Why dread a bump on the head?

The neuroscience of traumatic brain injury

Lesson 2: What does the brain look like?

I. Overview

In lesson 2, sheep brain dissections serve as a hands-on introduction to basic neuroanatomy. Students have the opportunity to explore the brain in the context of the unit on Brain Injury. Special attention is given to providing a functional understanding of brain regions through an interactive dissection guide. This guide contains directions, supplemental information, and discussion questions so groups of students can engage in the activity at their own pace.

Connections to driving question

In order for students to answer the question “Why dread a bump on the head?” they must first explore and build knowledge about the normal brain. This lesson deepens students’ understanding of neuroanatomy and physiology so they can begin to understand the underlying neuroscience of TBI.

Connections to previous lesson

In the previous lesson, students learn the broad, macro-level information which introduces them to TBI. This lesson gives further context to the discussion of TBI by giving students an opportunity to first investigate the structures and function of a normal brain.

II. Standards

National Science Education Standards

K-12 Unifying Concepts and Processes: Systems Order and Organization

- The natural and designed world is complex; it is too large and complicated to investigate and comprehend all at once. Scientists and students learn to define small portions for the convenience of investigation. The units of investigation can be referred to as "systems." A system is an organized group of related objects or components that form a whole. Systems can consist, for example, of organisms, machines, fundamental particles, galaxies, ideas, numbers, transportation, and education. Systems have boundaries, components, resources flow (input and output), and feedback. (K-12 1/1)

K-12 Unifying Concepts and Processes: Evidence, Models, and Explanation

- Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. Models help scientists and engineers understand how
things work. Models take many forms, including physical objects, plans, mental constructs, mathematical equations, and computer simulations. (K-12: 1/2)

K-12 Unifying Concepts and Processes: Form and Function

- Form and function are complementary aspects of objects, organisms, and systems in the natural and designed world. The form or shape of an object or system is frequently related to use, operation, or function. Function frequently relies on form. Understanding of form and function applies to different levels of organization. Students should be able to explain function by referring to form and explain form by referring to function. (K-12: 1/4)

**Benchmarks for Science Literacy**

**The Human Organism: Basic Functions**

- Communication between cells is required to coordinate their diverse activities. Cells may secrete molecules that spread locally to nearby cells or that are carried in the bloodstream to cells throughout the body. Nerve cells transmit electrochemical signals that carry information much more rapidly than is possible by diffusion or blood flow. (6C/H3*)

- The human body is a complex system of cells, most of which are grouped into organ systems that have specialized functions. These systems can best be understood in terms of the essential functions they serve for the organism: deriving energy from food, protection against injury, internal coordination, and reproduction. (6C/H6** (SFAA))

**The Human Organism: Human Development**

- The complexity of the human brain allows humans to create technological, literary, and artistic works on a vast scale, and to develop a scientific understanding of the world. (6B/H3*)

- Patterns of human development are similar to those of other vertebrates. (6B/H7** (BSL))

**III. Learning Objectives**

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<th>Assessment Criteria</th>
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<td>Define and demonstrate sagittal and coronal brain sectioning.</td>
<td>- During dissections, students correctly slice the brain along the sagittal (left to right) plane and the coronal (front to back) plane. Students can explain: - Cuts and/or images along the sagittal and coronal planes allow for different views of different sections and structures of the brain that are not on the external surfaces.</td>
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- Cuts/images along the sagittal and coronal planes allow for a three-dimensional look at the structure of the brain.
- MRI images allow people to look at thin slices of the brain along the sagittal and coronal planes.

**Demonstrate appropriate animal-specimen handling lab technique.**

**Students:**
- carefully/gently handle the sheep brain
- carefully use dissection tools only for their intended purpose of investigating specimen
- clean off tools properly after dissection
- properly store or dispose of tools and specimens

**Locate several neuroanatomical structures and identify basic functional anatomy of the sheep brain.**

**Examples include:**
- *occipital lobe* is responsible for vision
- *frontal lobe* is associated with personality and social behavior
- *parietal lobe* integrates sensory input
- *temporal lobe* is responsible for taste, hearing, memory processing, and recognition of words and faces
- *olfactory bulb* processes smell signals
- *hippocampus* is important for declarative memories
- *cerebellum* controls balance and muscle coordination
- *corpus callosum* connects the two hemispheres

**Describe how injury to one region of the brain may lead to behavioral changes citing connections between structure and function.**

**Examples of student explanations include:**
- Damage to the frontal lobe may result in changes in personality and social behavior (as was the case of Phineas Gage).
- Damage to the parietal lobe will likely disturb proper integration of sensory input.
- Damage to the temporal lobe could impact taste, hearing, memory processing, and the ability to recognize words and/or faces.
IV. Adaptations/Accommodations
Students who are uncomfortable with the brain dissection can be asked to work through The Sheep Brain Exploration Guide using the images and information contained in the guide. The images in the guide should allow the students to observe the anatomy of the sheep brain without handling the animal specimen.

If students are uncomfortable handing the brains, but still wish to participate in the dissection, they can work in groups with others who are comfortable with the dissection. These students can participate in the discussion questions and identification of the anatomical structures.

Safety
As with all dissections, students and teachers must be careful in using the dissection tools and in handling the sheep brain specimen. Sharp scissors or scalpel may be required to cut through some parts of the brain. The teacher can do this for each group if having sharp scissors at each station is a concern. Most parts of the brain are soft and do not require a sharp edge to cut through. Though there is little danger of preservative shooting out from the brain, it is recommended that students wear goggles while participating in the dissection.

V. Timeframe for lesson

Opening of Lesson
  • Discussion and information about lab techniques – 10 minutes
  • Opening “Big Brain, Little Skull” activity – 10 minutes

Main Part of Lesson
  • Brain dissection – 40-60 minutes (If two class periods are designated for the Brain Dissection, students should work through the examination of the exterior of the brain on Day 1, and make cuts on Day 2. Brains can be returned to storage solution overnight.)

Conclusion of Lesson
  • Clean-up – 10 minutes
  • Wrap-up and discussion – 10 minutes

VI. Advanced prep and materials

Opening of Lesson

Materials:
  • Newspapers (for optional activity)
Preparation:
- Collect enough newspaper for each student or group of 2-4 students has one large sheet of newspaper (for optional activity)

Main Activity: Brain dissection

Materials:
- sheep brains (1 per group)
- dissection trays (1 per group)
- gloves (1 pair per student + extras)
- goggles (1 per student)
- dissection kits: probes, scalpels or dissecting scissors, brain knives (1 per group)
- The Sheep Brain Exploration Guide (U4_L2_StudentPacket_SheepBrainExploration) – 1 per student or group
- Sheep Brain Exploration: Answer Sheet (U4_L2_StudentSheet_SheepBrainExplorationAnswerSheet) – 1 per student

Preparation:
- Dissection stations can be set up before the class period, or students may gather their own materials.
- Make copies of The Sheep Brain Exploration Guide (1 per student or group)
- Make copies of Sheep Brain Exploration: Answer Sheet (1 per student- to write their answers in if each student does not receive their own copy of the Sheep Brain Exploration Guide)

Homework

Materials:
- Brain exploration worksheet (U4_L2_Homework_BrainExplorationWorksheet) – 1 per student
- Lesson Journal (U4_L1_Homework_LessonJournal)

Preparation:
- Make copies of Brain Exploration Worksheet (1 per student)
- Students should have their Lesson Journal which was given to them in Lesson 1 but some extra copies may be required for those who misplaced theirs.

VII. Resources and references

Teacher resources
- Brain Voyager Brain Tutor software at http://www.brainvoyager.com/
References

- Image of Optic nerve, chiasm, and tract: from Miller-Keane Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health.
- Image of cross-eyed cat from: Bobbi Bowers, flickr.com
- Image of coronal cut of brain: Michigan State University Sheep Brain Atlas
- Images of CT scans: Loyola Stritch School of Medicine
VIII. Lesson implementation

Opening of Lesson:
Open the lesson with a discussion about what students recall about brain injury from lesson 1. In lesson 1, students are introduced to brain injury classification. Remind students that the case studies show that head injuries can cause different behavioral changes, depending on the severity and the areas of the brain affected. Ask students:

- What is the underlying cause of the various behavioral changes that result from head injury?

Ask students to think about how the anatomy of the brain and the structures affected by injury interact to cause the functional symptoms of injury. This discussion should motivate the dissection. To introduce the sheep brain dissection, ask students:

- How might we study head injuries?
- What information might we need to know about the brain to understand how brain injury can lead to changes in behavior or function?
- Why are head injuries so serious?
- What happens when you get a head injury?
- How can we identify the neuroanatomical locations affected by head injuries? One cannot simply take out the brain to examine an injury. There are some imaging techniques (CT, MRI, etc) that will be discussed in later lessons. Lead students to think about using animal models for identifying common anatomy of the human brain.
- Why is it important that we know the anatomy of the brain?

Before coming to class, students will have completed an internet search for Phineas Gage and a correlating worksheet. Start this lesson by discussing the information that students discovered during their search. Ask questions such as those that follow:

- What were some interesting things that you found about Gage?
- What actually happened to him?
- Which part of the brain did the rod go through?
- Although Gage did not immediately die, he did suffer some major changes to his life. Which aspect of his life was affected the most?
  - What was his behavior like as a result?
- After your research on Gage, were you able to make any predictions for the functions of the frontal lobe? What were they?
  - Do you think Gage would have encountered different lifestyle changes if the rod had gone through a different area in his brain?
    - Why?
Through this discussion, it should become clear that there are different parts of the brain, that each have different functions, and that the frontal lobe is important for personality, impulse control, social behavior, etc. This will serve as a transition to the brain dissection, where structures and their functions are identified.

**Big brain, little skull: Newspaper activity (optional)**
The objective of this activity is to give students a sense of how evolution has worked to produce a highly folded or gyrencephalic brain. Growth of the brain across evolution was constrained by the size of the skull. Ask students to brainstorm some constraints on skull size. Probably, skull size is limited because of bipedalism, hard to hold up a heavy head with a skinny neck and pelvic size--birth canal of mothers. So instead of simply growing bigger in area, the brain became more folded, convoluted, to fit into our relatively stable sized skull to maximize surface area in a fixed space.

For this activity, each student takes a single piece of newspaper and lays it flat as a single piece of paper. They are told this represents the area of the brain (not exactly the same but still a good analogy). But it has to fit into a circle about 6 inches in diameter. Have students think about solutions to this and how they would fit it in. Give them a few min. to think and then instruct them to try out one of their ideas. Students may crumple up the paper into a fist-sized ball. This crumpling is actually very close to what happened with evolution. Others may shred the paper, etc. and teachers can talk about how the connectivity needs to stay intact so shredding wouldn’t be as evolutionally efficient.

**Main Part of Lesson:**
While the sheep brain is different from the human brain, the sheep brain dissection is a good introduction to neuroanatomy because of the many conserved structural similarities. Remarkably, throughout many species neuroanatomical regions are preserved; learning the neuroanatomy of sheep, for example, can actually give us valuable information about human neuroanatomy.

Students will work in small groups through sheep brain dissections using the *Sheep Brain Exploration Guide*. The dissection is not technically challenging; in fact, there are only three cuts outlined in the guide. This allows students to think about the anatomy and move at their own pace. They can certainly review earlier parts of the dissection, take time during the dissection to read the information in the guide, and discuss the questions in the guide. The guide is intended to do just that: lead students through the brain anatomy with the objective of connecting the structure to meaningful information about the function. Advise students that they should work at their own pace through the dissection guide.

Each student or group of students should have a copy of *The Sheep Brain Exploration Guide*. This guide includes directions to lead students through the dissections, functional connections, and discussion questions. If multiple students or classes are sharing copies of the *Sheep Brain Exploration Guide*, give each student their own copy of the *Sheep Brain Exploration: Answer Sheet*. The answer sheet contains only the questions from the larger Exploration Guide document and provides a space for student to write answers to the questions that appear in the guide.
Students will work in groups and will need:

- Sheep brain
- Dissection tray
- Brain knife (can be shared among groups)
- Scalpel or dissecting scissors
- Probes
- Gloves
- Goggles

In their small group (3-5 students), students will work through the directions in the *Exploration Guide*. In summary, the guide examines:

1) the exterior of the brain,
2) a mid-sagittal cut, and
3) coronal cuts.

Students can take turns with different roles; some students may read the guide and record responses to discussion and guided reading questions, while other students work on the actual cutting and demonstration of the brain regions. The dissection guide is intended to lead students through the dissection, groups should move at their own pace, and feel free to return to previous sections.

**Teacher Pedagogical Content Knowledge**

While students can work independently through the guides, questions from the guide can be printed on separate handouts for collection and assessment. These handouts can also include directions according to teacher preferences, that is, including directions such as “Please read pages 1-3 in the Brain Exploration Guide, then work through the following questions.”

Students may be given dissection pins and label the brain regions as they work through the anatomy. This can be an additional assessment item for teachers.

**Conclusion of Lesson:**
Ask students to think about the anatomy of the brain in relation to head injury. From their dissection, what did they notice about the structure of the brain?

- What structures seem particularly susceptible to injury?
  - Students may identify cortical structures based on their readings from lesson 1. These readings and the brain dissection guide should help students connect structural injuries to behavioral changes.
- How might structures in the middle of the brain be injured?
Students have read in lesson 1 about external injury to the brain. Injuries to any brain region may result from stroke, or loss of blood supply to certain brain regions due to blocked arteries or veins. Without the oxygen from blood, the brain tissue can be damaged and cease to function.

Students should complete the Lesson Journal for Lesson 2 (U4_L1_Homework_LessonJournal) and complete any remaining discussion questions in the Brain Exploration Guide. The corresponding neuroanatomy summary worksheet (U4_L2_Homework_BrainExplorationWorksheet) can also be completed.

Teacher Pedagogical Knowledge
The Lesson Journals are completed for each lesson in the TBI unit, and they are used together as a review and assessment tool in the final lesson. Students will review material from the unit and will contribute to a class ‘zine’ that integrates ideas and content from the unit.

A zine (pronounced ZEEN) is a form self-publication with original text and images. Similar to a magazine, the topics are usually of a particular interest and the method of reproduction is via photocopiers.

Assessment
The sheep brain Exploration Guide has a variety of questions to evaluate students’ fact-based knowledge of neuroanatomy as well as some higher order thinking questions to assess students’ deeper understanding of neuroanatomy and how it can be affected by various extraneous variable. Also, the Exploration Worksheet is a good way for students to practice labeling the different parts of the brain. Finally, there are a number of opportunities for informal evaluation during discussions throughout the lesson, including before, during, and after the Main Activity.