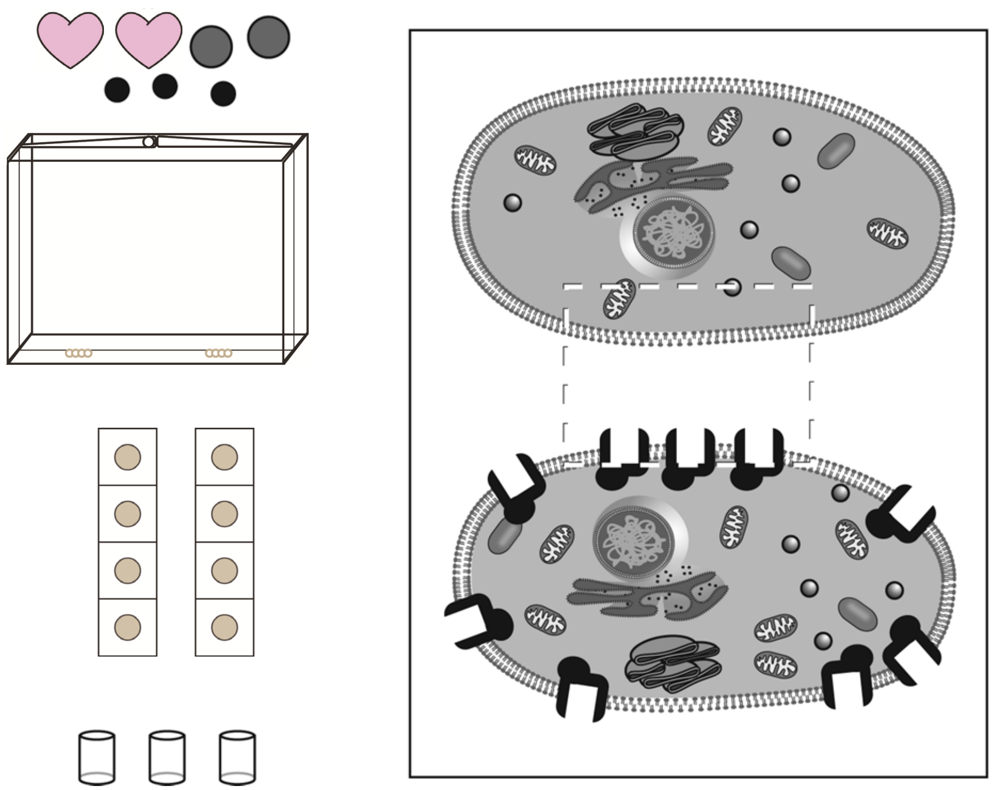
STO–133

Cell Communication

Part 1: Assemble a Cell Communication Model

In this activity you will use a model to explore how cells send, receive, and respond to signals. Then you will use this model to illustrate what happens when there are problems with cell communication.

Use the materials and the **Instructions for Making a Cell Communication Model** in your kit to assemble a cell communication model.



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Part 2: Play with Your Model

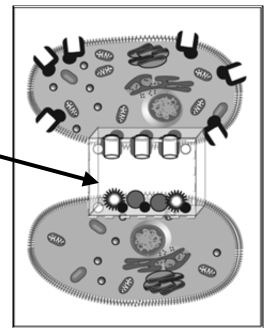
Cells communicate by sending and receiving signals. Most of the signals that cells respond to are molecules (chemicals) produced by one type of cell and received by other types of cells.

1. What parts of your model represents signal molecules?

    ____

2. Tilt your model so that all of the beads are in the signal sending cell.

Beads in Sending Cell

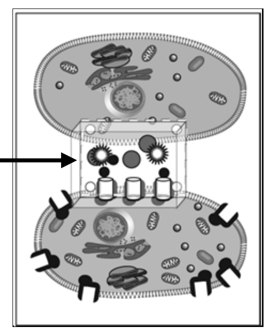


Receiving Cell on Top

Sending Cell on Bottom

3. Then, tilt the model so that the signal molecules travel from the sending cell to the signal receiving cell.

Beads Move from Sending to Receiving Cell



Sending Cell on Top

Receiving Cell on Bottom

4. Receptors are proteins on the plasma membrane of the receiving cell that can bind with signal molecules. What parts of the receiving cell model represents receptors?

    ____

5. Which color of bead represents a specific signal that is recognized by the receiving cell? Explain your answer.

    ____

6. Explain why the other beads represent signal molecules that <u>cannot</u> be recognized by the receiving cell.

    ____

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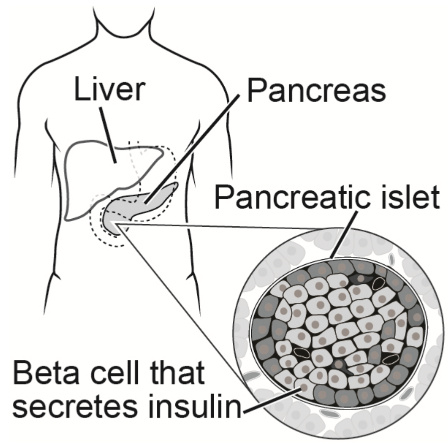
Part 3: Cells Communicate to Regulate Blood Glucose Levels

Regulating Blood Glucose Levels

When you eat and digest food, glucose (sugar) from the food diffuses from your digestive system into your blood. Your blood carries the glucose to all the cells in your body. To remain healthy, you need to keep a normal level of glucose in your blood. Your body uses glucose as a fuel for cellular respiration that provides energy for your life activities.



When the glucose level in your blood increases above normal levels, beta cells in your pancreas detect the glucose and begin secreting insulin, a chemical signal molecule (hormone). Insulin is secreted into the blood and travels in the blood to all cells of the body.

Use the information above and your cell communication model to answer the following questions.

1. What causes the pancreas cells to release insulin?

 ____

2. What part of your model represents insulin hormone molecules?

 ____

3. Which cell (sending or receiving) in your model represents a pancreas cell that secretes the hormone insulin?

 ____

4. What body system carries insulin from the pancreas to all other cells in the body?

 ____

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To receive the insulin signal, body cells have insulin receptors on the outside of their cell membranes. Receptors are like locks into which only keys that have a specific matching shape can fit. Insulin receptors have just the right shape to allow the insulin molecules to bind (attach) to them. The binding of insulin to an insulin receptor causes the receptor to trigger specific changes in the cell's interior.

Use the information above and your cell communication model to answer the following questions.

5. What part of your model represents insulin receptors?

   ____

6. Target cells are cells that receive and respond to a hormone. Which cell (sending or receiving) in your model represents a target cell in the body that will receive the insulin signal?

   ____

7. How do target cells detect the presence of insulin in the bloodstream?

   ____

8. In your model, the red beads are like a _________ (lock or key) that fit into the cups that are like a _________ (lock or key).

9. The pink and green beads represent other types of hormone signal molecules. Explain why the receptors <u>cannot</u> detect the presence of these hormone molecules.

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The binding of insulin to insulin receptors triggers changes in the cytoplasm of the receiving cell.

- All body cells respond to the insulin signal by the opening of glucose transport proteins in the cell membrane to allow glucose to diffuse out of the blood and into the body cells. This movement of glucose from the blood into cells results in decreased blood sugar level.
- In liver and muscle cells, the enzymes that convert glucose into glycogen (long chains of glucose molecules) are activated.
- In adipose (fat storing) cells, the enzymes that convert glucose into fat are activated.

Use the information above and your cell communication model to answer questions 10 through 13.

10. Your lab kit contains a sheet of diagrams entitled **Changes in Receiving Cell Function.** Which diagram represents what happens in membrane receptors of <u>all body cells</u> when insulin binds to the insulin receptors? Write the letter of the card here __________

11. Explain how the binding of insulin to insulin receptors on cells decreases blood sugar level.

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12. To store glucose in liver cells and muscle cells, many glucose molecules are linked together to form larger glycogen molecules. Which diagram represents what also happens in the cytoplasm <u>liver and muscle cells</u> when insulin binds to the insulin receptors? Write the letter of the card here __________

13. Adipose (fat storing) cells convert excess glucose molecules into fat for long term storage. Which diagram represents what happens in the cytoplasm of <u>adipose cells</u> when insulin binds to the insulin receptors? Write the letter of the card here __________

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Part 4: Diabetes - A Cell Communication Problem

People with diabetes have problems with the cell communication that regulates their blood glucose levels. Their blood glucose is too high because glucose cannot get <u>into</u> their body cells. When glucose cannot get into body cells, it stays in the blood.

Approximately 5% to 10% of all people diagnosed with diabetes have **Type 1** diabetes. Type 1 diabetes is called an autoimmune disease because the immune system attacks the person's own pancreas cells. The cells in the pancreas that produce and release insulin are destroyed. Most people with Type 1 diabetes produce little to no insulin. Without insulin, glucose cannot get into the cells and it accumulates in the blood.

Type 2 diabetes accounts for about 90% to 95% of all diagnosed cases of diabetes. People can develop Type 2 diabetes at any age - even during childhood, although most people with Type 2 diabetes are adults. People with Type 2 diabetes produce insulin but their cells do not respond normally to insulin. This problem may be caused by a lack of insulin receptors or by the failure of insulin receptors to trigger changes in the cell function.

Type 1 diabetes occurs when the immune system attacks the insulin-producing cells in the pancreas.

Type 2 diabetes occurs when receptors or receiving cells do not respond normally to insulin signals.

Use the information above and your cell communication model to answer the following questions.

1. Why does Type 1 diabetes result in high blood glucose?

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2. Describe how you could change your model to represent what happens in a person with Type 1 diabetes.

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3. How could Type 1 diabetes be treated? Describe how you could use the model to illustrate this change.

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4. Why does Type 2 diabetes result in high blood glucose?

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5. Describe how you could change your model to represent what happens in a person with Type 2 diabetes.

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6. Why might Type 2 diabetes be more difficult to treat than Type 1 diabetes?

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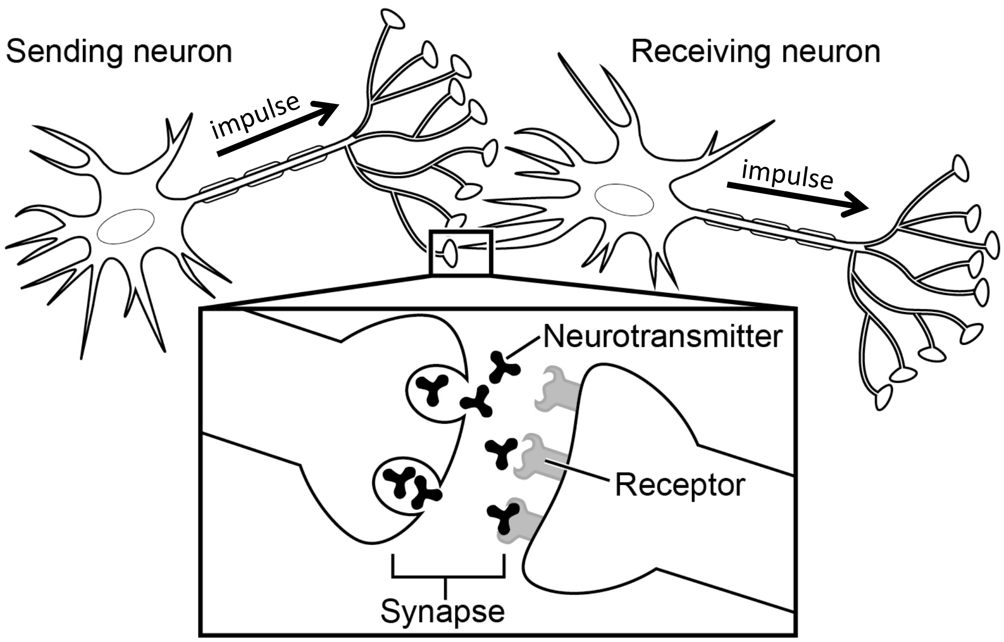
Part 5: Nerve Cell Communication

Your nervous system is made up of nerve cells called neurons. Neurons are long thin cells that carry electrical signals called impulses through your brain and your body. Neurons must be able to communicate with other neurons. But neurons do not touch each other. Instead, they are separated by a tiny gap called a synapse.



When an impulse reaches the end of a sending neuron, it cannot jump across the synapse. To get a signal from one neuron to the next, neurons produce and release signal molecules called neurotransmitters. Neurotransmitters are chemical signals that diffuse across the synapse and bind to receptors on a receiving neuron. The binding of neurotransmitters to receptors has a rapid effect. It causes ion gates on the receiving cell to open allowing Na^+ (sodium) ions to rush into the neuron. This creates a new impulse that can travel along the neuron.

Use the information above and your cell communication model to answer questions 1 through 9.

1. Why can't an impulse (electrical signal) pass directly from one nerve cell to another?

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2. What causes the sending neuron to release the neurotransmitter signal molecule?

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3. Which part of your model could represent neurotransmitters?

____

4. A synapse is a gap between sending and receiving neurons. What part of your model could represent the synapse?

____

5. By what process do the neurotransmitter molecules travel across the synapse?

____

6. What part of your model represents neurotransmitter receptors?

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7. How does the receiving neuron detect the presence of a neurotransmitter signal?

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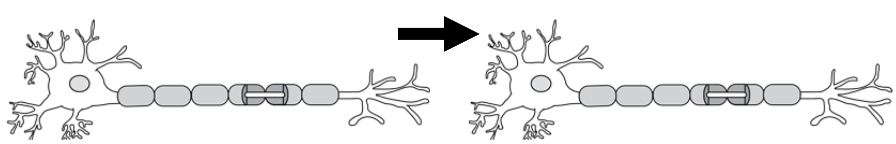
8. Explain why information can only pass in only one direction across the synapse.



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9. When neurotransmitters bind to receptors, ion gates on the surface of the receiving neuron open to allow Na^+ ions to rush into the neuron. This creates an electrical signal called an impulse in the receiving neuron. Which card on the **Changes in Receiving Cell Function** sheet represents what happens when neurotransmitter binds to the neurotransmitter receptors on neurons? Write the letter of the card here ________

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Part 6: Nerve Cell Communication Problems

Endorphins and Opiates

Endorphins are natural feel-good chemicals manufactured in the brain. Neurons in the emotion and pain areas of the brain have specific receptor sites for endorphins. When natural endorphins do their work, a person feels good and feels relief from pain.

Opiate drugs like opium, heroin, codeine and morphine have a chemical structure similar to endorphins. Like an evil twin, the opiate molecules have shapes like natural endorphins. They can bind to the endorphin-receptor sites on neurons in the brain and begin the succession of events that makes a person feel good, high, or euphoric, and feel relief from pain. Opiates are more powerful than the body's natural endorphins because a person can use morphine to get "high" or euphoric, and continued use may lead to addiction.

Use the information above and your cell communication model to answer the following questions.

1. What part of your model represents natural endorphins?

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2. What happens when natural endorphins fit into the receptors on neurons in the emotion and pain centers in a person's brain?

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3. Find the bag labeled "For Part 6" in your lab kit. Which pieces from this bag would best represent opiate drugs? Explain why you selected these pieces.

   ____

   ____

4. Add pieces you selected in question 3 to beads that are already in the model box. Explain how opiate drugs work to relieve pain and make people feel good.

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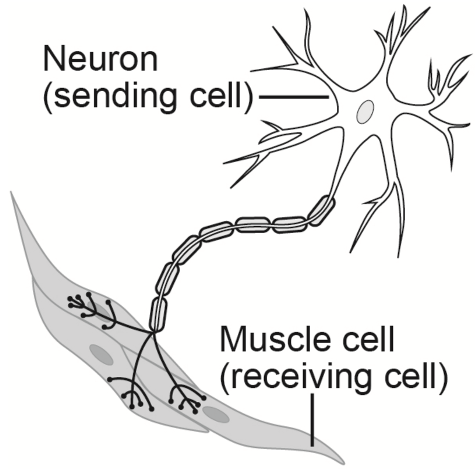
Neurons and Muscles

Normally, to make a muscle contract, neurons release acetylcholine signal molecules. Acetylcholine binds to receptors on muscle cells causing the muscle cells to contract.



Use the information above and your cell communication model to answer the following questions.

5. What part of your model represents acetylcholine molecules released by neurons?

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6. How does the acetylcholine affect muscle cells?

   ____

   ____

7. Botox is a chemical used to prevent muscle contractions that can lead to wrinkled skin. It does this by preventing the release of acetylcholine from nerve cells. How could you change your model to illustrate how Botox paralyzes the muscles that cause wrinkles?

   ____

8. Myasthenia Gravis is a disease that causes muscle weakness. The immune system of people with the Myasthenia Gravis mistakenly produces antibodies that attack and block the acetylcholine receptors on their muscle cells. Find the bag labeled "For Part 6" in your lab kit. Represent the effect of antibodies on muscle cells by permanently blocking (plugging) the tiny cups with the small sponges.

9. Explain why the production of antibodies that attack acetylcholine receptors causes muscle paralysis.

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