SENDING AND RECEIVING MESSAGES

Module 3

Guide to Module 3:

Sending and Receiving Messages

Introduction

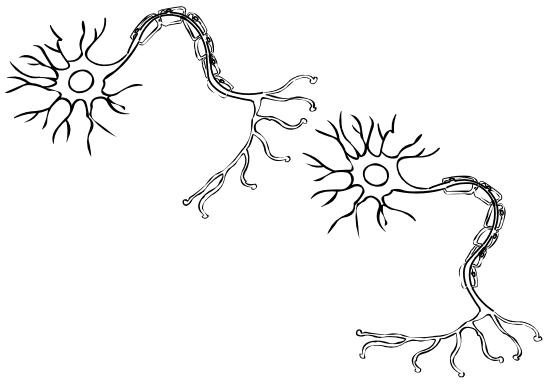
In module 1, students learned how to use scientific inquiry to solve problems. In module 2, they learned about four key parts of the brain and what each part does. During the third mission, students will simulate the process of neurotransmission: how information gets to and from the brain.

Learning Objectives

- Students simulate neurotransmission.
- Students discover how messages travel throughout the body.
- Students learn about the relationship between the brain and the rest of the nervous system.

Relationship to the *National Science Education Standards*

This mission aligns with two standards identified in the NSES: unifying concepts and processes and science as inquiry. (They use only parts of scientific inquiry for this mission.) The charts on the next page identify how the mission aligns with each of these standards.

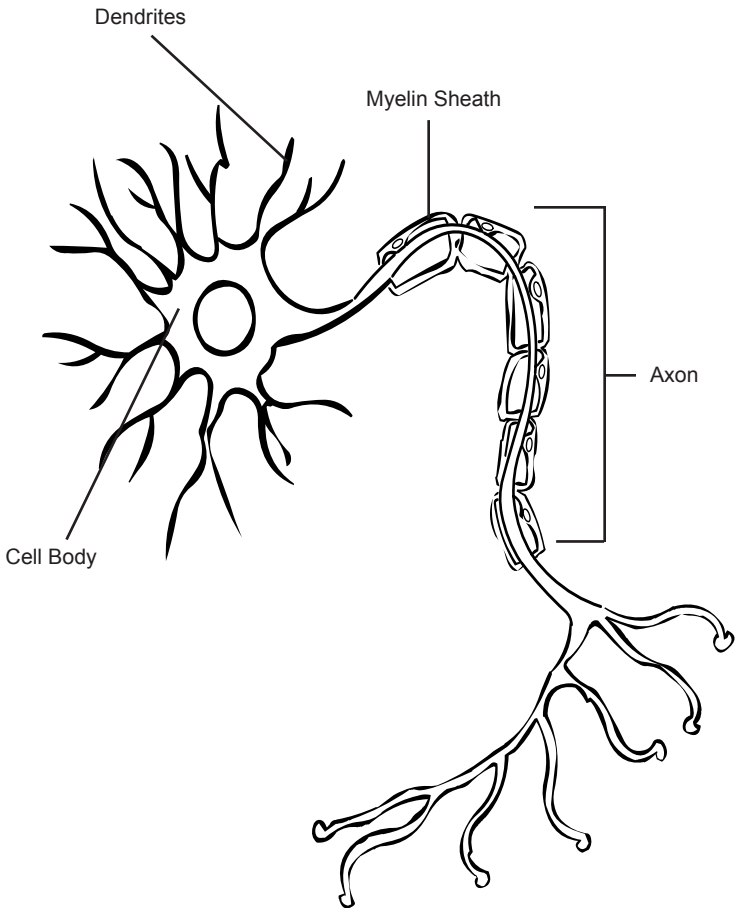


UNIFYING CONCEPTS AND PROCESSES	
Levels K–4	**How Mission is Aligned**
Systems, order, and organization	This mission builds on what students learned in module 2 about the brain as a system by illustrating how neurotransmission is part of that system. Students begin to understand how the brain works with the other parts of the nervous system to perform many key functions.
SCIENCE AS INQUIRY	
Levels K–4	**How Mission is Aligned**
Abilities necessary to do scientific inquiry	Students go through some of the steps of scientific inquiry: observing, making predictions, completing an investigation to test their predictions, illustrating a concept, and drawing conclusions.

Background

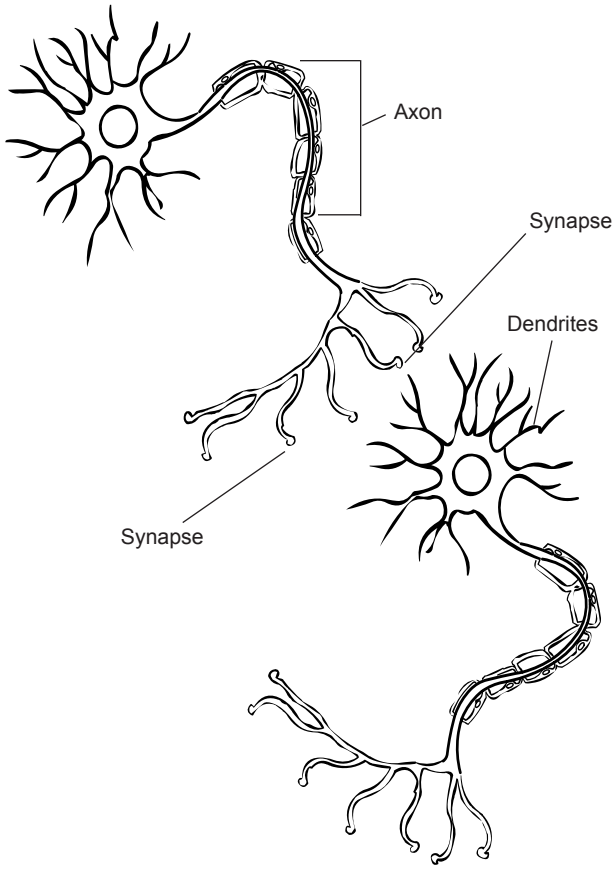
Messages, in the form of electrical impulses, constantly travel back and forth between the brain and other parts of the body. A special cell called a *neuron* is responsible for carrying these messages. There are about 100 billion neurons in the human brain.

A neuron has three main parts. The *cell body* directs all activities of the neuron. *Dendrites* extend out from the cell body and receive messages from other nerve cells. An *axon* is a long single fiber that transmits messages from the cell body to the dendrites of other neurons or to other body tissues, such as muscles. A protective covering called the *myelin sheath*, covers most neurons. Myelin insulates the axon and helps nerve signals travel faster and farther.

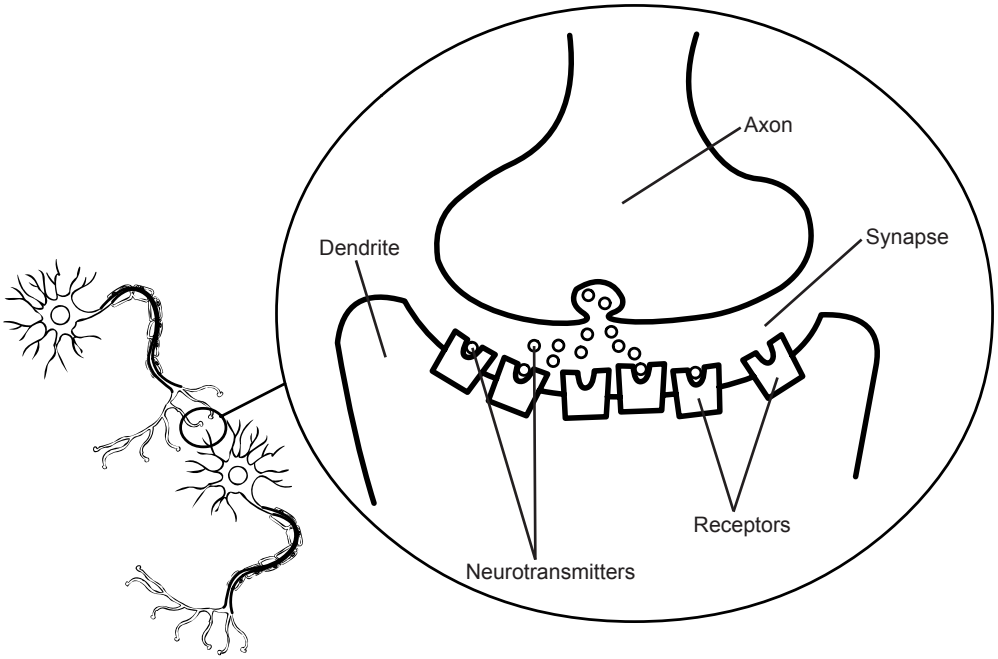


Messages travel along a single neuron as electrical impulses, but messages between neurons travel differently. The transfer of information from neuron to neuron takes place through the release of chemical substances into the space between the axon and the dendrites. These chemicals are called *neurotransmitters,* and the process is called *neurotransmission*. The space between the axon and the dendrites is called the *synapse*.

When neurons communicate, an electrical impulse triggers the release of neurotransmitters from the axon into the synapse. The neurotransmitters cross the synapse and bind to special molecules on the other side, called *receptors.* Receptors are located on the dendrites. Receptors receive and process the message.



What's particularly interesting about neurotransmission is that each neurotransmitter can bind only to a very specific matching receptor. A neurotransmitter binds to a receptor in much the same way a key fits into a lock. After transmission has occurred, the neurotransmitter is either broken down by an enzyme (a chemical that speeds up some of the body's processes) or is reabsorbed into the neuron that released it. The reabsorbed neurotransmitters can be reused at a later time.

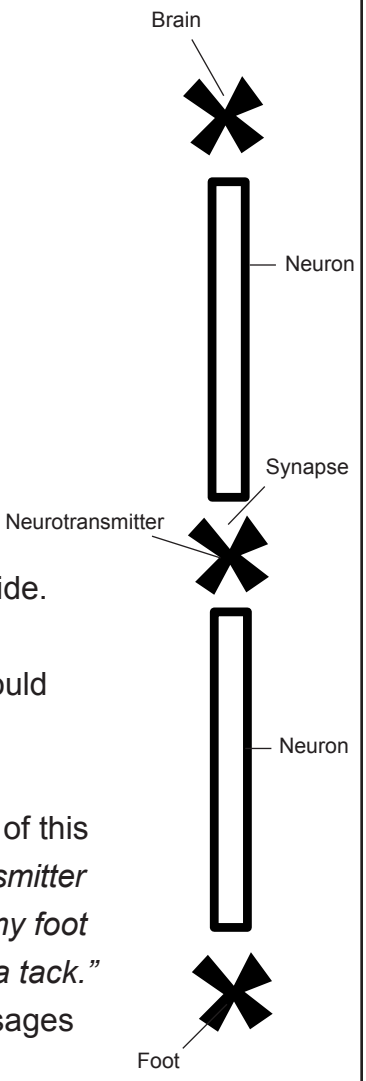


Materials

NIDA Junior Scientists DVD
One set of signs for each group
- 6 *Neuron Team* signs
- 1 *Neurotransmitter* sign
- 1 *Sore foot* sign
- 1 *Brain* sign

One set of messages for each group
- 1 *"Why does my foot hurt?"* message
- 1 *"Sit down. You hurt your foot on a tack."* message

Log sheets
Instruction sheets
Paper and pencils
Masking tape



Preparation

1. To familiarize yourself with the subject of neurotransmission, read the Background section of this guide.

2. If possible, reserve the gym or all-purpose room. Or you could do this activity outside on the blacktop.

3. Make copies of the messages and signs found at the back of this guide. You will need six *Neuron Team* signs, one *Neurotransmitter* sign, one *Sore Foot* sign, one *Brain* sign, one *"Why does my foot hurt?"* message, and *one "Sit down. You hurt your foot on a tack."* message for each group. The students will use these messages during the activity.

You may want to have parent volunteers or instructional assistants help set up the classroom for this activity.

Try to have at least one other adult in the room while the children are working on the activity.

4. Set up and label three areas of the room for this activity as shown on the previous page. Each area has a set of two lines of masking tape with a space between the rows. Each masking tape row represents a neuron. The space between "neurons" represents a synapse. (Refer to the diagram on the following page.)

5. Divide the class into groups of nine students, who will be working together as a team. If you have "extra" children, add them as extra members of a neuron team.

Procedure

1. Conduct a brainstorming session about how students think messages are carried throughout the body. For example, ask students the following: How does your brain "know" to perform an activity, such as raise your head? When we talk about messages traveling, what do we mean? Do you know what a neurotransmitter is? Write down any ideas students may have. Don't be surprised if they don't know too much about this process.

2. Before beginning the activity, briefly explain neurotransmission. Explain what the terms "neuron" and "neurotransmission" mean. You may want to show the first part of the DVD to accomplish this goal.

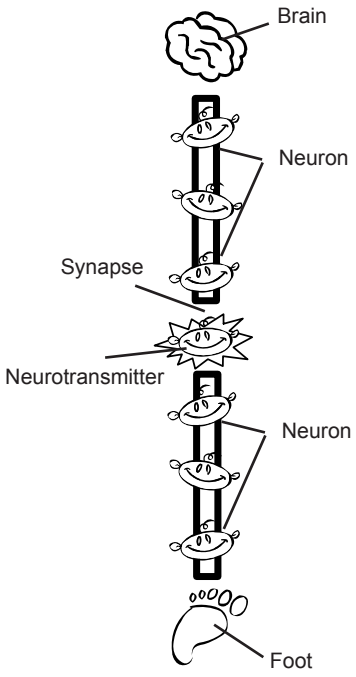
3. Tell each group of nine students to go to an activity area. In each area, have three students sit in each masking-tape outlined area. Tell them that they are a neuron team and give each student a *Neuron Team* sign. Each group of three represents one neuron.

4. Designate one student at each area as the neurotransmitter student. Have each neurotransmitter student sit in the space between the rows of masking tape. Give the neurotransmitter students their signs.

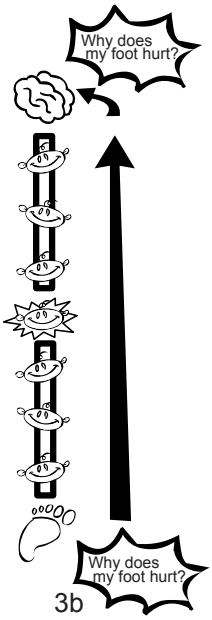
5. Then designate one student at each area as a person with a sore foot and one student as the brain, where the information is processed. The sore foot student should stand at one end of the neurons, and the brain should stand at the other end. (Refer to diagram 3a.)

6. Hand the student with the sore foot the message that says, “Why does my foot hurt?” Have the student begin the activity by pretending to have a sore foot. Then have the “foot” student hand the message to the first member of the neuron team.

7. Have the students quickly send the message down the line of neuron team members. The last student hands the message to the neurotransmitter student. After receiving the message, he or she gets up and hands it to the next neuron team. This neuron team leads to the brain. When the message reaches the last member of the neuron team, he or she gets up and hands the message to the student pretending to be the brain. (Refer to diagram 3b.)



3a



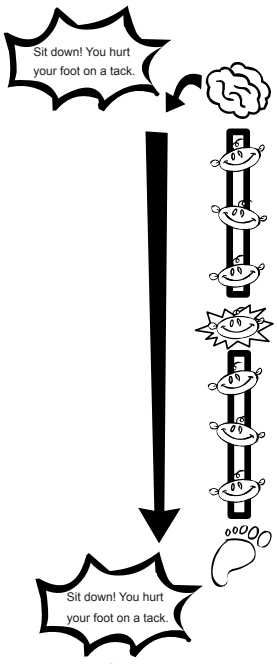
3b

8. When the "brain" receives the message, that student quickly exchanges it for the message saying, "Sit down. You hurt your foot on a tack." The message then proceeds down the line of students back to the student with a sore foot.

9. When the student with the sore foot reads the message, he or she discovers why his or her foot hurts and what to do about it. (Refer to diagram 3c.)

10. Have students go through the simulation one more time. They may want to switch roles the second time around or think of other messages to send.

11. **CONGRATULATIONS! YOUR STUDENTS HAVE JUST COMPLETED MISSION 3 OF *BRAIN POWER!***



3c

Discussion Questions

1. Using the simulation, have the students describe how they think messages travel throughout the body. Give several students an opportunity to explain the process in their own words.

2. Have the students think of different kinds of messages that travel throughout their bodies. Examples include the following:

    - What am I touching?
    - What is that sound?
    - Is the water hot or cold?

3. To reinforce what students learned, show the second segment of the DVD again. Then have the students figure out which part of the brain the message is going to. They may want to identify each section on their models of the brain.

Extensions

The activities listed below provide a link to other areas in the curriculum. These activities also make use of the trading cards included in the module.


Language arts


Art


Reading


Math


Science


Drama

1. Work with your students to develop a class newspaper. Ask the groups to write articles about the parts of the brain, what each part does, how messages travel throughout the body, and how the brain works with the nervous system to perform key functions.

2. Ask the students to guess how many neurons they think are in their bodies. Then write down the answer—100 billion (100,000,000,000). Discuss why so many neurons are needed. Then point out that each neuron has about 10,000 contacts with other neurons. Help the students grasp the enormity of this communication system.

3. Divide the students into groups and have each group draw a large poster showing the vast communication networks in our nervous system. They also may want to draw an outline of the human body and put the brain in the head. Then they can use string to show the relationship between the brain and other parts of the body. They also may want to compare our internal network to telephone wires, the power grid, or the Internet. Encourage each group to develop its own way to explain this network.

Assessment

1. Neurotransmission is a very difficult subject and may be a challenge for some second- and third-grade students. Our goal is for each student to understand by the end of the activity that messages travel from different parts of the body to the brain, where they are processed and sent back through the body.

2. In addition, look for the following indicators of understanding of key concepts:

    - Are the students able to simulate neurotransmission without difficulty? Can they describe in their own words how neurotransmission works?

    - Are the students able to apply what they learned to another message, such as "What does the flower smell like?"

    - Are students able to explain in pictures or words how neurotransmission works?

3. Put each student's log sheet in his or her student portfolio.

Additional Activities

Below are some additional activities that can be used after completion of the third mission. These activities are extensions to many other areas of the curriculum.

1. Divide the students into pairs and give each pair a set of trading cards. Have the pairs read the cards together and discuss them. Ask them if they have a favorite card. If so, have them give reasons for their choice.

2. Have each student design a trading card. The cards can show an activity, a brain, or a picture of how messages travel. Encourage students to use what they learned in the previous two modules when developing their trading cards.

3. Play neuroscience "Jeopardy." Possible categories could be "Scientific Inquiry," "Parts of the Brain," "How Messages Travel," and "Different Kinds of Scientists." Using all the materials learned to date, develop questions in each category. This is a good way to find out how much students have learned.

4. Have students make a three-dimensional communication network in your classroom. Have students create connections using string or rope to show how information travels. Make sure that students have messages traveling in one direction to a location designated as the brain, then back in the other direction.

5. Put on a class play about how messages travel throughout the body. Encourage students to create a scenario where having messages travel fast makes a big difference. For example, smelling smoke and then calling 911 prevents a house from burning down.

Resources

The lists below include resources for teachers and students.

Resources for Teachers

National Institute on Drug Abuse (NIDA)
www.drugabuse.gov, 301-443-1124
drugpubs.drugabuse.gov/
This Web site contains information about drug abuse as well as a section designed specifically for parents, teachers, and students.

NIDA Drug Pubs
drugpubs.drugabuse.gov, 1-877-NIDA-NIH (1-877-643-2644)
Drug Pubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

National Clearinghouse for Alcohol and Drug Information (NCADI)
http://store.samhsa.gov, 1-800-729-6686
NCADI provides information and materials on substance abuse. Many free publications are available here.

Nicholls, J.G., Wallace, B.G., Fuchs, P.A., & Martin, A.R. *From Neuron to Brain*. Sunderland, MA, Sinauer Associates, 2001. Developed for readers with an interest in the human nervous system with little or no background in the biological sciences; describes how nerve cells transmit signals and messages.

Woolsey, T.A., Hanaway, J., & Gado, M.H., *The Brain Atlas: A Visual Guide to the Human Central Nervous System*. Hoboken, New Jersey, John Wiley & Sons: Fitzgerald Science, 2003. This book is a comprehensive and accurate atlas of the brain. It includes nearly 400 images of the brain and its pathways.

History of Neuroscience
http://faculty.washington.edu/chudler/hist.html
Lists the history of neuroscience from 4000 B.C. to the present.

Resources for Students

Friedman, D. *Focus on Drugs and the Brain*. Frederick, MD: Twenty-First Century Books, 1990. Part of the "Drug-Alert Book" series; gives a good overview of the brain, neurotransmission, effects of drugs on the brain, and addiction.

Neuroscience for Kids
http://faculty.washington.edu/chudler/neurok.html
Contains information on the brain and neurotransmission, activities, experiments, pictures, and other resources for students and educators.

Student Instruction Sheet

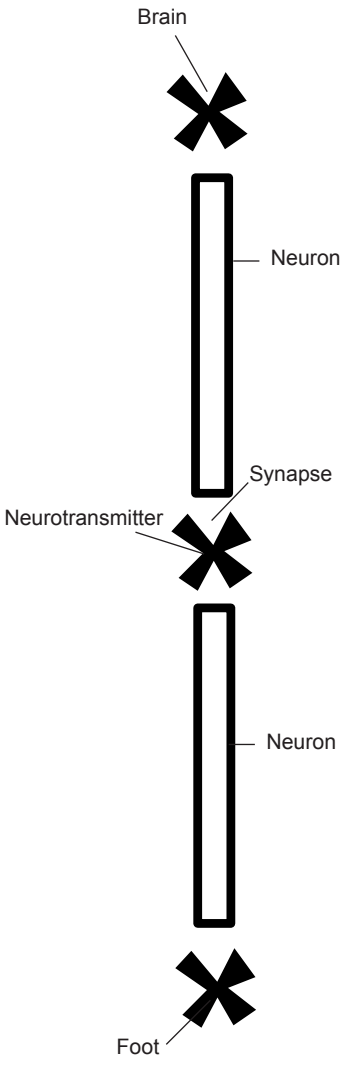
Module 3: Sending and Receiving Messages

1. How does your leg know when to move while walking?
   How does your arm know when you want to raise your hand? How are messages sent and received throughout the body? Think about these questions. Share your thoughts with your classmates. Your teacher will write your ideas on a chart.

2. You will be working in teams of nine at activity areas set up around the room. Go to an activity area with your teammates.

3. Three students will sit along each area marked by the masking tape. They are a *neuron* team. One student will sit between two neuron teams. He or she is pretending to be a chemical called a *neurotransmitter.* One student will be the "sore foot." Another student will be the "brain." Your teacher will tell you what to do and give you signs to hold. (Refer to the diagram.)

4. Your teacher will give the "sore foot" student the message that says, "Why does my foot hurt?" He or she hands the message to the first member of the neuron team.



5. The message should go to the other two students on the team. The last neuron team member hands the message to the neurotransmitter student in the middle.

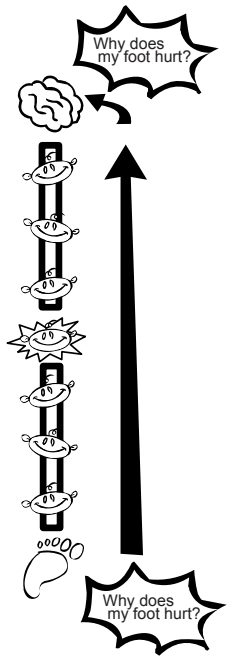
6. The neurotransmitter student gets up and hands the message to the next team of three students. This team sends the message to the brain. When the message reaches the last member of the neuron team, that student gets up and hands it to the student acting as the brain.

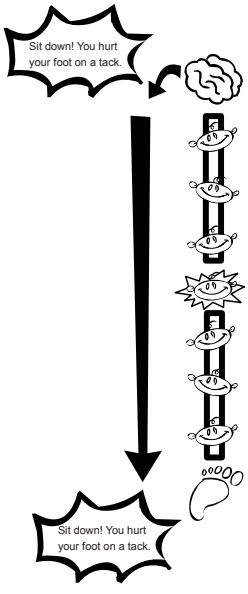
7. When the brain receives the message, that student exchanges it for another message. The new message says, “Sit down. You hurt your foot on a tack.” Send the message back to the student pretending to have a sore foot.

8. Now the student with the sore foot knows what to do.

9. You may want to go through these steps one more time. This stuff is tricky—but you can do it!

10. **CONGRATULATIONS! YOU HAVE JUST COMPLETED MISSION 3 OF *BRAIN POWER!***





If you do not have a DVD player, read this story to your class to introduce the mission.

Introductory Story for Module 3

"Oh, no," said Beth, looking at the flashing light of the *Brain Power!* answering machine. "I bet that means trouble. I'd better listen to it and see what's going on."

"Hi, Brain Storm. It's me, Teaser," said the voice on the answering machine. "I'm going to be a little late because I hurt my foot, and my mom wants me to get it checked out. I'll be there soon."

"I hope he's all right," Beth said to herself.

Just then, she heard dinging from the computer. Who should appear but Corty!

"Oh, Corty," said Beth. "Did you hear about Brain Teaser? Isn't it the worst news?"

"Yes, but it just so happens that it leads in really nicely to your next mission."

"What do you mean?" Beth asked.

"NIDA wants you to find out how Teaser knew that his foot hurt."

"That's easy," Beth replied. "He just, I mean, wow, it just hurt. Now I see what you mean. That is a good question. But I don't want to do the mission without Brain Teaser."

Just then, Kevin—Brain Teaser—came limping into the clubhouse.

"Hi, guys," said Kevin. "I'm back."

"Good to see you," Corty and Beth said together. "Are you ready to get started?"
"Sure. Now what's this I hear about NIDA Mission Control wanting us to find out how my brain knew

that I had hurt my foot? If that's the only question, I already know the answer. My brain heard me say, 'Ouch.'"

"Very funny. Somehow, I think it's more complicated than that," said Beth.

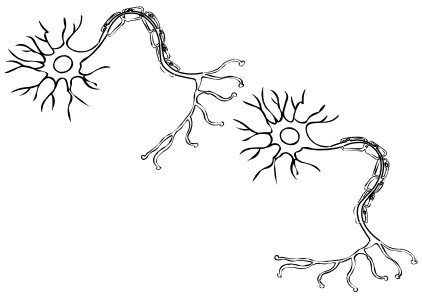
"You're right, Beth. It is," said Corty. "The way to find out how messages travel is to act it out. Here's what you should do. Kevin, you pretend you're a foot."

"A what?" asked Kevin.

"A foot," Corty calmly replied. "Beth, you be the brain. And now we need help from all those kids watching this DVD. Ask your teacher how to play the game. You'll need kids pretending to be neurons and a neurotransmitter, as well as a foot and a brain. If none of this makes sense to you right now, don't worry. It will soon."

Beth and Kevin nodded their heads in agreement. "Have fun," shouted Brain Storm and Brain Teaser. "And one more thing. What you're about to find out is really cool."

Log Sheet



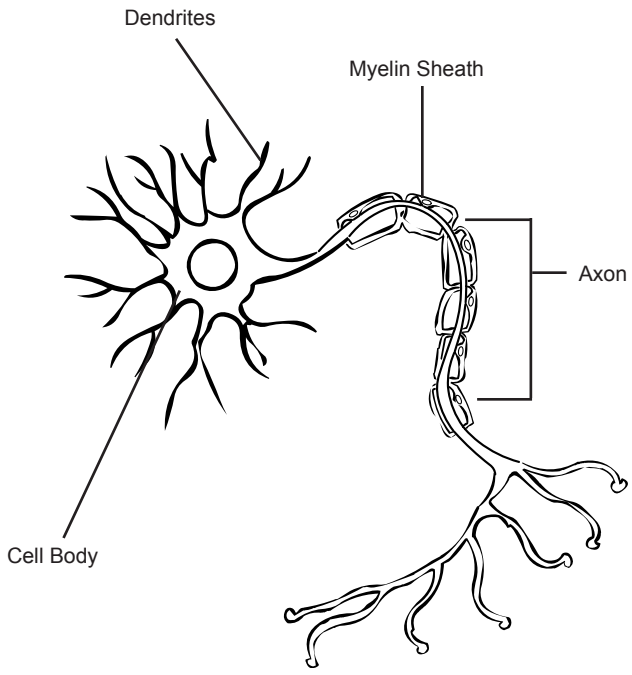
Name:_____

My picture of neurotransmission

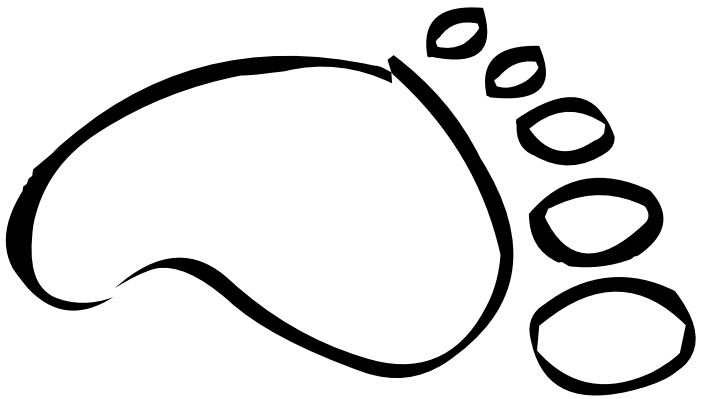
Questions I have about neurotransmission

What I learned about neurotransmission

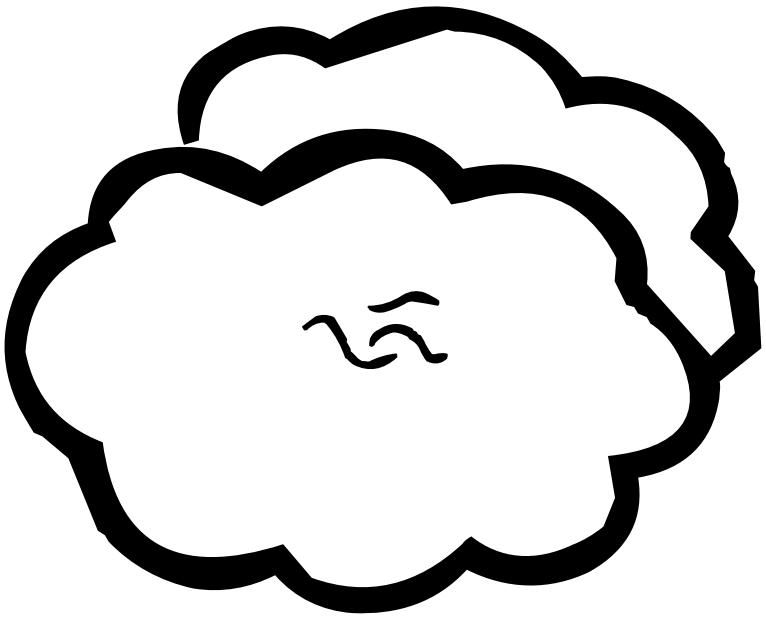
Neuron Team



Sore Foot



Brain



BRAIN POWER NEWS

Parent Newsletter

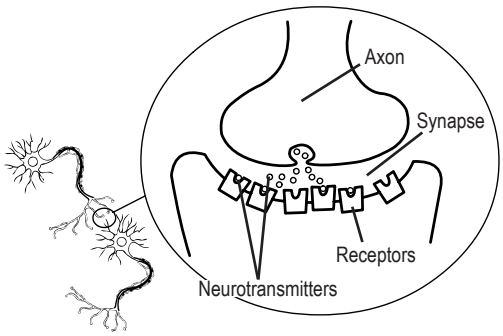
Volume 1, Number 3

Sending and Receiving Messages

How do we know if we hurt our foot? The way the brain receives information like this is explained in module 3 of the NIDA Junior Scientists Program.

Messages are sent throughout the body and received by the brain through a process called *neurotransmission*. The drawing below explains how neurotransmission works.

1. The cells shown here are called *neurons*. There are billions of neurons throughout the body. The illustration in the circle is an example of the process of neurotransmission.



2. If you hurt your foot, a message travels from your foot, via the neurons, to the brain. For communication between neurons to take place, an electrical impulse triggers the release of chemicals called *neurotransmitters*. Neurotransmitters are released into the space between the two neurons. This space is called the synapse.
3. When neurons communicate, the neurotransmitters from one neuron are released, cross the synapse, and attach themselves to special molecules in the next neuron called *receptors*. Receptors receive and process the message, then send it on to the next neuron.
4. Eventually, the message reaches the brain. The brain then gives directions about what to do next. In this case, the directions would be, "You hurt your foot on a tack. Sit down."

During the classroom activity, students simulate the process of neurotransmission. One student pretends to be the brain, another student is the foot, six students are neuron team members, and one student is the neurotransmitter. By acting out this process, students develop an understanding of our internal communication network. They also learn that the brain is the ultimate "information processor."

continued

We are introducing students to neurotransmission for several important reasons. For one, scientific information about the brain and the nervous system is growing at a rapid rate. By the time your child is an adult, we may understand the mechanisms behind many diseases of the nervous system, such as Alzheimer's disease and multiple sclerosis. People will need to understand how the brain works in order to make informed decisions about their health and the health of their families.

Another key reason for introducing neurotransmission is that we are paving the way for explaining what happens if people interfere with this process by taking drugs. Drugs have a major impact on neurotransmission. Students will be learning more about this during modules 4 through 6.

Science at Home

As a family, play "Whispering Down the Lane." One person whispers a sentence to a neighbor, who passes it on to the next person. Did the message arrive at its destination—by going through all your family members down the line—intact? Or did the message get confused? Either way, point out that neurotransmission is something like this game, although it is much more complicated. Messages have to go through neurons to the brain. Ask your child whether most messages are processed correctly by the brain. Then ask if the brain ever garbles messages. Give an example to your child, such as when you might say, "Get into the refrigerator," when you actually mean "Get into the bathtub."

What Does Your Child Think?

Have your child draw or write something about neurotransmission.

Additional Resources

The books and Web sites listed below have more information about neurotransmission.

National Institute on Drug Abuse (NIDA)
www.drugabuse.gov, 301-443-1124
This Web site contains information about drug abuse and a section designed specifically for parents, teachers, and students.

NIDA Drug Pubs
drugpubs.drugabuse.gov, 1-877-NIDA-NIH (1-877-643-2644)
Drug Pubs is NIDA's research dissemination center. Visitors can order hard copies of NIDA publications or download electronic versions in multiple formats.

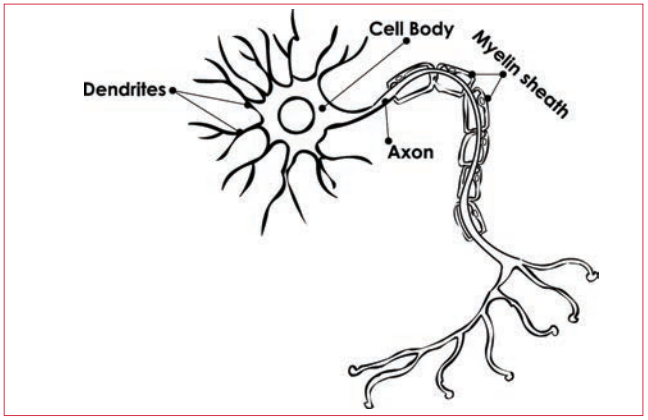
National Clearinghouse for Alcohol and Drug Information (NCADI)
http://store.samhsa.gov, 1-800-729-6686
NCADI provides information and materials on substance abuse. Many free publications are available here.

Woolsey, T.A., Hanaway J., Gado, M.H., The Brain Atlas: A Visual Guide to the Human Central Nervous System. Hoboken, New Jersey: John Wiley & Sons, 2003. This book is a comprehensive and accurate atlas of the brain. It includes nearly 400 images of the brain and its pathways.

History of Neuroscience
http://faculty.washington.edu/chudler/hist.html
Lists the history of neuroscience starting from 4000 B.C. to the present.

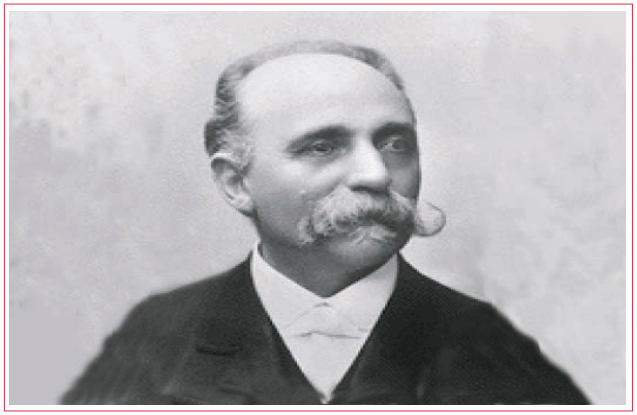
Neuroscience for Kids
http://faculty.washington.edu/chudler/neurok.html
This site contains information on the brain and neurotransmission, activities, experiments, pictures, and other resources.

Neuron



A neuron is a special kind of cell. Billions and billions of neurons make up the brain. Neurons carry messages through the body. They are so tiny you can't see them with just your eyes! You would need a powerful microscope to be able to see neurons.

Camillo Golgi

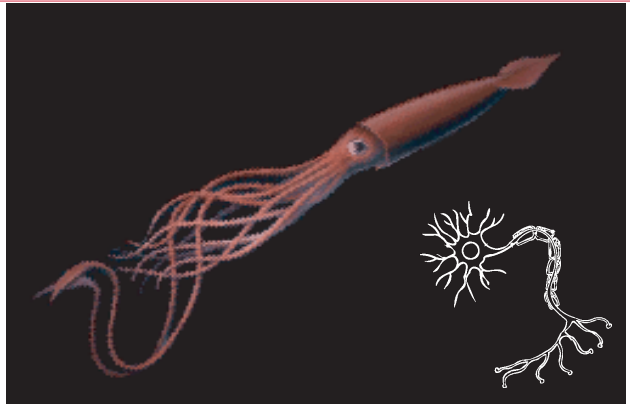


Camillo Golgi was a scientist from Italy. One day, he looked at a piece of owl's brain with a microscope. He saw something nobody had ever seen before—neurons! Camillo Golgi discovered neurons.

SURGICAL PAPYRUS

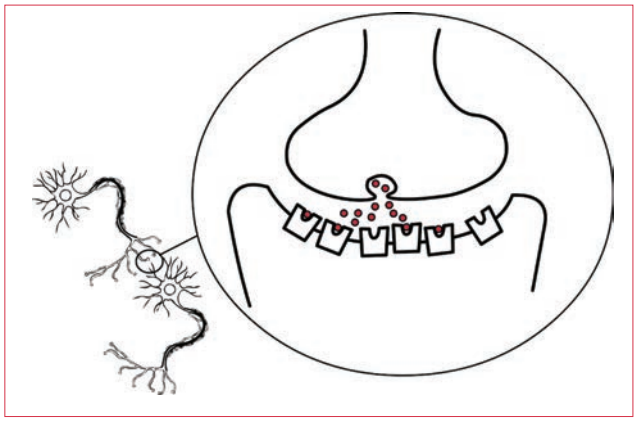
The Egyptians were one of the first people to write about the brain. They kept notes and called them the "Surgical Papyrus." It is one of the first things written about the brain that we still have today. They didn't think the brain was very important. When they were making a mummy, they scooped the brain out and threw it away. They didn't know that the brain is one of the most important parts of the body!

squid neuron



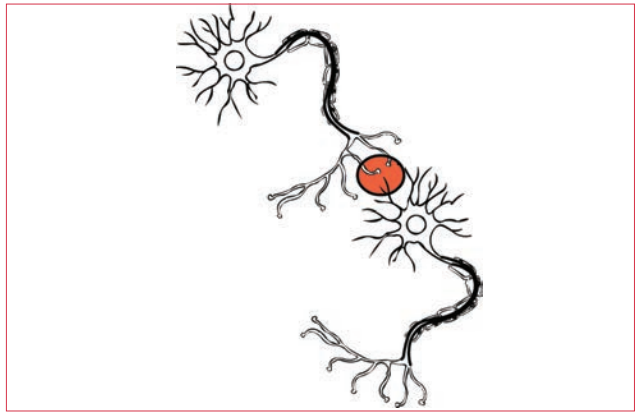
The squid's neurons are among the largest found in nature. The squid's neurons are much, much bigger than a human's. Because these neurons are so big, scientists use them in experiments.

NEUROTRANSMITTERS



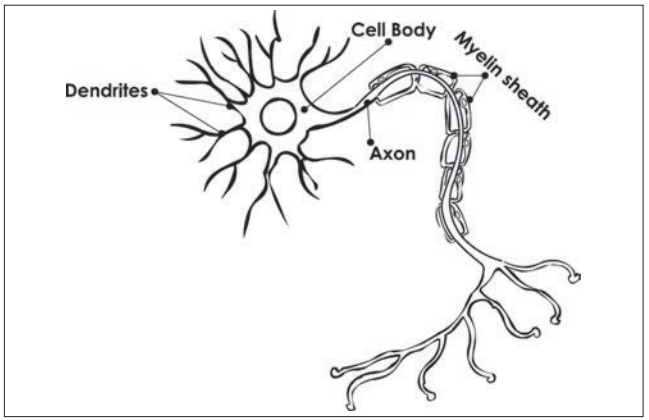
Neurotransmitters are chemicals that can be found in neurons. They carry messages from one neuron to another across the synapse. The messages travel really fast!

SYNAPSE



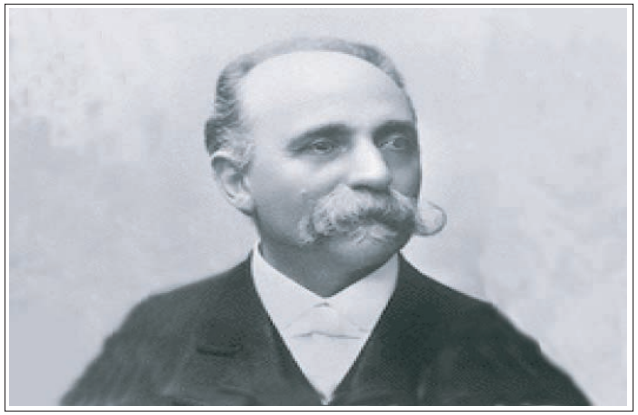
Neurons talk to each other all the time, but they never actually touch. Two neurons meet at a place called the synapse. Special chemicals called neurotransmitters carry the message across the synapse.

Neuron



A neuron is a special kind of cell. Billions and billions of neurons make up the brain. Neurons carry messages through the body. They are so tiny you can't see them with just your eyes! You would need a powerful microscope to be able to see neurons.

Camillo Golgi

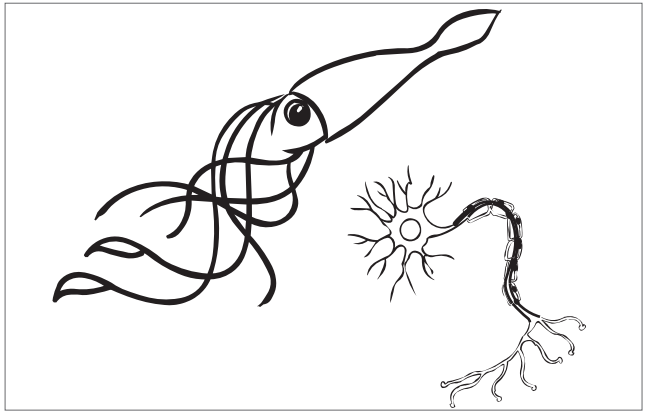


Camillo Golgi was a scientist from Italy. One day, he looked at a piece of owl's brain with a microscope. He saw something nobody had ever seen before—neurons! Camillo Golgi discovered neurons.

SURGICAL PAPYRUS

The Egyptians were one of the first people to write about the brain. They kept notes and called them the "Surgical Papyrus." It is one of the first things written about the brain that we still have today. They didn't think the brain was very important. When they were making a mummy, they scooped the brain out and threw it away. They didn't know that the brain is one of the most important parts of the body!

SQUID NEURON



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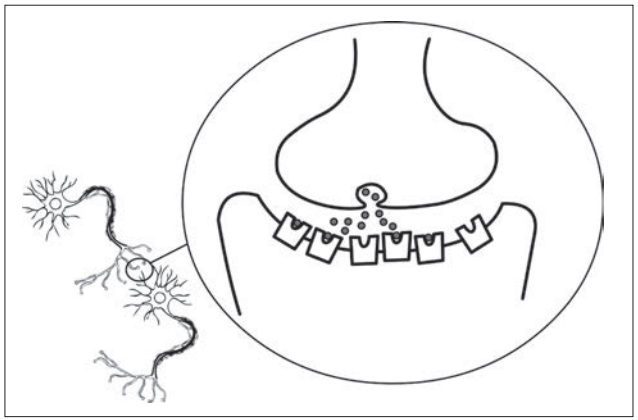
NEUROTRANSMITTERS



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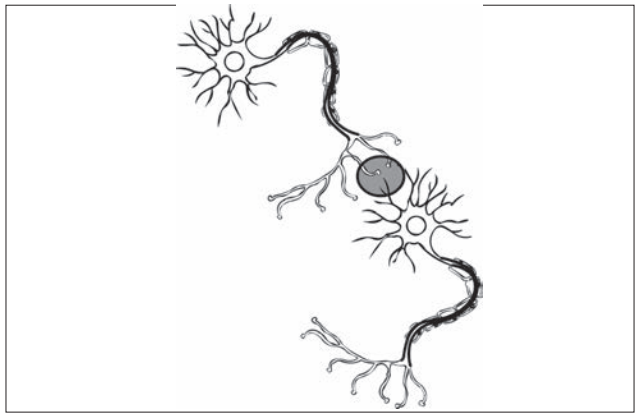
SYNAPSE



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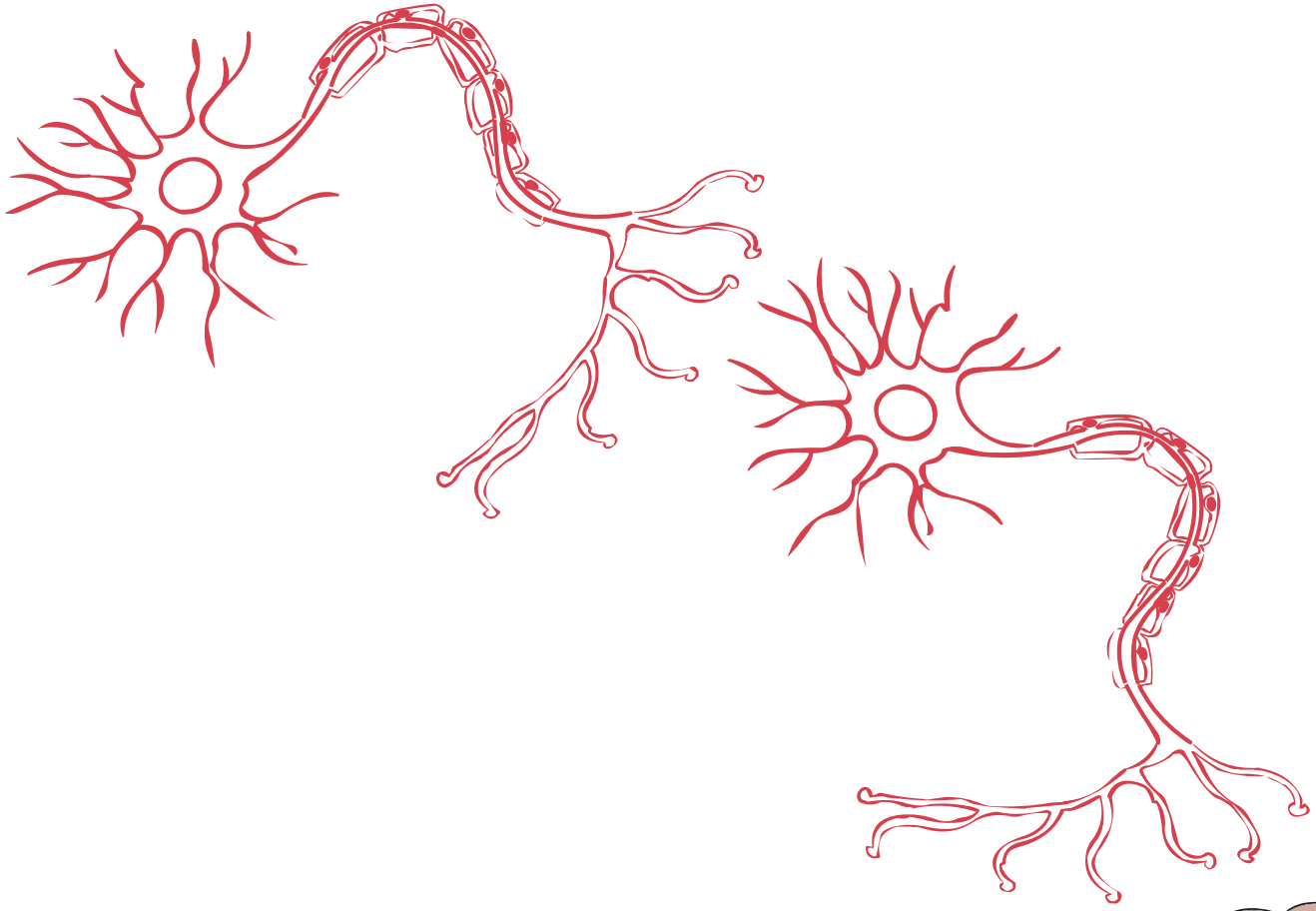
SENDING AND RECEIVING MESSAGES



The body is made up of billions of cells. Cells are the smallest unit of life. They are so small you can't even see them!

Cells of the nervous system are called "neurons." Neurons carry messages throughout the body. The human brain alone has about 100 billion neurons.