurred, will enough peas/beans/ions move to change significantly the concentration gradients you set up initially when your model was at rest? Would the sodium and potassium ions continue to move as they did during the action potential you simulated in this activity? (2 points)
11. In order to continue functioning properly, the cell must now somehow get back to its resting state. How might the cell do this? (1 point)
12. The simulation you have completed is with a model of an unmyelinated neuron. How would a myelinated neuron simulation differ? (1 point)