Nerve Cell Communication

Core Concept:

Nerve cells communicate using electrical and chemical signals.

Class time required:

Approximately 2 forty minute class periods

Teacher Provides:

For each student

- Copy of student handout entitled **Nerve Cell Communication**

For each team:

- Color copies of neuron diagrams (pages 3 through 6). Print the four diagrams that each show part of a neuron on 8.5” x 11” paper, cut along the dotted lines, and then tape the diagrams together to make two large neuron diagrams (a sending neuron with label boxes and a receiving neuron without label boxes). Consider laminating or placing these in clear sheet protectors for use with multiple classes.
- A sandwich (quart size) plastic bag containing:
    - List of contents of bag (page vii) used to check the bag contents
    - 15 red tri-beads (purchase at local or online craft store)
    - 2 large yellow beads that are not shaped like tri-beads (purchase at local or online craft store)
    - 2 large white beads that are not shaped like tri-beads (purchase at local or online craft store)
    - One set of white structure label cards (page xiii) - consider laminating or covering with clear packing tape for reuse
    - One set of blue function label cards (page ix) - consider laminating or covering with clear packing tape for reuse. Print on blue paper if you do not have access to a color printer.
    - 2 pink (+ and -) impulse card (page x) - consider laminating or covering with clear packing tape for reuse. Print on pink paper if you do not have access to a color printer.

Suggested Class Procedure:

1. Distribute a copy of **Nerve Cell Communication** to each student.

2. Ask one student to read aloud the information in the **Biology Brief: Neurons**.

3. Explain that, for many people, just listening to or reading the information in the Biology Brief is not enough to really understand and remember the information.

4. Explain that they will use a manipulative model to help them visualize and remember the information in the Biology Brief.

5. Distribute to each team of 2-4 students:
    - Two large neuron diagrams (one with label boxes and one without label boxes) to teams of 2-4 students.
    - Bag containing beads, pink (+/-) cut-outs, white structure label cards, and blue function cards to each team.

6. Ask students to work in teams of 2-4 students to follow the instructions for **Part 1: What are the parts of a neuron**? Encourage students to use the information in the **Biology Brief: Neurons** as they work.

7. Check students' structure label cards on the neuron. Initial on the line for teacher initials.

8. Students follow the instructions for Part 2: What are the functions of the parts of a neuron? Encourage students to use the information in the **Biology Brief: Neurons** as they work.

9. Check students' blue function cards on the neuron. Initial on the line for teacher initials.

10. Students follow the instructions for **Part 3: How do nerve cells communicate?** Encourage students to read **Biology Brief: Two Types of Neuron Signals** as they work.

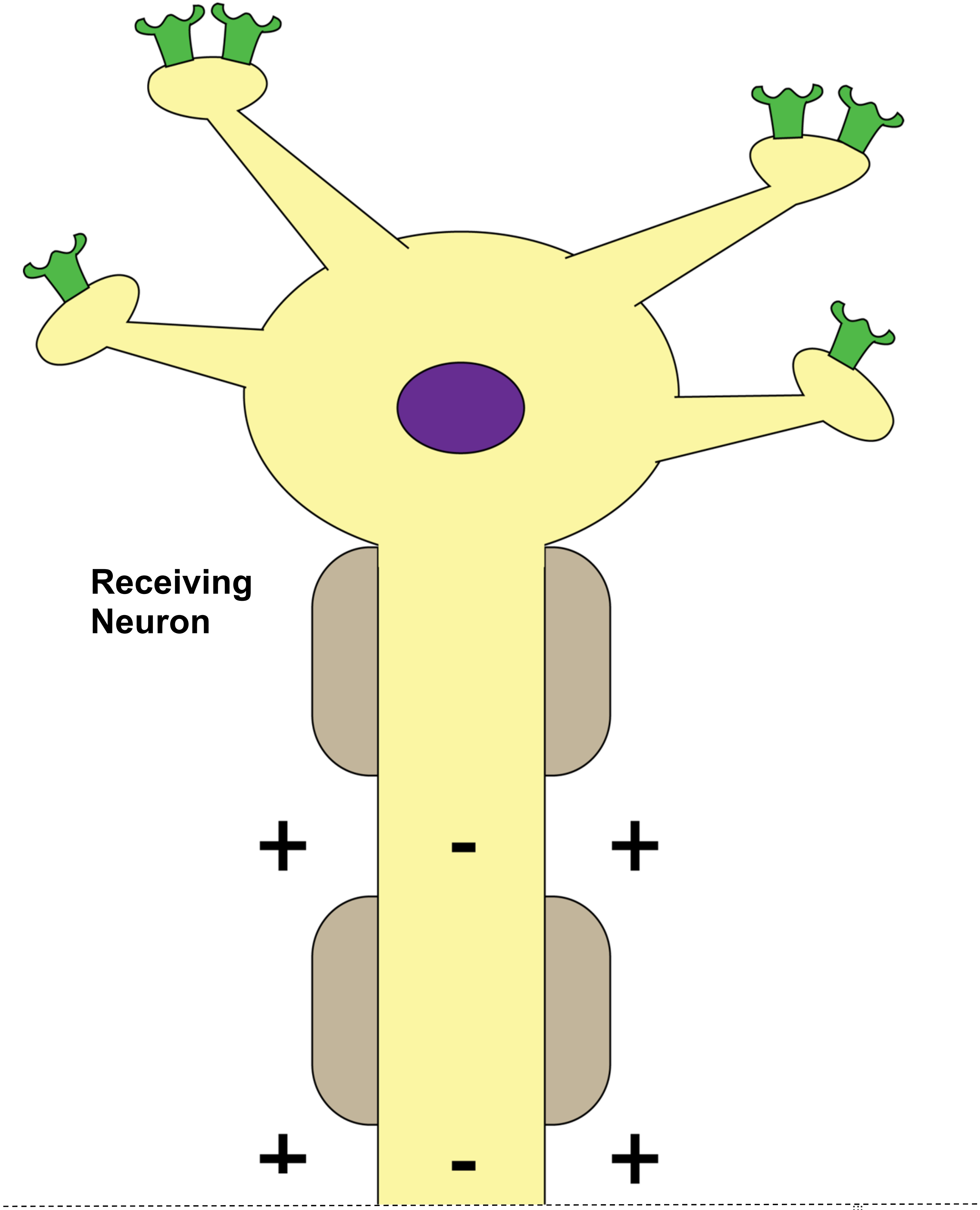
11. Students follow the instructions for **Part 4: Review and apply what you learned**. This may be completed in class or for homework.

Optional Consider using:

- A Nerve Cell Communication Animation is available for downloading from the Life Sciences Learning Center website at http://lifesciences.envmed.rochester.edu. This animation introduces several new terms and concepts including nodes of Ranvier and the recovery that occurs after an impulse has passed a region on the axon.

- The animation ***Crossing the Divide: How Neurons Talk to Each Other*** relates nerve cell communication to the effects of drugs on synaptic transmission. http://learn.genetics.utah.edu/content/addiction/reward/neurontalk.html

- The Mouse Party activity at http://learn.genetics.utah.edu/content/addiction/drugs/mouse.html is both engaging and informative way to explore the effects of different drugs on nerve cell communication. There is a worksheet to accompany this activity at http://teach.genetics.utah.edu/content/addiction/mouseparty.html



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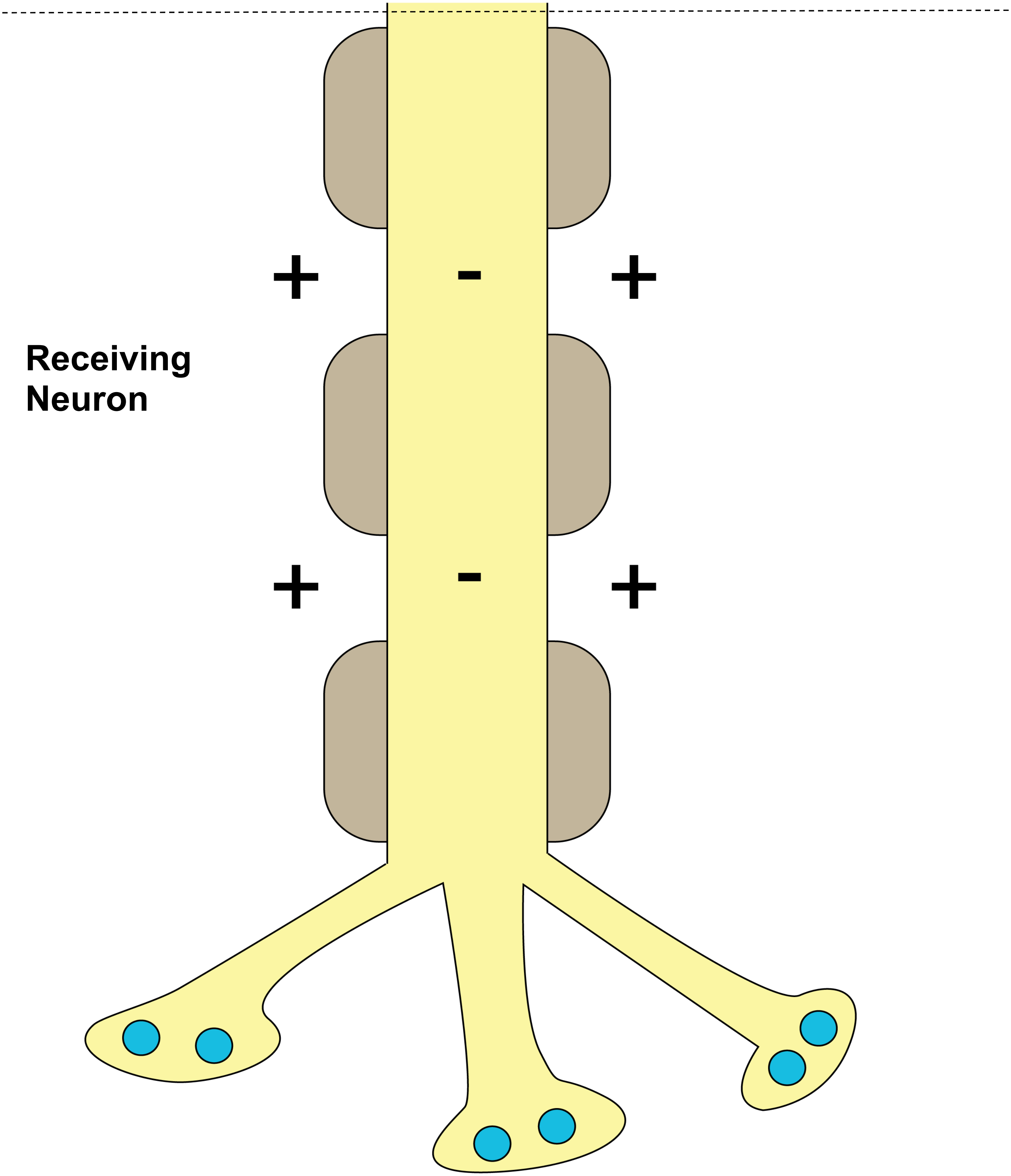
+
-
+
Receiving
Neuron
+
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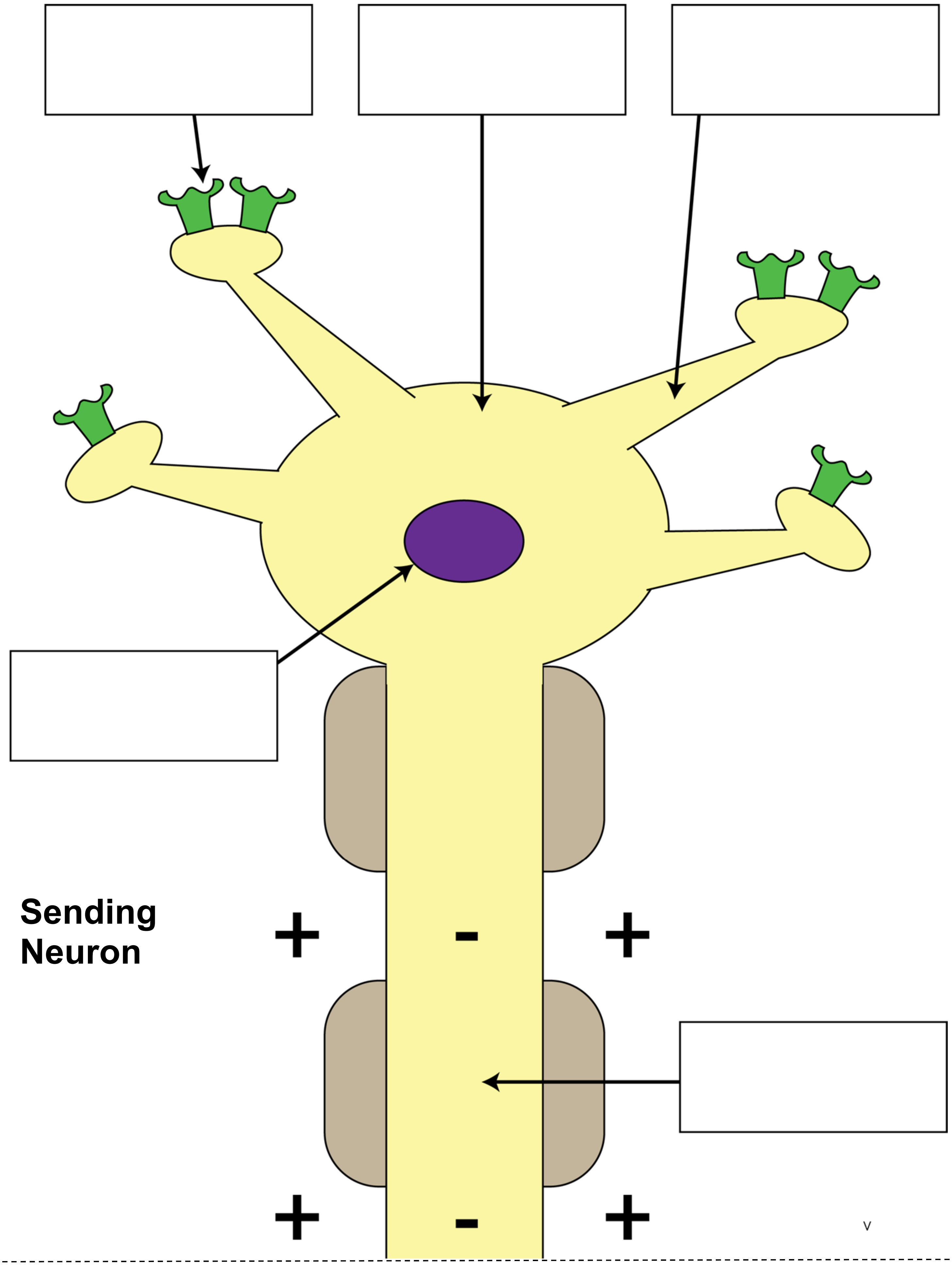
+



Sending
Neuron
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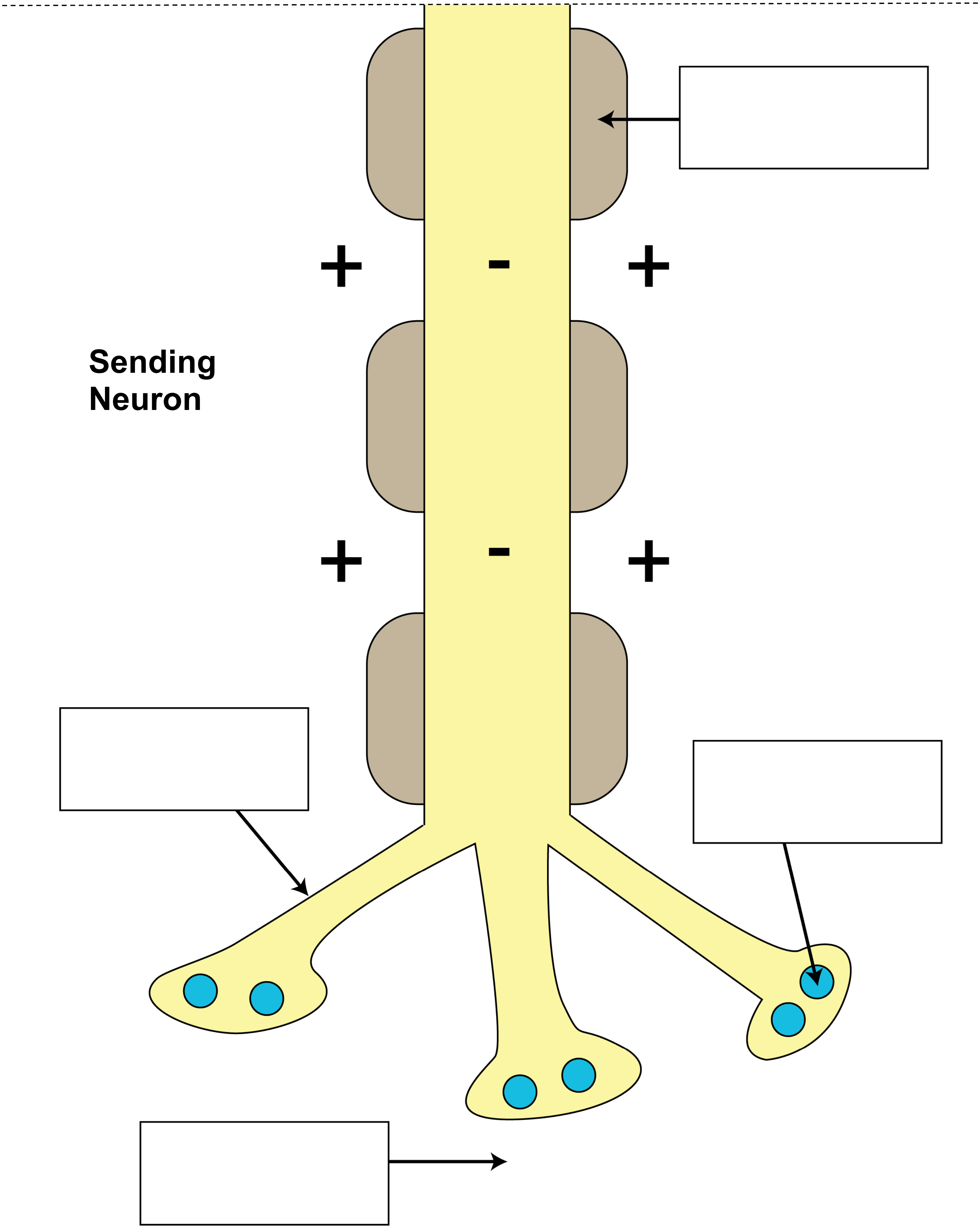

Sending Neuron
+
-
+

Contents of Bag

15 Red beads

2 White beads

2 Yellow beads

2 Pink impulse cards [- + -]

9 White Label cards:

1. Dendrite
2. Axon
3. Terminal Branch
4. Myelin Sheath
5. Nucleus
6. Cell Body
7. Vesicle
8. Receptor Protein
9. Synapse

9 Blue function cards:

1. Attaches to chemical signal molecules
2. Insulates neuron and speeds up impulse conduction
3. Controls life activities
4. Carries out life activities
5. Sends chemical signals to another neuron
6. Stores and releases chemical signal molecules
7. Gap between two neurons
8. Receives chemical signals
9. Conducts electrical signals called impulses

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Structure Label Cards

Cut along lines to create sets of white structure label cards for each team of students.

Receptor Protein	**Myelin Sheath**	**Nucleus**
Cell Body	**Terminal Branch**	**Vesicle**
Synapse	**Dendrite**	**Axon**

Receptor Protein	**Myelin Sheath**	**Nucleus**
Cell Body	**Terminal Branch**	**Vesicle**
Synapse	**Dendrite**	**Axon**

Receptor Protein	**Myelin Sheath**	**Nucleus**
Cell Body	**Terminal Branch**	**Vesicle**
Synapse	**Dendrite**	**Axon**

Function Cards

Cut along to create sets of blue function cards for each team of students.

Attaches to chemical signal molecules	Insulates neuron and speeds up impulse conduction	Controls life activities
Carries out life activities	Sends chemical signals to another neuron	Stores and releases chemical signal molecules
Gap between two neurons	Receives chemical signals	Conducts electrical signals called impulses

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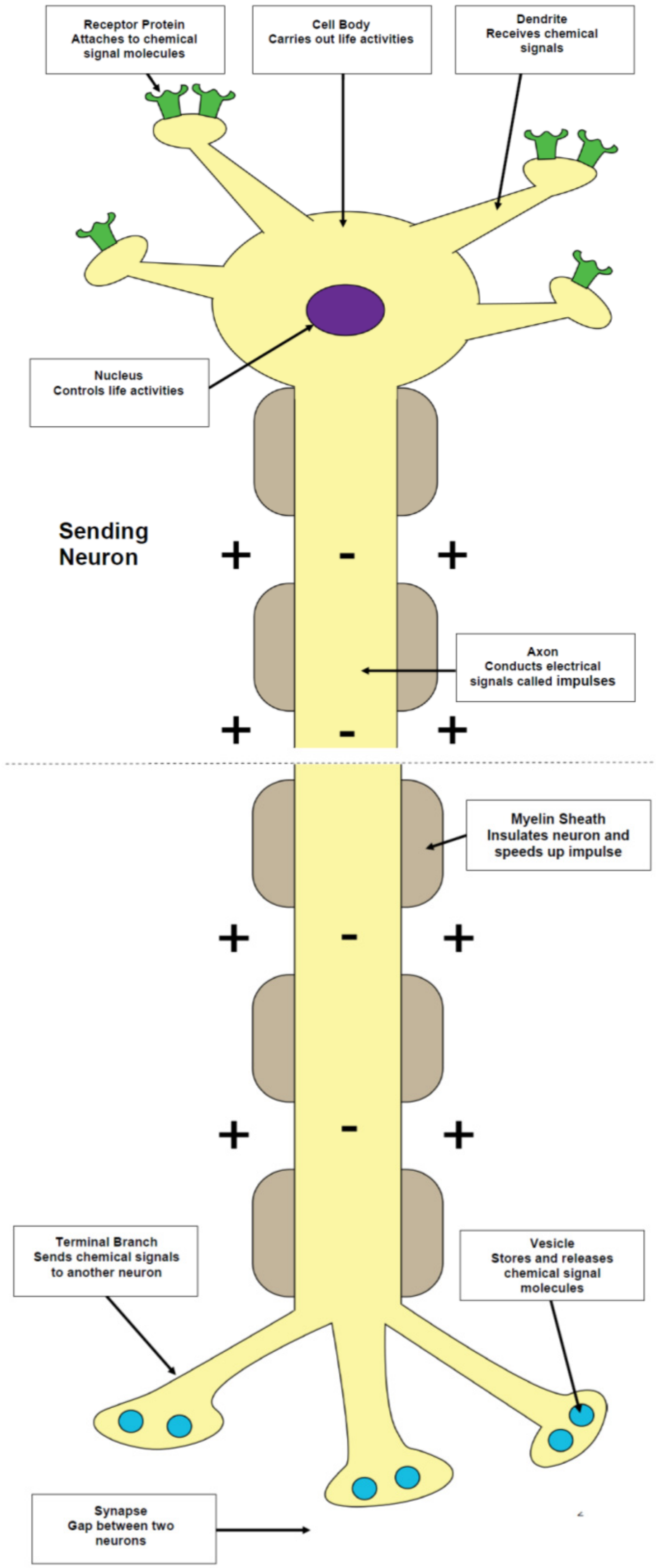
Carries out life activities	Sends chemical signals to another neuron	Stores and releases chemical signal molecules
Gap between two neurons	Receives chemical signals	Conducts electrical signals called impulses

Cut along dotted lines to make pink impulse cards (- + -)

-	Impulse +	-	-	Impulse +	-
-	Impulse +	-	-	Impulse +	-
-	Impulse +	-	-	Impulse +	-
-	Impulse +	-	-	Impulse +	-
-	Impulse +	-	-	Impulse +	-
-	Impulse +	-	-	Impulse +	-
-	Impulse +	-	-	Impulse +	-
-	Impulse +	-	-	Impulse +	-
-	Impulse +	-	-	Impulse +	-

Teacher Key for Neuron Model



Nerve Cell Communication

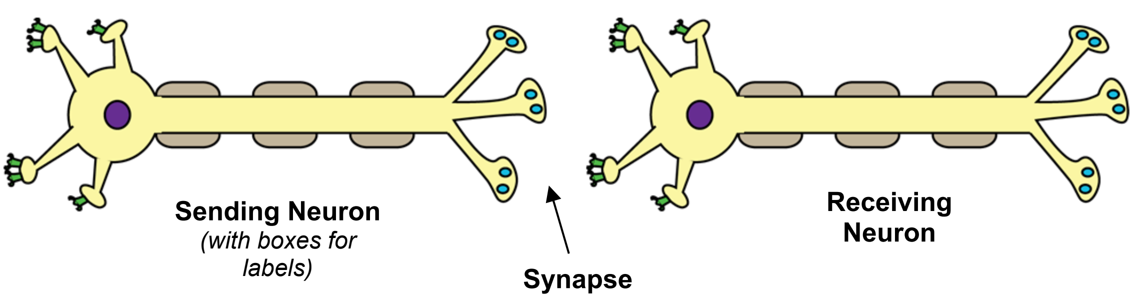
Part 1: What are the parts of a nerve cell?

1. Read the information in the ***Biology Brief: Neurons***. As you read, circle the names of the structures (parts) of the neuron.

Biology Brief: Neurons
Your nervous system is made up of nerve cells called neurons. Each neuron has a large cell body that carries on most of the life activities of the neuron. Inside the cell body is a nucleus which controls the life activities of the neuron. Attached to the cell body are short receiving branches called dendrites that receive chemical signals. Receptor proteins on the cell membranes of dendrites can attach to chemical signal molecules. Also attached to the cell body is a long conducting branch called an axon. The axon conducts electrical signals called impulses over long distances. The axon is covered by a myelin sheath which acts as an insulated covering and speeds up impulse conduction. The axon ends in short sending branches called terminal branches that send messages to other neurons. Knobs on the ends of the terminal branches contain vesicles (small sacs) that store and release chemical messenger molecules called neurotransmitters. Neurotransmitters can fit into the receptor proteins on another neuron. Neurons do not touch each other. They are separated by a small gap called a synapse.

2. Obtain the following materials from your teacher:
   - Two large diagrams of neurons—a sending neuron and a receiving neuron.
   - A bag of white label cards, blue function cards, colored beads, and a pink (+/-) card.

3. Arrange the large diagrams of sending and receiving neurons on your desk so that they are separated from each other by a small gap. This gap is called a **synapse**.



4. Use the information in the ***Biology Brief: Neurons*** reading to place the **white structure label** cards in the correct boxes on the sending neuron diagram.

5. Call your teacher over to check your work. TEACHER INITIALS ________________

Part 2: What are the functions of the parts of a nerve cell?

1. Read the ***Biology Brief: Neurons*** again. This time, underline the information in the reading that indicates functions of each part of a neuron.

2. Use the information in the ***Biology Brief: Neurons*** reading to place the **blue function cards** next to the matching white structure cards. For example, place the blue "controls life activities card" next to the white "nucleus" card.

3. Look at the beads (red, yellow, and white) in the bag. Which color of bead do you think best represents a neurotransmitter (chemical signal molecule) that would work to send a chemical message from the sending neuron to the receiving neuron? ___***Red***____

   Explain why you selected this bead.

   The red bead has a shape that fits into the receptor.

4. Add neurotransmitter molecules to your model by placing one of the colored of bead that you selected (in question 3) into each of the vesicles.

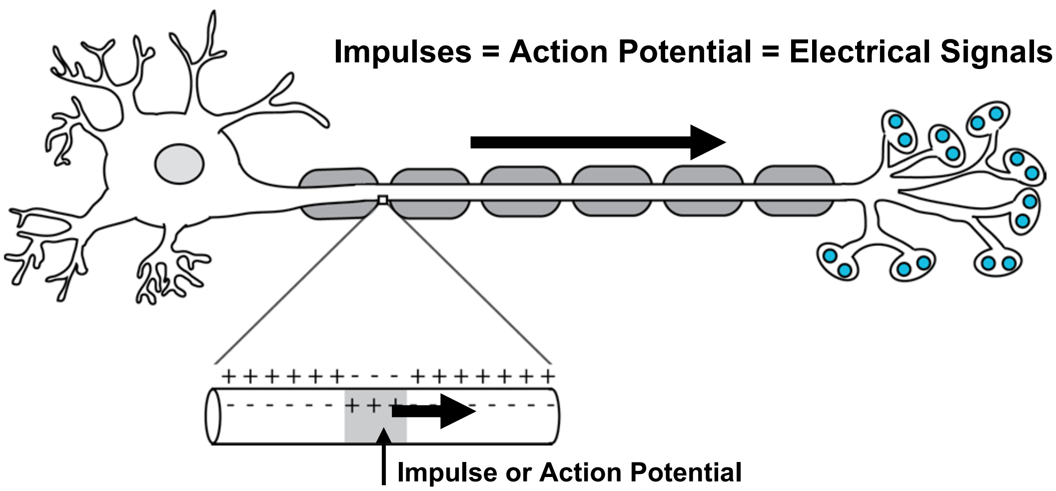
5. Call your teacher over to check your work. TEACHER INITIALS _________________

Part 3: How do nerve cells communicate?

1. Use the information in the ***Biology Brief: Two Types of Neuron Signals*** reading to answer questions 2-14.

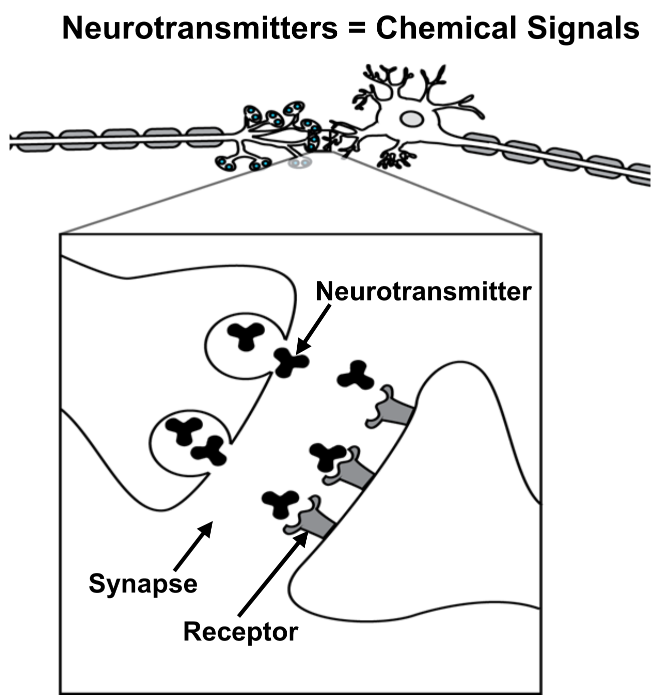
Biology Brief: Two Types of Neuron Signals

Neurons conduct electrical signals called impulses or action potentials. An impulse is an electrical signal that travels along a neuron. In a resting neuron (one that is not conducting an impulse) the outside of the neuron is positively charged. When the neuron is stimulated, an electrical change causes the outside of the neuron to become negatively charged. This electrical change is an impulse that travels very rapidly along the length of the neuron.



Neurons do <u>not</u> touch each other. Instead, they are separated by a tiny gap called a synapse. Impulses cannot jump this gap. When an impulse reaches the terminal branches of a neuron, it triggers the release of neurotransmitter molecules from the vesicles.

Neurotransmitters are chemical messenger molecules that diffuse across the synapse and attach to receptors on the dendrites of the receiving neuron. Receptors are like locks into which only keys that have a specific matching shape can fit. When neurotransmitters attach to receptors, it causes the receiving neuron to begin a new impulse.

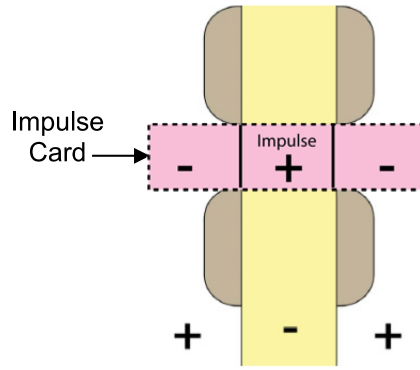


2. What are two names for the electrical signal that is conducted along a neuron called?

   Impulse or Action Potential

3. Place a pink "Impulse" card on one of the dendrites on the sending neuron model.

   Slide the pink impulse card from the dendrite to the cell body, to the axon and to the terminal branches. *Hint: As the impulse travels along the axon, you should arrange the impulse card as shown in the diagram on the right.*



   Stop at the terminal branches because an impulse cannot jump across the synapse (gap) that separates the two neurons in your model.

4. The outside of the neuron that is not conducting an impulse will have a __***positive***__ (negative or positive) charge.

5. An impulse (action potential) could be described as area of __***negative***__(negative or positive) charges that travel over the outside of the neuron.

6. Why can't an impulse pass directly from one nerve cell to another?

   The sending neuron does not touch the receiving neuron. Impulses cannot jump across the synapse.

7. When the impulse reaches the terminal branches, the vesicles release neurotransmitter molecules into the synapse. The neurotransmitter molecules then diffuse across the synapse and attach to the receptors.

   - Model the release and movement of neurotransmitters by moving the red beads out of the vesicles in the terminal branches, across the synapse, and into the binding sites on receptors of the next neuron.

8. What is the chemical signal that diffuses across the synapse from a sending neuron to a receiving neuron?

   A neurotransmitter

9. What causes the sending nerve cell to release a chemical message into the synapse?

   An impulse travelling through the sending neuron

10. Which part of the model represents a neurotransmitter (the chemical signal that carries information across the synapse)?

    Red beads

11. Which part of a neuron releases the chemical message?

    The vesicles or terminal branches of a sending neuron

12. When a neurotransmitter temporarily binds to the receptor, the receptor triggers the receiving neuron to make a new impulse that travels through the receiving neuron.
    - Place the pink impulse card on the neuron and move it along the axon to the terminal branches.
    - When the impulse reaches the terminal branches, the receiving neuron becomes a sending neuron that releases its neurotransmitters to send messages to other neurons.

13. Which part of a neuron receives the chemical message?

    The receptors on a receiving neuron

14. What happens in a receiving neuron after neurotransmitters have attached to the receptors?

    The receiving neuron makes a new impulse and becomes a sending neuron.

15. Your lab kit contains yellow beads and white beads that represent other types of molecules such as hormones or food molecules. Do you think that these molecules (yellow and white beads) could be used to carry messages from your sending to your receiving cell? Explain why or why not.

    No, they do not fit into the receptor protein.

16. Some drugs, such as heroin and oxycontin, mimic the size and shape of a neurotransmitter. **Imagine** that someone added some green beads (to represent heroin molecules) to the synapse. These green beads are the same size and shape as the red beads. What might happen in the receiving neuron if heroin was present in the synapse?

    The heroin could attach to the receptors and trigger an impulse.

Green Beads
Same size and same shape as red beads

17. Some drugs block the binding of neurotransmitters to receptors. Imagine that someone plugged the receptors on your model with clay. How might this affect the receiving neuron?

    The receiving neuron would not make an impulse.

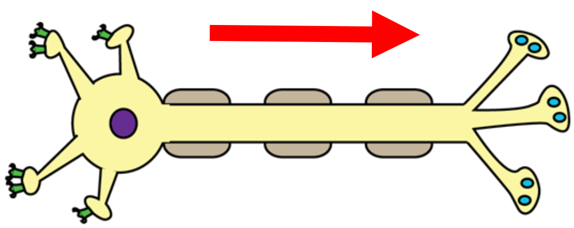
18. There are **reuptake carriers** in the terminal branches that collect neurotransmitter molecules and return them to vesicles in the terminal branches so that the neurotransmitters do not remain in the synapse and continue to stimulate the receiving neuron.

- Act like a reuptake carrier by returning all of the beads to the vesicles in the terminal branches of the sending neuron diagram.

19. Some drugs, like cocaine, block the action of reuptake carriers. Imagine that someone plugged the reuptake carriers on your model with clay. What might happen in the receiving neuron if something blocked the action of reuptake carriers?

The neurotransmitter would remain in the synapse and continue to signal the receiving cell to make impulses.

20. The diagram below shows two neurons. Draw arrows on the axons to indicate the direction that impulses would move in each of the neurons.

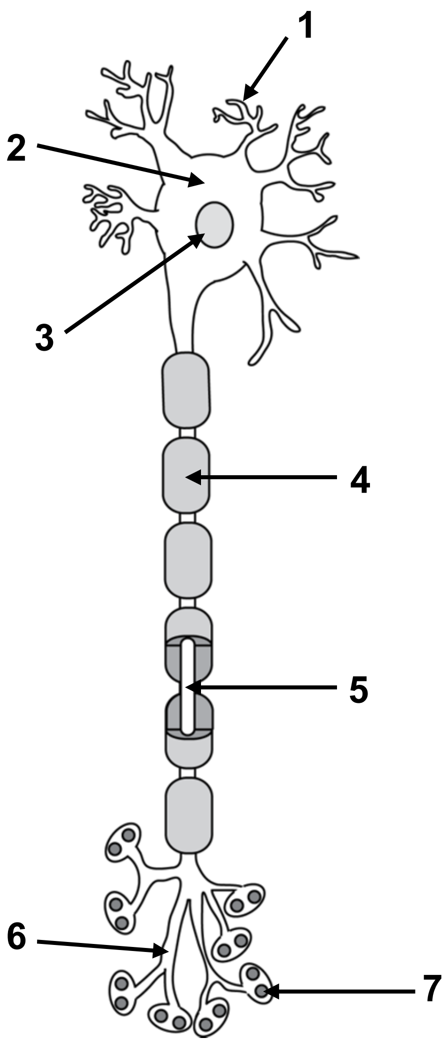


21. Explain why the impulses do not move in the opposite direction on the two neurons.

Impulses start in the dendrites and stop in the terminal branches OR Impulses can only start in the ends of the neurons that have receptors. They cannot start on the terminal branches.

Part 4: Review and apply what you learned

For questions 1- 7, write the names of each of the numbered structures on the lines to the right. Refer to the information in the ***Biology Brief: Neuron*** if you do not remember the name of the structure.



1. ***dendrite***
2. ***cell body***
3. ***nucleus***
4. ***myelin sheath***
5. ***axon***
6. ***terminal branch***
7. ***vesicle***

For questions 8-18, write the name of the structure or substance that answers the question. Refer to the information in the ***Biology Brief: Neuron*** if you do not remember the name of the structure or substance.

8. What is the electrical signal that is conducted by a neuron? ***Impulse or Action Potential***

9. Which part of a neuron receives chemical signals from other neurons? ***Dendrites***

10. Which part of a neuron sends chemical signals to other neurons? ***Terminal branches***

11. Which part of a neuron conducts electrical impulses over long distances? ***Axons***

12. Which structure forms an insulated covering for axons? ***Myelin sheath***

13. Which structure in a neuron stores chemical signal molecules? ***Vesicle***

14. Which structure speeds up impulse conduction along an axon? ***Myelin sheath***

15. What are the chemical signal molecules produced by a neuron called? ***Neurotransmitters***

16. Which part of a neuron controls the life activities of the neuron? ***Nucleus***

17. What is the gap between two neurons called? ***Synapse***

18. Which part of the neuron has receptor proteins attached to the cell membrane? ***Dendrites***

Base your answers to questions 19 through 22 on the information in the box below

People communicating

Neurons communicating

There are billions of neurons in your brain and the branching nerves in your body. Each of these neurons can form synapses with many other neurons.

19. Which part of a neuron is like the ears of a person who is listening to a sound message?

    The receptors on the dendrites

20. What substance acts like a verbal (spoken) message to carry information from one neuron to another?

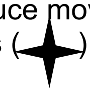
    Neurotransmitters

21. Do you think that a neuron can receive messages from many other neurons? Explain why or why not.

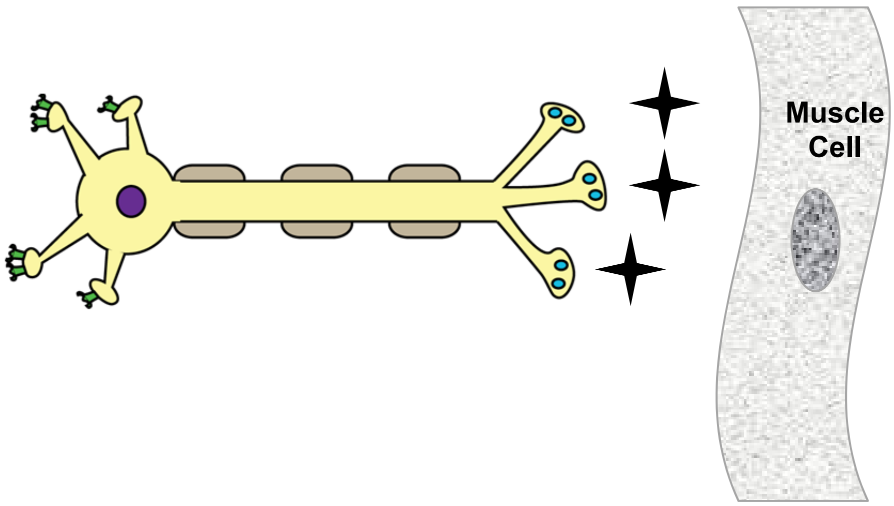
    Yes, because its dendrites may be attached to terminal branches of many other neurons. Some advanced students may indicate the answer depends on what neurotransmitters and receptors the neurons have.

22. Do you think that a neuron can send messages to many other neurons? Explain why or why not.

    Yes, because its terminal branches may be communicating with dendrites of many other neurons. Some advanced students may indicate the answer depends on what neurotransmitters and receptors the neurons have.

23. Some neurons send chemical messages to muscle cells in your body. When a muscle cell receives the message, it contracts to produce movement. The diagram below shows a neuron that is sending chemical messages () to a muscle cell.

On the muscle cell below, **draw a receptor** that could receive the chemical signal that causes the muscle cell to contract (get shorter).



There are many different ways that students might draw the receptor. Look for a drawing that fits the neurotransmitter. Examples may include: