**LIGHTS, CAMERA, . . .**

**ACTION POTENTIAL!!**

**NAME \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DATE \_\_\_\_\_\_\_\_\_\_ 36 points**

**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: 2 aluminum pie pans

dried black-eyed peas 2 Post-itTM notes

dried baby lima beans (or Navy beans) posterboard

dried black beans toothpicks

metric ruler 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:**

**Answer the following questions using your model of an axon.**

1. Notice that the concentration (number) of ions is different inside and outside the cell. (3 points)

a. Where is there a higher concentration of sodium (Na+)? \_\_\_\_\_\_\_\_\_\_\_\_\_\_

b. Where is there a higher concentration of potassium (K+)? \_\_\_\_\_\_\_\_\_\_\_\_\_\_

c. Where is there a higher concentration of chlorine (Cl-)? \_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. 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: (4 points)

a. Which direction would they tend to move based on their concentration: into or out of the cell? Explain.

b. Which direction would they tend to move based on their charge: into or out of the cell? Explain.

3. A sodium channel opens for about one millisecond. Each group’s timekeeper will time the opening of the sodium channel for 15 seconds, representing one millisecond. Before he/she begins timing, decide which direction the sodium ions will move based on your answers to questions 2a and 2b.

When the teacher gives the signal, the timekeeper will begin timing for **15 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.

After 15 seconds, close the gates (toothpicks).

Note - Leave the sodium ions where they are now as you answer questions 4-9, but close the sodium channel. If you used Post-itTM notes to mark “negative” and “positive” switch the position of these notes now.

4. Why do you switch the Post-itTM notes? (1 point)

5. Look at the number of sodium ions on each side of the cell membrane now. Compared to the number in each pan at the beginning, there are:

(**Circle one**.) (1 point)

a. More sodium ions inside the cell now than there were before

b. Fewer sodium ions inside the cell now than there were before

6. Based on your answer to question 5, the internal medium of the cell is:

(**Circle one**.) (4 points)

a. More negative than it was before.

b. More positive than it was before.

Explain your answer.

c) This is known as depolarization. Explain why.

7. Look at the numbers of lima beans in the pans, both inside and outside the cell. If the potassium channel was suddenly open so that potassium ions could move across the cell membrane: (4 points)

a. Which direction would they tend to move based on their concentration: into or out of the cell? Explain your answer.

b. Which direction would they tend to move based on their charge: into or out of the cell? Explain your answer.

8. A potassium channel opens for one to three milliseconds. Follow the directions in number 2 above, except now you must open the potassium channel for **10 seconds**.

\*\*\*Remember to decide which direction the potassium will move based on your answers to questions 6a and 6b before the teacher gives the signal for the timing to begin.

9. Look at the numbers of potassium ions on each side of the cell membrane now. Compared to the number in each pan at the beginning, there are:

(**Circle one**.) (1 point)

a. More potassium ions inside the cell now than there were before.

b. Fewer potassium ions inside the cell now than there were before.

10. Based on your answer to question 9, do you think the internal medium of the cell is: (5 points)

(**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).

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.

c. This is known as repolarization. Explain why.

d. Switch the Post-itTM notes again. When the cell membrane has gone through depolarization and repolarization and the charge on the inside is negative again and the charge on the outside is positive again, it is called an

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11. In the nerve cell axon, something happens call sodium channel inactivation. This means that after the sodium gates open and close, they cannot open again for a few milliseconds. (4 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? What effect would it have on the nerve impulse? (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.

12. Everything you did involves the axon of one neuron. Explain how an action potential travels to another neuron. (3 points)

13. In order to continue functioning properly, the cell must now somehow get back to its resting state. What do cells use in order to do this? (1 point)

14. The simulation you have completed is with a model of an unmyelinated neuron. How would a myelinated neuron simulation differ? (1 point)

15. If we kept doing this simulation, will enough peas/beans/ions move to change significantly the concentration gradients you set up initially when your model was at rest? **(Yes or No)** Would the sodium and potassium ions continue to move as they did during the action potential you simulated in this activity? Explain your answers. (4 points)

**BONUS QUESTION: 3 points**

**Chloride ions gated channels are in this model, but we did not use them. Why do we have them? Investigate the role of chloride channels in cystic fibrosis. What is the effect of faulty chloride channels on a person with CF?**