Build-a-BRAIN Project

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Students Design and Model the Brain of an Imaginary Animal


PHOTOS COURTESY OF THE AUTHORS

Students create colorful brain models from homemade dough.

The brain is a truly fascinating structure! As we know, it controls the body and allows us to think, learn, speak, move, feel, remember, and experience emotions. Although the brain is a single organ, it is very complex and has several regions, each having a specific function. These functionally diverse regions work together to allow for coordination of behavior.

The lesson presented below uses easily identifiable characteristics, such as proportion of brain to body mass, relative size of specific brain structures, complexity of cerebrum and cerebellum, and differential development of the frontal cortex. The depth and breadth of the science content can be easily varied to meet the needs and abilities of a wide range of participants.

The project

Before brains of imaginary animals can be built, students must learn about various brain regions. (See sidebar on page 30, and Resources for a downloadable student handout on this topic as well as for other sites containing additional information and diagrams.)

After the general structures and functions of the brain have been presented to students, they are asked as a class to discuss how certain animals' brains may differ. Comparisons are made between animals students know (i.e., cat versus dog, dolphin versus manatee, chimpanzee versus human, herbivore versus carnivore). The students will be asked to make predictions about the brain structure based on what they know about the animals' behaviors. If necessary, students can be prompted to predict specific differences, such as which animals

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have a more complex cortex or a proportionately larger cerebellum. Comparison of cat and dog brains often gets quite exciting because individuals usually have a preference and insist their favorite animal must be smarter and thus have a more complex cortex. Luckily, these and other comparisons/predictions can be verified by exploration of brain specimens easily available on the internet (see Resources), allowing students to determine which animal has a larger cerebellum, a larger olfactory bulb, more convolutions, and a bigger brain.

Depending on the group composition and amount of time devoted to exploring the question, this distinction can lead to discussion of multiple intelligences. After this thought exercise, students break into smaller groups (two to three students is ideal) to design and model the brain of an imaginary animal. It is helpful to brainstorm a list of questions with the students that they will consider for their imaginary animal, such as the environment it lives in, its senses, its specialized behaviors for moving or finding food, and so on.

After the students have had some time to discuss what they want their animal to be able to do, hand out modeling dough and other art supplies to students. It is helpful if each group can have several colors of modeling dough (see recipe in Figure 1). Students then draw, model, or portray in some other media what their animal's brain would look like.

As students begin to build their brains, teachers can keep them on task by asking the small groups questions such as:

- What is your animal?
- What does your animal do?
- How is its brain built to perform these tasks?

After the brains are made, the groups describe their animal's talents and brain structures to the class. Since

FIGURE 1 **Modeling dough recipe**

1 cup flour
½ cup salt
3 tbsp oil
1 package of Kool-Aid (for color and scent)
½ cup of water

Mix ingredients and keep refrigerated. If it gets too sticky, add flour. Keep in an airtight container.

FIGURE 2 **Rubrics for the Build-a-Brain Project**

Holistic scoring rubric

Outstanding Rating = 4. Student gives complete descriptions that make logical sense; provides both detailed and specific comparisons; rationale is clearly stated; thinking process is evident. The brain is accurately assembled.
Good Rating = 3. Student gives complete descriptions; comparisons may be less detailed; rationale is consistent; shows a thinking process. The brain is accurately assembled.
Satisfactory Rating = 2. Student gives incomplete or simplistic descriptions; rationale is not consistent. The brain is accurately assembled.
Serious Flaws Rating = 1. Student gives answers that are not complete or understandable; rationale is not consistent; gives a lot of wrong answers. The brain is not accurately assembled.
No Attempt Rating = 0.
(modified from Brown and Shavelson 1996)

Presentation rubric

Organization	Student presents information in a logical, interesting sequence that the audience can follow.
Creativity	Student's brain model is visually interesting and highly original.
Elocution	Student uses a clear voice and correct, precise pronunciation of terms so that all audience members can hear the presentation.

Students receive 0–4 points on each of the above areas.

they are imaginary animals, some students may design brains that do not look like real brains and may include novel additional structures for abilities such as ESP. Regardless of the appearance of their brain model, the students' explanation should relate structure to function in a way that demonstrates an understanding of the science content they have learned. While the students are presenting their brains, teachers can evaluate them using the rubric given in Figure 2. A content rubric is also available with the online version of this article. This final presentation provides an additional opportunity to clear up any misconceptions and

General structures and functions of the brain

Brain size—Different animals not only look different, but also have various brain adaptations. Brain size is one of the most obvious brain adaptations. Animals need bigger brains to control more muscles and complex systems and behaviors. More important than overall brain size, however, is relative brain size—the size of the brain adjusted for body weight. If two different species have the same brain weight, the species with the lower body weight would probably be more intelligent.

Cortical complexity—Brain weight can be increased while maintaining the same brain size by packing more neurons into the same space. Increased neuronal density is accomplished by convolutions, or folding, of the cerebral cortex. Consequently, animals with a more convoluted or complex cerebral cortex tend to be more advanced. Also, the greater the relative size of the cerebral cortex compared to the rest of the brain, the more advanced the animal.

Cerebellum size—Another noticeable feature of the brains of different species is the relative size of the cerebellum. The cerebellum is important for balance and coordination. Thus, a cat has a proportionally larger cerebellum than a dog, allowing the cat to be more agile.

Olfactory bulb size—The olfactory bulb is important for the sense of smell. In humans, this portion of the brain is quite small and is found on the underside of the brain. The olfactory bulb on the mouse is relatively large and can be seen sticking out in front of the frontal cortex. The Tasmanian devil has an enormous olfactory bulb and relies heavily on its sense of smell for survival.

Adaptations by classes of vertebrates—Vertebrates are divided into five classes: pisces (fish), amphibians, reptiles, avians (birds), and mammals. Although all vertebrates have three main brain regions (forebrain, midbrain, and hindbrain), there are many adaptations in their neuronal structures. For example, the components of the cerebellum vary greatly across classes. Fish generally have the most primitive cerebellar organization since they do not need to support their weight on land. The amphibian and reptilian cerebellums are quite similar and are intermediate in complexity. The most complicated cerebellums are present in birds and mammals. Both the mammalian and avian cerebellums are convoluted (folded) and the mammalian cerebellum has a much more complicated pattern of development. The avian cerebellum has a central region highly developed for flying, while the mammalian cerebellum has a lateral (side) expansion. Bat brains have interesting cerebellums since they have both the lateral expansion seen in mammals and the highly developed central region for flying. It is always interesting to have students predict what the bat cerebellum will look like. As the cerebellum increases in complexity across classes of vertebrates, animals are able to perform more complicated tasks and develop finer control of movements.

Although not obvious from an external examination of the brain, the limbic system shows great differences across vertebrate classes. In fact, some scientists believe the limbic system did not truly exist until mammals existed, suggesting that other classes of animals do not have the same emotions as mammals. However, even fish can learn to avoid areas where punishments were given, so it is likely that functions of the limbic system are present in these older classes in some modified form.

The largest distinction among vertebrate classes is the expansion of the cerebral cortex. Thus, the forebrain region displays the greatest diversity across vertebrate classes. Mammals have an extensive layered cerebral isocortex that is not present in other animals. The frontal lobes of the cortex, and specifically the prefrontal cortex at the very rostral (front) part of the frontal lobes, are more elaborate and larger in humans than in other primates. The prefrontal cortex is important for planning, complex intellectual activities such as sorting a deck of cards, and the emotional response to pain.

to reinforce the important science content that they should have learned.

This project can be conducted in one hour, including the time to review the major brain structures. If a shorter time is necessary, the number of real animals compared can be reduced. However, it is very helpful to have the class make predictions on at least one set of comparative animals, such as dog versus cat. Students should be given approximately 15 minutes to design and build their brains and time should be allotted for their presentations. This project fits in well with a life science curriculum and contributes to a visual arts curriculum. It addresses the following National Content Standards: (A) Science as Inquiry: Thinking critically and logically to identify questions that can be answered through scientific investigations, interpret data, and develop models; (C) Life Science: Develop an understanding of the structure and function of living systems (brain) and diversity and adaptations of organisms; and (D) Science in Personal and Social Perspectives: Science influences the way society views the environment (animals) through its products and processes (brain images).

Extensions

In addition to having students list attributes of an imaginary animal, a language arts extension can include writing a story about an imaginary animal and then drawing or modeling its brain. Another option is to have students research the behavioral and/or physical characteristics of at least two animals (see Resources) in order to relate these to differences in functional brain anatomy.

Possible mathematics and technology connections for this lesson include building the brain to scale to reflect the fact that the size of the brain is proportional to the size of the animal. For exceptionally large animals, students can mathematically work out a scale for the brain they are constructing. Additionally, the images that are available online are presented in six views with a corresponding scale so that students can measure the size and volume of brain structures from various real animals to determine both their absolute and relative size, as well as the proportion of the brain that is contained within a specific structure. Additional media technology extensions could include having students model their brains using a graphics program. If additional time is allocated to the project, students could make up a website or presentation to go with their modeled brain. ■

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Reference

Brown, J.H., and R.J. Shavelson. 1996. *Assessing hands-on science: A teachers guide to performance assessment*. Thousand Oaks, CA: Corwin Press.

Resources

Diversity and adaptations of the brain—*www.cbn-atl.org/education/brainintro.pdf*
A pdf file of a student handout on general brain function suitable for this project.

Brain Museum, comparative mammalian brain collections—*brainmuseum.org*
Great site for downloadable brain images maintained jointly by the University of Wisconsin and Michigan State, as well as by the National Museum of Health and Medicine.

Animal diversity web—*animaldiversity.ummz.umich.edu/index.html*
Site with an extensive database that catalogs behavioral and physical characteristics of a great number of animals.

Eric Chudler's neuroscience for kids—*staff.washington.edu/chudler/neurok.html*
Wealth of information about the nervous system, including extensive information on the basic parts of the brain, songs related to this lesson, and additional creative writing projects.