



Nerve Cell Communication

Core Concept:

Nerve cells communicate using electrical and chemical signals.

Class time required:

Approximately 40 minutes if Part 4 is completed for homework.

Teacher Provides:

For each student

- Copy of student handout entitled **Nerve Cell Communication**
 - Copy of **Biology Brief: Neurons** (page 7)
 - Copy of **Biology Brief: Two Types of Neuron Signals** (page 8)

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 for use with multiple classes.
- A sandwich (quart size) bag containing:
 - List of contents of bag (page 9) 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 10) - consider laminating for reuse
 - One set of blue function label cards (page 11) - consider laminating for reuse
 - 1 red (+ and -) impulse card (page 12) - consider laminating for reuse

Suggested Class Procedure:

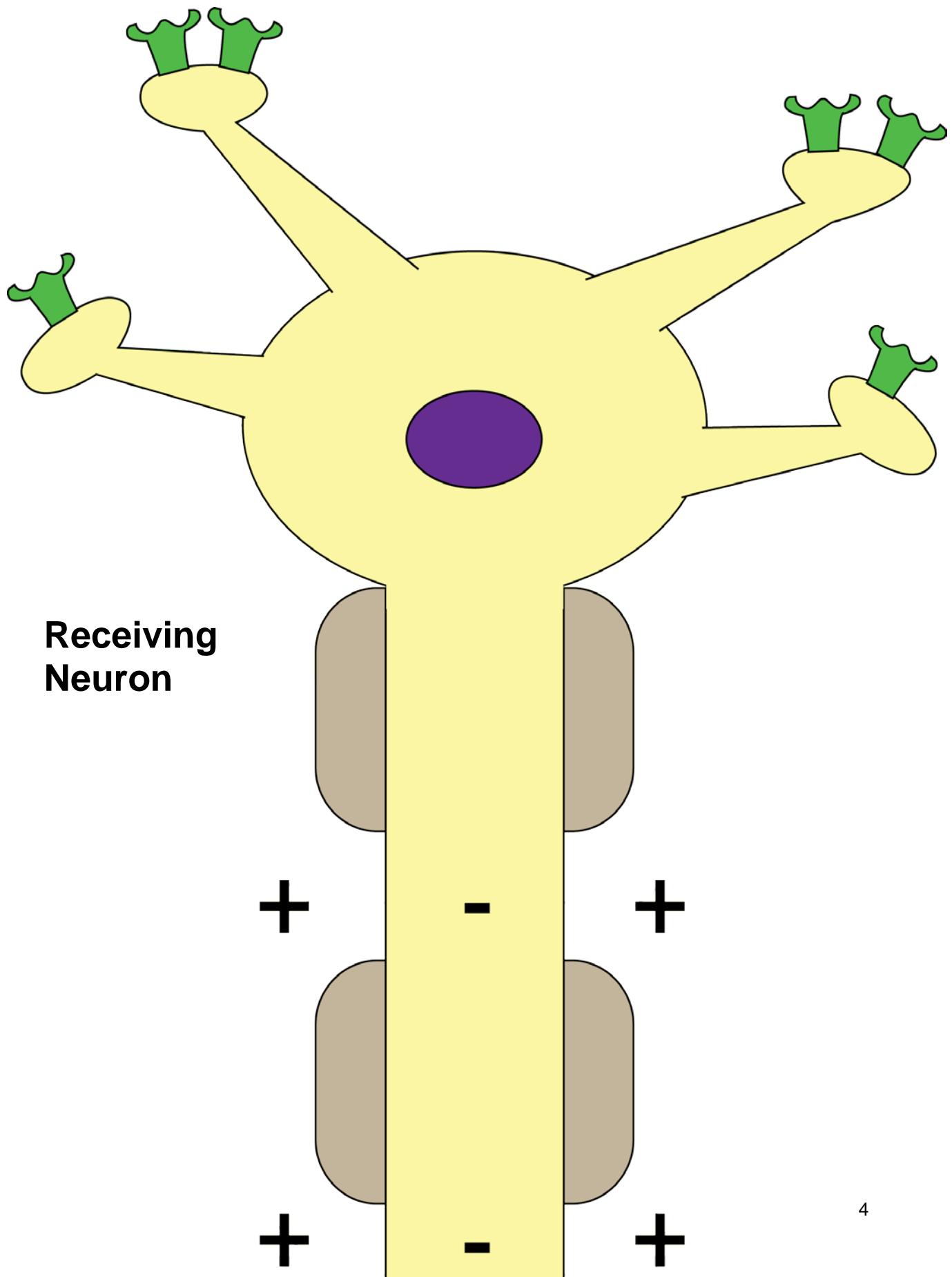
1. Distribute a **Biology Brief: Neurons** to each student.
2. Ask one student to read aloud the information in the **Biology Brief: Neurons**.
3. Explain that, for many people, just listening to or reading the information in the Biology Brief is not enough to really understand and remember the information.
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:
 - o Copy of student instructions **Nerve Cell Communication**
 - o Two large neuron diagrams (one with label boxes and one without label boxes) to teams of 2-4 students.
 - o Bag containing beads, red (+/-) 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.

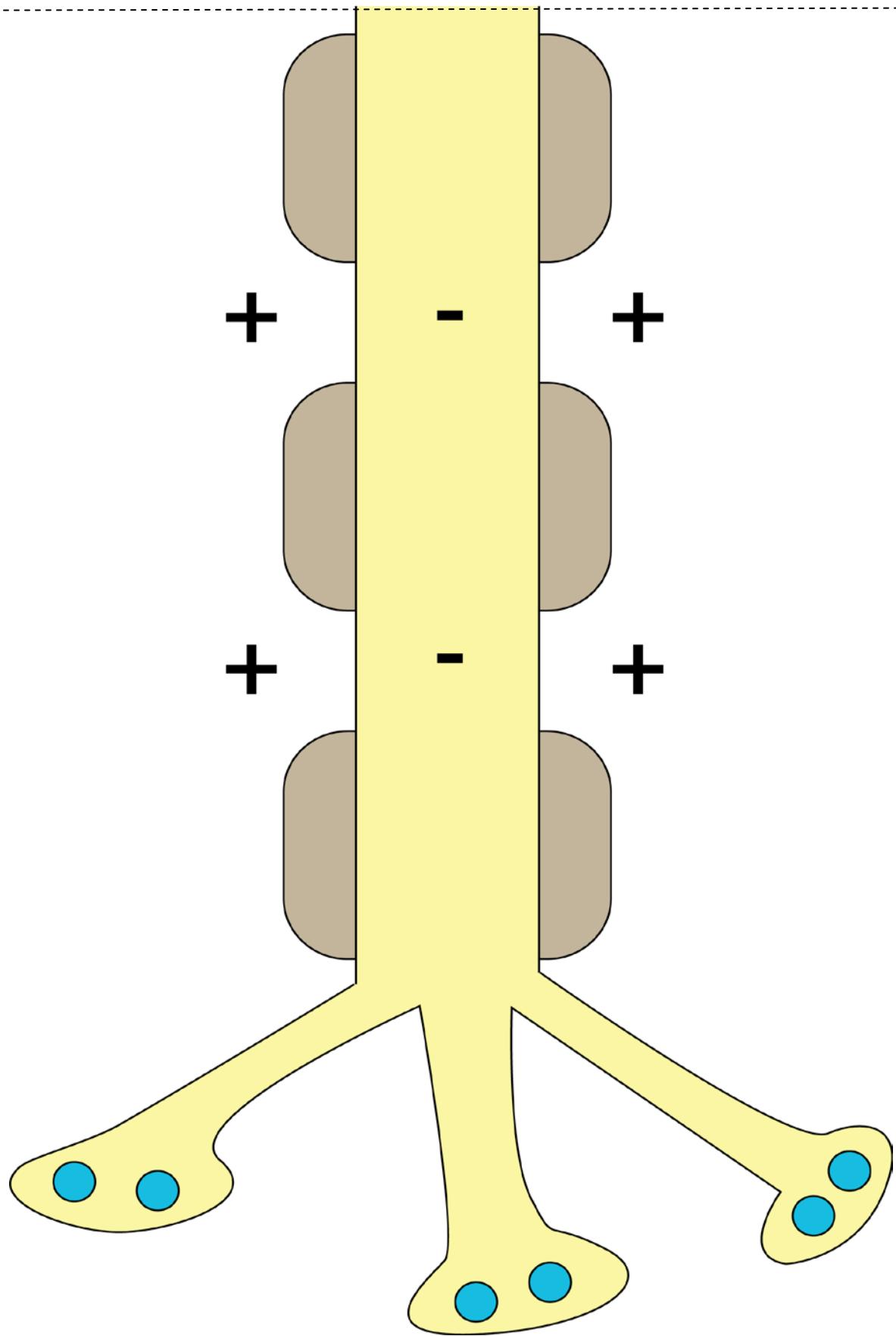
Optional Consider using:

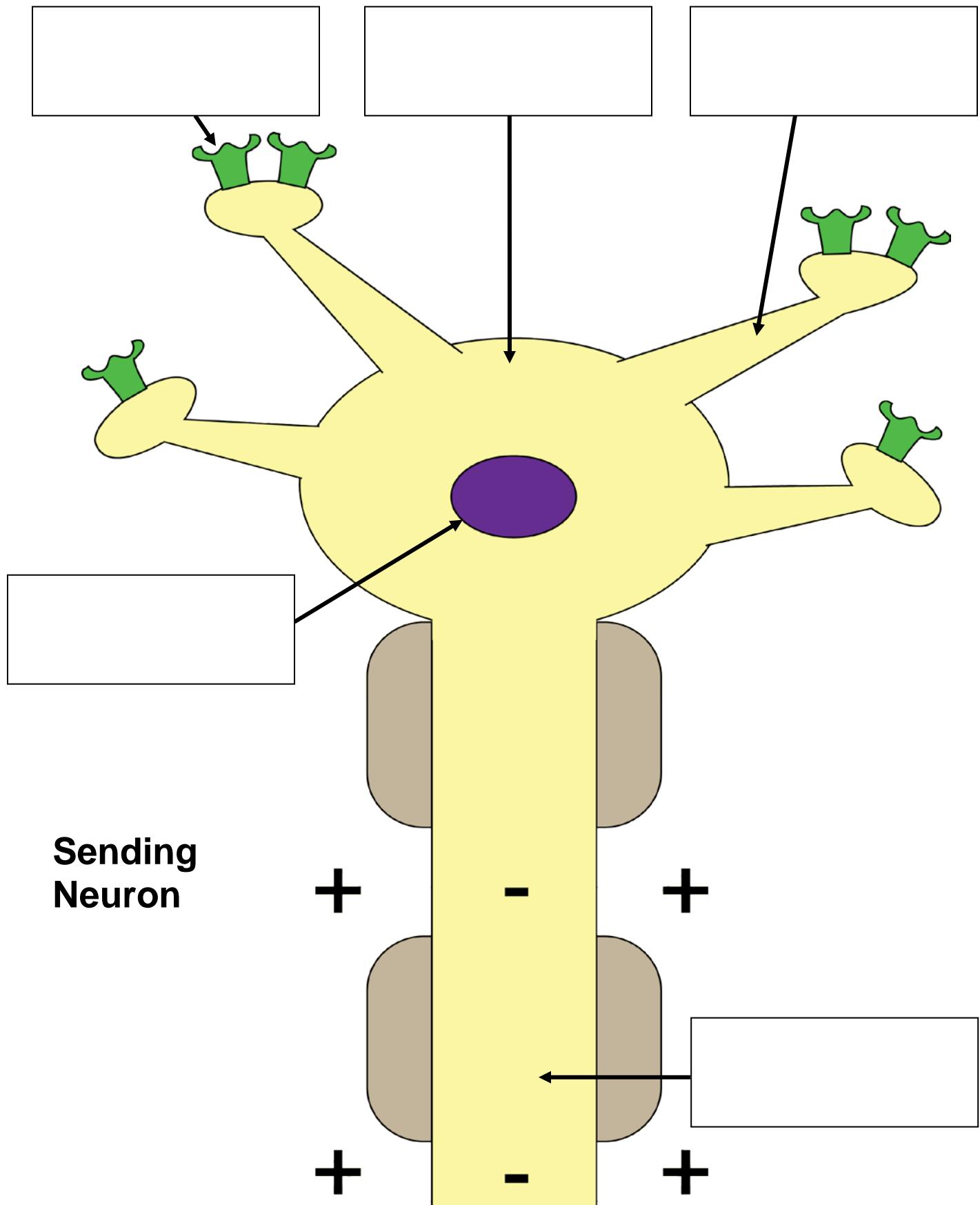
- A Nerve Cell Communication Animation is available for downloading from the Life Sciences Learning Center website. This animation introduces several new terms and concepts including nodes of Ranvier and the recovery that occurs after an impulse has passed a region on the axon.
- The animation ***Crossing 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>

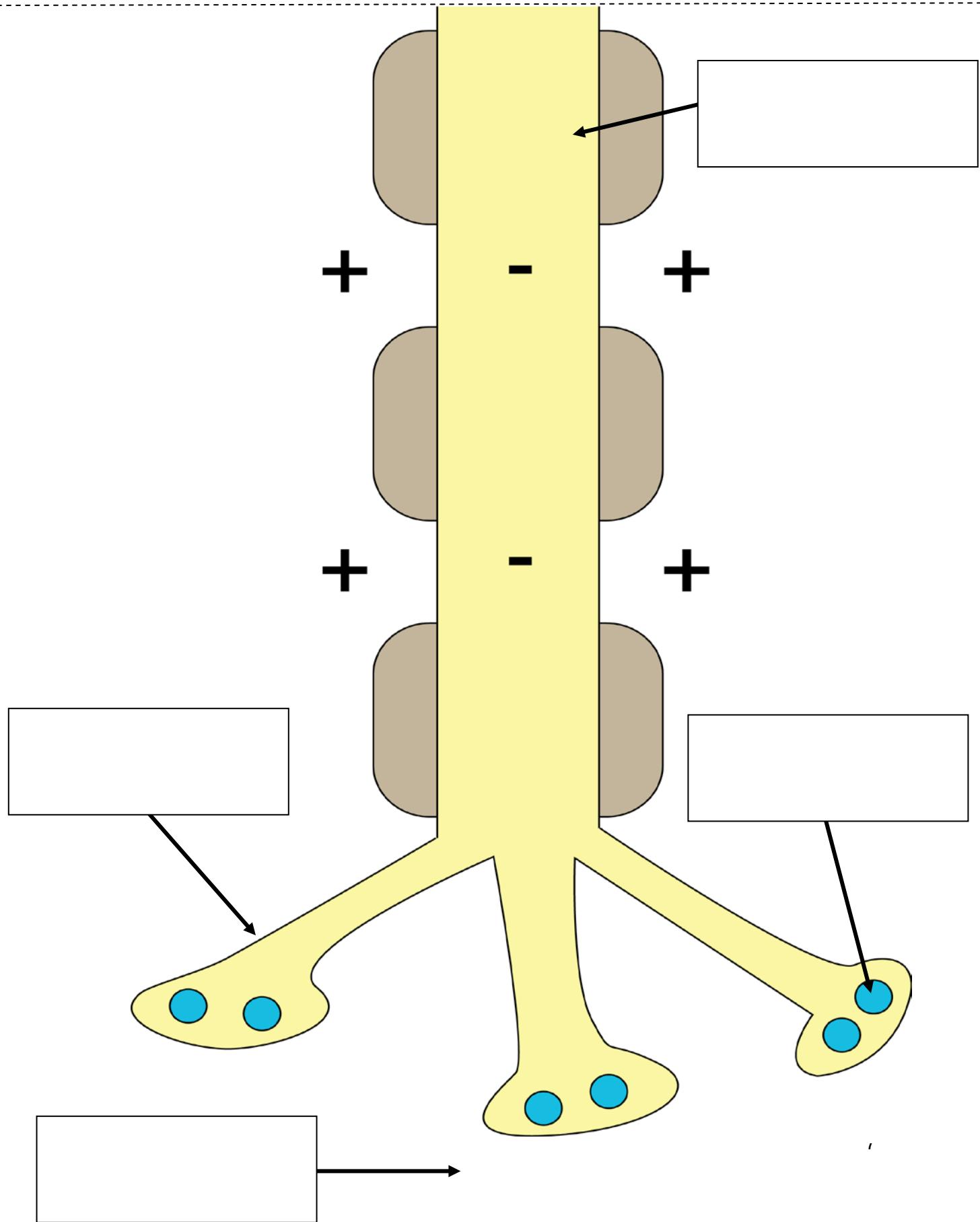
- The Mouse Party activity at <http://learn.genetics.utah.edu/content/addiction/drugs/mouse.html> is both engaging and informative way to explore the effects of different drugs on nerve cell communication. There is a worksheet to accompany this activity at <http://teach.genetics.utah.edu/content/addiction/mouseparty.html>

Credit: Thanks to Kathy Hoppe, Instructional Support Specialist at Monroe-2-Orleans Board of Cooperative Educational Services, who provided the idea for the large neuron manipulative model used in this activity.







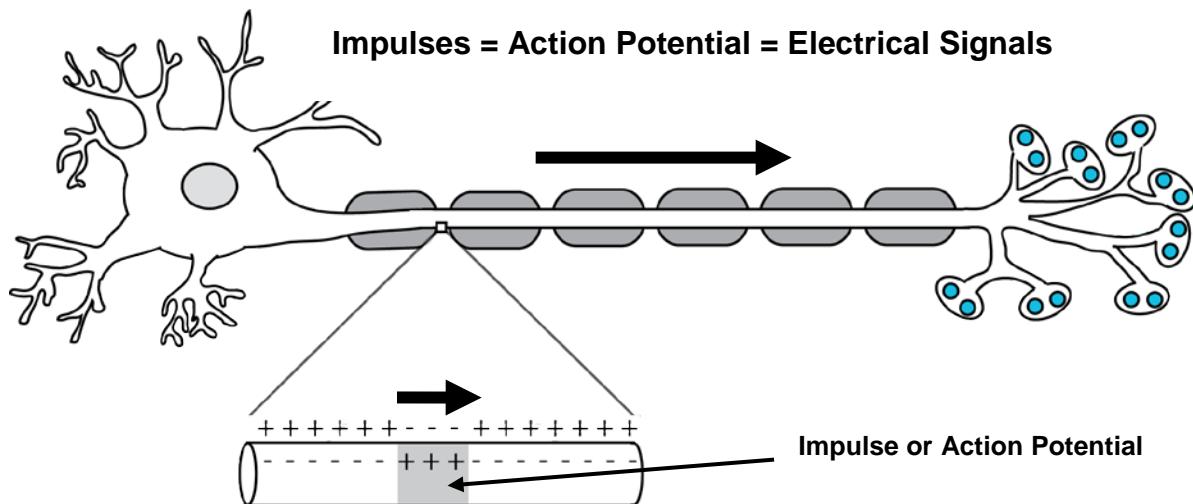


Biology Brief: Neurons

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 signal molecules called neurotransmitters. The chemical signal molecules, called 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.

Biology Brief: Two Types of Neuron Signals

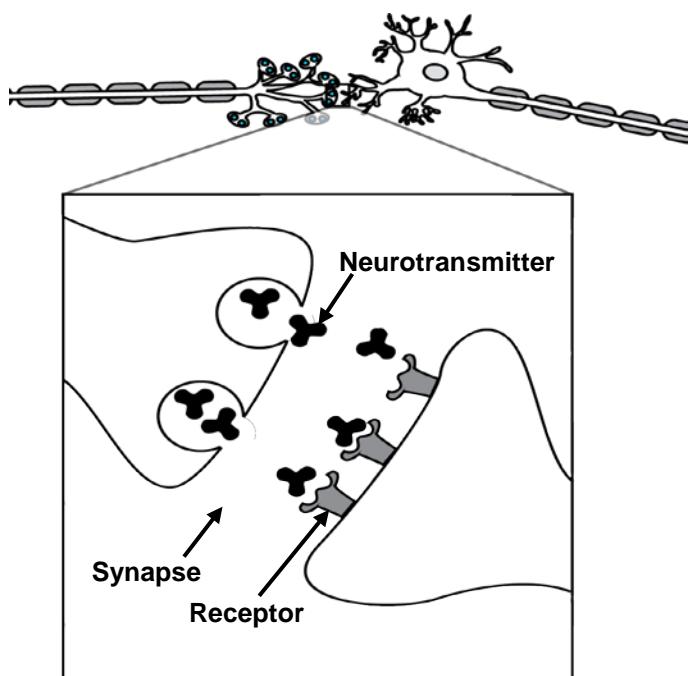
Neurons conduct electrical signals called impulses or action potentials. An impulse is an electrical signal that travels along a neuron. In a resting neuron (one that is not conducting an impulse) the outside of the neuron is positively charged. When the neuron is stimulated, an electrical change causes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

Neurotransmitters = Chemical Signals



Contents of Bag

- 15 Red beads
- 2 White beads
- 2 Yellow beads
- 1 Red card [- + -]
- 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

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Receptor Protein	Myelin Sheath	Nucleus
Cell Body	Terminal Branch	Vesicle
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Function Cards

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

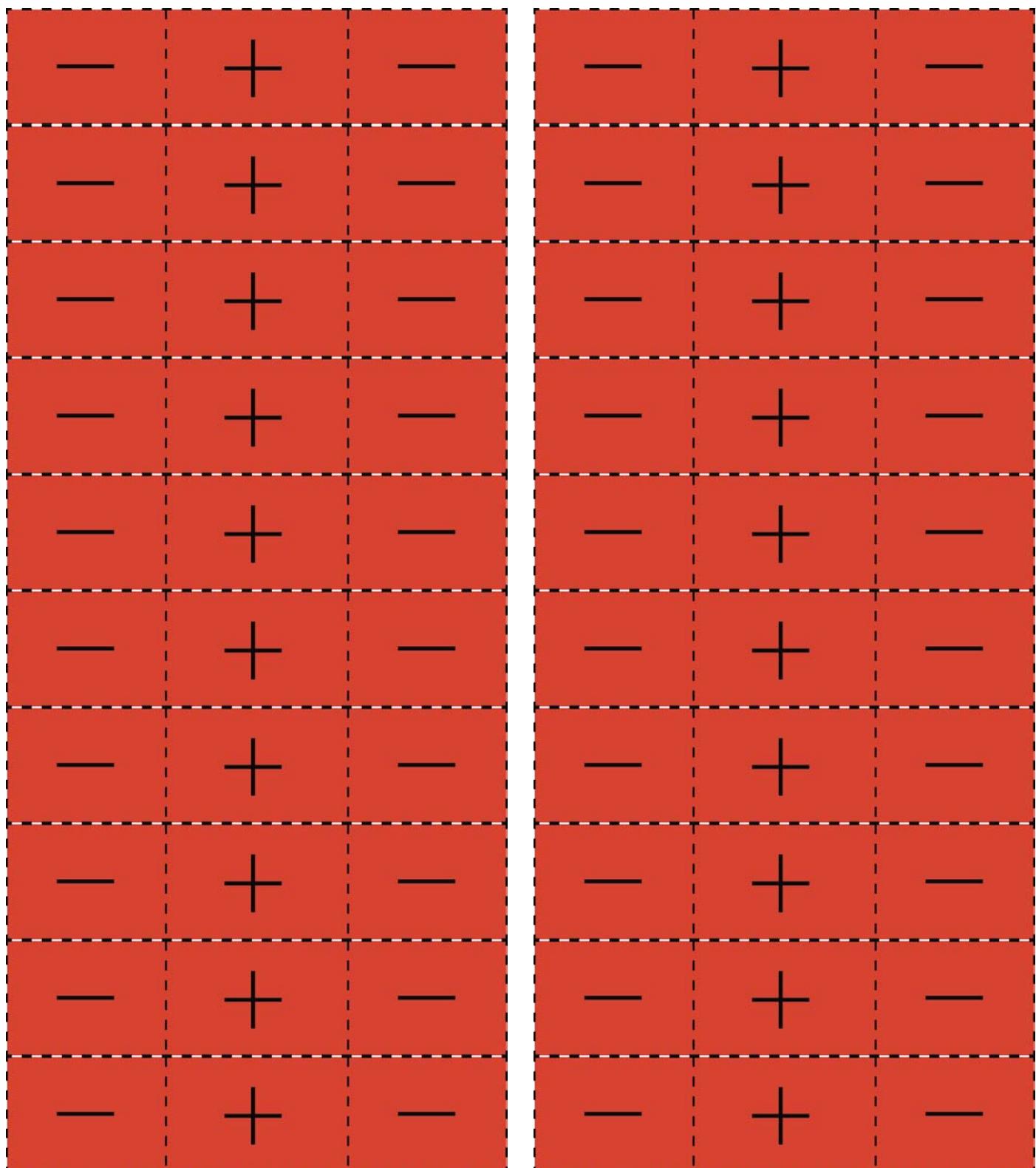
Attaches to chemical signal molecules	Insulates neuron and speeds up impulse conduction	Controls life activities
Carries out life activities	Sends chemical signals to another neuron	Stores and releases chemical signal molecules
Gap between two neurons	Receives chemical signals	Conducts electrical signals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

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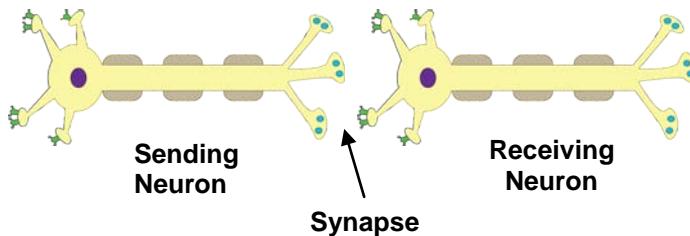
Cut along dotted lines to make red impulse cards (- + -)



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.
2. Obtain the following materials from your teacher:
 - Two large diagrams of neurons—a sending neuron and a receiving neuron.
 - A small bag of white label cards, blue function cards, colored beads, and a red (+/-) 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** on top of the matching white structure cards. For example, place the blue “controls life activities card” on top of 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 bead that you selected (in question 3) into each of the vesicles.
5. Call your teacher over to check your work. TEACHER INITIALS _____

Biology Brief: Neurons

ANSWER KEY

Bold = neuron structure

Underline = neuron function

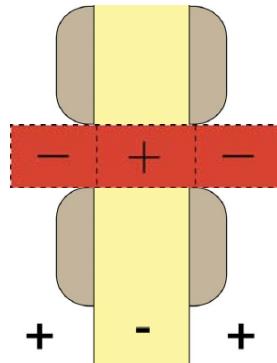
Your nervous system is made up of nerve cells called neurons. Each neuron has a large **cell body** that carries on most of the life activities of the neuron. Inside the cell body is a **nucleus** which controls the life activities of the neuron. Attached to the cell body are short receiving branches 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 signal molecules called neurotransmitters. The chemical signal molecules, called 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**.

Part 3: How do nerve cells communicate?

1. Use the information in the **Biology Brief: Two Types of Neuron Signals** reading to answer the following questions.
2. What are two names for the electrical signal that is conducted along a neuron called?

Impulse or Action Potential

3. Place a red "Impulse" card on one of the dendrites on the sending neuron model. Slide the red 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 called?

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 red 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 message from the sending to the receiving cell?

No, they do not fit into the receptor protein.

16. Some drugs, such as heroin and oxycontin, have a shape that is like the shape of a neurotransmitter. Imagine that someone added some green beads that were the same size and shape as the red beads to the synapse of your model. 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.

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.

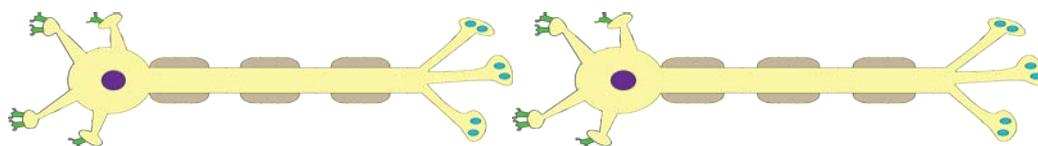
18. There are **reuptake carriers** in the terminal branches that collect neurotransmitter molecules and return them to vesicles in the terminal knobs so that the neurotransmitters do not remain in the synapse and continue to stimulate the receiving neuron.

- Act like a reuptake carrier by returning all of the beads to the vesicles in the terminal knob 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.

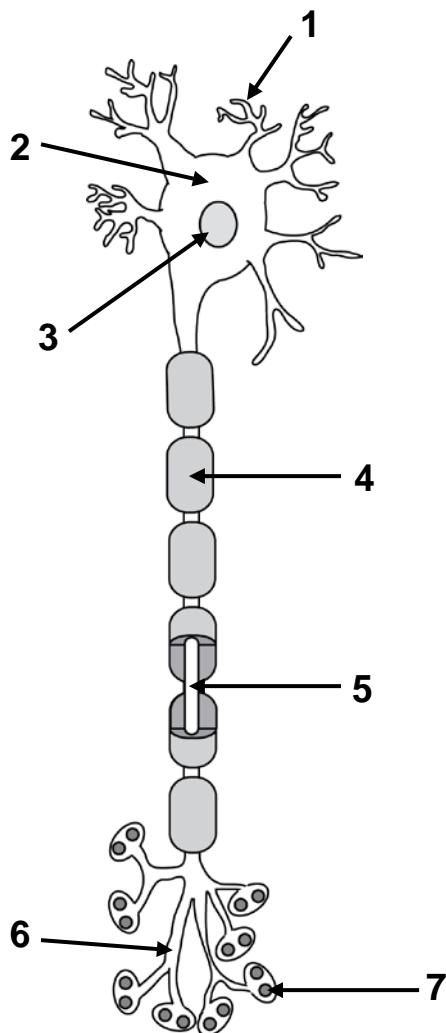


21. Explain why the impulses do not move in the opposite direction on the two neurons.

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**

8. What is the electrical signal that is conducted by a neuron? **Impulse or Action Potential**
9. Which branches of neurons receive chemical signals from other neurons? **Dendrites**
10. Which branches of neurons send chemical signals to other neurons? **Terminal branches**
11. Which branches of neurons conduct 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 on the right.

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 acts like a sound 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.

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

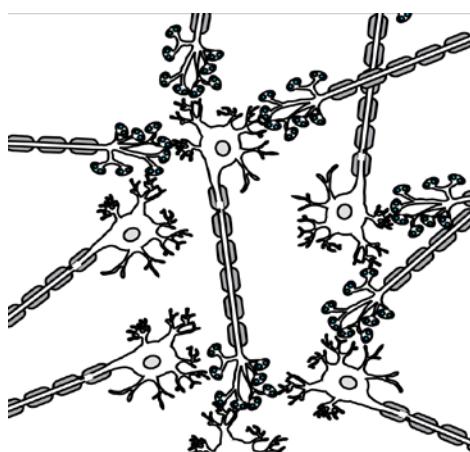
Yes, because its terminal branches may be communicating with dendrites of many other neurons.

People communicating



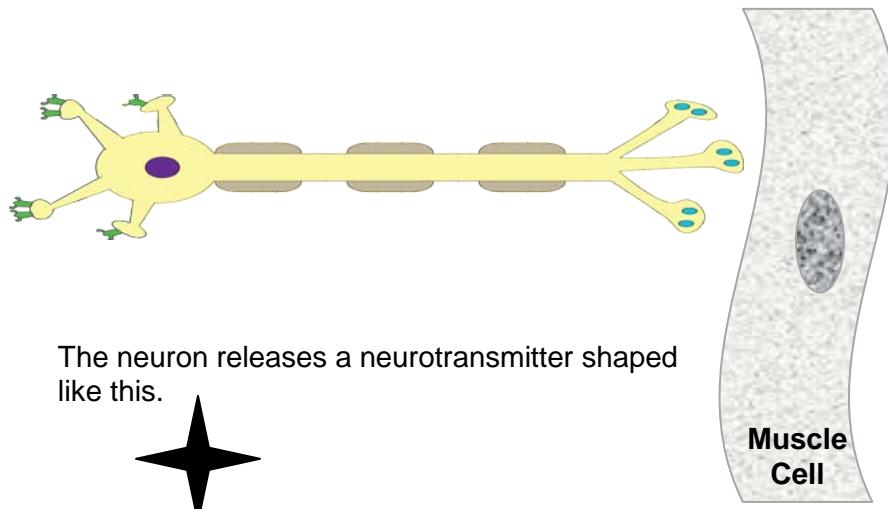
There are billions of neurons in your brain and the branching nerves in your body. Each of these neurons can form synapses with many other neurons.

Neurons communicating



23. Some neurons send messages to other neurons. Other neurons send 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 a message to a muscle cell.



The neuron releases a neurotransmitter shaped like this.



On the muscle cell, 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:

