Brain Comparisons of Animals from the Five Vertebrate Classes

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Suggestions for the Teacher

Purpose

To observe and record the similarities and differences among the brains of animals from different vertebrate classes.

Objectives

1. Students will gain an understanding of the basic five part structure of the vertebrate brain.
2. Students will note the modifications that take place in the basic brain structure as animals become more complex.
3. Students will relate brain functions with brain parts and note the changes that reflect structural adaptation.
4. Students will learn to organize the observational data into comprehensive summary charts.

Materials

- Wall charts illustrating brain structures.
- Models of brains for the 5 Vertebrate classes (Fish, Amphibians, Reptiles, Birds, and various Mammals).
- Resource comparative anatomy texts.
- Preserved specimens (if available) of brains representative of the 5 vertebrate classes [fish brain, frog (amphibian) brain, snake (reptile) brain, chicken (aves) brain, rat, mouse, cat, sheep, monkey, human (mammalian) brains].

Preparation

This laboratory activity should provide students with an insight to the complex design of the mammalian brain compared to the simpler fish, amphibian, reptile, and bird brains. Starting with the fish brain students can note the lobular, linear outline of the cephalic structure. The anatomy reflects the brain's configuration during a portion of vertebrate embryological development. During embryology, the central nervous system originates from a cylindrical dorsal neural tube. This tube dilates at the anterior portion forming three sections termed the Forebrain, Midbrain, and Hindbrain.

These primary three lobes undergo further differentiation into 5 lobes. The Forebrain is transformed into the anterior Telencephalon, and posterior Diencephalon. The Midbrain remains as the Mesencephalon; while the Hindbrain pinches into the Metencephalon and terminal brain portion, the Myelencephalon which continues down to the spinal cord.

These five lobes subsequently become the Cerebrum, Thalamus, Midbrain, Cerebellum and Pons, and the Medulla. In this exercise, students will carefully observe these various portions of the brain to note the different developmental levels attained by each section in animals representative of the 5 vertebrate classes.

One of the early anatomists (Ernst Haeckel - about 1880) remarked that "Ontogeny recapitulates Phylogeny". This referred to the fact that the development of the brain appears to proceed from the earlier developmental morphology in the simpler phyla or classes to its more elaborate asymmetrical mushroom form in the more complex forms. Thus the fish and amphibians will show a simpler brain structure, the reptilian brain becomes somewhat more convoluted, with increased complexity shown in the birds and mammals.

Functionally, students should note the large olfactory lobes characteristic of fish; they should remark about the comparatively huge cerebellum in birds, and certainly should regard the significance of the excessively convoluted human cerebrum. As they note these major differences, the students will then compare and contrast the sizes, shapes, juxtapositions, attachments, and other noteworthy features of the five fundamental brain lobes.

They should be able to construct a table and also diagram the brain parts that will enable them to identify the sections and also to assign a function to each region.

Students should list outstanding features of the brains that they are examining. As a group they should interact by brainstorming and identifying aspects that appear unique for each vertebrate class. After assembling a list of brain anatomical characteristics, they should attempt to relate these attributes to adaptations that are indigenous to the animals found within the individual vertebrate classes. This laboratory activity will require students to refer to reference texts, charts, and notes. Student interaction will enrich the activity while the instructor can assist by asking pertinent questions when visiting each group. The activity would require one lab (2 - 3 hours) for the initial investigation of

the specimens and orientation, and a second lab session to reinforce and review the material.

This activity is suitable for Biology advanced placement HS students, high school anatomy and/or anatomy and physiology courses, college zoology, anatomy, and comparative anatomy classes.

Procedure

1. Students will form study groups of 3, 4, or 5 members to cooperatively work together to compare and contrast the animal brains.

2. Place sets of the brain models, Plexiglas brain displays, or preserved mounts at different lab tables. It is preferable to have 4 to 5 sets of these specimens for separate stations.

3. Class should have been introduced to an overview of the developmental embryology of the central nervous system. Have the students produce concept maps or outlines listing everything they know about the brain.

4. Have each group generate a data table outline that will enable them to clearly organize their comparisons of the brains.

Safety

1. If preserved specimens are removed from preservative and placed in examining dishes, students should wear safety goggles and use rubber gloves for handling.

2. If mounted and enclosed specimens are used, there are no specific safety precautions.

Questions to Ask

1. What similarities can you discern between the embryological progression of brain differentiation and the adult vertebrate brains that you observe here?

2. What is the significance of the major brain changes that you note in the samples from each class?

3. Which part of the brain appears to have undergone the most extensive change in the sheep brain as compared to the fish brain?

4. The cerebellum of the bird is proportionately larger in the bird brain than in the other animals. Can you account for this anatomical expansion?

5. Part of the human brain is referred to as our 'reptilian' brain. Comparing the reptile brain with the human brain, where might this 'lower' brain be located and what would you consider its function to be?

Where to Go From Here

This lab activity fits into the section covering the central nervous system in anatomy or anatomy/physiology classes. It can also be used in majors biology or zoology courses as part of either the anatomy or evolution section to demonstrate the theory of 'recapitulation', that developmental stages can be seen to progress along with the increasing complexity of the classes. This exercise serves to orient the student to the changes and morphology of the asymmetrical higher brain of mammals. By starting with the simpler brains and observing the gradual changes that occur with evolution, the student gains a better visual perception of the complex brain anatomy and the relationship of its parts. It would be reinforcing to invite a neuroanatomist or neurophysiologist to class to share some insights into their research into the structure and function of the brain.

References

1. Butler, Ann B & William Hodos (1996). **Comparative Vertebrate Neuroanatomy: Evolution and Adaptation.** New Jersey:John Wiley & Sons.

2. Diamond, Marian C., Arnold B. Scheibel, Lawrence M. Elson (1985). **The Human Brain Coloring Book.** New York:Harper & Row, Inc.

3. Hyman, Libbie H. & Marvalee H. Wake (Editor) (1992). **Hyman's Comparative Vertebrate Anatomy**. Illinois:University of Chicago Press.

4. Kent, George C.(1992). **Comparative Anatomy of the Vertebrates**. Iowa:William C. Brown.

5. Tortora, Gerald J. (1995). **Principles of Human Anatomy.** Massachusetts:Addison-Wesley Publishing Co.

6. Zihlman, Adrienne L.(1982). **The Human Evolution Coloring Book**. New York:Harper & Row,Inc.

Resources

The following biological supply houses stock display mounts of preserved brains from the five different vertebrate classes (fish, amphibian, reptile, bird, and mammal), charts, and preserved brain specimens.

Carolina Biological Supply Company, 2700 York Road,
Burlington, NC 27215 1-800-334-5551
http://www.carosci.com

Science Kit & Boreal Laboratories, 777 East Park Drive.
Tonawanda, NY 14150-6784 1-800-828-3299
http://sciencekit.com

Wards Biology, P.O.Box 92912, Rochester, NY 14692-9012
1-800-962-2660
www.wardsci.com

If university or other research or veterinarian facilities are located nearby, phone and ask if brain specimens are available.

Suggestions for Assessment

Each cooperative study group will present their analyses for five minutes to the entire class. Each member will now develop a concept map that illustrates his/her understanding of the brains studied. In addition, each student will be quizzed individually by the instructor, each will identify 5 parts of one animal's brain and then explain the functional significance or how it has evolved.

Towards a grading rubric, each instructor may emphasize different parts of the activity making up the brain comparisons activity. One plan that might work for a total of 25 points:

5 points might focus on the thoroughness of the concept flow-chart and its organization.
5 points on the student's adroitness at identifying the parts of different vertebrate brains.
10 points for the functions that the brain areas specifically regulate
5 points might be awarded for a comparison of the different roles that parts of the brain take on in the various vertebrate classes.

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Student Activity

Purpose

To observe and record the similarities and differences among the brains of animals from different vertebrate classes.

Procedure

Each group of students will work with a display of preserved brains from the 5 classes of the vertebrates. If preserved specimens are available for handling, then you must wear safety glasses and use protective gloves. Rinse the brains with deionized water and place in examining dish. Only the external surfaces of the brain will be studied in this exercise.

Wall charts, models, illustrations, resource anatomy texts are available for reference.

The activity focuses on your observational skills. You have already been introduced to be basic anatomy of the human brain and you are familiar with the embryonic development of this brain. You will be able to view in some of the display examples some of the basic five-part segmentation of the brain into Telencephalon, Diencephalon, Mesencephalon, Metencephalon, and Myelencephalon.

1. The first part of this assignment requests that as a group, you produce a data chart outline that enables you to list the derivative structures that can be noted in these 5 parts. It may be in this form or one that you select.

ADD TITLE:_____
(to be completed by student)

Telenceph.	Dienceph.	Mesenceph.	Metenceph.	Myelenceph.

2. After you have detailed and outlined the structures that are associated with the 5 brain segments, each student group should develop an outline data chart that compares the differences in the segments from each animal class specimen. This process should enable you to trace some of the changes that result from the irregular differentiation of the lobes that account for the asymmetry of the mammalian brain. The table might look something like this. Probably you will develop a study guide that will be more suitable for your needs.

ADD TITLE:_____

(to be completed by student)

Animal	Telen.	Dien.	Mesen.	Meten.	Myelen.	Diagram
Fish						
Amphib						
Rept						
etc.						

3. Make another chart to explain how these brain asymmetries in the five classes account for the animal's competencies and adaptations. In other words, explain how these differences in structures provide specialized functions for these organisms