NEUROTRANSMISSION

MODULE 3

National Institute on Drug Abuse

MODULE 3: NEUROTRANSMISSION

Introduction

In the second mission, the students learned about the parts of the brain and what each part does. During this mission, they learn about neurotransmission—the process by which information travels to and from the brain—by playing a board game and then devising their own original way to explain this process.

Learning Objectives

- ★ Students learn about neurons and what they do.
- ★ Students find out how neurons communicate with each other.
- ★ Students explore the relationship between the brain and the rest of the central nervous system.
- ★ Students learn more about neurotransmission by playing a board game.
- ★ Students apply what they have learned by figuring out a unique way to explain the topic.

Relationship to the *National Science Education Standards*

This mission aligns with the following standard in the NSES: unifying concepts and processes. The chart below shows how the mission aligns with this standard.

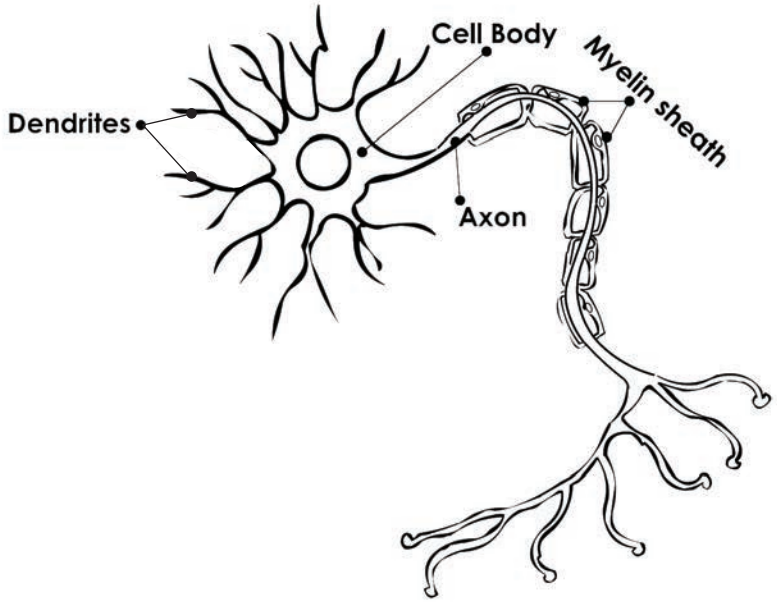
Unifying Concepts and Processes

Levels 5-8	How Mission is Aligned
Systems, order, and organization	This mission adds key knowledge to what was learned in Module 2 by showing how neurotransmission is part of the nervous system. Students develop an understanding of how the brain works with other parts of the nervous system to keep the entire human body functioning.

Background

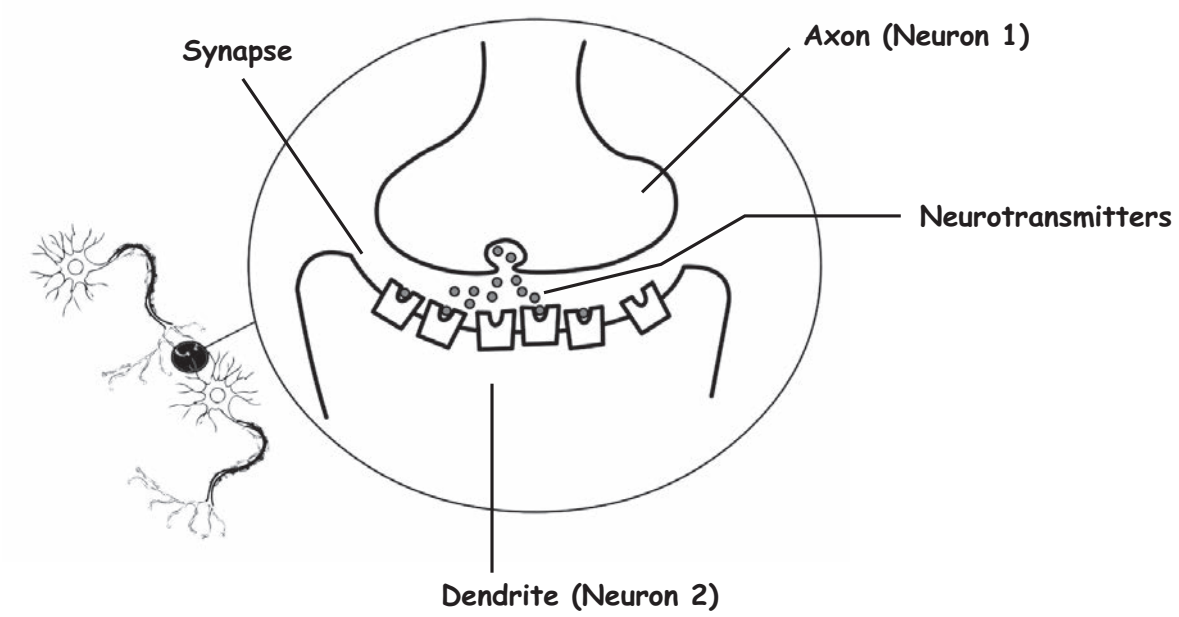
Information is constantly exchanged between the brain and other parts of the body by both electrical and chemical impulses. A cell called a neuron is responsible for carrying this information. The human brain is made up of 100 billion neurons.

A neuron has three main parts. The cell body directs all of the neuron's activities. Dendrites, short branches that extend out from the cell body, receive messages from other neurons and pass them on to the cell body. An axon is a long, single fiber that transmits messages from the cell body to the dendrites of other neurons or to other tissues in the body, such as muscles. A protective covering called the myelin sheath covers the axons of many neurons. Myelin insulates the axon and helps messages from nerve signals travel faster, farther, and more efficiently.



The exchange of information from the axon of one neuron to the dendrites of another is called neurotransmission. Neurotransmission takes place through the release of chemicals into the space between the axon of the first neuron and the dendrites of the second neuron. These chemicals are called neurotransmitters. The space between the axon and the dendrites is called the synapse.

When neurons communicate, an electrical impulse traveling down the axon causes neurotransmitters to be released from the end of the axon into the synapse. The neurotransmitters cross the synapse and bind to special molecules on the other side, called receptors. Receptors are found on the dendrites and cell bodies of all neurons. These receptors convert the information into chemical and/or electrical signals for processing in the neuron.



Our body produces many different types of neurotransmitters. Each neurotransmitter has a specific role to play in the functioning of the brain. A neurotransmitter binds to a receptor in much the same way that a key fits into a lock. A specific neurotransmitter only binds to certain receptors. Once the neurotransmitter has bound to a receptor, a series of events follow. First, the message carried by the neurotransmitter is received and passed on to the receiving nerve cell. Second, the neurotransmitter is inactivated and either broken down by an enzyme or reabsorbed from where it was released. The reabsorption is completed by other molecules called transporter molecules. These molecules are located in the cell membranes of the axon that releases the neurotransmitters. They pick up specific neurotransmitters from the synapse and carry them back across the cell membrane into the axon. The neurotransmitters are then recycled for use at a later time. Note that this process is true for most neurotransmitters, but not for all of them.

Materials

- ✓ Copy of a board for the board game (for each group)
  - Sample found in the back of the Teacher's Guide, Module 3
- ✓ Set of 10–15 blank cards for each group (use index cards or scratch paper)
- ✓ Spinners or dice and playing pieces (a set for each group)
  - Sample of the playing pieces found in the back of the Teacher's Guide, Module 3
- ✓ Paper and pencils
- ✓ Black Line Master of Neurotransmission (found in the back of the Teacher's Guide, Module 3)
- ✓ DVD and DVD player

Preparation

- ★ Familiarize yourself with the topic of neurotransmission by reading the background section of the guide.
- ★ Create an overhead transparency showing neurotransmission by using the Black Line Master at the back of this guide.
- ★ Decide how you want to group the students for this activity. Each group should consist of three to four students.
- ★ Make enough copies of the board and the cards so that each group receives one set.

> *You may want to have parent volunteers or instructional assistants help make copies of the materials needed for this activity.*

Procedure

1. Begin the activity by asking the students if they have ever learned about neurotransmission. The students who worked on other modules in the *Brain Power!* program may remember something about this process.
2. Show the students the overhead transparency of neurotransmission. Explain the steps in the process.
3. Watch the Module 3 DVD. Stop the DVD at the break.
4. Tell students that to better understand this complex process, they are going to design a board game explaining how neurotransmission works and how information is communicated between the brain and other parts of the body.

5. Pass out a board game set to each group. Tell students that the game works like this: The spaces on the board will tell students what to do when they are playing the game. The students must fill in these spaces before playing the game. Ideas are listed below. Once the students have filled in the spaces, have them play. Each student should spin, move a certain number of spaces, and follow the instructions on the space. If they answer the question correctly, they spin again. The player who returns to the starting place first wins the game.

   Ideas for the Board

   - Neurotransmitters were just released into the synapse. Move two spaces.
   - A message didn't go through. Go back three spaces.
   - You just had a brilliant idea! Move ahead four spaces.
   - Brain overload! Go back three spaces.
   - Pick a card and follow the instructions.

   Ideas for the Cards

   - Name the parts of a neuron.
   - Explain how your brain "knows" that your arm hurts.
   - What is the myelin sheath? Why is it important?
   - What are neurotransmitters?
   - What are receptors?
   - What are transporter molecules?
   - What parts of a neuron communicate with each other?
   - Where does communication take place?

6. Resume the DVD. When the DVD is finished, give students class time to play the game. It may be a good idea to leave the overhead transparency on while students are playing. That way, they can refer to it if they have questions while playing the game.
7. After the students are finished playing the game, have them clean up and come back together as a class. Conclude the activity by asking them what they learned about neurons and how they communicate (neurotransmission).

Discussion Questions

- Show the DVD to the students. Discuss what new neurotransmission information they learned from the DVD.
- Challenge the students to develop their own way to explain neurotransmission. It could be by developing another board game, a simulation, or a play.
- Ask the students if they think it would be better if the *Junior Scientists* collaborated with the *Spectacular Scientists Club* kids instead of competing with them. Tell them that they will be asked later in the program about the value of competition versus collaboration.

Extensions

The activities listed below provide a link to other areas of the curriculum.


Language arts


Math

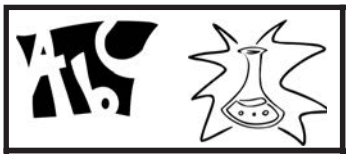

Drama


Art


Science


Social Studies


Reading

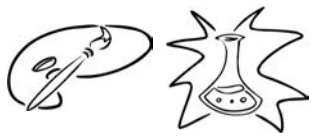
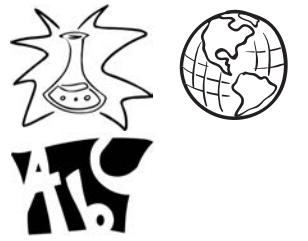
	Have the students share their ideas about how to explain neurotransmission. Keep a list of all of their ideas.
	Develop a class play explaining how neurotransmission works. The students may have the characters be the parts of the neuron, or kids showing what happens if neurotransmission works—and if it doesn't.
	Draw a class poster showing the different parts of a neuron. Students could also draw the steps of neurotransmission.

Assessment

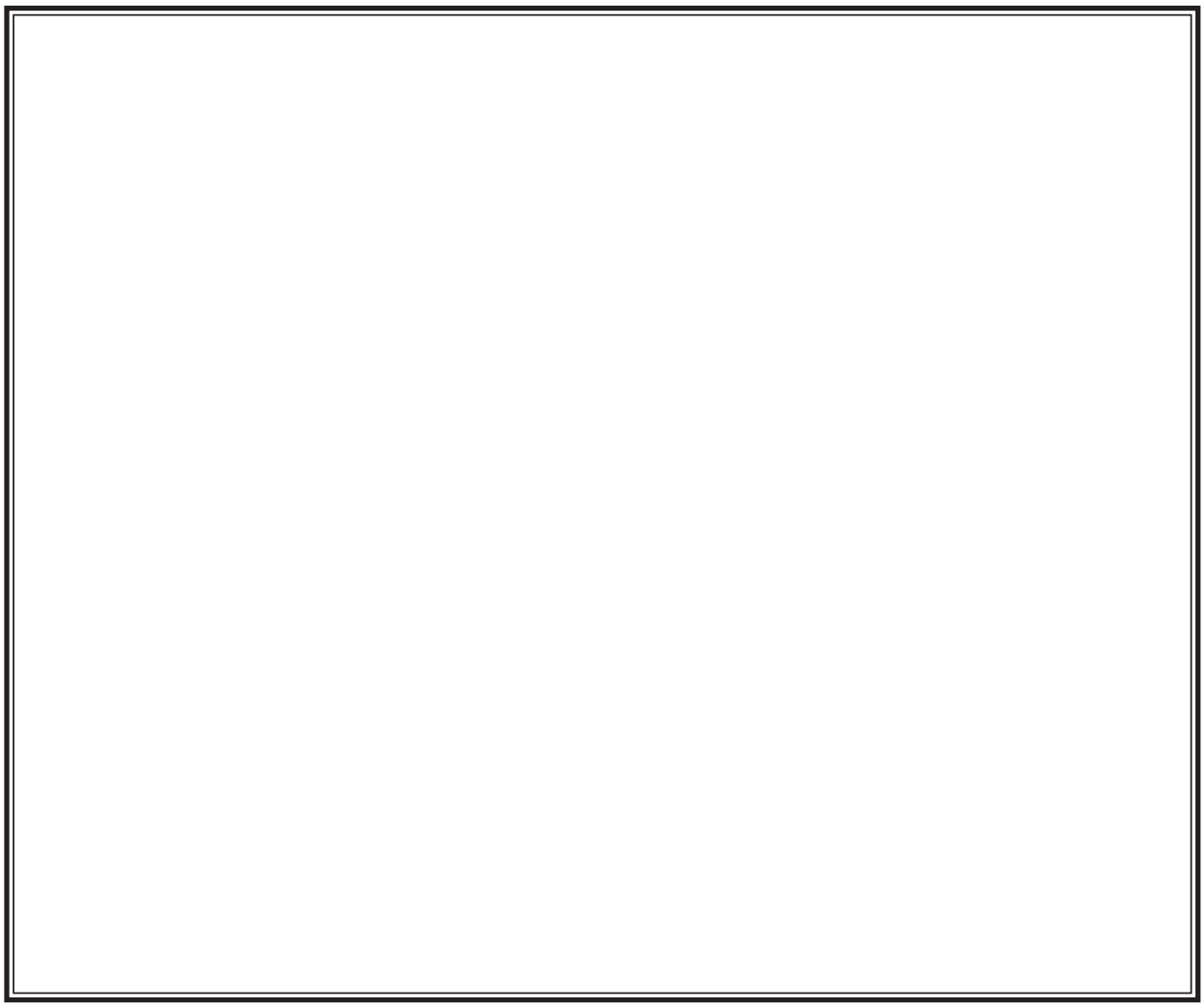
1. If students worked on the *Brain Power!* program for grades 2 and 3, they may have some knowledge of neurotransmission. For those learning about it for the first time, expect some difficulties in understanding it. Neurotransmission is a very difficult topic for elementary school students. Our goal is for the students to have a basic understanding of the process by the end of the module.
2. Look for the following indicators of understanding of key concepts:
    - Did they have a working knowledge of the key terms learned during the mission?
    - Were the students able to play the game?
    - Were they able to apply what they learned to a new situation, such as developing a new way to explain this process?

Additional Activities

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

	Working in pairs, have students make a comic strip explaining neurotransmission. Make sure they include information about neurons, how messages are received, and what chemicals are involved in the process.
	Have the students find out how many neurons are in the human body at different life stages. At which stage do people have the most neurons? Ask students why the number varies. The best ways for the students to find this information would be on the Internet or in library books.
	Have students look in newspapers, magazines, and on the Web for information about the latest developments in brain research. What information do we have now that we didn't have 10 or 15 years ago?
	Working in small groups, have the students make a timeline showing major findings in brain research beginning in 1900 and going to the present. They can use reference books and the Internet to complete their research. The Neuroscience for Kids Web site contains information on brain research. http://faculty.washington.edu/chudler/hist.html

Notes:



Resources for Teachers

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. Publications and other materials are available free of charge at drugpubs.drugabuse.gov.

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.

From Neuron to Brain.,4th Edition [Nicholls, J. G., Martin, A. R., Wallace, B. G., Fuchs, P. A., &] 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.

The Brain Atlas: A Visual Guide to the Human Central Nervous System, 3rd Edition. [Woolsey, T. A., Hanaway, J., Gado, M. H.]: John Wiley & Sons, Inc., 2007.

This book is a comprehensive and accurate atlas of the brain. It includes nearly 400 images of the brain and its pathways.

Resources for Students

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 for the students and educators.

Phineas Gage: A Gruesome but True Story About Brain Science. [Fleischman, J.] Boston, MA: Houghton Mifflin Co., 2002.

Written for ages 9 through 12, this book tells the story of a railroad employee who experienced personality changes after a 13-pound iron rod shot through his brain.

Focus on Drugs and the Brain. [Friedman, D.] Frederick, MD: Twenty-First Century Books, 1990.

This book, part of the "Drug-Alert Book" series, gives a good overview of the brain, neurotransmission, effects of drugs on the brain, and addiction.

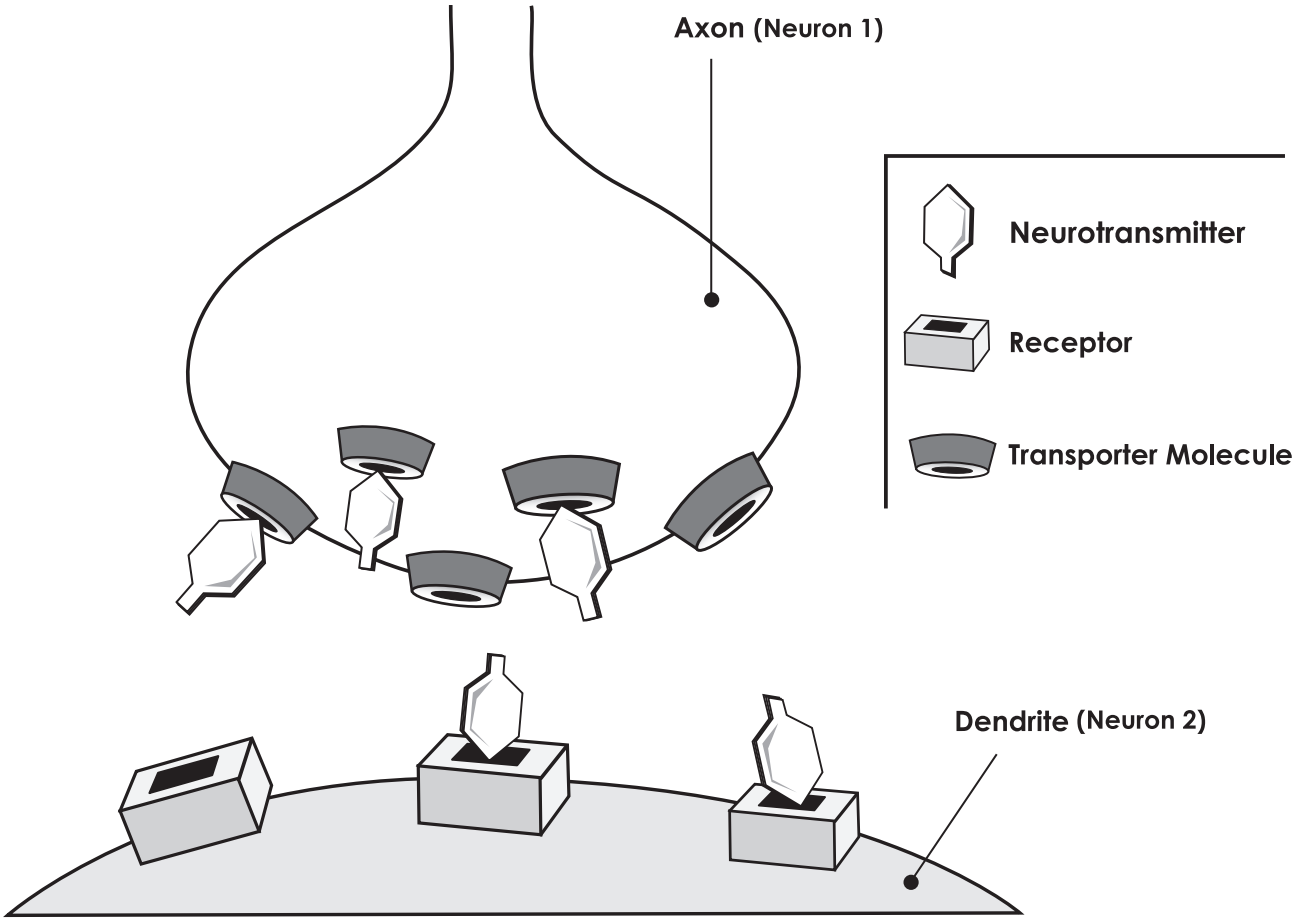
Understanding Your Brain (Science for Beginners Series). [Treays, R.] Newton, MA: EDC Publications, 1996.

This book describes the parts of the brain and the process of neurotransmission.

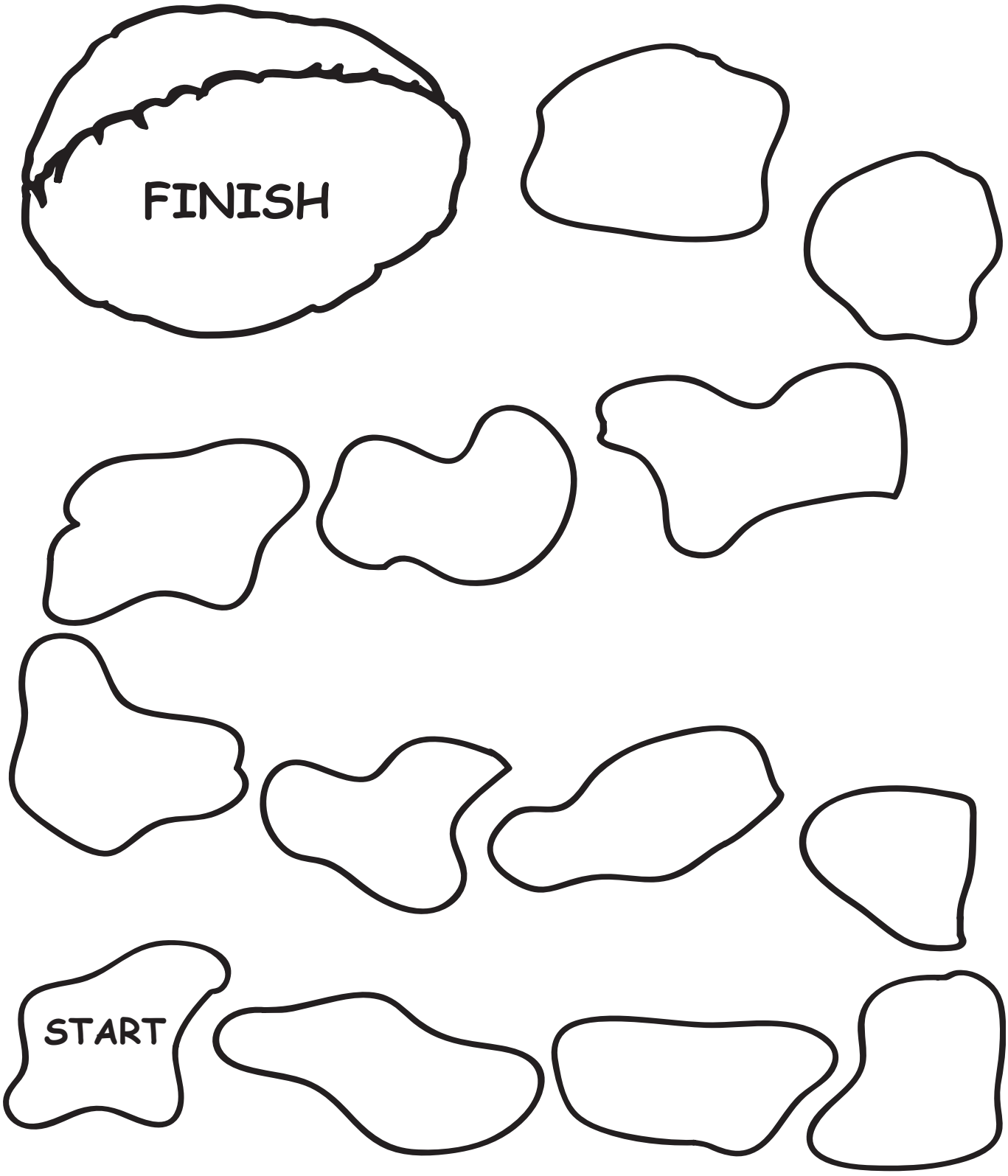
The Brain: Our Nervous System. [Simon, S.] New York: Collins Publishers, 2006.

This book presents a simple, yet detailed, overview of the brain and neurotransmission.

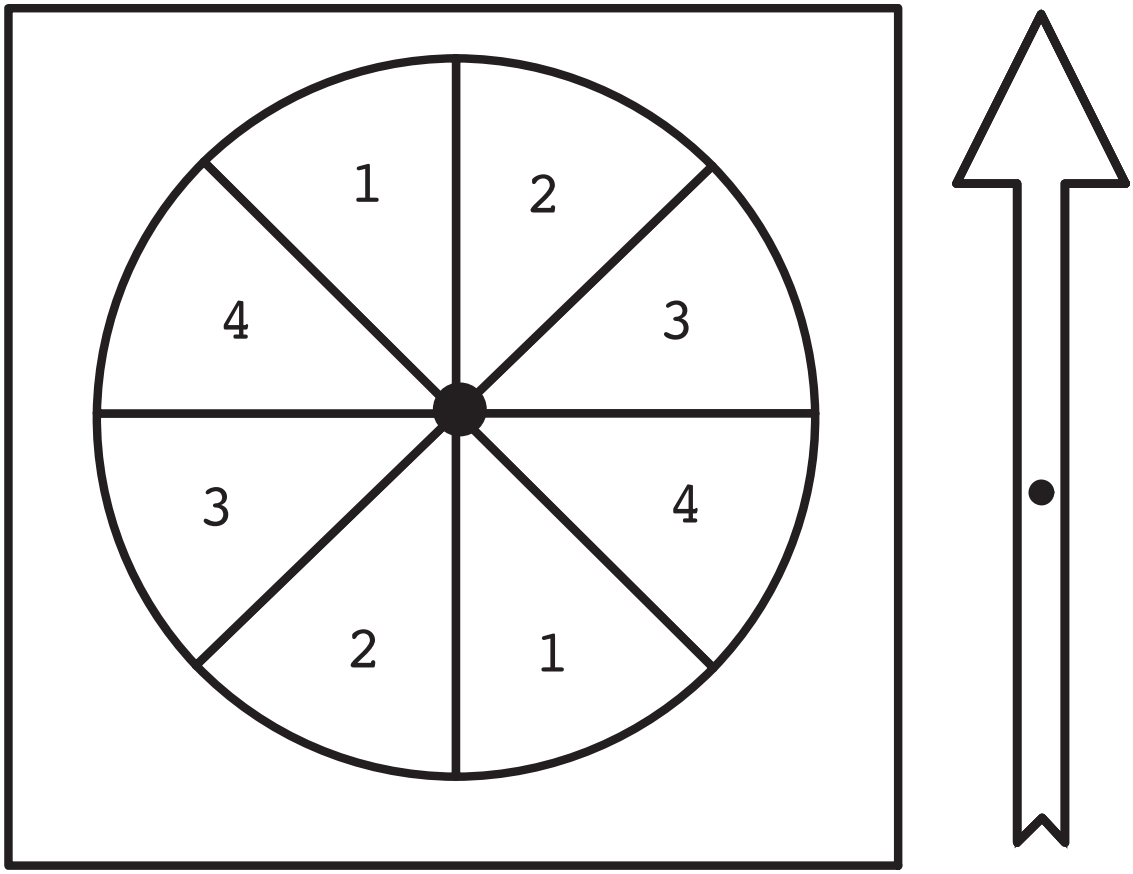
Black Line Master of Neurotransmission



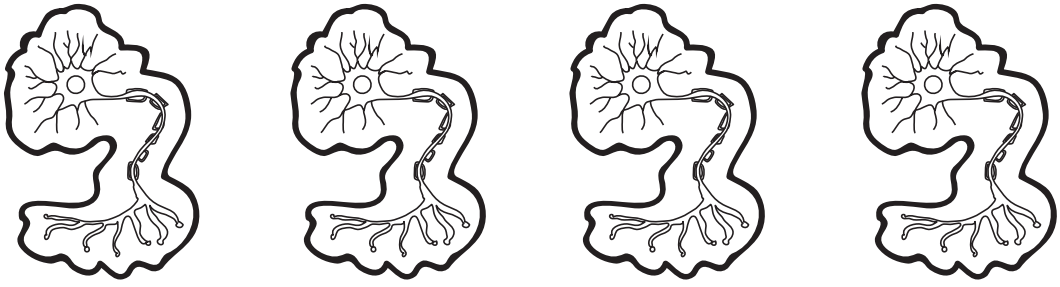
Game Board



Spinner



Playing Pieces



(Make each team's neuron playing piece a different color)

Introductory Story for Module 3: NEUROTRANSMISSION

Jay and Latisha are sitting in the chairs in the *Brain Power!* clubhouse. They're taking turns checking each other's reflexes using the rubber hammer doctors use on patients' knees.

Latisha says, "You have good reflexes, Jay."

Jay responds, "A sign of someone ready to kick off a serious campaign to become a future Junior Scientist!"

"It would be fun to be Junior Scientists like the *Brain Power!* Club kids, wouldn't it?" Latisha says. "I like it here in their clubhouse. And I think that if we do a good job with our next mission, we might get promoted!"

Corty appears, emerging from a nearby computer monitor. He says, "Oh, wow, that's just what I have for you, a mission! You are going to compete with the Junior Scientists to see who can solve more missions."

Latisha and Jay are both really excited.

Corty says, "The Junior Scientists solved the last one, so this is up to you. Your mission, should you choose to accept it, is learning about neurotransmission. It's the process that takes information to and from the brain."

Latisha and Jay look at each other confused and a little concerned. Latisha says, "I must be having a neurotransmission breakdown because I don't get it." Jay agrees.

Corty asks them for examples on how to send information.

The kids respond, "By telephone, e-mail, instant message, letters…"

Corty says, "Right. But brains don't have telephones or computers. Well, I mean, I do, but I'm…different." The kids totally agree.

Corty says, "Typical brains have to find another way to communicate with the rest of their bodies. And they do it by using the synapses between neurons—or brain cells—as a kind of Internet, like when you send Instant Messages."

The kids are still confused. Corty says, "Maybe it's time to call in an expert."

A scientist named Elliot Stein appears on the computer screen and explains neurotransmission. The kids see a 3-D animation showing neurotransmitters being released from one neuron into the space between neurons, called the synapse. The neurotransmitters cross the synapse between the neurons and then attach to the receptors on the next neuron. Then the computer screen goes blank.

Corty says, "There you go! Your mission is to design a board game to teach other kids about neurotransmission."

Latisha says, "Whoa!" Jay says, "Cool! Hard, but cool."

Corty says, "Of course, board games are best when played in teams." He looks at the kids and clears his throat meaningfully. The kids look at each other and roll their eyes.

Stop here until students have designed a game.

Jay and Latisha work hard on their board game. They put the finishing touches on it and draw a picture of Corty on the board. Jay makes the final stroke and says, "Ta-dah-finished!"

Latisha explains how to play the game, "Each player is a neuron, a brain cell. See how the pieces are shaped like neurons? The goal is to be the first to get an important piece of information to the brain."

Jay chimes in, "At the beginning of the game, each player finds out, from a booklet, what that piece of information is. Mine is that I'm being chased by a hungry lion. I need to let my brain know so it can tell my body what to do—Ruuuun!"

Latisha says, "Mine is that I'm hungry for pizza, and I have to get that information to my brain so that my body knows how to get a slice—hold the anchovies, please."

Jay picks up two stacks of cards and says, "There are two sets of cards." He points to one stack and takes a card from it. "This set tells the players how many spaces to move their pieces. This one says, "Neurotransmitters were just released into the synapse. Move ahead two spaces."

Latisha points to the other stack of cards and says, "Then there's another set of cards called "Challenge Cards,"with questions to test the players' knowledge of neurotransmitters. This one asks you to name the parts of a neuron. If you get it right, you spin again."

Corty says, "Well, I have a question for you: What part of the brain would help you if we're taking a test in math class?" Jay and Latisha look at each other and shrug.

Corty says, "Which part of the brain helped you make up this game?" They shake their heads because they don't know. Corty says, "Don't know? Well, this is a good game, but it only tells half the story. You know where you'd find the other half?"

Latisha says, "I know. The *Brain Power!* kids had a mission that taught them about the brain."

Corty says, "Now your synapses are firing. You need to work together to make this game a real brain teaser."

Jay says, "Well, it would be more fun to play with four."

Corty says, "Maybe you can do your next mission together. You'll need to know about the brain and neurotransmission to solve it."

Brain Power!

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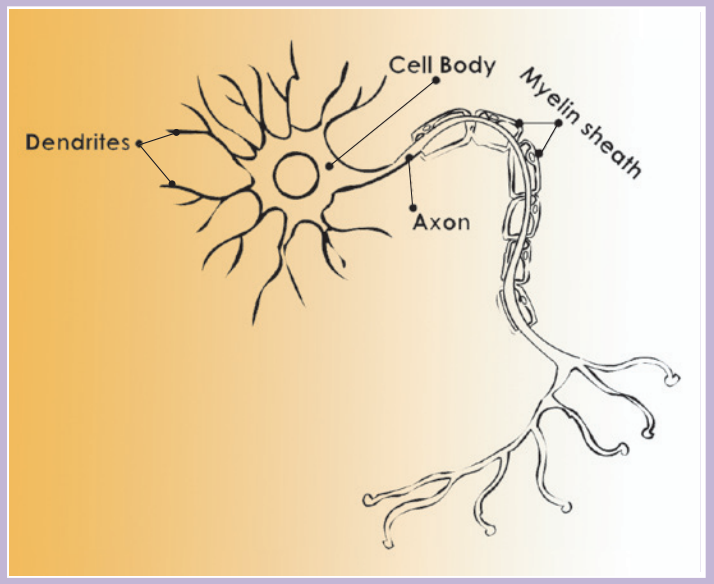
Junior Scientists

Brain Power!

NIDA

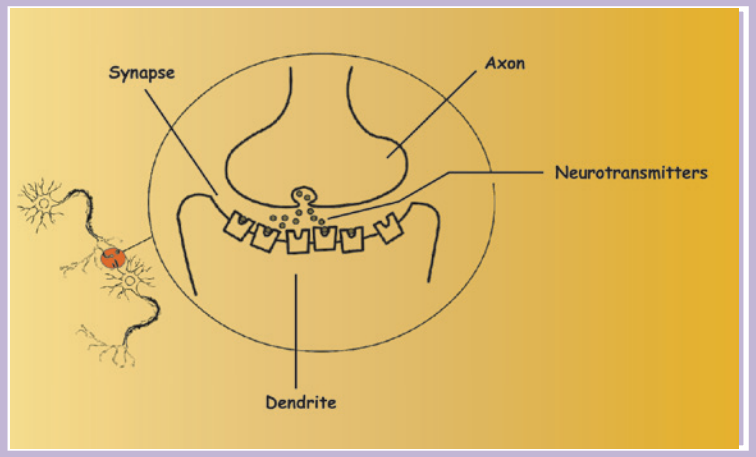
Junior Scientists

Neuron



Neurons are the cells in the brain. Neurons send messages all over the body that help you to move, hear, see, taste, smell, remember, feel, and think. Two parts of the neuron are the dendrites and the axon. Neurons are so small you need a powerful microscope to see them. They are very important to your brain.

Neurotransmitters



Neurotransmitters are chemicals in the brain that carry messages from one neuron to another. They are released from one neuron, move across the synapse, and attach to another neuron. Different kinds of neurotransmitters are used for different functions. For example, dopamine is a type of neurotransmitter associated with feelings of pleasure.

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Junior Scientists

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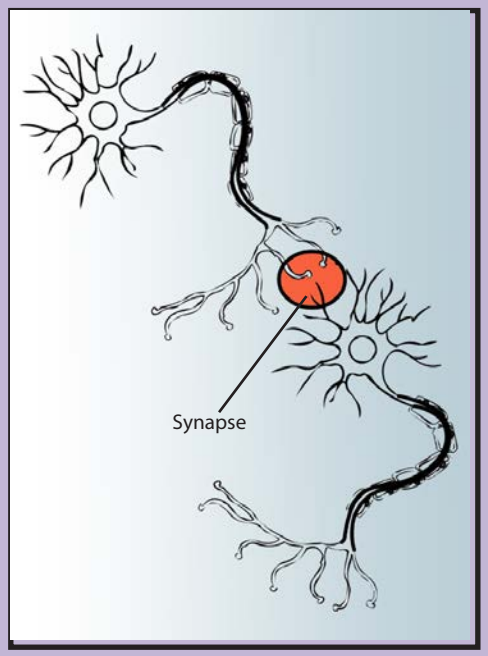
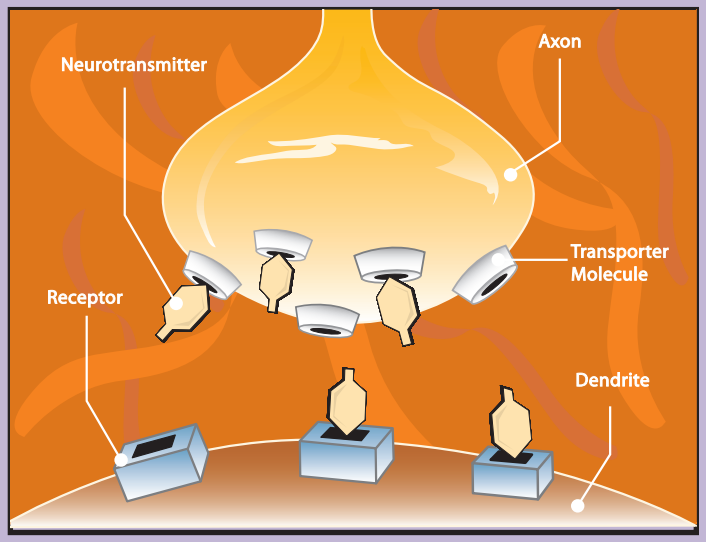
Junior Scientists

Synapse



The space between neurons is called the synapse. Neurotransmitters cross the synapse to send messages to neurons on the other side. The word "synapse" comes from the Greek: "syn" meaning "together" and "haptein" meaning "to clasp."

Normal Neurotransmission



Each kind of neurotransmitter attaches to a specific set of receptors, like a key fitting into a lock. During normal neurotransmission, neurotransmitters are released into the synapse and attach to specific receptors, where they send a message. Then, the neurotransmitters are released from the receptors and broken down or reabsorbed by transporter molecules into the neuron that released them.

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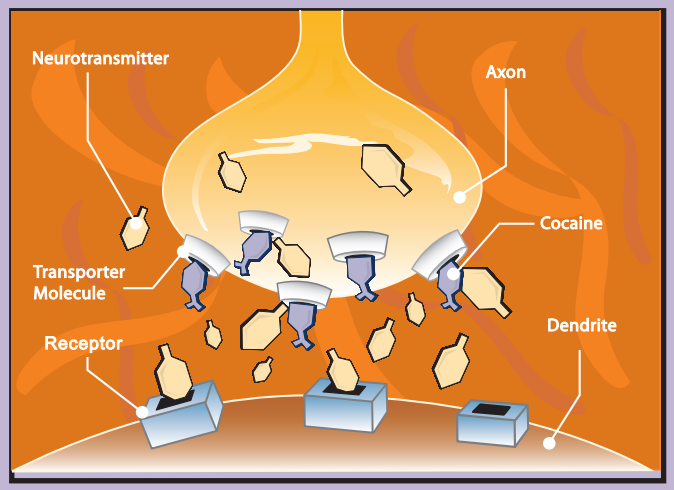
Disrupted Neurotransmission

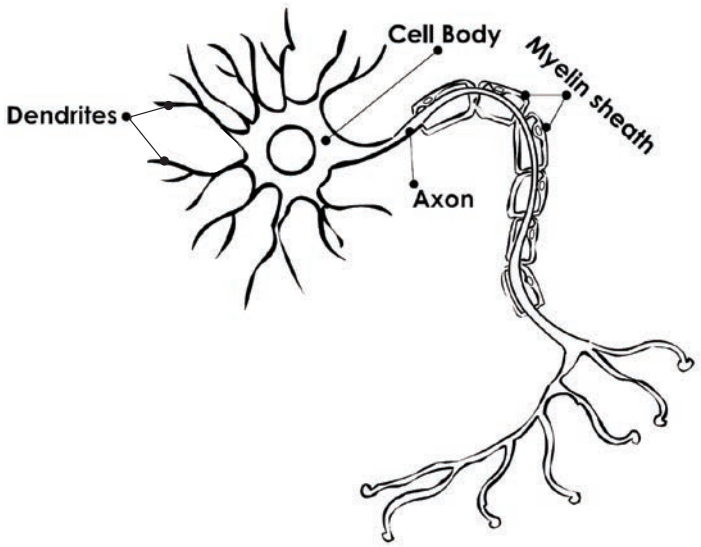


Drugs can attach to receptors meant for certain neurotransmitters. Drugs can also stop neurotransmitters from being broken down or reabsorbed by preventing them from being picked up by the neuron that released them. Drugs can stop the neurotransmitters, keeping them from doing their job causing problems in normal brain and body functioning.

Neuroscientist

Neuroscientists study the different parts of the brain and how they all work together. Because the brain has so many parts, neuroscientists usually focus on one specific part or function. They do this to learn how diseases and drugs affect the brain, and how to keep the brain healthy. A person has to go to school for a long time to become a neuroscientist.

Neuron



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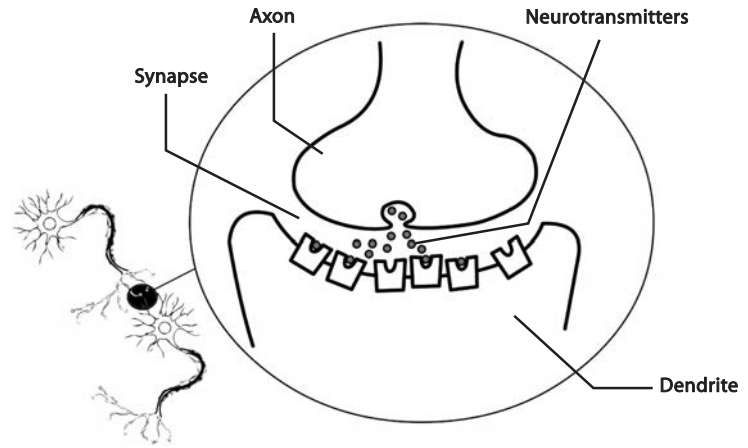

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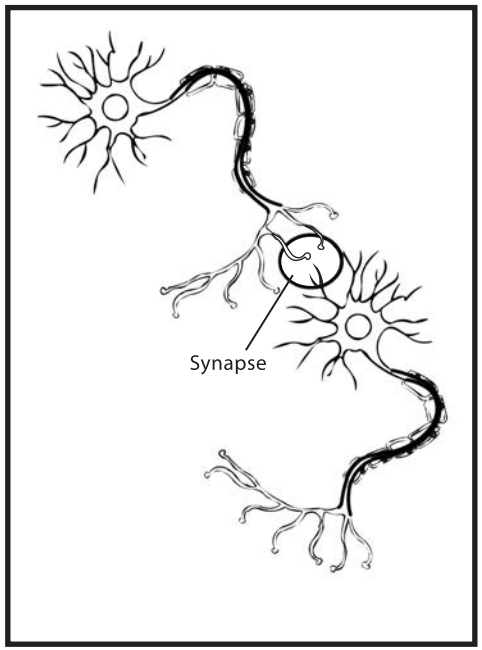
Synapse



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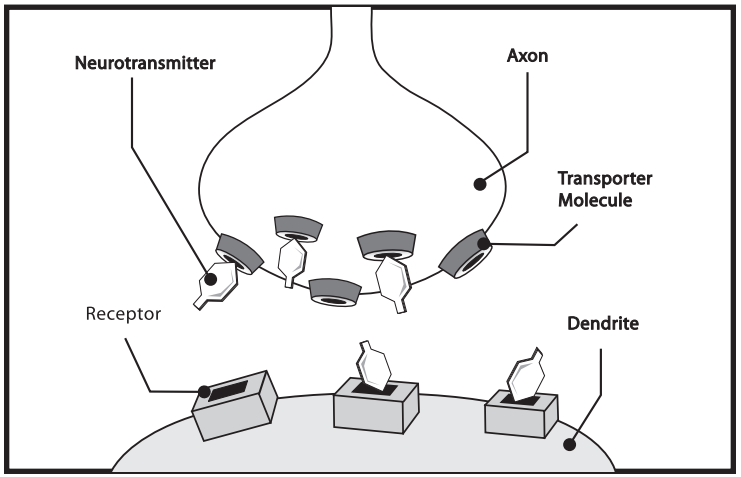
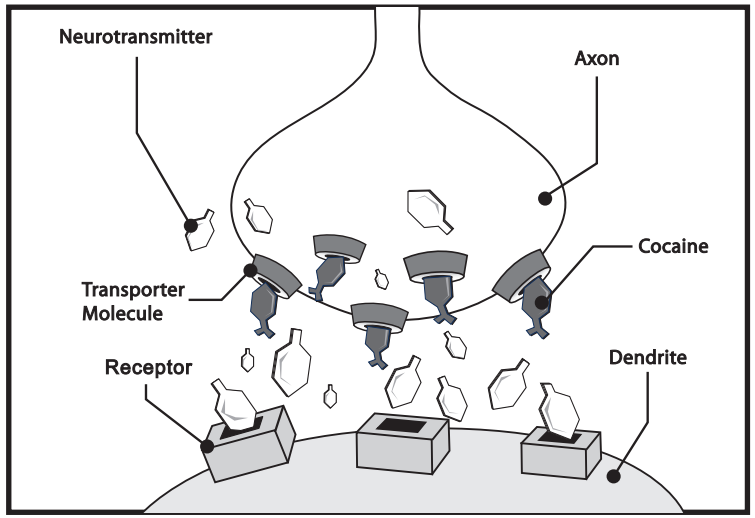
Normal Neurotransmission



Each kind of neurotransmitter attaches to a specific set of receptors, like a key fitting into a lock. During normal neurotransmission, neurotransmitters are released into the synapse and attach to specific receptors, where they send a message. Then, the neurotransmitters are released from the receptors and broken down or reabsorbed by transporter molecules into the neuron that released them.

Disrupted Neurotransmission

NIDA



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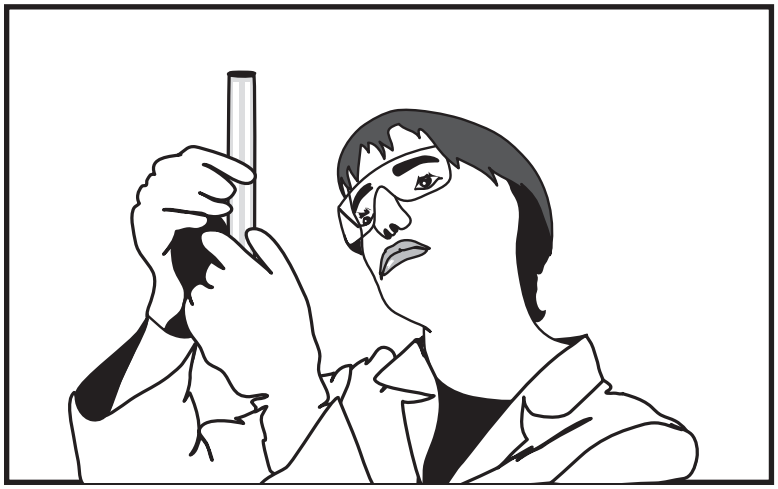


Neuroscientists study the different parts of the brain and how they all work together. Because the brain has so many parts, neuroscientists usually focus on one specific part or function. They do this to learn how diseases and drugs affect the brain, and how to keep the brain healthy. A person has to go to school for a long time to become a neuroscientist.

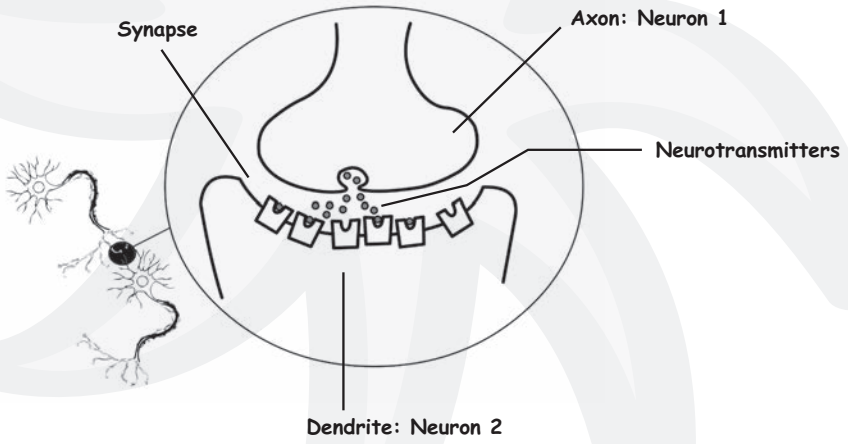
BRAIN POWER NEWS

PARENT NEWSLETTER VOLUME 1, NUMBER 3

Neurotransmission

Module 3 focuses on neurotransmission. In Module 2, your child learned all about the brain and the functions of the brain. In this module, your child will learn more about the brain and how messages are sent and received. Neurotransmission is part of the process where information is transported to, from, and within the brain. A cell called a neuron is responsible for carrying information. The human brain is made up of 100 billion neurons. Neurons have different parts that carry out different functions.

The exchange of information from one neuron to another is accomplished through neurotransmission. Neurotransmission takes place when one neuron releases chemicals into the space between neurons (called the synapse). The chemicals then cross the synapse and bind to specific molecules on the second neuron. The molecules on the second neuron are called receptors. Once the chemicals attach to the receptors, they cause changes in the second neuron, and the message continues onward. This process is known as neurotransmission.



This activity aligns with the following standard identified in the *National Science Education Standards*: unifying concepts and processes. This mission adds key knowledge to what was learned in Module 2 by showing how neurotransmission is essential to the function of the nervous system. The students develop an understanding of how the brain works with other parts of the nervous system to keep the entire human body functioning.

Science at Home

Ask your child what he or she learned about neurotransmission. Discuss the parts of a neuron and the different steps of neurotransmission. Have your child draw neurons and label each part.

Have your child draw or write down five activities that require the process of neurotransmission. (Hint: Everything you do requires neurotransmission to take place.)

Additional Resources

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. Publications and other materials are available free of charge at drugpubs.drugabuse.gov.

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.

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 for students and educators.

Phineas Gage: A Gruesome but True Story About Brain Science. [Fleischman, J.] Boston, MA: Houghton Mifflin Co., 2002. Written for ages 9 through 12, this book tells the story of a railroad employee who experienced personality changes after a 13-pound iron rod shot through his brain.

Understanding Your Brain (Science for Beginners Series). [Treays, R.] Newton, MA: EDC Publications, 1996. This book describes the parts of the brain and the process of neurotransmission.

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

The Brain: Our Nervous System. [Simon, S.] New York: Collins, 2006. This book presents a simple, yet detailed, overview of the brain and neurotransmission.

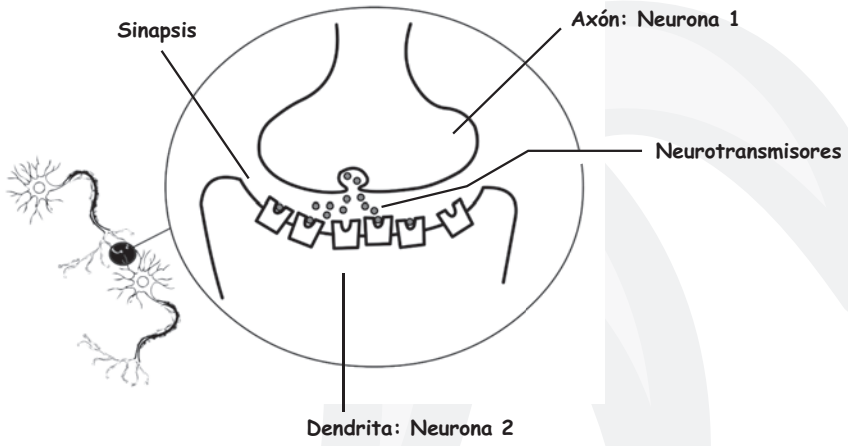
NOTICIAS SOBRE EL PODER DEL CEREBRO

BOLETÍN INFORMATIVO PARA PADRES VOLUMEN 1, NÚMERO 3

La neurotransmisión

El Módulo 3 se concentra en la neurotransmisión. En el Módulo 2, su hijo aprendió mucho acerca del cerebro y sus funciones. En este módulo, su hijo aprenderá más sobre el cerebro y cómo se envían y se reciben los mensajes. La neurotransmisión forma parte del proceso mediante el cual se transporta la información hacia y desde el cerebro y dentro del mismo. La responsable de transportar la información es una célula llamada neurona. El cerebro humano está formado por 100 mil millones de neuronas. Las neuronas tienen distintas partes que cumplen distintas funciones.

El intercambio de información de una neurona a otra se logra mediante la neurotransmisión. La neurotransmisión ocurre cuando una neurona libera sustancias químicas al espacio que hay entre las neuronas (llamado sinapsis). Luego, las sustancias químicas atraviesan la sinapsis y se unen a moléculas específicas en la segunda neurona. Las moléculas en la segunda neurona se llaman receptores. Una vez que las sustancias químicas se unen a los receptores, éstos provocan cambios en la segunda neurona y así el mensaje sigue adelante. Este proceso se conoce como neurotransmisión.



Esta actividad cumple con el siguiente estándar identificado en los *Estándares Nacionales de Educación Científica* (*National Science Education Standards*): unificación de conceptos y procesos. Esta misión agrega un conocimiento clave a lo aprendido en el Módulo 2, mostrando por qué la neurotransmisión es fundamental para la función del sistema nervioso. Los estudiantes desarrollan una comprensión de cómo trabaja el cerebro con otras partes del sistema nervioso para mantener en funcionamiento todo el cuerpo humano.

La ciencia en el hogar

Pregunte a su hijo lo que aprendió sobre la neurotransmisión. Comenten sobre las partes de una neurona y los distintos pasos de la neurotransmisión. Haga que su hijo dibuje neuronas y que escriba el nombre de cada parte.

¿Qué piensa su hijo?

Haga que su hijo dibuje o escriba cinco actividades que requieran del proceso de neurotransmisión. (Pista: todo lo que hacemos requiere la neurotransmisión).

Recursos adicionales

National Institute on Drug Abuse (NIDA)
www.drugabuse.gov, 301-443-1124
Este sitio Web tiene información acerca del abuso de drogas y una sección destinada específicamente a padres, maestros y estudiantes. Hay publicaciones y otros materiales disponibles sin costo en drugpubs.drugabuse.gov. Muchas publicaciones están disponibles en español.

National Clearinghouse for Alcohol and Drug Information (NCADI)
http://store.samhsa.gov, 1-800-729-6686
NCADI provee información y materiales relacionados con el abuso de sustancias. Aquí se pueden obtener muchas publicaciones gratuitas.

Neuroscience for Kids
http://faculty.washington.edu/chudler/neurok.html
Este sitio Web contiene información sobre el cerebro y la neurotransmisión, así como actividades, experimentos, dibujos y otros recursos para estudiantes y educadores.

Phineas Gage: *A Gruesome but True Story About Brain Science.* [Fleischman, J.] Boston, MA: Houghton Mifflin Co., 2002. Escrito para niños de 9 a 12 años, este libro cuenta la historia de un empleado ferroviario que sufrió cambios en su personalidad luego de que una barra de hierro de 13 libras [unos 6 kilos] le atravesó el cerebro.

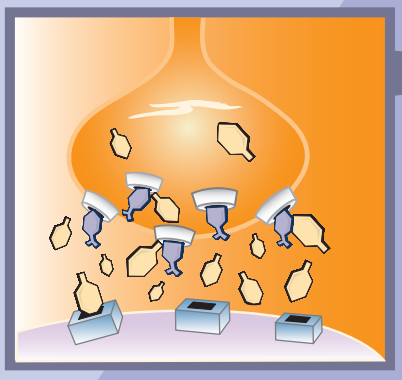
Understanding Your Brain (Science for Beginners Series). [Treays, R.] Newton, MA: EDC Publications, 1996. Este libro describe las partes del cerebro y el proceso de neurotransmisión.

Focus on Drugs and the Brain. [Friedman, D.] Frederick, MD: Twenty-First Century Books, 1990. Parte de la serie de libros de alerta sobre las drogas; proporciona un buen compendio del cerebro, la neurotransmisión, los efectos de las drogas en el cerebro y la adicción.

The Brain: Our Nervous System [Simon, S.] New York: Collins, 2006.
Este libro presenta un compendio simple, pero detallado, del cerebro y la neurotransmisión.

NEUROTRANSMISSION

Normal Neurotransmission



Neurotransmission Disrupted by Cocaine

Key

- Neurotransmitter
- Transporter Molecule
- Receptor
- Cocaine