

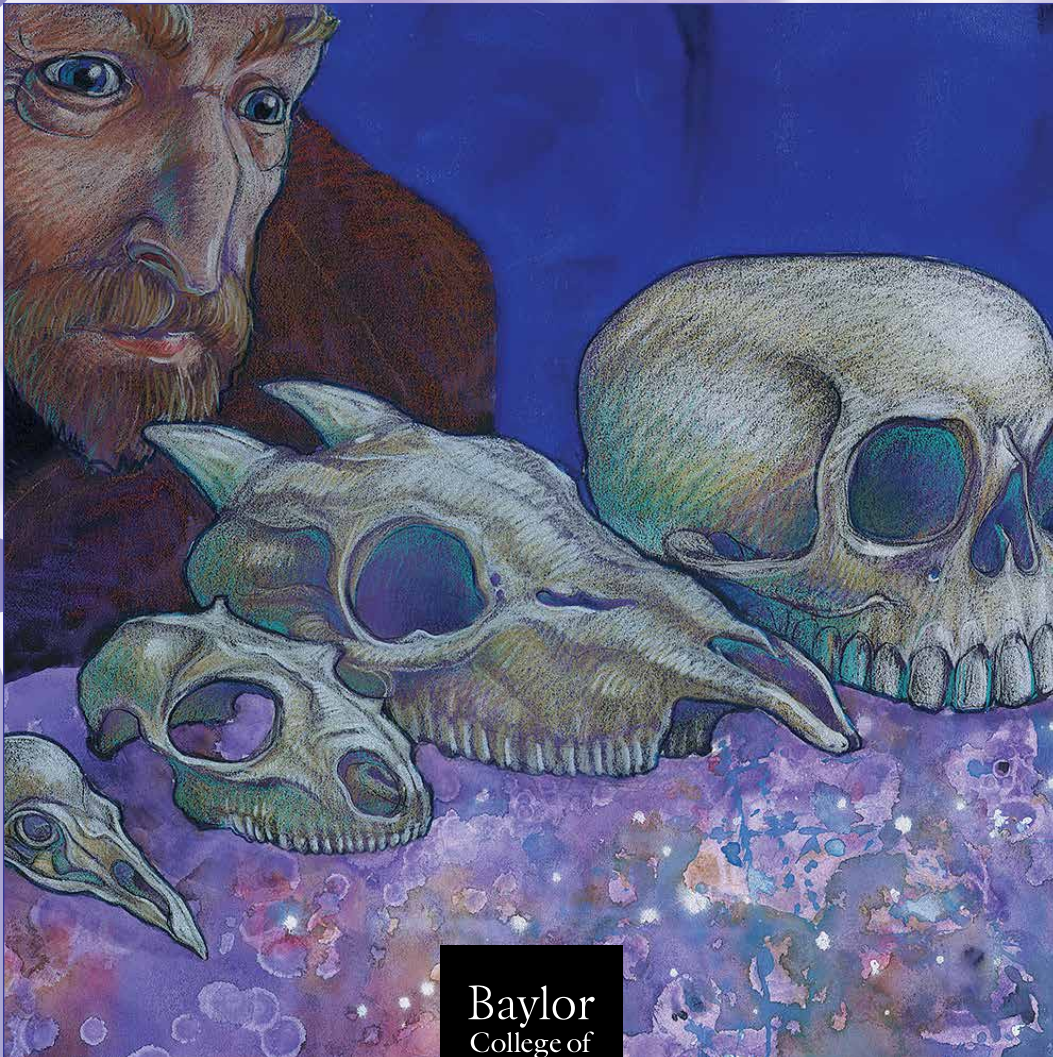


BRAIN COMPARISONS

Teacher's Guide

Written by

Leslie Miller, Ph.D., Barbara Tharp, M.S., Judith Dresden, M.S., Katherine Taber, Ph.D., Karen Kabnick, Ph.D., and Nancy Moreno, Ph.D.



Baylor
College of
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BioEd Teacher Resources from the
Center for Educational Outreach
Baylor College of Medicine

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The activities described in this book are intended for school-age children under direct supervision of adults. The authors, Baylor College of Medicine and the publisher cannot be responsible for any accidents or injuries that may result from conduct of the activities, from not specifically following directions, or from ignoring cautions contained in the text.

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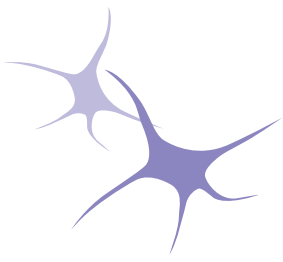


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BRAIN COMPARISONS

This BrainLink® teacher's guide is designed to be used with the following other components of this unit.

- *Skullduggery: A Case of Cranium Confusion*
- *Explorations*
- *The Reading Link*



ACKNOWLEDGMENTS

“The brain is the last and grandest biological frontier, the most complex thing we have yet discovered in our universe. It contains hundreds of billions of cells interlinked through trillions of connections. The brain boggles the mind.”

James D. Watson from
Discovering the Brain, National
Academy Press, 1992

The BrainLink® project at Baylor College of Medicine has benefited from the vision and expertise of scientists and educators from a wide range of specialties. Our heartfelt appreciation goes to James Patrick, Ph.D., Vice President and Dean of Research, and Head, Division of Neuroscience; Stanley Appel, M.D., Professor and Chairman of Neurology; Carlos Vallbona, M.D., Distinguished Service Professor of Family and Community Medicine; and William A. Thomson, Ph.D., Professor of Family and Community Medicine at Baylor College of Medicine, who have lent their support and expertise to the project. We also express our gratitude to Cynthia Bandemer, M.P.H., Director of Education, Houston Museum of Health and Medical Science, who directed BrainLink activities sponsored by the Harris County Medical Society.

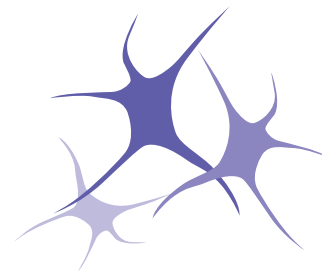
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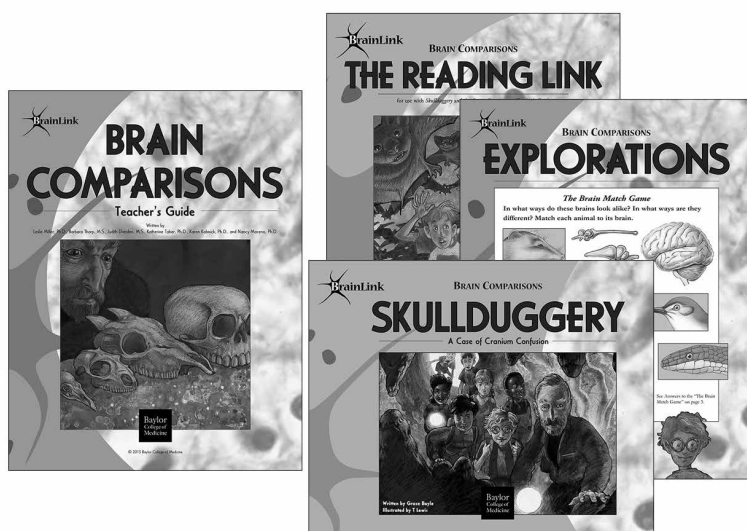
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We are especially grateful to the many classroom teachers in the Houston area who eagerly participated in the field tests of these materials and provided invaluable feedback.

ABOUT BRAINLINK®



The BrainLink® project's exciting activities, explorations and adventure stories “link” students, teachers and parents to advanced knowledge of the brain and nervous system and to vital science and health information. Prepared by teams of educators, scientists and health specialists, each BrainLink® unit focuses on a different aspect of the brain and the nervous system. The activity-based, discovery-oriented approach of the BrainLink® materials is aligned with the National Science Education Standards and the National Health Education Standards.



The four integrated components of this BrainLink® unit help students learn why their brains make them special.

- *Brain Comparisons Teacher's Guide* presents inquiry-based lessons that entice students to discover concepts in science, mathematics and health through hands-on activities.
- *Skullduggery* presents the escapades of the NeuroExplorers® Club in an illustrated storybook that also teaches science and health concepts.
- *The Reading Link* provides language arts activities related to the student storybook.
- *Explorations* is a colorful mini-magazine full of information, activities and fun things for children and adults to do in class or at home.

BrainLink® materials offer flexibility and versatility and are adaptable to a variety of grade levels and teaching and learning styles.

BRAINLINK UNITS

BioEd offers the following BrainLink teaching units to help you and your students learn more about the brain and central nervous system.

BRAIN COMPARISONS

(major structures of the brain in humans and other animals)

MEMORY AND LEARNING

(how the brain stores and retrieves information)

THE MOTOR SYSTEM

(reflexes, movements, and coordination between the brain and body)

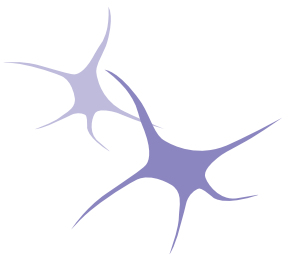
THE SENSORY SYTEM

(how the senses work, visual illusions, and how the brain processes sensory information)

BRAIN CHEMISTRY

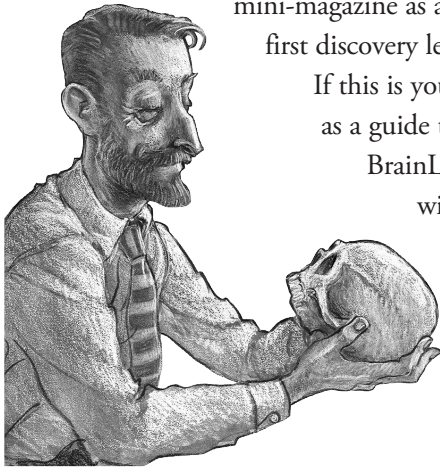
(the brain and neurons, chemical communication in the body, risk perception vs. reality, and how personal choices can affect brain function and performance)

For complete resources, visit www.bioedonline.org today!



WHERE DO I BEGIN?

The teachers guide to activities, adventures storybook, reading supplement mini-magazine and components of each BrainLink® unit are designed to be used together to introduce and reinforce important concepts for students. To begin a BrainLink® unit, some teachers prefer to generate students' interest by reading part or all of the adventures story. Others use the cover of the mini-magazine as a way to create student enthusiasm and introduce the unit. Still others begin with the first discovery lesson in the teacher's guide.



If this is your first BrainLink® unit, you may want to use the pacing chart on the following page as a guide to integrating three of the components of the unit into your schedule. When teaching BrainLink® for 45–60 minutes daily, most teachers will complete an entire BrainLink® unit with their students in two to three weeks. If you use BrainLink® every other day or once per week, one unit will take from three to nine weeks to teach, depending on the amount of time you spend on each session.

The BrainLink® *Teacher's Guide* provides background information for you, the teacher, at the beginning of each activity. In addition, a listing of all materials, estimates of time needed to conduct activities and links to other components of the unit are given as aids for planning. Questioning strategies, follow-up activities and appropriate treatments for student-generated data also are provided. The final

activity in each guide is appropriate for assessing student mastery of concepts and may also be given as a pre-assessment prior to beginning the unit.

USING COOPERATIVE GROUPS IN THE CLASSROOM

Cooperative learning is a systematic way for students to work together in groups of two to four. It provides an organized setting for group interaction and enables students to share ideas and to learn from one another. Through such interactions, students are more likely to take responsibility for their own learning. The use of cooperative groups provides necessary support for reluctant learners, models community settings where cooperation is necessary, and enables the teacher to conduct hands-on investigations with fewer materials.

Organization is essential for cooperative learning to occur in a hands-on science classroom. There are materials to be managed, processes to be performed, results to be recorded and clean-up procedures to be followed. When students are “doing” science, each student must have a specific role, or chaos may follow.

The Teaming Up model* provides an efficient system. Four “jobs” are delineated: Principal Investigator, Materials Manager, Reporter and Maintenance Director. Each job entails specific responsibilities. Students may wear job badges that describe their duties. Tasks are rotated within each group for different activities, so that each student has an opportunity to experience all roles. Teachers even may want to make class charts to coordinate job assignments within groups.

Once a cooperative model for learning has been established in the classroom, students are able to conduct science activities in an organized and effective manner. All students are aware of their responsibilities and are able to contribute to successful group efforts.

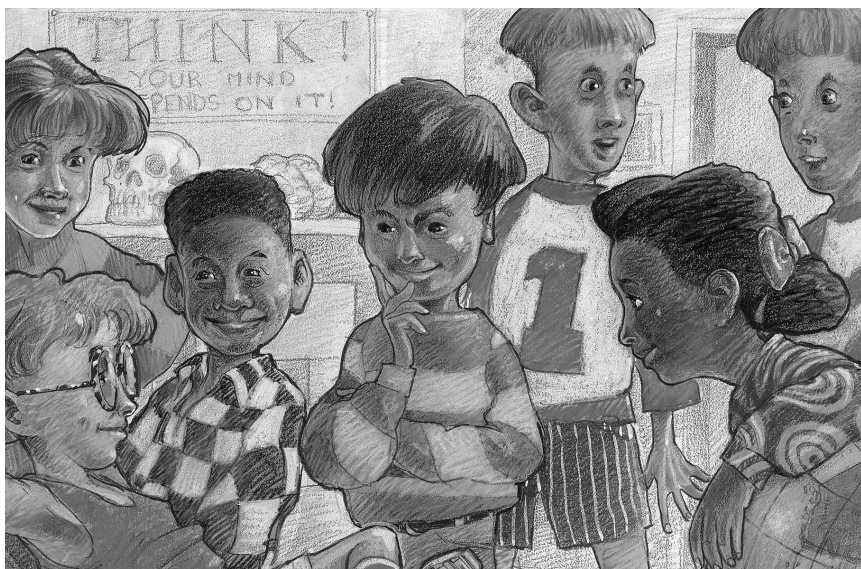
* Jones, R. M. 1990. *Teaming Up!* LaPorte, Texas: ITGROUP.

SAMPLE SEQUENCE

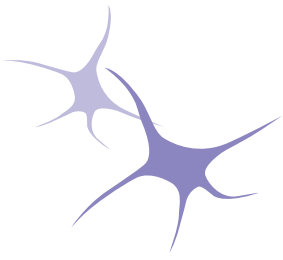


The components of this BrainLink® unit can be used together in many ways. If you have never used these materials before, the following outline might help you to coordinate the activities described in this book with the Brain Comparisons unit's adventure story, *Skullduggery*, and student magazine, *Explorations*.

Similar information also is provided for you in the “Unit Links” section of each activity in this book.



ACTIVITY	CONCEPTS	CLASS PERIODS TO COMPLETE	LINKS TO OTHER COMPONENTS OF UNIT	
			SKULLDUGGERY	EXPLORATIONS
1. Did You Know?	The brain is the command center of the body. The brain has three main parts.	1	Story, Chapters 1–3; Science boxes, pp. 3 and 6	“Matter of Fact!” p. 2
2. Build a Skull	The brain is shielded by the skull, which also needs protection.	3	Story, Chapters 4–5; Science boxes, pp. 7–9; 13	“Eggheads,” and “Did You Know?” p. 4; “Your Colossal Cranium,” p. 8
3. Good Wrinkles	Wrinkles allow more cerebral cortex to fit into the skull and correlate to higher intelligence in animals.	1	Story, Chapters 6–7; Science box, p. 18	A-Mazing Brains” p. 3; “Knead A Brain?” p. 5; “Just the Facts,” p. 6; “Brain Busters!” p. 7
4. Comparing Brains	The size and shape of the cerebrum, cerebellum and brainstem differ among animal species.	1 or 2	Story, Chapters 8–9; Science box, p. 23	“The Brain Match Game,” on the cover; “Matter of Fact!” p. 2
5. How Much Brain Do You Need?	The size of an animal’s brain relative to its body size is a predictor of intelligence.	2	Story, Chapters 10–11; Science box, p. 23	“The Brain Match Game,” “Matter of Fact!” p. 2; “A Weighty Subject,” p. 6
6. Create a Brain	Summary and assessment activity	1	Story, Chapters, 12–13; Science boxes, review all	“Careers for NeuroExplorers,” p. 7; “Matter of Fact!” p. 2



UNIT MATERIALS

Activity 4: Animal Molds

For information about obtaining cat and rabbit molds for use with Activity 4, contact the Center for Educational Outreach at 713-798-8200 or edoutreach@bcm.edu.

You will need the following materials and consumable supplies to teach this unit with 24 students working in six cooperative groups. See “Setup” sections within each activity for alternatives or specifics.

ACTIVITY 1 (p. 1)

- 24 blue markers or crayons
- 24 red markers or crayons
- 24 yellow markers or crayons
- 11-in. helium-quality balloon
- Container for oatmeal
- Package of instant oatmeal
- Scale or balance (to measure water-filled balloons)
- Tap water

Optional: Poster/picture of human brain and skull

ACTIVITY 2 (p. 6)

- 11 BrainLink balloons (or 11-in. helium-quality balloons)
- 6 rolls of tape (clear or masking) and/or glue
- Recycled materials such as boxes and other containers, bags, bubble wrap, egg cartons, milk cartons, cloth, etc. (to construct skull for balloons)
- Scale or balance (to weigh water-filled balloons)
- Tap water

ACTIVITY 3 (p. 12)

- 6 metric rulers
- 6 pairs of scissors
- 6 rolls of tape (clear or masking) and/or bottles of glue
- 6 sheets of red construction paper, 9-in. x 12-in.
- 6 sheets of newspaper (at least 20-in. x 20-in.)
- Paper clips

ACTIVITY 4 (p. 15)

- 24 blue markers or crayons
- 24 red markers or crayons
- 24 yellow markers or crayons
- 6 9-oz disposable cups
- 6 8-oz measuring cups
- 6 craft sticks
- 6 molds of a cat brain
- 6 molds of a rabbit brain
- 3 cups of quick-setting plaster (about 1/4 cup per mold)
- Tap water

ACTIVITY 5, 6 (p. 21, 26)

No special materials required.

DID YOU KNOW?

Did you ever wonder what a human brain really looks like? How much it weighs? What it feels like? Most of us will never see or touch a real brain, but we can capture much of the excitement of neuroscience while teaching some simple concepts about the brain.

The brain is the command center of the body. It is enclosed within the skull dome, or cranium. This bony shell protects the brain and also forms the shape of the head. The brain is further protected by a cushion of fluid and is covered by three thin but tough membranes called meninges.



SKULLDUGGERY

Story, Chapters 1-3
Science boxes, p. 3 and 6
(If using BrainLink® for the first time, have students read “How the Club Began . . .,” p. ii; and “The NeuroExplorers,” pp. iii-iv.)

EXPLORATIONS

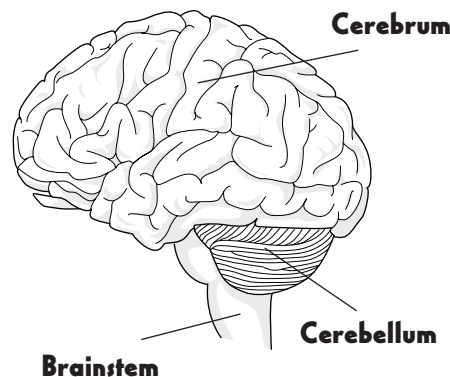
“Matter of Fact!” p. 2

The brain is the most complex organ of the body. It has three major parts, each of which plays a particular role. The brainstem controls automatic activities of the body, such as heartbeat, digestion, breathing, swallowing, coughing and sneezing. It is connected to the spinal cord. The cerebellum sits at the back of the brainstem. It helps the muscles work together for coordination and learning of rote movements. It also controls the sense of balance. The largest part of the mammalian brain, the cerebrum, is responsible for thinking, learning, remembering, feeling sensations and

emotions, and moving muscles voluntarily.

The surface of the cerebrum has folds, called gyri, and grooves, called sulci. These wrinkles allow more cerebral surface tissue to fit into a limited space. More wrinkles on the cerebral surface are thought to correlate with higher intelligence levels among various animal species.

The general structure of all mammalian brains (for example, rabbit, cat, human) is similar. Each has three major regions—the cerebellum, the cerebrum and the brainstem. As the needs and behaviors of different animal species have changed over long periods of time, so too have their brains. Cerebellums and brainstems differ among



OVERVIEW

Students are introduced to the brain, the most complex organ of the body, and explore some of its properties.

CONCEPTS

- The brain is the command center of the body.
- The brain has unique physical characteristics.
- The brain has three major parts, each with a special role.
- The brain is protected by the skull.

SCIENCE & MATH SKILLS

Observing, estimating and measuring

TIME

Preparation: 10 minutes

Class: 30-45 minutes

MATERIALS

- 11-in. helium-quality balloon
- Container for oatmeal
- Package of instant oatmeal (prepared in advance)
- Scale or balance to weigh a water-filled balloon
- Tap water

Each student will need:

- Set of yellow, red and blue crayons or markers
- Copy of “Brain Diagram” page

Optional: Poster/picture of human brain and skull

Brain Facts

- The brain is the command center of the body.
- An average human brain weighs about three pounds.
- Brain tissue is about 80% water.
- The outermost layer of the cerebrum is sometimes referred to as “gray matter.” This layer contains the cell bodies of many of the neurons in the cerebrum.
- The texture of the brain is something like cooked oatmeal, or butter at room temperature.
- The brain is divided into left and right halves, or hemispheres, which are connected and can share information. In the case of injury, one hemisphere sometimes can take over functions originally handled by the other hemisphere.
- The brain has three main parts: brainstem, cerebellum and cerebrum.
- Each part of the brain has a specific job to do.
- The brain contains about 100 billion neurons. This number is comparable to the number of stars in the Milky Way.
- In addition to some automatic functions, the brainstem controls the “fight or flight” reaction.

mammals, mainly in size. Cerebrums, on the other hand, vary widely in both size and surface appearance. In addition, parts of the brain that are used more frequently or control important senses tend to become larger or more developed.

Animals’ brains fit snugly inside their skulls. Brains are protected by the meninges and the fluid that

surrounds the brain, but most of the protection is afforded by the skull, as shown in the activity, “Build a Skull.” There is a close relationship between the shape and size of the brain and the shape and size of the cranium.

SETUP

This activity is teacher-directed and is best presented as whole class instruction.

Prior to class, fill the balloon with water. To do this, first stretch the balloon. Then fill it with water by placing the open end of the balloon over a faucet until the balloon contains approximately three pounds (48 oz or 1,450 mL) of water. Use a scale or compare the balloon to something of appropriate weight to estimate when you have reached three pounds.

Prepare instant oatmeal according to package directions. Let cool and place in a plastic bag or container. (As an alternative to oatmeal, you may use softened butter or shortening.)

PROCEDURE

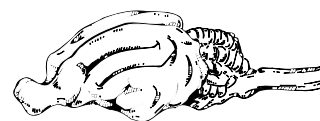
1. Ask your students to tell you what they know about the brain. On the board, make a list of things the students think they know and of things they would like to find out. To help them along, you might ask questions such as these.
 - *Where is the brain located?*
 - *How much would you predict the average brain weighs?*
 - *What color do you think it is?*
 - *What would it feel like if you touched it?*

Explain to students that even though scientists have learned much about the brain, there still are many unanswered questions. This activity will help students learn about the physical properties of the brain.

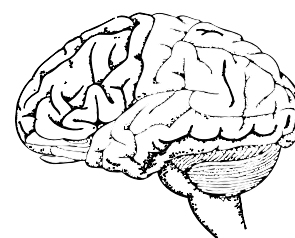
Rabbit brain



Cat brain



Human brain



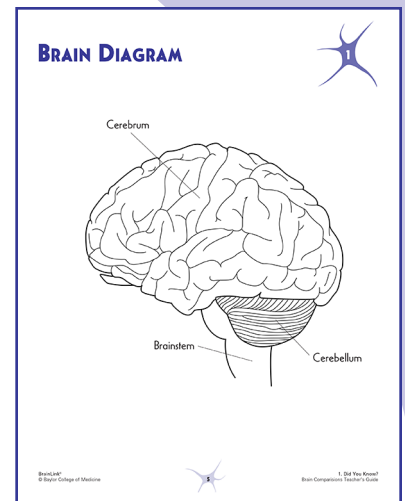
2. Bring out the water-filled balloon and have a student assistant hold it in his or her hands. Use the “Brain Facts” listed in the sidebar to the right to expand upon students’ comments. You might say something like:
 - *Did you know that the average brain weighs about 1.45 kg (three pounds)? That is about the same weight as this balloon filled with water.* (Allow students to feel the weight.)
 - *Did you know that the brain is about the consistency of cooked oatmeal, shortening or butter at room temperature?* (Allow students to touch the oatmeal.)
3. Mention the three major parts of the brain: brainstem, cerebellum and cerebrum. Ask, *Did you know that each part of the brain has a special job to do?* As you introduce the three major parts of the brain, locate each on the balloon and outline it with a marker to clarify the position. Refer to the “Brain Diagram” student sheet.

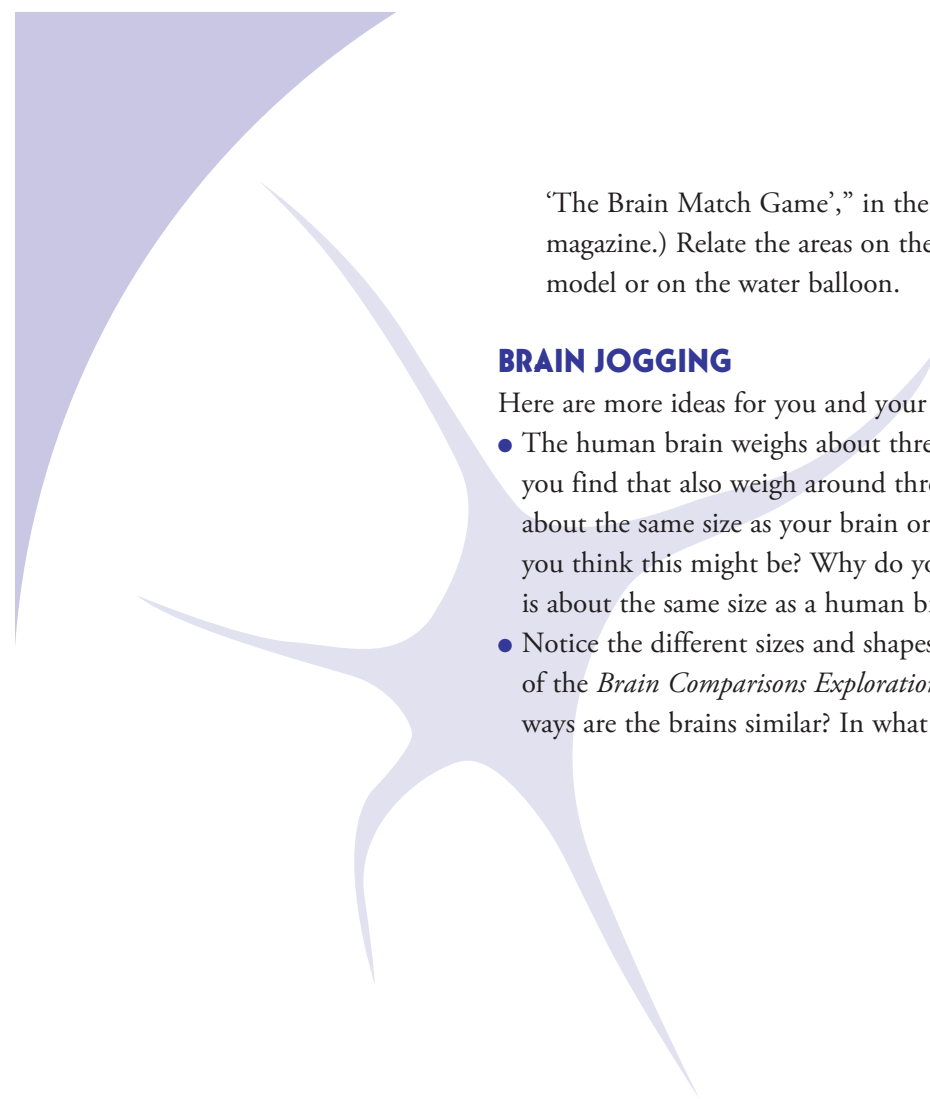
The brainstem is located at the back of the brain and is connected to the spinal cord. The cerebellum is found at the back of the brainstem. The cerebrum, the largest section of the brain, has many wrinkles. If you look at the brain from the top, there are two distinct halves, or hemispheres.

4. Explain that the wrinkles printed on the balloon represent folds in the surface. They are not smooth areas as they appear on the balloon. These folds—gyri—enable needed brain material to fit into a limited space. (The activity, “Good Wrinkles,” in this unit illustrates how this is accomplished.)
5. If one is available, show and discuss a picture or poster of the human brain and skull. Relate the concepts you covered earlier to the model and once again tie them back to the students’ initial observations.

Possible lead questions might include the following.

- *Would the human brain really feel the same as this model? Is it harder than the model, or softer?*
 - *Can you identify the three parts of the brain from this model? What about the two halves, or hemispheres?*
 - *Do you think all animals with backbones have brains like human brains?*
 - *What is the primary source of protection for the brain?*
 - *How is the brain positioned in the skull?*
 - *Do you think it is possible for a large animal to have a small brain?*
 - *Is it possible for a small animal to have a large brain?*
6. Have students color their copies of “Brain Diagram” pages so that the cerebrum is yellow, the cerebellum is red and the brainstem is blue. (These colors correlate with the illustrations on page 3, “Answers to





‘The Brain Match Game’,” in the *Brain Comparisons Explorations* magazine.) Relate the areas on the diagram to those on the brain model or on the water balloon.

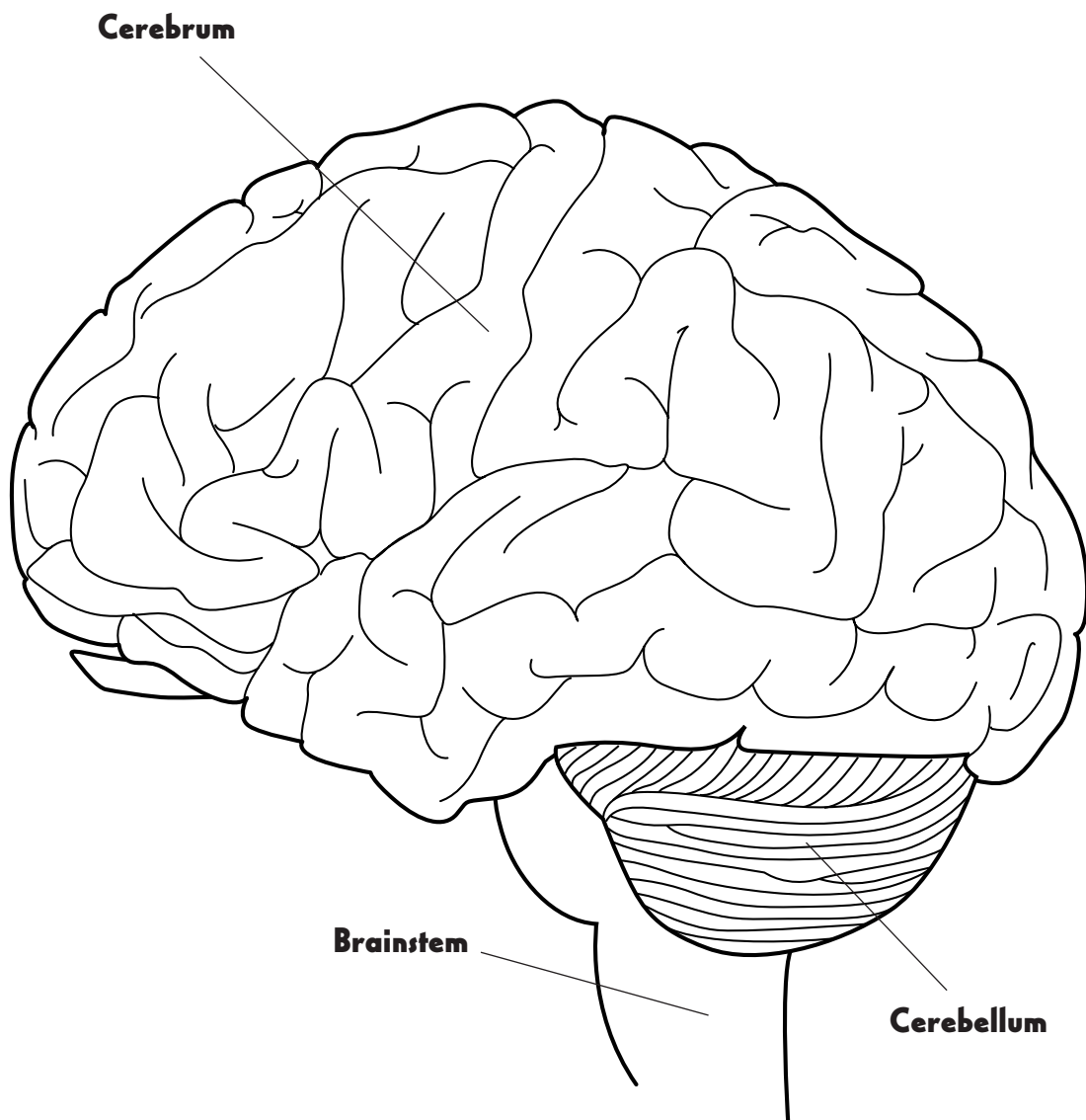
BRAIN JOGGING

Here are more ideas for you and your students to explore.

- The human brain weighs about three pounds. What other things can you find that also weigh around three pounds? Are the additional things about the same size as your brain or the water balloon brain? Why do you think this might be? Why do you think that the water balloon brain is about the same size as a human brain?
- Notice the different sizes and shapes of the brains depicted on the cover of the *Brain Comparisons Explorations* component of this unit. In what ways are the brains similar? In what ways are they different?



BRAIN DIAGRAM



BUILD A SKULL

OVERVIEW

Students will create and test protective covers for water balloon “brains” using various recycled materials.

CONCEPTS

- The skull protects the brain.
- The skull also needs protection.

SCIENCE & MATH SKILLS

Measuring, observing, predicting, modeling and inferring

TIME

Preparation: 10 minutes

Class: one session of 30 minutes to present skull facts and plan design; one session of 45 minutes to build and present skulls; one session of 30 minutes to test skulls outside and discuss results

MATERIALS

- 5 11-in. helium-quality balloons for demonstrations
- Scale or balance to weigh water-filled balloon

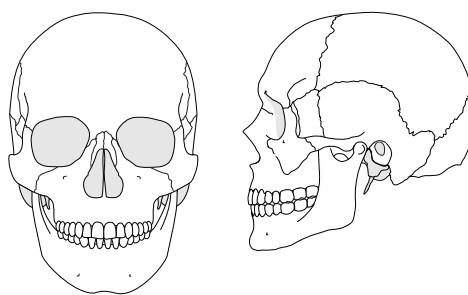
Each group will need:

- 11-in. helium quality balloon
- Recycled materials such as boxes and other containers, bags, bubble wrap, egg cartons, milk cartons, cloth, etc.
- Roll of tape (clear or masking) and/or glue
- Tap water
- Copies of “Skull Diagram” and “Front View of the Skull” student pages

The skull, the body’s most complex bony structure, is comprised of 22 bones. It forms a hard, protective covering around the brain. Inside the skull, the brain also is supported by a liquid cushion—the cerebrospinal fluid. The fluid protects the brain and spinal cord by absorbing shock waves from blows and falls.

Eight bones compose the part of the skull that covers the bulk of the brain. Together, these form the brain’s protective “helmet,” known as the cranium. Because its top is curved into a dome, the cranium is self-bracing. This allows the bones to vary from thick to thin and yet, like an eggshell, the cranium remains very strong for its weight.

A baby is born with a soft spot, a place on the top of the head where the bones of the skull have not yet grown together. If the bones were fused, they might be broken during birth. Instead, they are able to move. Also, further growth of the brain would be impossible if these bones were fused at birth.



Front and side views of human skull

smooth edges. The largest and strongest bone of the skull—the mandible, or jawbone—is the only skull bone that can be moved freely.

The skull has about 85 openings. The most important openings include those that allow passage of the spinal cord and the major blood vessels, and those that form holes for the eyes and nose.

There are four pairs of air-filled cavities (sinuses) actually within the skull. One sinus of each pair is on each side of the skull. Three sets of sinuses (maxillary, ethmoid and sphenoid) are present at birth. Frontal sinuses develop around the age of eight. Each sinus is connected to the



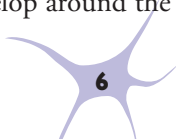
SKULLDUGGERY

Story, Chapters 4-5
Science boxes, p. 7-9, 13

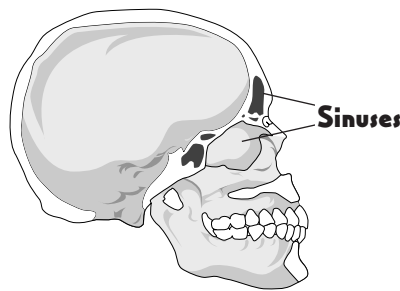
EXPLORATIONS

“Eggheads,” and “Did You Know?” p. 4; “Your Colossal Cranium,” p. 8

The bones of the skull meet at irregular, linear joints called sutures. Even though the bones fuse in later life, the joints remain visible. The jagged structure of these bones provides extra strength to the skull because the edges lock together more securely than would two



nasal cavity by a tiny tunnel (duct) about the size of a pencil lead. These ducts can become blocked easily, leading to headache, fatigue, congestion and face pain, all signs of sinus infection. Sinuses are lined with thin layers of tissue (or membranes) that filter and humidify the air we breathe. Sinus problems arise when those tissues become infected or inflamed.



Cross-sectional view of skull

SETUP

Several days before beginning this activity, have students bring clean recyclable materials to class. They will use the materials as they work in teams to build skulls for water balloon brains. Three class periods should be devoted to this activity: one to plan the skulls, a second for construction and a third to complete and test the skulls.

Prior to class, fill two balloons with water. First, stretch one balloon. Then fill it with water by placing the open end of the balloon over a faucet until the balloon contains approximately three pounds (48 oz or 1,450 mL) of water. Use a scale or compare the balloon to something of appropriate weight to estimate when you have reached three pounds. Repeat with the second balloon.

Students should work in groups of 4 to plan and build their skulls.

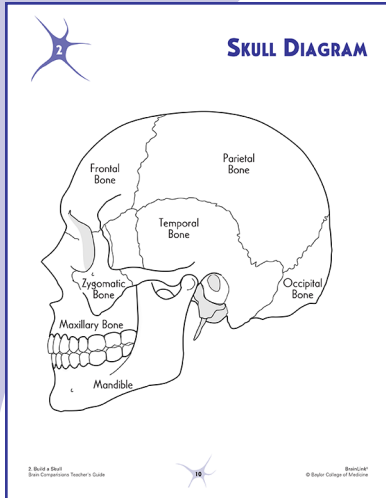
PROCEDURE

Planning

1. Take the class outside. Demonstrate to students how easily the “brain” balloon can be damaged by forcefully throwing one water-filled balloon onto a hard surface. The balloon should burst. Point out that the brain is about as fragile as the water balloon. Ask students if the unprotected water balloon brain would survive a fall from a bicycle or a slowly moving car.
2. Hold the second water-filled balloon in front of the students as you challenge them to create a protective skull for a water balloon out of materials that they have brought from home or that you have provided.
3. Let each group brainstorm ways to make a strong, resistant skull to protect its water balloon brain. Ask students, *Which available*

Injury Facts

- Every 15 seconds, a head injury occurs in the U.S.
- More head injuries occur in cars than in all other types of accidents combined.
- Traumatic brain injury is the fastest-growing type of injury in the U.S.
- Falls are the primary cause of head injuries in children under five years of age.
- Bicycle accidents are the primary cause of head injuries in children 5-12 years of age.
- Each year, about 1,200 bicyclists are fatally injured and more than 500,000 bicycle-related injuries are treated in hospital emergency rooms.
- The most common cause of death and serious injury from bicycle accidents is injury to the brain.
- A bicycle helmet is the best protection from an accident that could kill or disable for life.
- Helmets reduce, by 85%, the risk of brain injury from accidents involving bicycles, motorcycles, etc.
- When purchasing a bicycle helmet, look for a sticker inside certifying that it meets the safety standards of the SNELL Memorial Foundation or the U.S. Consumer Product Safety Commission.



materials would give the brain protection? How could the materials best be combined to form that protection?

Building the Skull

1. Give each group of students a balloon. Tell them first to stretch the balloon, then to fill it slowly with water by placing the end over a faucet. The balloon should contain about three pounds (1.45 kg) of water. Place a pre-filled balloon next to the sink to give children an idea of how much water they will need in their balloons. OR have them use a scale or balance to adjust the amount of water to approximately three pounds. When they have roughly the correct amount of water in the balloon, have them tie the end. Warn students to work carefully, with their hands under the balloons, to avoid breakage.
2. Have the groups construct skulls around the balloons.
3. When the students have finished working, each group should present its “skull” to the class. The students should explain their choices of materials and construction techniques.

Testing the Skull

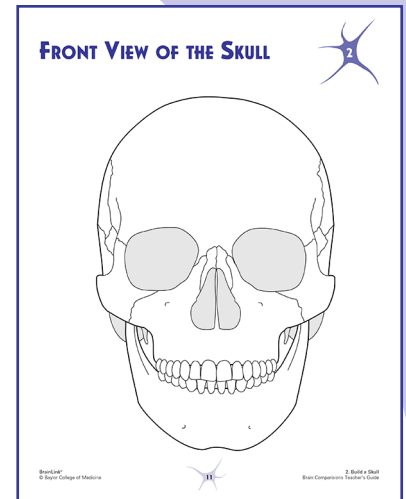
1. Test the skulls outside. Using an unprotected water balloon, demonstrate the effects of dropping a balloon onto grass, throwing a balloon onto grass, dropping a balloon onto a hard surface and throwing one forcefully onto a hard surface. Discuss why the water balloons might or might not break in those different situations.
2. Let the students test their skulls. One skull should be tested at a time, so the entire class can watch. Have each group test its skull on different surfaces, as described above. Discuss the results with the students. You might mention that the brain balloon is not exactly like a brain, but that it does illustrate the fragile nature of the brain. This exercise also shows that even a well-designed skull cannot protect the brain against everything.
3. Give each student a copy of “Skull Diagram” and “Front View of the Skull” student sheets. Use the information given at the beginning of this activity and the following questions to encourage a discussion. Have students think about the need for wearing a helmet during activities like baseball, bicycling, rollerskating, roller blading and motorcycling.
 - *Why does the brain need a skull?*
 - *What is the human skull made of?*
 - *What can you do to help protect your brain? Your skull?*
 - *Is it ever important to wear a helmet? If so, when?*

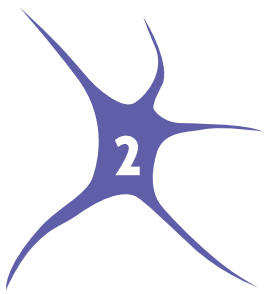
- *Why do you think we have sinuses?*
 - *How can our sinuses cause us problems?*
4. Describe the sinus cavities and their function. Mention that the caves in *Skullduggery*, the corresponding BrainLink adventures story, are shaped like sinus cavities.

BRAIN JOGGING

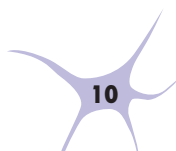
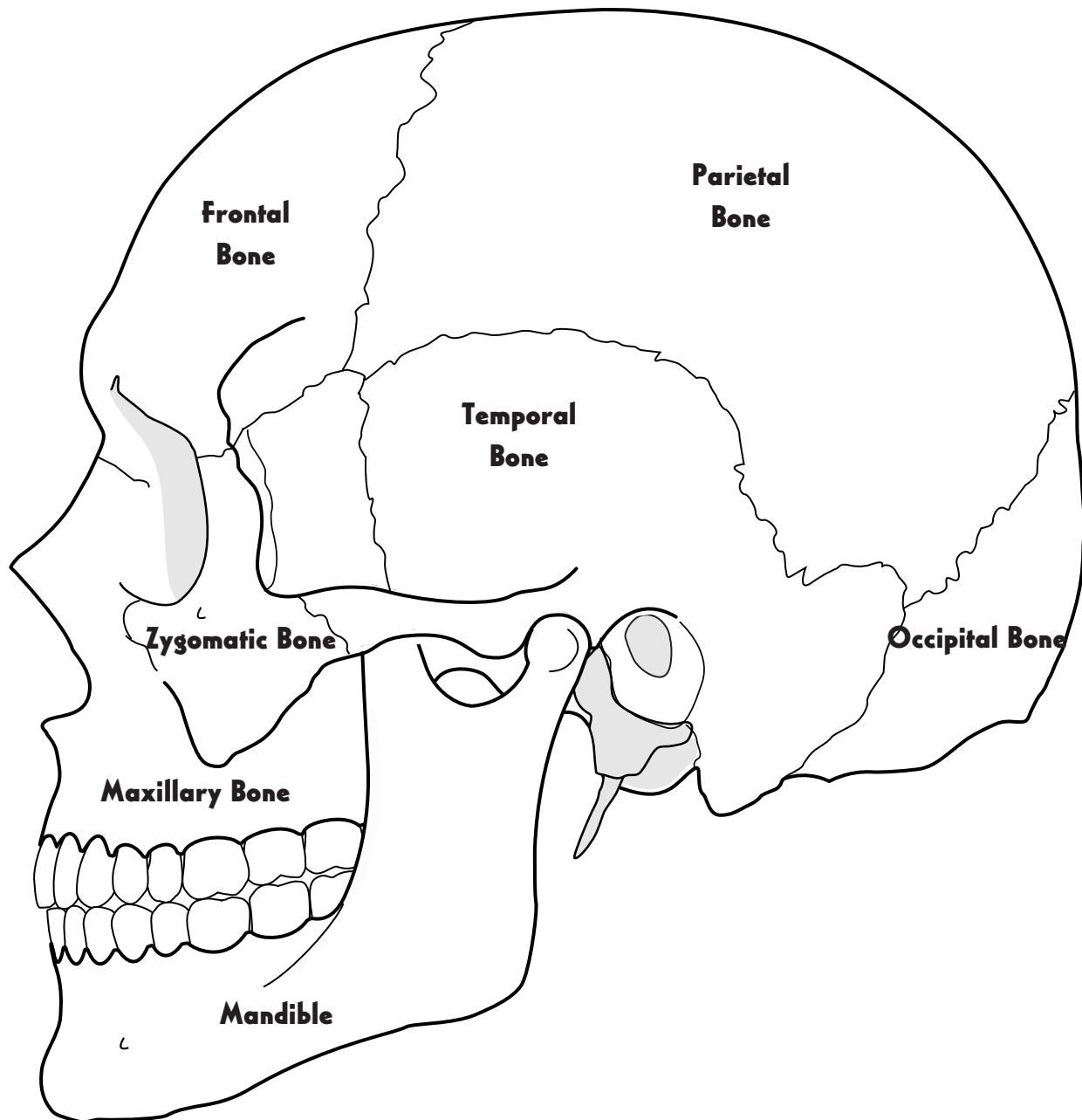
Here are more ideas for you and your students to explore.

- Do you think we should walk around with helmets on our heads all the time to protect our brains? Why is this a good idea? Why is this not such a good idea?
- Woodpeckers have many air spaces in their skulls. Why might this be so? Consider what they do for a living.
- The curved bones at the top of the skull form a strong arching structure. Where else do you see materials put together in this way?

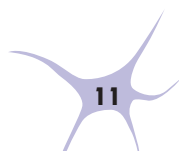
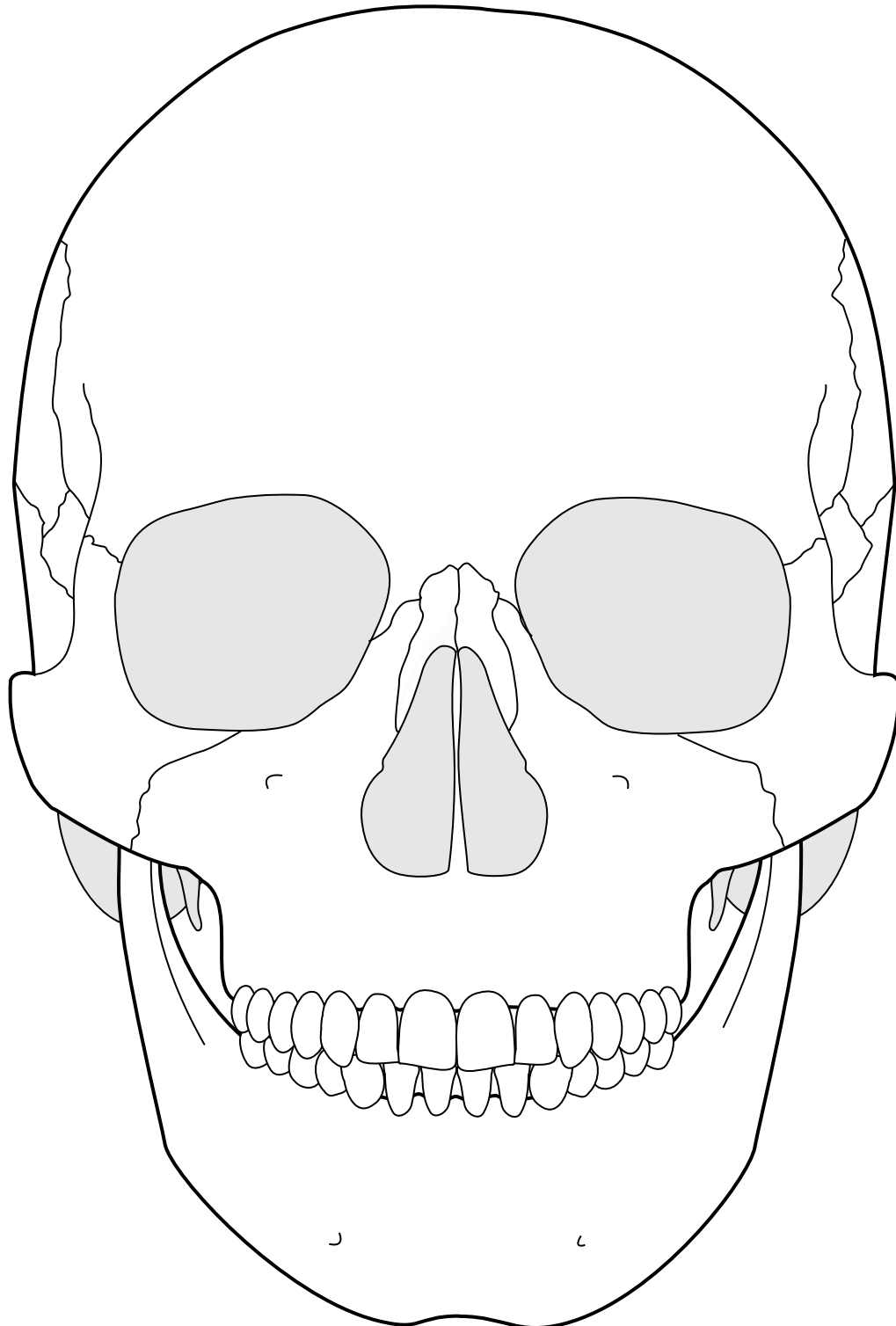




SKULL DIAGRAM



FRONT VIEW OF THE SKULL



OVERVIEW

By using paper to represent the surface areas of the cerebrum and the skull, students will learn about the significance of wrinkles on the surface of the mammalian cerebrum.

CONCEPTS

- Wrinkles in the cerebrum correlate to higher intelligence in animal species.
- Wrinkles evolved to allow more cerebral cortex to fit within the skull.

SCIENCE & MATH SKILLS

Measuring, comparing measurements, problem solving and drawing conclusions

TIME

Preparation: 10 minutes

Class: 30-45 minutes

MATERIALS

Each group will need:

- Large sheet of newspaper (at least 20 in. x 20 in.)
- Metric ruler
- Pair of scissors
- Paper clips
- Roll of tape (clear or masking) and/or glue
- Sheet of red construction paper (or other color)
- Copy of "Mammalian Brains" student sheet

Animal intelligence is a fascinating topic. Experts believe that the more brain mass a species has relative to its body weight, the smarter it is. It also generally is accepted that the ability to perform complex tasks is related to the number of folds (gyri) and grooves (sulci) found on the surface of the cerebrum.

Gyri and sulci evolved through the ages, as animals developed higher-level thinking skills, to accommodate increasing amounts of cerebral surface tissue (known as the cerebral cortex) within the limited space inside of the cranium. Just as one would fold something large to fit it into a small space, the brain's cerebral cortex over time has folded upon itself to fit more and more surface area into the cranium. The cerebral cortex consists of a sheet of nerve cells about 2.5 mm thick, forming the uppermost layers of the cerebrum.

In this activity, students will use a sheet of newspaper to represent the surface area of the human cerebrum.

They will attempt to fit the newspaper into a smaller space without hiding any of the information written on the page. They will relate their findings to the "folding" of the surface of the cerebrum.

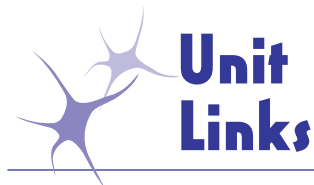
Large numbers of folds are quite common in the brains of many mammals. Human beings have large numbers of gyri and sulci, as do some other mammalian species (such as the chimpanzee, orangutan, gorilla, dolphin and whale).

SETUP

Students may work in groups of 4.

PROCEDURE

1. This is intended to be a discovery lesson. Therefore, without any introduction, give each student or group of students a 9 in. x 12 in. piece of construction paper and ask them to measure and cut it to approximately 23 cm x 23 cm (9 in. x 9 in.). Ask older students to calculate the surface area of the sheet and to write the result (529 cm^2 or 81 in.^2).
2. Give each student or group of students a sheet of newspaper, which

**SKULLDUGGERY**

Story, Chapters 6-7

Science box, p. 18

EXPLORATIONS

"A-Mazing Brains" p. 3; "Knead A Brain?" p. 5; "Just the Facts," p. 6; "Brain Busters!" p. 7

they should measure and cut to about 49 cm x 49 cm (19.2 in. x 19.2 in.). Ask them to calculate the surface area of this sheet and to write the result (2,401 cm² or 369 in.²).

3. Ask the students to find the difference between the areas of the sheets (2,401–529 = 1,872 cm² or 369–81 = 288 in.²).
4. Challenge each group to find a way to make the larger piece fit evenly over the smaller piece without cutting or wrapping the newsprint. All the surface area of one side of the newsprint should remain visible from some angle. The newsprint can be fastened to the edges of the smaller sheet, if desired. Give students an opportunity to experiment.
5. Once students have finished working, let them share and discuss their solutions. All solutions will be unique, but all will involve some kind of folding or wrinkling.
6. Tell students that the plain sheet of paper has about the same surface area as the helmet-shaped part of an average human skull and that the sheet of newspaper has about the same surface area as an average human cerebrum. Explain that the sheets of paper served as models for the top of the skull and the cerebrum, respectively. Discuss how the problem of fitting more cerebral tissue (thinking part of the brain) into a limited amount of space was solved during the course of evolution. (Increasing amounts of cerebral tissue were folded into wrinkles, allowing the brain to store and process more information in a smaller space.)
7. Point out that the amount of folding differs among animal species. Discuss these differences in terms of the relative intelligence of animals, as described at the beginning of this activity. Pass out copies of the “Mammalian Brains” sheet. Discuss the number of gyri present in each brain and what the students know about the activities and relative intelligence of members of each species.

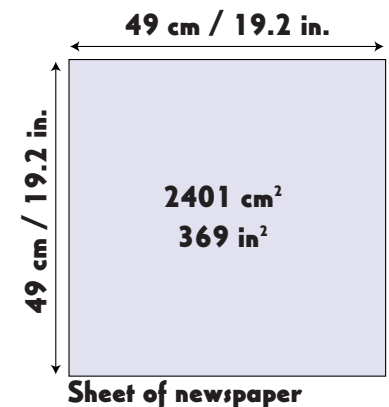
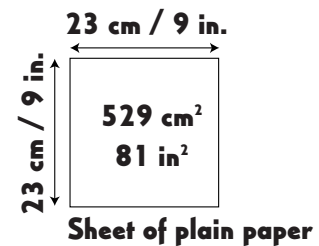
BRAIN JOGGING

Here are more ideas for you and your students to explore.

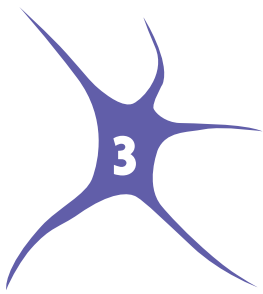
- What other parts of your body use wrinkling or folding as a strategy to fit into a smaller space? Where else do you see folding or wrinkling used in a similar way?

Cerebral Cortex

The thin cerebral cortex contains two-thirds of the 100 billion neurons in the human brain. “Cortex” means rind or bark in Latin.



Fitting the large piece of paper over the smaller piece without cutting.



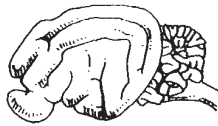
MAMMALIAN BRAINS



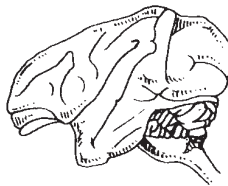
Opossum brain



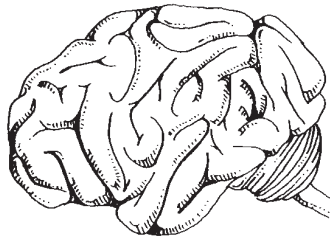
Rabbit brain



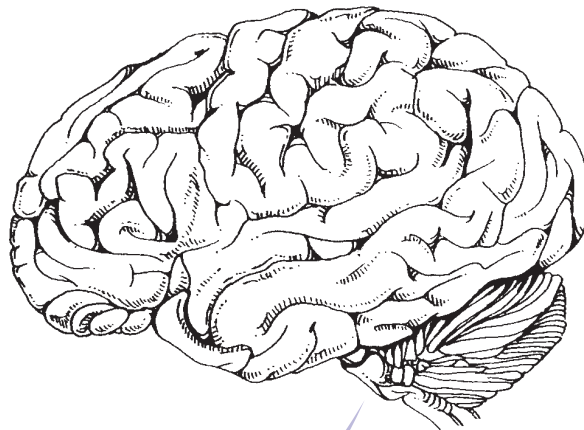
Cat brain



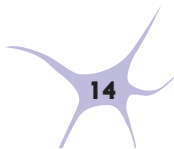
Monkey brain



Chimpanzee brain



Human brain



COMPARING BRAINS

The brainstem, as the name suggests, looks like a stem. It originates at the base of the cerebrum and connects the brain to the spinal cord. It controls basic survival functions such as breathing, heartbeat, regulation of body temperature and digestion. The brainstem varies in size among vertebrate animal species in relation to the size of the animal. However, its structure remains similar in all cases. This makes good sense when you consider that the brainstem affects processes that

are vital to life in all vertebrates.

The cerebellum is located behind the brainstem. It adjusts sequences of muscle contractions so that movements are smooth and even. Think of a cat's graceful movement or a rabbit's agile maneuvering. Animals, like humans, have well-learned movements. The cerebellum plays a role in learning and controlling these movements.

Since all vertebrate animal species have muscles and can

move, all have cerebellums. The size of the cerebellum is dependent upon two factors: the size of the animal and the complexity of its movements.

The cerebrum is the top part of the brain, located above the brainstem and cerebellum. Considered the "thinking" area of the brain, it is the center for thought, memory and emotion, and it initiates all voluntary movement. On the surface of the cerebrums of advanced mammals are folds, called gyri. The complexity and density of these folds in human brains, as well as the relative sizes of our cerebrums, are what truly set us apart from other animals.

Obvious olfactory bulbs, or "smell brains," project forward on the brains of some animals, such as cats and rabbits. The same structures are present on the human brain, but are relatively smaller in size. Olfactory bulbs receive and process information about odors from sensors in the nose. This information is relayed to several areas of the brain, including the center for smell in the cerebral cortex.

The relatively large olfactory bulbs of the cat and rabbit brains are clear evidence of the importance of smell to the survival of these animals. Similarly, the relatively small olfactory bulbs of the human brain indicate that humans rely far less on the sense of smell.



Unit Links

SKULLDUGGERY

Story, Chapters 8-9; Science box, p. 23

EXPLORATIONS

"The Brain Match Game," cover;
"Matter of Fact!" p. 2

4

OVERVIEW

Students compare and contrast life size models and/or drawings of cat and rabbit brains. Students also may make optional plaster models of cat and rabbit brains.

CONCEPTS

- The relative sizes and shapes of brain parts vary among mammals.

SCIENCE & MATH SKILLS

Measuring, comparing irregular shapes and inferring

TIME

Preparation: 10 minutes

Class: 30-45 minutes to make models; 30-45 minutes for discussion

MATERIALS

- Overhead transparency of "Brains from Different Points of View" student page

Each group will need:

- 9-oz disposable cup
- 8-oz measuring cup
- Craft stick for stirring
- Lab plaster (about 1/4 cup per mold)
- Mold for a cat brain
- Mold for a rabbit brain
- Set of yellow, red and blue markers or crayons
- Tap water
- Copy of "Brain Parts" and "Brain Mold Instructions" student sheets

Brain Molds

For information about obtaining cat and rabbit molds for use with Activity 4, contact the Center for Educational Outreach at 713-798-8200 or edoutreach@bcm.edu.

SETUP

To begin, have students follow the steps on the “Brain Mold Instructions” sheet to prepare the cat and rabbit brain models. The models may be made by students working in cooperative groups or on their own at a center you have set up in the classroom. For the class discussion, give each student a copy of “Brain Parts.”

As an alternative, this activity will require just one class period if you purchase prepared models of cat and rabbit brains to use with the student sheets OR if you use only the student sheets.

Have students work in groups of 4.

PROCEDURE

1. Let students examine the cat and rabbit brain models. Ask them to make observations about each brain. Consider displaying a human brain model (if available) or illustration of one for comparison. Lead a discussion, asking questions such as those below.
 - *Can you find the brainstems on the cat and rabbit brains? The cerebrums? The cerebellums?*
 - *Which part connects each brain to the spinal cord?*
 - *Which part of each brain would be located inside the top of the skull?*
 - *What might be a clue to tell the tops of the brains from the bottoms?*
 - *How do you think the brains might be situated in each animal’s head?*
 - *What differences do you notice between the brains?*

Point out the protruding olfactory bulbs, which are important for animals that depend on the sense of smell.

2. Distribute the activity sheet, “Brain Parts,” to students. Ask them to use this sheet as a reference to identify the three different brain parts on their models. Have the students color the illustrations as follows: brainstem blue, cerebellum red and cerebrum yellow. Olfactory bulbs, which connect to the cerebral cortex, may be left uncolored.
3. Using the completed “Brain Parts” activity sheets, have students color the corresponding parts of their brain molds using the same colors. (Markers work well for coloring plaster models.)
4. Project an overhead transparency of “Brains from Different Points of View.” (You also may wish to give each student a copy.) Have students compare the cat and rabbit brains on the overhead to their “Brain Parts” student sheets and brain models. Have the students hold their brain models in the same orientations as shown on the transparency—front, back, bottom, top. This will help the students visualize how the brain sits in the animal’s skull. You might ask, *If we hold the brain in this direction, where would the eyes be? Where would the ears be? Where would the spinal cord be?*

5. Have students think about how differences in brain structure reflect differences in the activities of cats and rabbits. For example, the cat brain has more gyri than the rabbit brain. In the wild, cats are stalking predators and have to make decisions as they hunt to survive. Rabbits, on the other hand, are plant-eaters and need to make far fewer choices of action than the cat. Have students think about other differences that they can observe. They also should compare the cat and rabbit brains to the human brain.

BRAIN JOGGING

Here are more ideas for you and your students to explore.

- Can you predict which other animals might have a keen sense of smell? What would you predict about their brains? How could you find out if your predictions are right?
- Do all animals have brains? How about a jellyfish? An earthworm? A frog? Do bacteria or other one-celled organisms have brains? What animal or other organism do you wonder about? How could you find the answers?

Brain Mold Tips

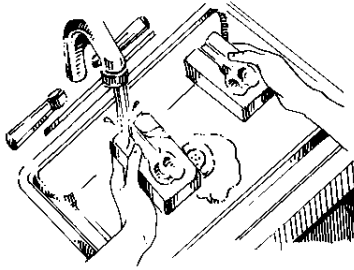
- Mound the plaster only into the brain indentations on each half of the mold, NOT over the entire interior surface.
- Once the mold is filled and the halves are pushed together, pound the side of the mold gently (a few times) on a flat surface to eliminate air bubbles.
- To remove a finished brain model, separate the two halves of the mold. Flex the mold half that contains the model brain and have another person lift the model from the mold.



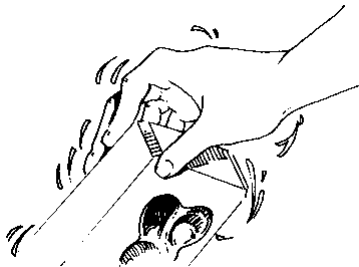
BRAIN MOLD INSTRUCTIONS

Before you begin, read all the instructions. The mixture begins to harden very quickly, so do not mix until you are ready to pour it into the molds.

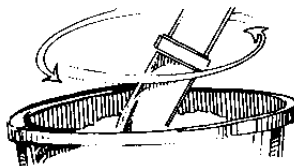
1. Using clean tap water, rinse both halves of the mold. Make sure there is no old lab plaster in the brain area of the mold.



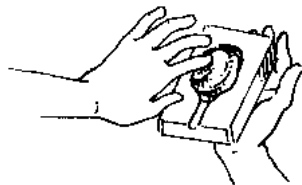
2. Do NOT dry the mold. Shake water from the mold surface, but leave some moisture in the brain area of the mold. The mold MUST be damp before the plaster is poured.



3. Use a disposable cup to mix 2 parts powder with 1 part water at room temperature. Stir the mixture until it has the consistency of a thick milk shake. This probably will not take longer than about 60 seconds. You have 2 minutes working time.

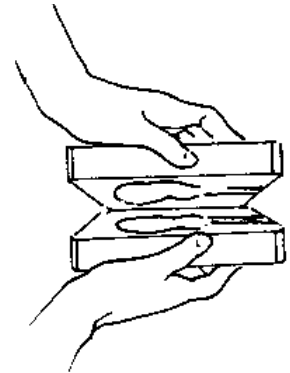


4. Pour the plaster into each side of the mold. You may use your fingers to push it into all the

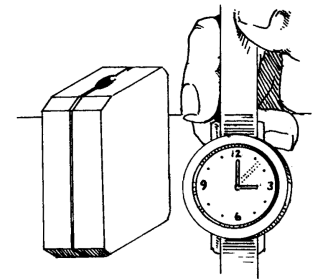


crevices. Make sure one side is slightly over-filled (mounded) so that the two sides will bond.

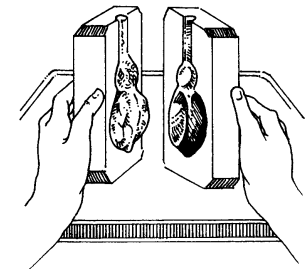
5. Line up the two pieces of the mold and push them firmly together.



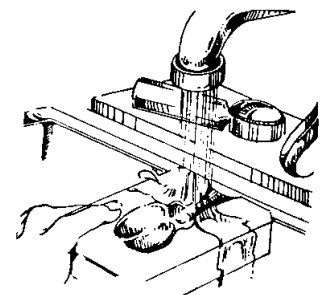
6. Put the mold in a safe place and let it harden for **AT LEAST** 10 minutes.



7. **GENTLY** pull the two sides of the mold apart and remove the model.



8. Rinse out the inside of the mold before storing it or re-using it.



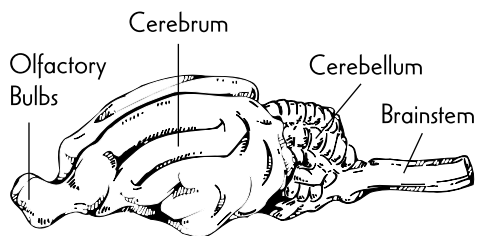
If sides of mold no longer slip together easily, lubricate with a very light coating of mineral oil.

BRAIN PARTS

4

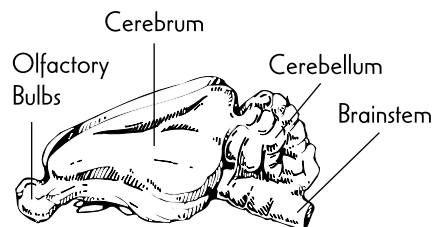
Cat

Side

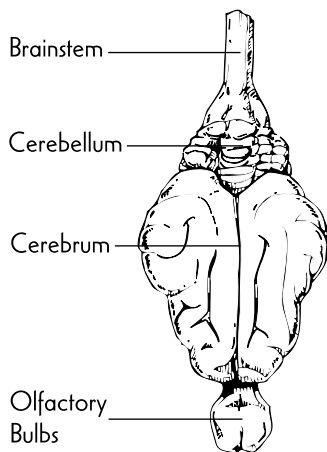


Rabbit

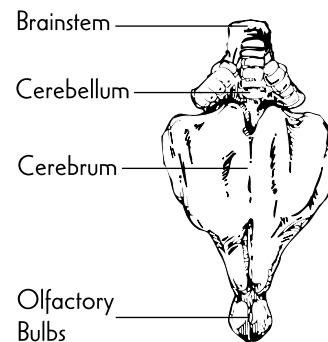
Side



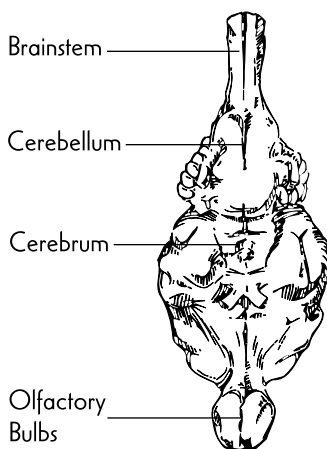
Top



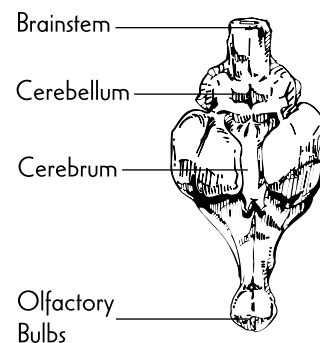
Top



Bottom



Bottom

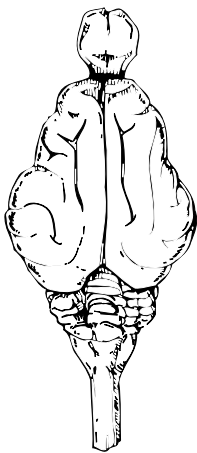




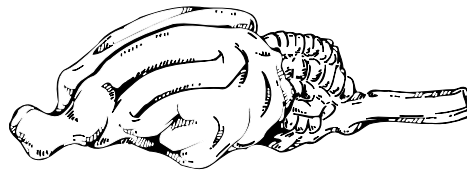
BRAINS FROM DIFFERENT POINTS OF VIEW

Cat

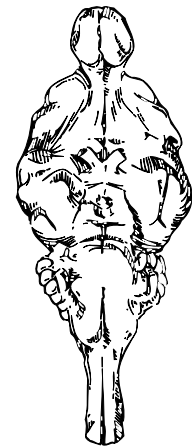
Top view



Side view

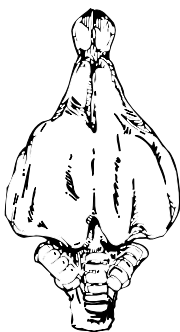


Bottom view

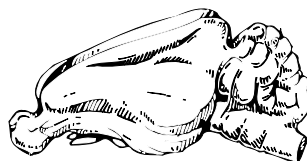


Rabbit

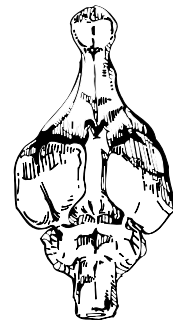
Top view



Side view



Bottom view



How Much Brain Do You Need?

Overall, animal intelligence is roughly correlated with the number of gyri on the cerebrum (see Activity 3, p. 12). The percentage of brain weight compared to body weight also is a good predictor of intelligence. In fact, the two characteristics usually are related. Usually, mammals with large cerebrums relative to their body sizes also have many gyri.

It is a common error to compare brain size directly with intelligence. Very large animals often have large brains (for example, cow, horse and

elephant). Nonetheless, the amount of brain for body weight in these large animals remains small compared to that of other, more intelligent animals (for example, gorilla, chimpanzee, human and porpoise).

Why did some animals evolve to be more intelligent than others?

There are many factors that influence how much intelligence an animal needs to survive and reproduce.

One way to look at intelligence is to consider how many decisions an animal has to make about obtaining

food, protecting itself or interacting with others. For example, predators that stalk their prey might make more decisions than animals that simply wait for their food to come to them. Animals that are both predator and prey might need to make more decisions than animals that are only one or the other. Another important factor is how much an individual animal interacts with and relates to other animals in its group. Some animals live most or all of their lives alone, while others live as part of a larger group that stays together. Animals that live as part of a group are “social” animals, and much of their time is spent interacting with other animals in their groups. For example, animals that forage or hunt together have to coordinate their activities within the group. Any interaction with another animal in the group is likely to involve making decisions, which requires more intelligence.

SETUP

The activity can be conducted with the whole class or with students working in small groups or as individuals.



SKULLDUGGERY

Story, Chapters 10–11
Science box, p. 23

EXPLORATIONS

“The Brain Match Game,” cover;
“Matter of Fact!” p. 2;
“A Weighty Subject,” p. 6

OVERVIEW

Students are asked to think about and list the activities of several common animals, and to estimate how intelligent each animal is by comparing its activities with those of the other animals. Students then compare their estimates with actual brain weight to body weight ratios (provided).

CONCEPTS

- Animal intelligence is roughly related to the amount of folding of the cerebrum.
- The relative size of an animal’s brain, as compared to the overall size of its body, also is related to intelligence.
- Different species of animals need different attributes to survive in their particular environments.

SCIENCE & MATH SKILLS

Collecting background information, inferring, comparing, expressing ratios as percentages and drawing conclusions

TIME

Preparation: 5 minutes

Class: 45 minutes to list activities and decisions of each animal; 45 minutes to examine brain weight to body weight ratios and draw conclusions

MATERIALS

Each student or group will need:

- Copies of “Predict How Smart” and “Brain Proportions” student pages

Animal Differences

Alligator: Nonstalking predator, hunts alone, may live in groups or alone, little interaction among individuals

Baboon: Both predator and prey, occasionally hunts, lives in groups (troops), social, highly interactive

Chimpanzee: Both predator and prey, occasionally hunts, lives in groups (troops), social, highly interactive

Human: Both predator and prey, may hunt in groups, social, with very complex interactions among individuals

Lion: Stalking, group-hunting predator, lives mostly in groups (prides), social

Ostrich: Mostly a plant eater, but will prey on insects and small vertebrate animals, may live in groups when not mated

Porpoise: Both predator and prey, hunts in groups, lives in groups (pods), social, highly interactive

Wolf: Both predator and prey, hunts in groups, lives in groups (packs), social

PROCEDURE

Looking at animal activities

1. Introduce the lesson with a brief discussion of animal activities based on the ideas at the beginning of this activity and in the “Animal Differences” (see left sidebar). In particular, consider the possible lifestyles of alligators, lions, porpoises, ostriches, wolves, baboons, humans and chimpanzees.
2. Have students write their ideas about the different animals on the “Predict How Smart” worksheet. Suggest that students think about how each animal obtains its food, protects itself and interacts with others. You may want to let students gather additional information about the animals from the library or other resources.
3. Once they have listed types of decisions and activities carried out by each kind of animal, have students rank the animals within each pair according to intelligence, based on the information on their worksheets and their own knowledge of the animals.
4. Finally, have the students rank all eight animals in order of most (1) to least (8) intelligent.
5. Tell students to set the “Predict How Smart” sheet aside, so they can come back to it later.

Looking at brain to body weight ratios

1. Provide each student or group of students with a “Brain Proportions” worksheet. This sheet shows the actual body weights and brain weights of each of the animals listed on the Predict How Smart sheet. The percentage (of the total weight of each animal) that is devoted to the brain has been calculated for students and is shown in the fourth column of the table.
2. Have students compare the percentage of brain tissue composing each animal’s weight within each pair of animals. Then have them rank the animals within the pairs according to which has the largest percentage of brain weight to body weight. This should help students understand that some animals have more of their body weight given to brain tissue than other animals.
3. Next, ask the students to rank all the animals listed, in order of the percentage of brain weight to body weight, from the greatest to least (1=greatest, 8=least; see “Rank of Brain Weight to Body Weight” in the sidebar on page 23).
4. Ask students to compare the rankings on their “Predict How Smart” worksheets to the rankings on their “Brain Proportions” worksheets. They should first compare their rankings within pairs. Ask, *Based on*

your predictions, does the animal with a greater percentage of brain weight to body weight tend to be more intelligent?

5. They should then compare their rankings among all eight animals. Ask, *Based on your predictions, is there a rough correlation between percentage of brain weight to body weight and intelligence?*
6. Go over the results in a large group. Discuss reasons for their answers. Discuss the correlations between percentages of brain weight to body weight and intelligence. Also discuss the discrepancies that may have occurred between students' predictions and the rankings on the "Brain Proportions" sheet. Ask, *Is there a perfect match between the rankings on your Predict How Smart worksheet and the rankings on your Brain Proportions worksheet? If not, does this bother you? Do you think scientists also have to deal with situations where everything doesn't "match" perfectly?*

BRAIN JOGGING

Here are more ideas for you and your students to explore.

- Do you think there is a limit to how much brain you could use? If our cerebrums were as much as half the total weight of our bodies, do you think we would be smarter? Why?
- Why do you think some individuals of a species are smarter than others? Do you think smarter individuals have more gyri or larger cerebrums than other individuals? If you were a scientist, how would you figure out an answer to this question?
- Which characteristics or behaviors define intelligence in animals? Do you think these ideas also apply to humans?

Intelligence and Brain Size

People who seem to be more intelligent do not necessarily have larger brains or more gyri than others. Instead, differences in abilities to gather, process and apply information are believed to be related to connections among neurons within the brain.

RANK OF BRAIN WEIGHT TO BODY WEIGHT

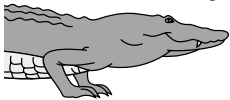

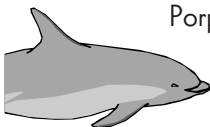





(1 = Greatest, 8 = Least)

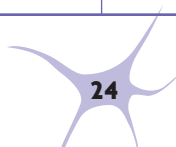
- 1 = Human
- 2 = Porpoise
- 3 = Baboon
- 4 = Chimpanzee
- 5 = Wolf
- 6 = Lion
- 7 = Ostrich
- 8 = Alligator



PREDICT HOW SMART

List some activities and kinds of decisions each animal has to make in its daily life. Then decide which of the two animals in each pair is probably more intelligent. Finally, rank all of the animals on the page in order of intelligence, from “1” for most intelligent to “8” for least intelligent.

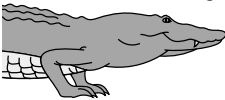

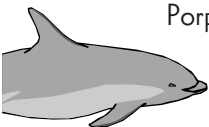





ANIMAL	TYPES OF ACTIVITIES	TYPES OF DECISIONS	RANK WITHIN THE PAIR	RANK AMONG ALL EIGHT
 Alligator				
 Lion				
 Porpoise				
 Ostrich				
 Wolf				
 Baboon				
 Human				
 Chimpanzee				



BRAIN PROPORTIONS



Rank the animals within the pairs according to which has the largest percentage of brain weight to body weight. Then rank all the animals in order of the percentage of brain weight to body weight, from the greatest to least (1 = greatest, 8 = least).

ANIMAL	BODY WEIGHT	BRAIN WEIGHT	PERCENTAGE OF BRAIN WEIGHT TO BODY WEIGHT	RANK WITHIN THE PAIR	RANK AMONG ALL EIGHT
 Alligator	220,000 gm	15 gm	0.01%		
 Lion	200,000 gm	260 gm	0.13%		
 Porpoise	170,000 gm	2,000 gm	1.17%		
 Ostrich	130,000 gm	44 gm	0.03%		
 Wolf	30,000 gm	170 gm	0.57%		
 Baboon	20,000 gm	190 gm	0.95%		
 Human	60,000 gm	1,450 gm	2.41%		
 Chimpanzee	60,000 gm	400 gm	0.67%		

CREATE A BRAIN

OVERVIEW

Students are asked to imagine characteristics and activities of a fictitious animal and to decide what kind of brain the animal would need. There are no right or wrong answers, but students should be able to justify their ideas using concepts from Activities 1-5. This activity may be used for pre- and/or post-assessment.

CONCEPTS

- The brain has three main parts, each with specific jobs.
- Wrinkles in the cerebrum allow more tissue to fit into a small space.
- Intelligence in animals is related to the amount of wrinkling of the cerebrum and to the relative size of the brain, as compared to body size.

SCIENCE & MATH SKILLS

Applying prior knowledge to a new situation, calculating percentages and estimating proportions

TIME

Preparation: 5 minutes

Class: 45 minutes

MATERIALS

Each student will need:

- Copy of “A Most Amazing Animal” student page

At this point in the unit, students should be able to begin to tie together and apply the concepts that have been covered. Some of the basic concepts of this unit include the following.

- There are three main parts of the brain, and each one has a particular job. The brainstem controls basic life functions, such as breathing and heart rate. The cerebellum is important for balance and coordination, and for performing well-learned movements. The cerebrum is the largest part of the brain and is larger in more advanced animals. It controls voluntary movements, thinking and emotions.
- The folds and wrinkles in the cerebrum are nature’s way of compacting lots of storage capacity (intelligence) into a small space.
- The intelligence of an animal is related to the proportion of brain weight to body weight. Absolute size of the brain does not determine intelligence.



SKULLDUGGERY

Story, Chapters 12-13; Review all science boxes

EXPLORATIONS

Review “Matter of Fact!” p. 2;
“Careers for NeuroExplorers,” p. 7

SETUP

Let students work alone or in groups to complete the “A Most Amazing Animal” activity sheets. This activity can be used to assess the entire unit of study. As long as students’ justifications are compatible with the concepts presented in the unit, there are no right or wrong answers.

Consider having students present their creations to the class or letting them display their descriptions and drawings in a central location.

PROCEDURE

1. Through a class discussion, allow students to review some basic concepts—three brain parts that have different jobs, wrinkling, significance of brain to body weight ratios, etc. Remind students of the differences that they observed among the brains of different animals and how those differences were related to the animals’ behaviors or activities.
2. Follow up by challenging students to use their imaginations and knowledge about the brain to create their own animal profiles, using the “A Most Amazing Animal” student sheets.


You may want to demonstrate the process by profiling an imaginary animal and characteristics with the entire class before having students create their own. OR you might provide a real-life example by discussing an animal that they already have considered in this unit, such as the alligator. Point out, for example, that the alligator is a solitary predator, which has a large cerebellum, a long, slender skull, few wrinkles and a brain weight of only about 15 grams.

3. When students have completed the activity, have them share their creations with one another. Be certain to assess whether student explanations for characteristics of their animals are compatible with what they have learned.

BRAIN JOGGING

Here are more ideas for you and your students to explore.

- Are the characteristics of an animal's brain caused by its lifestyle, or does an animal's lifestyle determine the characteristics of its brain?
- Imagine an animal even smarter than a human being. Draw what you would predict the brain of that organism would look like.




A MOST AMAZING ANIMAL

Imagine an animal. What would it be like – graceful or clumsy, fast or slow, smart or not so smart? How would its brain be shaped to fit inside its skull? Create a brain for your animal that matches its or her needs. Have fun!


1. My animal is a _____.
2. My animal lives in _____.
3. My animal is very good at _____
and _____.
4. My animal is not very good at _____
or _____.
5. This animal weighs about _____.
6. Its brain weighs about _____.
7. That means that its brain is very _____ for its body weight.
8. Because this animal is so _____
it probably has a very _____ cerebellum.
9. Because it is so _____
it probably has a very _____ cerebrum.

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A MOST AMAZING ANIMAL (CONTINUED)



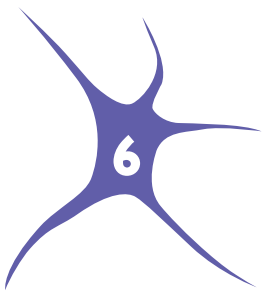
10. Draw a side view of the skull showing the three parts of the brain inside.
The brain and skull of my animal look like this:

11. My animal's brain looks like that because

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A MOST AMAZING ANIMAL

Imagine an animal. What would it be like—graceful or clumsy, fast or slow, smart or not so smart? How would its brain be shaped to fit inside its skull? Create a brain for your animal that matches his or her needs. Have fun!

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6. Its brain weighs about _____.
7. That means that its brain is very _____ for its body weight.
8. Because this animal is so _____,
it probably has a very _____ cerebellum.
9. Because it is so _____,
it probably has a very _____ cerebrum.



A MOST AMAZING ANIMAL

(CONTINUED)

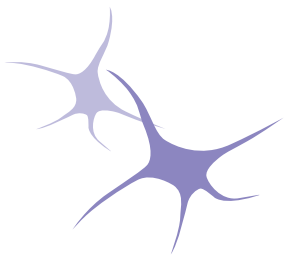


10. Draw a side view of the skull showing the three parts of the brain inside.

The brain and skull of my animal look like this:

11. My animal's brain looks like that because





GLOSSARY

brain - the control center of the nervous system, located within the skull and attached to the spinal cord; the command center of the body

brainstem or brain stem - structure that connects the rest of the brain to the spinal cord and controls basic survival activities, such as breathing, heartbeat, body temperature and digestion

cerebellum - part of the brain located directly above the brainstem that controls the sense of balance and helps the muscles work together for learning and coordination of rote movements

cerebral cortex - the outermost layer of the brain's cerebrum

cerebral hemisphere - either of the two rounded halves of the cerebrum

cerebrospinal fluid - fluid that acts as a protective liquid cushion around the brain and spinal cord

cerebrum - the large, rounded outer layer of the brain where thinking and learning occur, sensory input is received and voluntary movement is started

cranium - the bony shell that protects the brain and forms the shape of the head

frontal bone - the front bone of the skull, forming the forehead

gray matter - gray-colored nervous system tissue that forms the outer layer of the cerebrum (cerebral cortex) and is the central component of the spinal cord

gyri - the outward folds or creases on the surface of the cerebral cortex (gyrus - singular)

lobe - a curved or rounded part of a body organ

mammalian - belonging to the group of mammals; warm-blooded vertebrate animals which nourish their young with milk and are characterized by the presence of hair

mandible - jawbone; the only freely movable bone in the skull

maxillary bone - upper bone of the mouth which holds the upper teeth and forms the roof of the mouth

meninges - three thin membranes that cover the brain and spinal cord

nervous system - the brain, spinal cord and network of nerves in the body

neuroscience - a branch of science related to the study of the nervous system

occipital bones - bones that form the back of the skull

olfactory bulb - small, rounded structure that projects forward from the lower part of each cerebral hemisphere, where the sense of smell is processed in the brain; enlarged in animals that have a heightened sense of smell

parietal bones - a pair of bones that form the roof of the skull

predator - an animal that captures or seizes other animals for food

prey - an animal hunted or caught for food

sinus - an opening or cavity for the passage of air or fluid within the bones of the skull

skull - all the bones of the head, including the cranium and the facial bones

sphenoid bone - a butterfly-shaped bone on the inside of the skull behind the eyes

sulci - grooves formed between folds in the surface of the cerebral cortex (sulcus - singular)

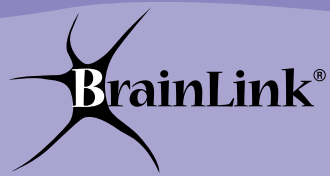
sutures - irregular, linear joints where the bones of the skull meet

temporal bones - bones on both sides of the skull next to the forehead and the eyes, in the area of the temples and partly covered by the ears

vertebrate - an animal having a segmented "backbone" or spinal column

zygomatic bone - the cheekbone





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