BioEd℠

THE LEARNING BRAIN

Brain Chemistry
Teacher's Guide

Pre-assessment: The Brain

Written by

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Free, related neuroscience education resources and online versions of these lessons are available at www.bioedonline.org/.

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Page 4: MRI image of developing brains courtesy of NIH from the MRI Study of Normal Brain Development project, http://pediatricmri.nih.gov/nihpd/info/image_gallery.html/.

Overview: Pre-assessment

This pre-assessment/focus activity introduces students to the brain, the most complex organ of the body, and some of its most important functions (see Answer Key, sidebar, p. 2).

The Brain

Did you ever wonder why you can respond so quickly when you are startled? Wonder why you can "see" a picture in your mind's eye? Wonder why you can remember facts, events and skills that you learned or experienced a long time ago? Your nervous system makes these and many more things possible. The brain is the command center of the nervous system; it controls virtually all functions of the body.

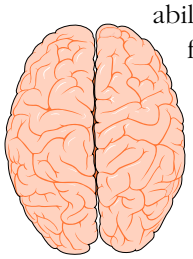
Unit Links

Legacy of Lost Canyon
"Beginnings: The NeuroExplorers," p. ii-iv;
Chapters 1-3
Science box, p. 7

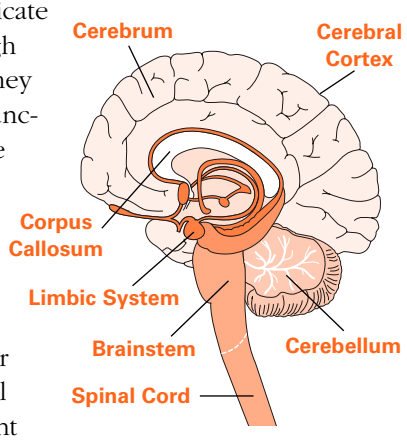
Brain Chemistry Explorations
Cover activity
"Brain To Body," p. 2-3

The brain of the average adult weighs about three pounds and fills over half the skull. Even though it is soft (like pudding), the brain can be divided into several regions, each with very specific functions.

The cerebrum, about 85% of the brain's mass, sits above the brainstem and cerebellum. The surface of the cerebrum, known as the cerebral cortex, has bumps (gyri) and grooves (sulci). The cerebrum enables one to think, learn, reason, remember, feel sensations and emotions, and move muscles purposefully. It is comprised of two hemispheres (or halves), separated by a deep fissure. The hemispheres are connected by a large bundle of nerve fibers known as the corpus callosum. They communicate with each other constantly. Even though the hemispheres may look the same, they are somewhat specialized for certain functions. For example, in most people, the ability to form words is a function that seems to be located within the left hemisphere, while the right hemisphere is better at processing spatial information. Different parts of each hemisphere handle specific functions, including hearing, vision, speech, memory, decision making and long-term planning.



Cerebral Hemispheres
(superior view)



The Brain and Spinal Cord
(sagittal view)

The cerebellum sits at the back of the brainstem and is about the size

Continued

Concepts

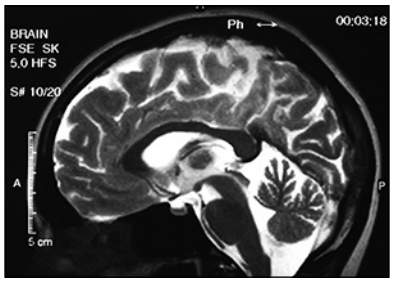
- The brain is the center of thinking, learning, reasoning, memory, the senses, emotions and movement.
- The brain has unique physical characteristics.
- The brain is specialized into many different areas, each with a different job.
- Brain functions and abilities develop over time.

Science & Math Skills

Observing, measuring, predicting, comparing and drawing conclusions

Time

Setup: 10 minutes
Activity: 30–45 minutes, in two sessions

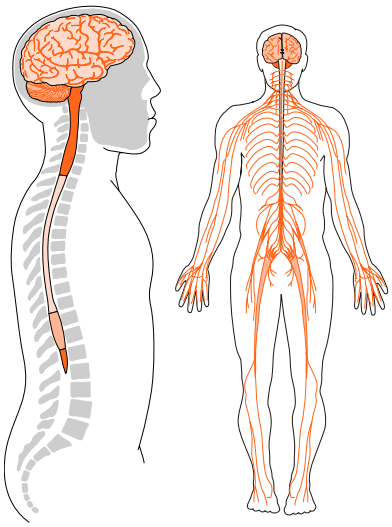


This MRI of a normal brain reveals the different regions of the brain, each of which has specific functions (see illustration, left). Such detailed images allow physicians to visualize diseases, effects of injuries and abnormalities in the brain.

Brain Differences

Individual talents and skills cannot be predicted based upon the appearance of someone's brain. All humans have brains of about the same size with the same pattern of folding. Differences among individuals are determined by the numbers and kinds of connections among nerve cells within each person's brain.

The Human Nervous System



The brain and spinal cord make up the central nervous system. All other nerves in the body form the peripheral nervous system.

Answer Key

The following are answers to the pre-assessment activity.

- **True:** 1, 2, 3, 5, 6, 8, 9, 10, 12, 14, 15, 19, 20, 22
- **False:** 4, 7, 11, 13, 16, 17, 18, 21

of a tennis ball. It helps us maintain balance and posture, and coordinates our movements. The cerebellum also plays an important role in our ability to learn and remember new motor skills, such as riding a bike.

The limbic system is comprised of a number of interconnected brain regions, including areas within and under the cerebral hemispheres. It is involved in many emotions and motivations, especially those related to survival, such as anger, fear, and even the fight-or-flight response. The limbic system also plays an important role in feelings of pleasure, such as those experienced from eating and sex.

The brainstem connects directly with the spinal cord and is responsible for automatic functions of the body, including heartbeat, digestion, breathing, swallowing, coughing and sneezing. Automatic functions are present at birth and happen without thinking about them.

The brain's main communication channel to the rest of the body is the spinal cord. Nerves branch out from the spinal cord and send and receive information.

Functions and abilities develop as the brain grows and matures. The human brain generally reaches close to 80% of its adult weight by the age of two or three, yet it continues to develop throughout adolescence and early adulthood. The region of the cerebral cortex responsible for judgment, organization and reasoning appears to be one of the last brain areas to reach maturity.

MATERIALS

Teacher (See Setup)

- 7 11-in. round, plain balloons
- Document projector (or overhead projector and a transparency of "The Human Brain" page)
- Water

Optional: Human brain model

Per Group of Students

- Balloon filled with water
- Sheet of drawing or chart paper

Per Student

- Copy of the "Know Your Brain?" pre-assessment

SETUP

Prior to class, fill one balloon with approximately three pounds (48 oz, or 1,450 mL) of water for each group of students, and one additional balloon for demonstration purposes. Use a scale to weigh the balloons, or compare the balloons to something that weighs approximately three pounds to estimate when you have reached the desired weight.

Photocopy the pre-assessment, "Know Your Brain?" (one per student). Before beginning the activities, have students complete the pre-assessment individually. Have students work in groups of four to discuss functions of the brain (with the balloon), and work individually to create timelines.

PROCEDURE

Pre-assessment and brain basics

1. Distribute copies of the pre-assessment. Without discussion, ask students to answer the questions. Collect the finished sheets and

keep them for use with the post-assessment at the end of the unit. (*Do not grade the papers.* For Answer Key, see sidebar, p. 2).

2. Begin a class discussion by mentioning that research scientists have learned much about the brain but that there still are many unanswered questions. Discuss students' answers to the assessment and tally the answers for each question on a chart at the front of the room. Moderate the discussion, but do not give answers to the assessment. You may wish to make a separate list of students' questions about the brain.
3. Show the water-filled balloon to the class. Ask, *How is this like a real brain? How is it different?* Give each group one balloon filled with water. Have students within each group share ideas. The Recorder should prepare a chart with two columns labeled "Same" and "Different," and record the students' ideas. Students may use a permanent marker to draw a picture of the brain on their balloons.

   Optional: Provide students with access to a brain model.
4. Discuss group answers as a class. Some responses might include the following.
   - **Same:** Balloon is similar size, similar weight, contains water, fragile.
   - **Different:** Balloon is not alive, not made of cells, not wrinkled, without defined parts, not connected to anything.

   You also may want to use information listed in Brain Facts (sidebar, upper right).

Functions of different brain areas

1. Project "The Human Brain" page. Discuss the different areas of the brain and the functions that are governed by those areas.
2. Prompt student thinking by asking questions such as, *What part of the brain would be involved in planning your homework?* (cerebrum) *Coordinating your movements when you play soccer?* (cerebellum) *Controlling your rate of breathing?* (brainstem) *Feeling angry?* (limbic system)
3. Then have students consider what parts of the brain are involved in different activities. Reading, for example, involves many areas of the brain (visual information and language is processed in the cerebrum; eye movements are coordinated by the brainstem; triggered emotions might involve the limbic system). Have student groups come up with other common activities or functions and discuss which regions of the brain might be working together during these activities. Have groups present their examples to the class.

Brain development timeline

1. Begin a class discussion by asking, *Do you have the same capabilities and skills as when you were born? Which capabilities have you always had?* Encourage students to think about automatic functions, such as breathing, or senses, such as hearing. Ask, *Which capabilities or skills*

Continued

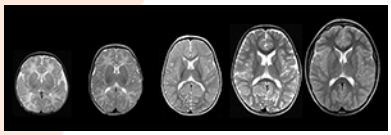
Brain Facts

- An average brain weighs about three pounds.
- Brain tissue is about 80% water.
- The brain contains over 100 billion neurons (equivalent to the number of stars in the Milky Way galaxy).
- The brain is contained within and protected by the skull.
- The brain is divided into left and right halves.
- The brain has three main parts, each with a special job (cerebrum, where thinking and processing of sensory information take place; cerebellum, which coordinates muscle movements; and brainstem, which governs automatic functions such as breathing and heart beat).
- The brain is pinkish-gray and has the consistency of cooked oatmeal or pudding.

Good Wrinkles

The cerebrum is responsible for many aspects of thinking, reasoning, the senses, and movement. Its surface, known as the cerebral cortex, is very wrinkled, with raised parts or bumps known as gyri, and creases or valleys referred to as sulci. These folds allow more cortical cells to fit into the confines of the skull. In fact, if you spread out the cerebral cortex it would take up approximately 2.5 square feet!

Normal Brain Development



The MRI images above show normal brain development (left to right) at ages 1 week, 3 months, 1 year, 2 years, and 10 years. Images such as these serve as a baseline for pediatricians when determining problems within the brain.

Sensitive Timing

Early in development, there are windows of time during which the brain is especially changeable and sensitive to experience. Some areas of the brain rely on cues from the external environment to develop normally. For example, the visual system must have visual input to form the connections necessary for sight. If a baby's vision is distorted by cataracts and is not corrected at an early age, the visual area of the brain corresponding to the affected eye will not develop appropriately, which may lead to permanent blindness.

There also is a sensitive developmental window for the acquisition of language. Most people who learn new languages after the age of 10 will speak the new language with the accent of their native tongue. It is important to recognize, however, that these sensitive periods are not the only times at which the brain can be affected by experience. For example, it is possible for adults to learn, and even master, new languages. In fact, the brain is constantly changing, and learning occurs throughout life.

have you developed since then? Responses might include walking, talking and reading.

2. Tell students they will be creating timelines of important events in their development. The timelines will include milestones such as the first time they sat up, walked, ran or spoke a word. Remind students that all of these functions are controlled in some way by the brain.
3. Guide students as they create templates for their timelines. The timelines should include spaces to record at least three important developmental events for each of the first two years of their lifetimes. At least one milestone should be recorded for each subsequent year. Students probably will need to consult their parents or other family members for details about the earliest events. The timelines also should identify whether each milestone was *most* related to movement, communication, senses, thinking, planning or emotions (see "Sample Timeline," right).

Sample Timeline

Age	Milestone	Type
1 mo.	Smiled	Emotion
3 mos.	Rolled over	Movement
1 year	Walked	Movement
14 mos.	Ran	Movement
14 mos.	Spoke 1st word	Communication

4. Have students bring their timelines to class to share in small groups or with the entire class. Ask students if they noticed any similarities in the types of milestones that were most significant in early years of development. In many cases, students will have recorded early events related to basic movements and beginning communication skills. Follow by having students discuss the types of milestones that occurred as they became older. Many of these milestones will be related to thinking, planning, complex movements and types of communication.
5. Conclude by helping students understand that their brains still are changing. For example, brain areas involved in judgement and reasoning (frontal lobes of the cerebrum) continue to develop throughout adolescence and into early adulthood. As the brain continues to mature, adolescents develop increased abilities to plan, reason and exercise self-control.

MRI image courtesy of NIH from the MRI Study of Normal Brain Development project.

Know Your Brain?

Name _____

Read each statement below. Circle T if it is true or F if it is false.

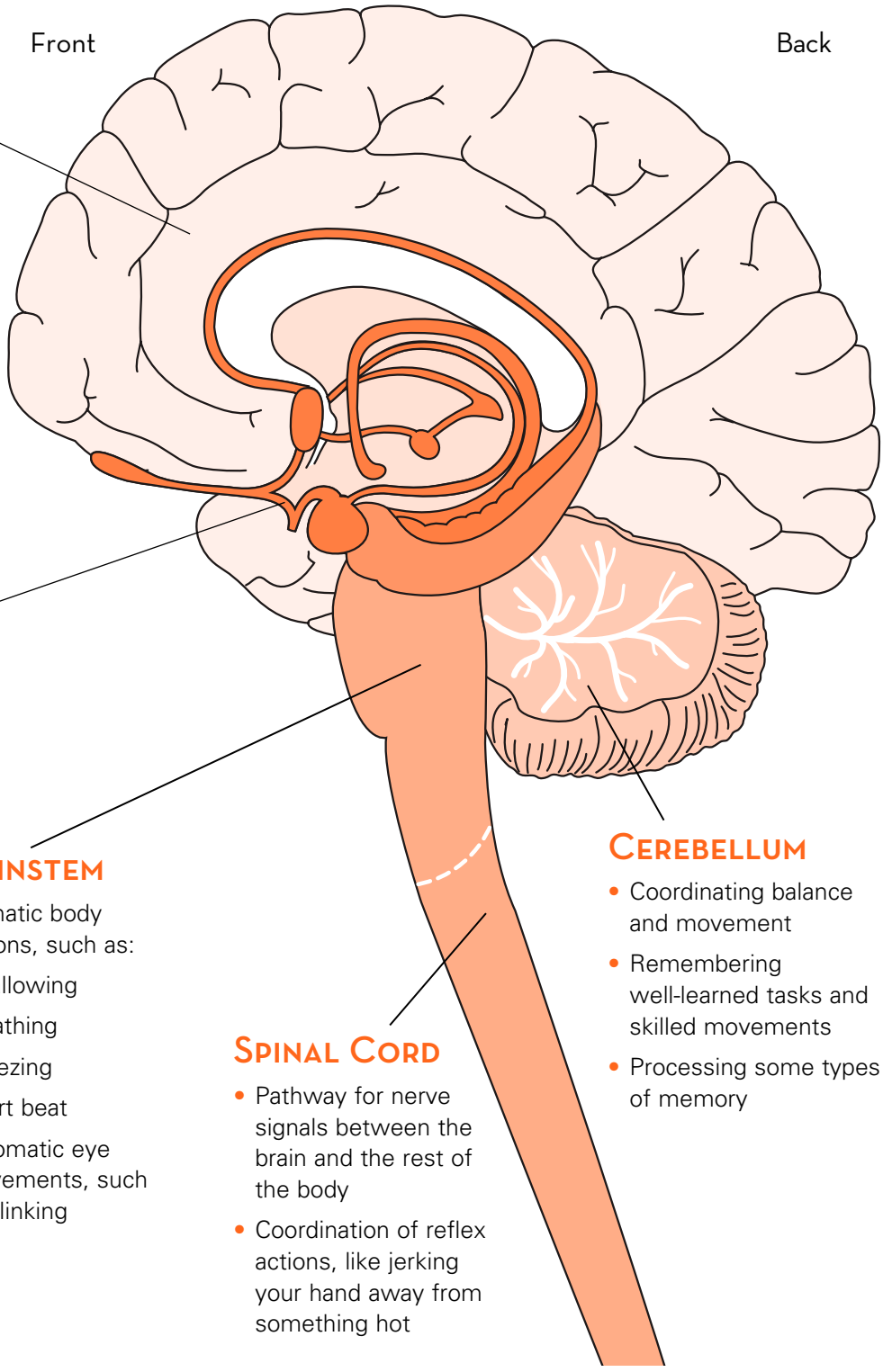
1.	Nerve cells can process many incoming signals from other nerve cells.	T F
2.	Hormones are chemical messengers that circulate in the bloodstream.	T F
3.	Our personal desires can affect how we interpret risks to ourselves and to others.	T F
4.	One special chemical acts as a messenger within the body.	T F
5.	Many automatic functions of the body, like breathing, are controlled by the brain.	T F
6.	Stress is a response by the body to help it survive.	T F
7.	Scientists now understand everything about the brain.	T F
8.	The pleasure system in the brain can be activated in harmful ways by some drugs of abuse.	T F
9.	Nerve cells use electricity and chemistry to send signals.	T F
10.	A person's skills and abilities are related to connections among nerve cells.	T F
11.	All nerve cells are alike.	T F
12.	The brains of teenagers still are developing and maturing.	T F
13.	It is easy to stop being addicted to a drug.	T F
14.	Our experiences contribute to the development of our brains.	T F
15.	Signals in the nervous system can travel from the brain all the way to the toe.	T F
16.	Nicotine, a drug in cigarettes, is not very addictive.	T F
17.	The part of the brain responsible for judgment and planning is one of the first parts to develop.	T F
18.	The brainstem is the thinking part of the brain.	T F
19.	The brain has many specialized areas.	T F
20.	Some drugs interfere with the sending and receiving of nervous system signals.	T F
21.	Neurotransmission is part of a car.	T F
22.	Whole grain breads and cereals provide a steady supply of energy to the brain.	T F

The Human Brain

Cerebrum

(Cerebral Cortex)

- Thinking
- Learning
- Remembering
- Sensing
- Speaking
- Feeling emotions
- Voluntary movement (movements you choose to do)
- Planning
- Decision making
- Reasoning



Limbic System

- Emotions related to survival, such as fear and anger
- Processing of memories for long-term storage
- Feeling pleasure
- Regulation of body temperature, thirst and appetite or hunger

Brainstem

Automatic body functions, such as:

- Swallowing
- Breathing
- Sneezing
- Heart beat
- Automatic eye movements, such as blinking

Spinal Cord

- Pathway for nerve signals between the brain and the rest of the body
- Coordination of reflex actions, like jerking your hand away from something hot

Cerebellum

- Coordinating balance and movement
- Remembering well-learned tasks and skilled movements
- Processing some types of memory