Module 1—An Introduction to the Brain and Nervous System

Overview

Summary

This introductory module of the *Brain Power! Challenge* Program is designed to help students learn about the parts of the brain, the functions of these parts, and how the brain communicates with the rest of the body. The process of neurotransmission is described in detail. This module provides a key foundation for the next five modules, which will discuss the impact of specific drugs on the body and the brain.

Students will refer to the information covered in this introductory module throughout the entire *Brain Power!* curriculum. If the students did not participate in the *Brain Power! The NIDA Junior Scientists Program* for grades K–5, the information in this module may need to be covered in greater depth.

Learning Objectives

At the end of this module:

- Students can name the main parts of the brain: the cerebral cortex, hypothalamus, cerebellum, brain stem, and limbic system.
- Students can identify the lobes of the cerebral cortex: frontal, parietal, occipital, and temporal.
- Students can explain the functions of the major brain parts.
- Students can identify the components of a neuron: cell body, dendrites, and axon.
- Students can explain the process of neurotransmission.

Background

MAJOR PARTS OF THE BRAIN

Cerebral Cortex

The cerebral cortex is the largest part of the human brain, making up more than 75 percent of this organ. The cerebral cortex is also the most highly developed part of the brain. It controls thinking, perception, and understanding language.

The cerebral cortex is divided into two hemispheres–the right hemisphere and the left hemisphere.

- The right hemisphere controls the left side of the body and is largely responsible for artistic expression and for understanding relationships in space–tasks such as reading a map.

- The left hemisphere controls the right side of the body. It is largely responsible for mathematical ability, problem solving, and comparing information needed to make decisions. It is also the brain's language center.

The two hemispheres communicate with one another through a bundle of fibers called the corpus callosum. The corpus callosum is the bridge between the two hemispheres.

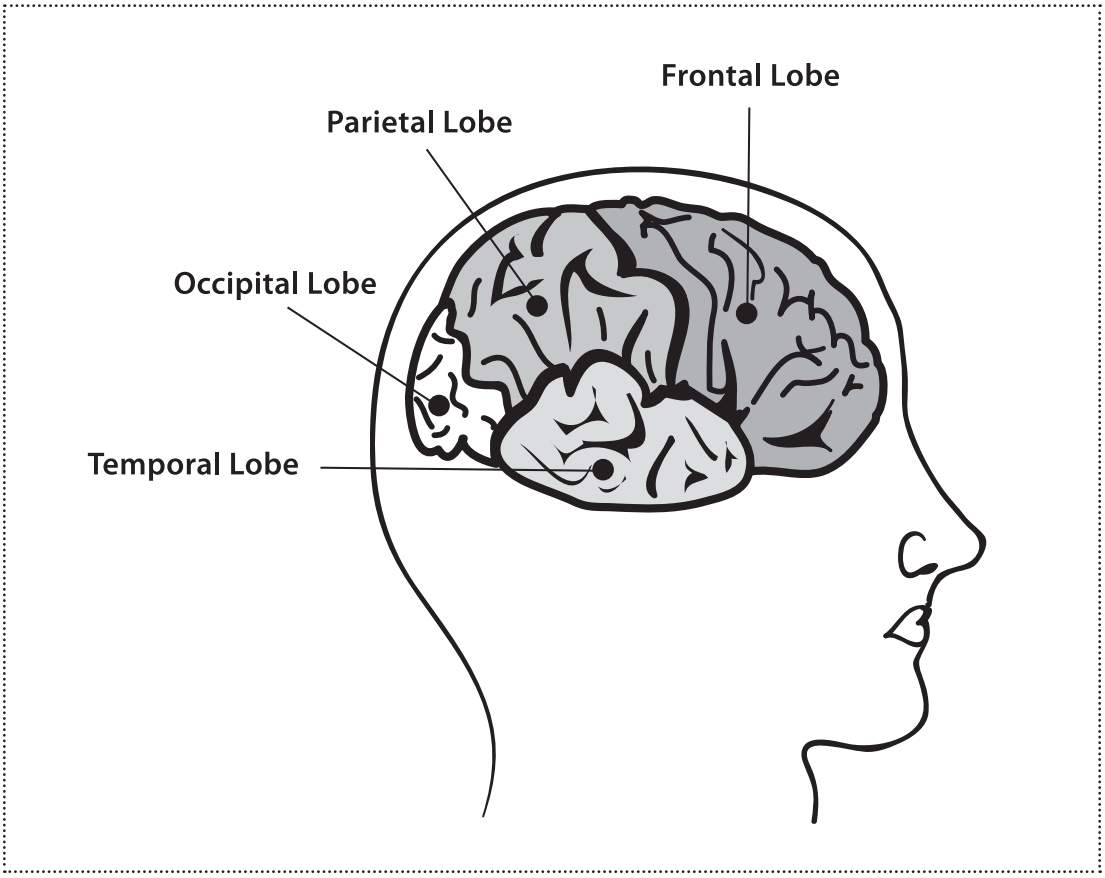
The cortex is specialized. Four specific areas of the cortex, called lobes, are responsible for different tasks:

- The **frontal lobe** is responsible for initiating and coordinating motor movements and higher cognitive skills, such as problem solving and thinking.

- The **parietal lobe** processes sensory information from the whole body–for example, information about pain, touch, and pressure.

- The **occipital lobe** processes visual information coming into the brain.

- The **temporal lobe** is in charge of making sense of the auditory information from the environment.



Hypothalamus

The **hypothalamus** is situated deep inside the center of the brain. The hypothalamus links the nervous system to the endocrine system by producing and releasing hormones. The endocrine system is made up of glands that regulate, coordinate, and control hormones. The hypothalamus regulates body temperature, hunger, and thirst.

Cerebellum

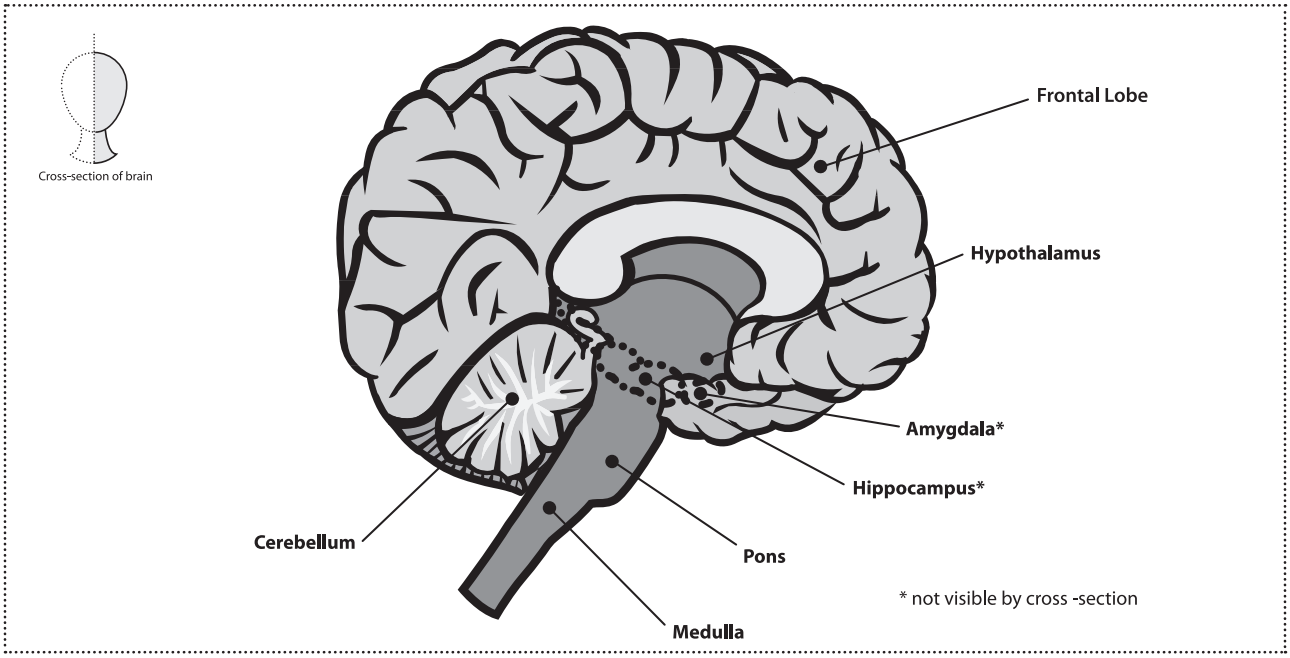
The **cerebellum** is located at the back of the head near the spine. It controls posture, movement, and the sense of balance. Playing ball, picking up objects, and playing musical instruments are among the activities that fall under the control of the cerebellum.

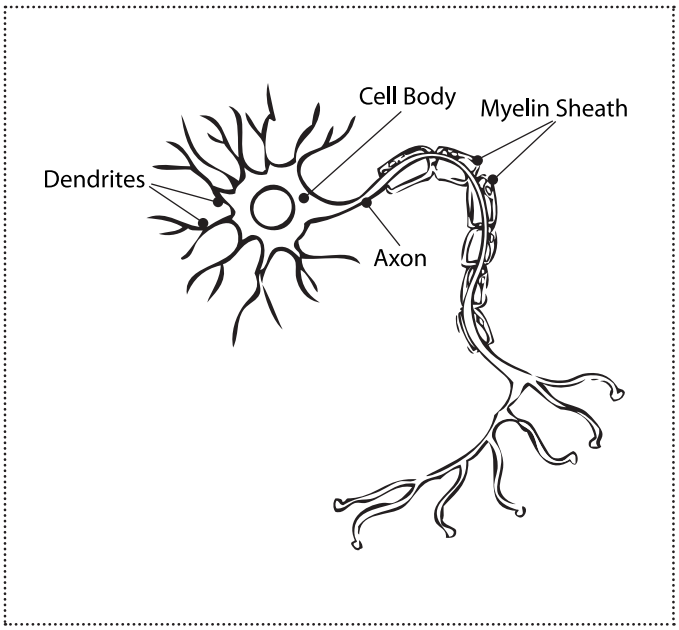
Brain Stem

The **brain stem**, the most primitive part of the brain, connects the brain to the spinal cord. It is located near the cerebellum. The two main parts of the brain stem are the **pons** and the **medulla.** The pons contains nerve fibers that connect the cerebral cortex with the cerebellum and the spinal cord. The pons controls sleep, awakening, and dream onset. The medulla controls heart rate, respiration, and blood pressure. The brain stem also controls simple reflexes, such as coughing and sneezing.

Limbic System

The **limbic system** is located deep inside the brain. It has many parts, but two of the most important are the **hippocampus** and the **amygdala.** The hippocampus is mainly responsible for learning and memory. The amygdala plays an important role in emotional behavior. The limbic system is greatly affected by substances such as nicotine, alcohol, and illegal drugs.





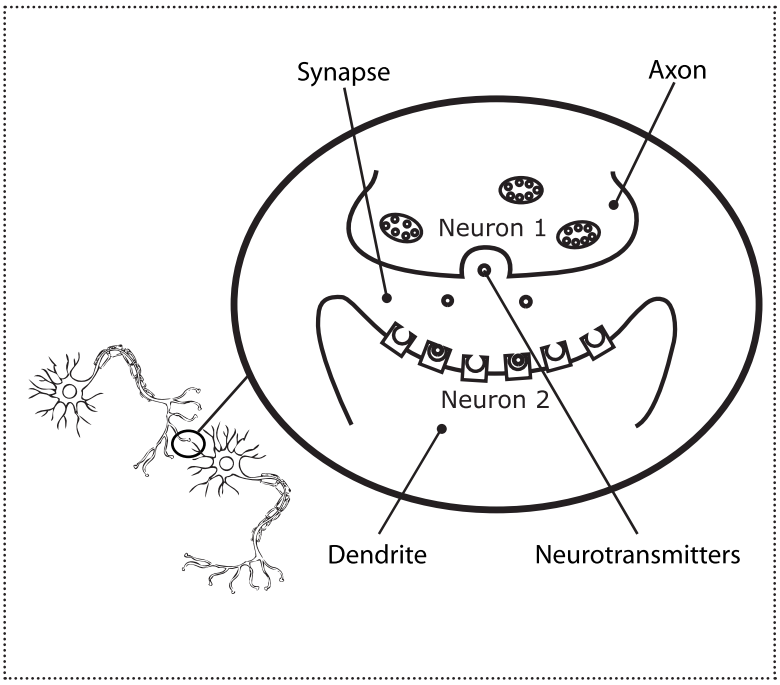
NEURONS

Information is constantly exchanged between the brain and other parts of the body by both electrical and chemical impulses. Cells called neurons are responsible for carrying this information. All of the major brain parts discussed above are composed of neurons—almost 100 billion neurons total!

A neuron has three main parts. The **cell body** directs all 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 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 axons and helps messages from nerve signals travel faster, farther, and more efficiently.

NEUROTRANSMISSION

The exchange of information between the axon of one neuron and the dendrites of another neuron 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 dendrite is called a **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, called receptors, on the dendrite of the second neuron. Receptors are found on the dendrites and cell bodies of all neurons. The receptors convert the information into chemical or electrical signals which are then transmitted to the cell body and eventually to the axon. The axon then carries the signal to another neuron or to body tissues such as muscles.

Once a neurotransmitter binds to a receptor, a series of events follow. First, the message carried by the neurotransmitter is passed on to the receiving neuron. Second, the neurotransmitter is inactivated. It is either broken down by an enzyme or reabsorbed by the axon from which it was released. Other molecules, called transporter molecules, complete this reabsorption process. 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 and into the axon, where they are recycled for use at a later time. Note that this process is true for most neurotransmitters, but not for all of them.

The human 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 will bind only to its corresponding receptor.

The process of neurotransmission as described here is shown step-by-step in Module 1 of the CD-ROM in Room 1—*NT 101: An Introduction to Neurotransmission*.

Neurotransmitter messages can be generalized as either excitatory or inhibitory messages. An excitatory neurotransmitter is one that increases the activity of neurons, and an inhibitory neurotransmitter decreases the activity of neurons. Over the course of these modules, several specific neurotransmitters will be discussed, including acetylcholine, GABA, and dopamine.

Neurotransmitter	Brain Function
Acetylcholine (excitatory)	Plays an important role in the function of the hippocampus, which is in charge of learning and memory.
GABA (inhibitory)	A neurotransmitter in the cerebral cortex, which controls thinking, perceiving, and understanding language.
Dopamine (excitatory)	Plays an important role in the pleasure/reward system in the brain.

Preparation

- Read the Background section of this module for more information about the brain and neurotransmission.
- Provide students with the Module 1 magazine *The Brain and Nervous System* for background knowledge.
- Determine which activities you want the class to complete.
- Arrange for computer lab time or prepare the classroom computer for students' Internet and CD-ROM use.
- Photocopy and pass out the Brain Parts Fact Sheet and the Neurotransmission Fact Sheet for students to complete during the lecture.
- Prepare transparencies and photocopies for the lesson.

Introduction

Reading: Begin by giving students adequate time to read the student magazine. Have students pay particular attention to the following sections: Background, Stats and Facts, and Science in the Spotlight.

Discussion: After students have read the magazine, facilitate a discussion about the brain using the following questions. If necessary, review this information with your students, using the diagrams provided.

Time:

15–20 minutes

Supplies:

Transparencies of diagrams if needed

Handouts:

Module 1 magazine

Brain Parts Fact Sheet

Neurotransmission Fact Sheet

The Parts of the Brain

- What does the brain do?
- What are the four lobes of the brain?
- What are the functions of the right and left hemispheres?
- What does the limbic system control?
- What are three functions of the brain stem?

Neurotransmission

- What are the three main parts of a neuron?
- Approximately how many neurons are in the brain?
- What are the steps of neurotransmission?
- What are the definitions of neurotransmitters, synapse, and receptors?

Activity 1: Brain Messages

Time:

45 minutes

Supplies:

One large piece of butcher-block paper per group

Markers/crayons/ pencils

Handouts:

Neurotransmission Fact Sheet

This is the first activity in a series of six. These activities are all part of the *Brain Power! Challenge* competition. Before you begin, go over the competition details that are found on page vii of this guide.

Part 1:

1. Give each group the Neurotransmission Fact Sheet. Make sure students understand the role of the brain and neurons in transmitting messages throughout the body.

2. Give each group a large sheet of butcher-block paper, pencils, and markers. Tell each group to draw the steps involved in neurotransmission. Students should be able to describe the parts of a neuron, how information exchange takes place, and how information is sent throughout the body. They should include a short written explanation of how the process works.

Part 2:

3. Have groups take turns showing the steps of neurotransmission. Encourage students to ask questions in a discussion format in between the presentations.

4. Based on the clarity, information, and creativity in the groups' presentations, you will give each group a score from 0–10. These scores need to be recorded on the Group Scorecard, as each *Challenge* activity for the *Brain Power!* modules involves a similar scoring system. At the end of all the modules, the team with the most points wins the *Brain Power! Challenge* competition.

Activity 2: Scavenger Hunt

Time:

45 minutes

Supplies:

Timer if needed

Pen or pencil

Handouts:

Neurotransmission Scavenger Hunt

In this activity, students will learn about neurotransmission by using the Internet. Have students work together in groups to complete an Internet scavenger hunt.

Ideas for making this activity more suitable for a bigger class: If there are not enough computers for all groups, send groups one at a time while the rest of the class completes other activities. Use a timer to record each group's completion time.

Students should try to find the answers as quickly as possible. You can use the provided Scavenger Hunt handout or develop one of your own. The following Web site contains all the information students need to complete the scavenger hunt:

Prior to this activity, add the Internet resource listed below to the computer's Internet "Favorites" drop-down menu. **http://faculty.washington.edu/chudler/neurok.html**

CD-ROM

The CD-ROM includes games and materials to supplement the information presented in the module. The room labeled "1" contains the following activities and specific information pertaining to this module:

- **Learning Objectives:** these are presented at the beginning of each CD-ROM module
- **Parts of the Brain:** a short film about brain parts
- **Cerebral Cortex:** a short film about the cerebral cortex
- **Hemisphere Quiz:** a personal quiz students can take to determine their own "dominant hemisphere"
- **Harry Human Superguy:** an interactive quiz and cartoon about brain parts and functions
- ***NT 101: An Introduction to Neurotransmission:*** this activity details the process of neurotransmission step-by-step
- **Module Quiz**: this quiz is the final part of the module, intended to assess students' learning

1.  Divide the students into pairs and give each a copy of the Brain Parts Fact Sheet. Assign each pair a part of the brain and have them draw their own original cartoon character or superhero that represents this brain part. For example, students assigned the occipital lobe might draw a character with very large eyes, and students assigned the cerebellum might draw their character playing football or dancing ballet. After drawing the cartoon, each pair should think of a fun name for their character and then introduce him or her to the class.

2.   Have students develop timelines charting the major findings and breakthroughs in brain research. Divide the students into small groups and have each group focus on a specific timeframe (e.g., 0–1700 AD, 1700–1900, 1900–present). Encourage students to highlight key milestones on their timelines. The following Web site is a good starting point:
http://faculty.washington.edu/chudler/hist.html

3.    Have students create a plan for a board game to show the process of neurotransmission. Make sure they cover all the major parts of the process. You can present the activity with the following framework to build motivation.

> The object of the game is for the neurotransmitter to reach the receptors across the synapse. What kind of obstacles would the neurotransmitter face in your game? What pieces would the neuron need to collect before it can send the message? What would the board look like?

Have students create a visual presentation for their games. In this activity, you are the president of a board game company looking to make and sell the best neurotransmission game. Judge the presentations based on creativity and scientific accuracy.

Key to Icons

 Art

 Science

 History

 Business

 Social Studies

 English

 Math

Assessment

As students complete the activities in the module, observe whether they have mastered the following:

1. Do students know the main parts of the brain and the major functions of each part?

2. Do students know the main parts of a neuron? Can they explain the function of the neurotransmitters?

3. Can students explain neurotransmission? Do they have a clear understanding that this is the process through which messages are sent throughout the brain and body?

4. Do students understand the importance of the brain and its many functions?

5. Did students participate in the class activities and discussion? Did they engage in the topics?

Resources

RESOURCES FOR TEACHERS

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

National Clearinghouse for Alcohol and Drug Information (NCADI)
http://ncadi.samhsa.gov, 1-800-729-6686
NCADI is the world's largest resource for information and materials concerning substance abuse. Many free publications are available here.

***The Amazing Brain*. Ornstein, R., & Thompson, R. F.** Boston: Houghton Mifflin Company, 1991. This uniquely illustrated, comprehensive presentation of the numerous and complex functions of the brain is an ideal source for health educators and older students.

Brain Basics: Know Your Brain
www.ninds.nih.gov/disorders/brain_basics/know_your_brain.htm
Provides an excellent overview of the architecture and functions of the brain.

RESOURCES FOR STUDENTS

Neuroscience for Kids
http://faculty.washington.edu/chudler/neurok.html
Useful for both adults and children, this Web site contains information on the brain and neurotransmission, activities, experiments, pictures, and other resources.

The Physical Brain. **Byrnie, F.** Woodbridge, CT: Blackbirch Press, Inc., 2001. This book, part of *The Amazing Brain* series, uses a variety of illustrations and pictures to describe the development, functions, and specializations of the brain. The book also contains an overview of neurotransmission.

The Great Brain Book: An Inside Look at the Inside of Your Head. **Newquist, H.P.** New York: Scholastic Reference, 2005. *The Great Brain Book* uses medical illustrations, cartoon illustrations, and interesting photographs to tell the complete story of the brain, from the history of the brain to the future of brain science.