Brain Injury and Safety

By Natalie Frederick, Dustin Goncharoff, Arin Pamucku, and Nelly Papalambros
(Adapted from a workshop created by: Theanne Griffith, Matthew Schroeder, Laura Shanahan, and Eugenie Suter)

Lesson Objectives:

- Understanding how the brain protects itself.
- Learning how common brain injuries occur and how famous cases allowed researchers to learn about the function of different brain areas.
- Demonstrating the importance of protecting your brain and how velocity can affect the size of injury.

Basic Neuroanatomy:

The brain is composed of three different areas: brainstem, cerebellum and cerebral cortex. The major roles of the brainstem are to maintain homeostasis and act as a relay station between the cortex and spinal cord. The cerebellum is important for motor learning and fine tuning of movements. The cerebral cortex is the area of the brain most developed in humans compared to other animals. The cortex is composed of four major lobes: frontal, parietal, temporal and occipital. The frontal lobe regulates emotion, along with other executive functions as well as movement. Within the parietal lobe the areas of the brain responsible for somatosensation (touch) and visual processing are located. The main role of the occipital lobe is primary visual processing. The temporal lobe is important for memory and some auditory functions.

The brain is suspended in the skull by cerebrospinal fluid (CSF). CSF is created within the ventricles of the brain and bathes both the inside and outside of the brain. One of the major roles of CSF is to protect the brain during accelerating movements from hitting the skull and damaging the nervous tissue.

Famous Brain Injuries:

Phineas Gage:

Phineas Gage was a railroad foreman in the 1800s, and when he was preparing explosives his tamping iron struck a rock creating a spark, propelling his tamping iron through his skull. Amazingly he was able to survive his injuries, but he was no longer the same. Before his accident Phineas was known to be a reliable, well tempered man, and after his accident he became poor at planning and could no longer hold a job. He also showed changes in his mood and behavior. We now know the area of the frontal lobe behind the eye called the ***Prefrontal cortex*** regulates personality and planning.

Links:

http://gizmodo.com/5911184/watch-how-a-rod-impaled-a-19th-century-mans-skull-without-killing-him/all
http://www.youtube.com/watch?v=MvpIRN9D4D4

Patient H.M. (Henry Molaison):

Henry Molaison began suffering from intractable epilepsy around age seven, thought to be caused by a bicycle accident. When he was in his twenties, the source of his epilepsy was localized to both his left and right ***medial temporal lobes***. He underwent surgery to remove the tissue causing the seizures. Overall the operation was a success, but no one could have predicted the outcome. Located within the temporal lobe that was removed in Henry Molaison is the ***hippocampus***, and today we know this structure is important for the creation of new memories. H.M. could no longer form new memories, but retained all of his memories from before the surgery. Based on this observation, it has been suggested that after creation of new memories in the hippocampus, the memories are "transferred" to other brain regions for long-term storage. H.M. was further studied over the course of many decades and further analysis revealed that he was capable of motor learning, such as being able to learn how to throw a ball, but he could not remember the experience that he had learned how to throw a ball. Overall, researchers we able to determine that the hippocampus is important for the formation of ***declarative memories*** which is defined as memories that can be consciously recalled (e.g., memories for events aka "what, when, where" memory, and memories for facts), but not for motor learning and retrieval of long-term memories (although this is a subject of major debate today in neuroscience).

Links:

http://deskarati.com/2012/01/21/the-brain-of-hm-henry-molaison/ http://thebrainobservatory.ucsd.edu/content/video-scientia-nova-memory
http://www.youtube.com/watch?v=IKP6tBhM2T4

Aphasias:

Aphasias are defined as the disturbance of the comprehension and formulation of language caused by dysfunction in specific brain regions. There are two main types of aphasias: ***Broca's and Wernicke's aphasias***, both named after the physicians that first described them. Patients with Broca's aphasia have a lesion on the left side of the brain in a region called ***Broca's area***, and these patients present with an inability to generate fluent speech. These patients have intact language comprehension and know what they want to say, but have trouble expressing themselves in both speech and writing. Patients with Wernicke's aphasia have a lesion on the left side of the brain corresponding to ***Wernicke's area***. These patients can speak with normal sounding rhythm and syntax, but have a major impairment in understanding language. Their word choices do not make sense in context.

Links:

http://www.youtube.com/watch?v=1aplTvEQ6ew
http://www.youtube.com/watch?v=dKTdMV6cOZw

Strokes:

There are two main categories of strokes: ischemic and hemorrhagic. ***Ischemic strokes*** are caused by a blockage of an artery supplying blood to the brain, about 85% of strokes are ischemic strokes. The other 15% of strokes are ***hemorrhagic strokes*** cause by a break in the blood vessel. Both types of strokes cause nervous tissue to die in the area surrounding the infarction, often times causing a loss of function. One example of a stroke patient is Senator Mark Kirk that suffered an ischemic stroke in his right motor cortex, causing loss of movement function in his left hand and leg. Additionally, both Broca's and Wernicke's aphasias can be caused by strokes.

Links:

http://www.youtube.com/watch?v=yH6WqBNBOZQ
http://www.youtube.com/watch?v=gnZcxJ7MZY4

Concussions:

Concussions are a common form of traumatic brain injury and can also be referred to medically as mild traumatic brain injury (MBTI), minor head trauma, or minor head injury (MHI). A concussion occurs when the head hits an object (or an object hits the head) with enough force that the cerebral spinal fluid surrounding the brain cannot cushion the blow. Symptoms of concussions include confusion, headache, loss of consciousness, and nausea/vomiting. The impact of the blow sends shock waves through the brain that can lead to bruising of the brain, broken blood vessels and nerve damage. Helmets can protect the head from such trauma, however, in high impact sports such as football, the incident of concussions is high. Long-term consequences of repeated concussions have been observed in professional football players, demonstrating the effects of repeated brain injury and the importance of avoiding any type of head trauma.

Links:

http://science.kqed.org/quest/video/sidelined-sports-concussions/

Recovery After Injury:

The brain is capable of some recovery after injury, and you may have witnessed this with a stroke patient relearning how to do everyday tasks. The process that regulates recovery is ***synaptic plasticity***. Current connections in the brain can be strengthened or weakened with usage and training that can allow the brain to reorganize. However, depending on the severity of the injury a significant recovery may not be possible.

Activities:

Cerebrospinal fluid (CSF): this activity demonstrates the importance of CSF

Materials:

- 2 brain erasers (pkg 50 is $15-20 on Amazon)
- 2 jars to hold the erasers and allow for the eraser to move (we used old spice jars)
- water

Place a brain eraser in each jar and add water to one of the jars. The water will represent the CSF. Now shake both jars and observe how the brain erasers move in each jar. The eraser in the water jar moves at a slower velocity and does not impact the jar as frequently.

Questions for the students:

1. What is the CSF? What is its function? Where is it?
2. Why is the CSF important?
3. If the CSF was thicker/more viscous, do you think it would protect the brain better? Can you think of disadvantages of a thicker/more viscous CSF?
4. If you did not have CSF, would you have more or less concussions?

Brain Injury: this activity demonstrates the importance of wearing a helmet.

Materials:

- Play-doh (4 - 5oz containers $5-10 on Amazon)
- Brain mold (Fred and Friends Brain Freeze Ice Cube Tray, $8 on Amazon)
- Small weights (Pebbles from Michael's $2)
- Lego sheet (Lego store $5, or any other textured surface)
- Helmets (we made ours from paper mache, about the size of a fist with five layers of paper mache)
- Bubble wrap/paper towels/etc. (for lining the helmet)

Creating the brain: first line the brain mold with a small amount of Play-doh and then fill with weights, add more Play-doh to the top to seal the brain. It is best not to completely fill the mold since this makes it hard to remove the brain. To remove the brain from the mold, press on all sides to compress the brain and it will fall out of the mold. Alternatively, you do not have to use a brain mold but wrap Play-doh around the weights. Now, have the students drop the brain onto the Lego sheet and observe the indentations. You can allow the students to experiment with dropping the brains from various heights and observing any changes in the resulting indentations (if they have taken physics you can have them calculate the velocity upon impact).

Now make a brain and place it in a helmet lined with different materials (bubble wrap/paper towels/fabric). Upon dropping it observe the damage to the brain (lack thereof). Let the students compare the differences between the brains and again dropping the helmeted brain from different heights. You can also have students design their own helmets to see what helmet properties work best in protecting the Play-doh brain.

Questions for the students:

1. Which brain was better protected? With or without a helmet.

2. When the brain is dropped from higher heights is there more or less damage? Why?
3. How could you design a better helmet?
4. Is a helmet enough to protect your brain?

<u>Stroke:</u> this activity demonstrates tissue damage after a stroke

Materials:

- Tissue paper
- Dropper
- Water with red food coloring

Crumple the tissue into roughly the basic shape of a brain, and drop some of the colored water on the tissue paper. The area that gets wet will "dissolve" representing the area that is damaged in a stroke. Ask the students to name the general area that is involved by comparing to a picture of a brain (see below) and the possible loss of function associated with the stroke.