SHEEP BRAIN DISSECTION

LESSON PLAN

Title: Sheep Brain Dissection
Setting: In Classroom
Subject: Biology - Neuroscience
Grade Level: 9th-12th Grade
Time Frame: 1 Hour
Paired Dana Foundation Fact Sheets:
9th-12th Grade How Does the Brain Work?
Next Generation Science Standards:
Meets HS-LS1-1-2, HS-LS1-3, HS-LS4-2

STUDENT OBJECTIVES

- Learn how to safely and respectfully examine the organ of a previously living organism.
- Touch and identify inner and outer structures of a sheep brain.
- Explore brain structures and their relationships to function by visually comparing the brains of different species.
- Feel the bumps (gyri) and grooves (sulci) on the brain and understand what purpose they serve.

BACKGROUND

This interactive lesson plan features the dissection of a sheep brain. Teachers will learn about and share knowledge regarding comparative and gross neuroanatomy, function, and homeostasis.

MATERIALS

- Printed copies of 9th-12th grade Dana Foundation fact sheet, "How Does the Brain Work?" **downloadable at www.dana.org/factsheets/** and the Neuroanatomy Quick Definitions Guide (see pages 10-11).
- Gloves: SafeTouch Nitrile Exam Gloves, ASIN: B000OFKDXA, can be ordered from **www.amazon.com.**
- Sheep Brains can be ordered from Carolina Biological Supply Company, **www.carolina.com.** Order one or more of: Carolina's Perfect Solution > Sheep Brain, Dura Mater Intact, Item #228718.
- Dissection tools
    - Long Bladed Scalpel: Scalpel Blades, #22, 10 pack, and Scalpel Handle, #4, can be ordered from **www.homesciencetools.com.**
    - Forceps, stainless steel, can be ordered from **www.homesciencetools.com.**
    - Dissection scissors can be ordered from **www.homesciencetools.com.**
- Dissection trays or disposable plastic plates: Premium Aluminum Lab Dissecting Dissection Pan with Wax ,11 inches x 7 inches x 1-1/2 inches, can be ordered from **www.amazon.com.**
- Lab glasses: Gateway Safety 6980 Cover2 Safety Glasses, Clear Lens, Black Temple, can be ordered from **www.amazon.com.**
- Paper towels.
- Hand soap.

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TEACHER BACKGROUND INFO

WHAT TO KNOW BEFORE YOU TEACH

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BRAIN STRUCTURES

Below we will look at labeled diagrams of a sheep brain for reference.

On the outside of the brain, superficially, we can see many important structures.

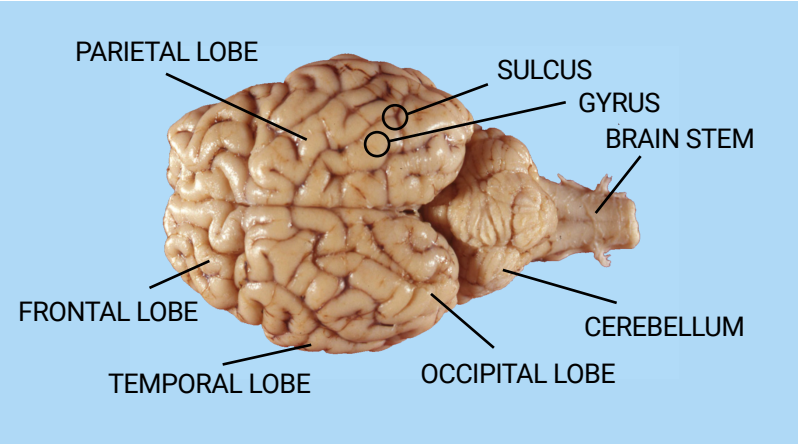
The cerebral cortex is the wrinkly outer layer of the brain that is responsible for higher cognitive thought and for processing sensory information. The wrinkles maximize the surface area of the brain, allowing for more neurons and increased connections between them.

The cortex is divided into distinct areas called "lobes" that sub-serve different functions:

- **The frontal lobe** - planning, reasoning, speech, movement, and problem-solving.
- **The temporal lobe** - important for memory and learning, hearing, and language.
- **The occipital lobe** - visual processing center of the brain.
- **The parietal lobe** - processes sensory information like touch, pressure, temperature, and pain; integrates this with motor information.

Other very important regions of the brain include the cerebellum and brain stem.

- **Cerebellum** - structure at the base of the brain that regulates balance and coordination. This area receives information from the eyes and muscles to detect where the body is relative to space (proprioception).
- **Brain stem** - also known as "the reptilian brain," it is the most primitive part of our brain. Regulates basic functions such as breathing, heart rate, and blood pressure.



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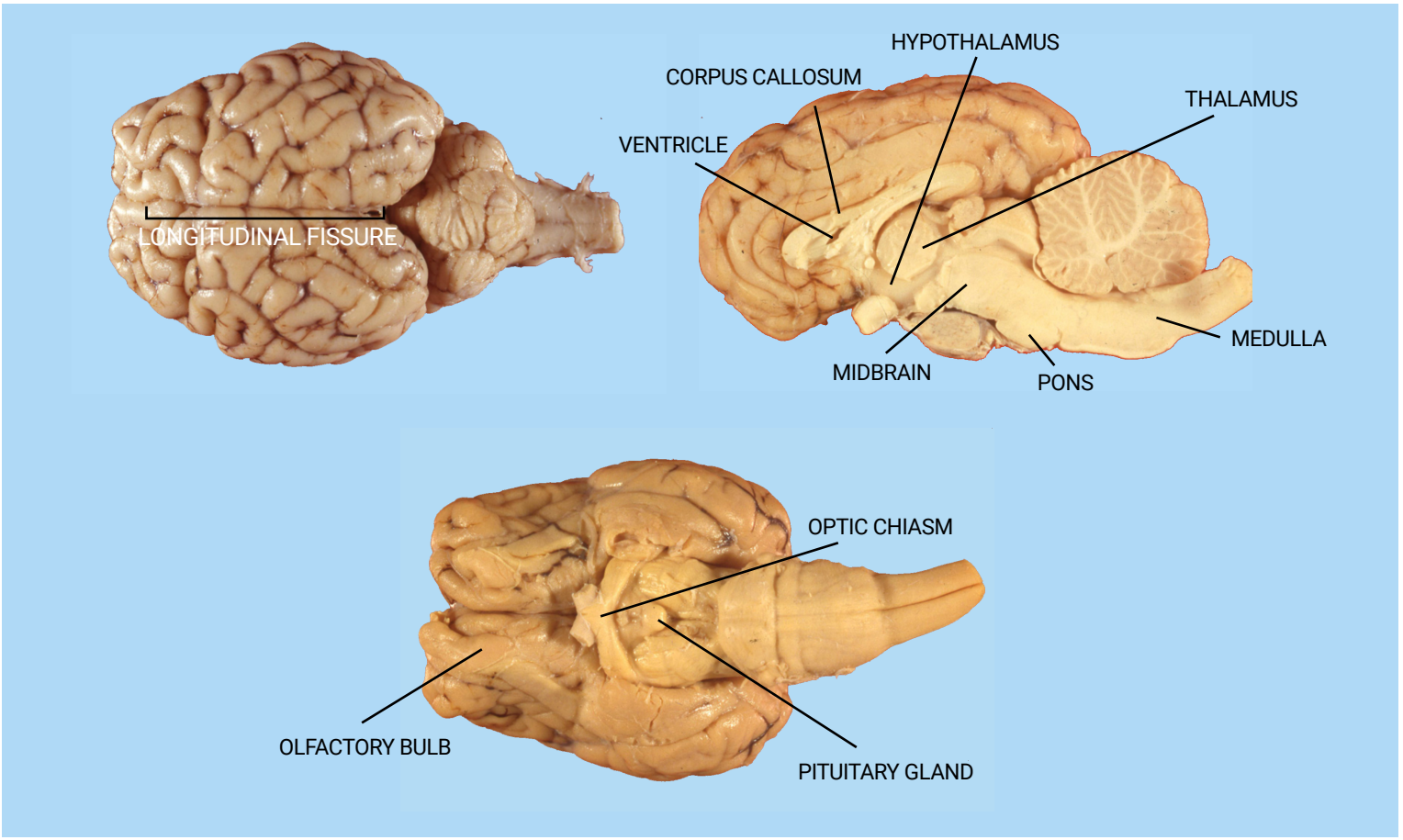
Some other structures you might be able to see include:

- **Olfactory Bulb** - processes smell.
- **Optic Nerve** - connects to the eyes and meets at the Optic Chiasm.
- **Pituitary Gland** - important for hormone secretion. Hormones are chemical signaling molecules that travel long distances through the body to target organs. By acting on these target organs, hormones regulate both physiology and behavior.
- **Longitudinal Fissure** - separates the brain's two hemispheres or halves.
- **Meninges** – the three membranes around the brain that provide protection and support, known as the Dura mater, Arachnoid mater, and Pia mater. Dura mater is the outermost membrane and is extremely tough. Arachnoid mater is between the Dura and Pia mater. Pia mater is the innermost, delicate layer that lies very tightly to the surface of the brain. It is important for protecting your brain and keeping it from hitting your skull.



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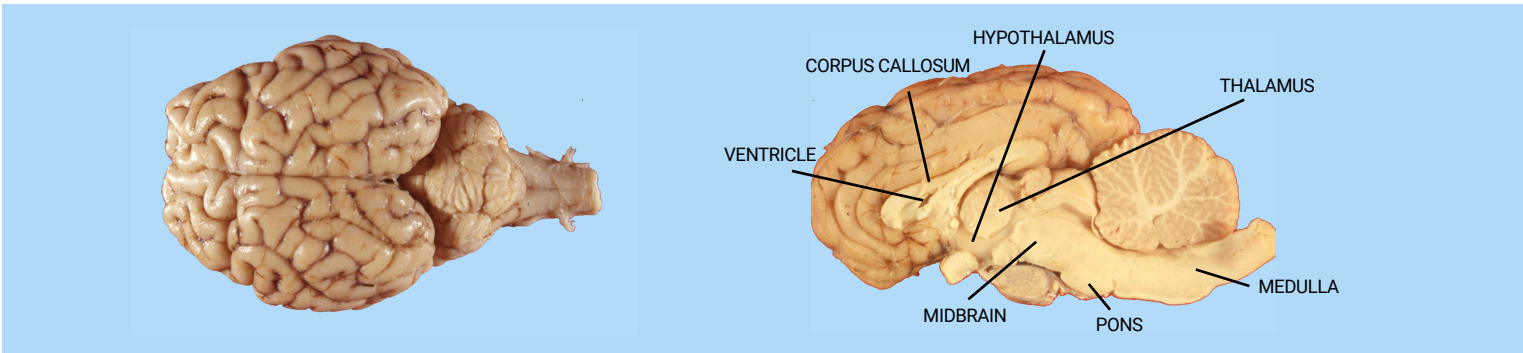
As we look inside the brain, we have access to many more structures.

- **Corpus Callosum** - bundle of nerve fibers that connects and allows communication between the left and right hemispheres of the brain.
- **Ventricles** - cavities in the brain where cerebrospinal fluid (fluid that encases and cushions the brain and spinal cord) is produced.
- **Thalamus** - relays information regarding senses and pain to other parts of the brain. Commonly known as the "gateway in and out of the cortex."
- **Hypothalamus** - coordinates the autonomic nervous system; important for homeostasis.
- **Midbrain** - A part of the brain stem that controls visual and auditory systems as well as some body movement. A part of the midbrain called the substantia nigra produces dopamine, a neurotransmitter which plays a role in movement, as well as motivation and reward. The degeneration of neurons releasing dopamine in this brain region is one of the main causes of Parkinson's Disease.
- **Pons** - A part of the brain stem that connects the cerebral cortex to the medulla. It has several functions including controlling autonomic functions, arousal, and relaying information.
- **Medulla** - A part of the brain stem that is a continuation of the spinal cord. It controls several basic functions such as swallowing, breathing, and heart rate.



You may notice the symmetry of structures between the two hemispheres. Although structures of both hemispheres appear to be mirror images for the most part, some asymmetry in function does exist. This specialization of function is known as brain lateralization. An example of brain lateralization is the fact that language and speech abilities in the majority of humans (but not all!) is localized in the left hemisphere. In addition, we know the left side of the brain controls the right side of the body and vice versa.

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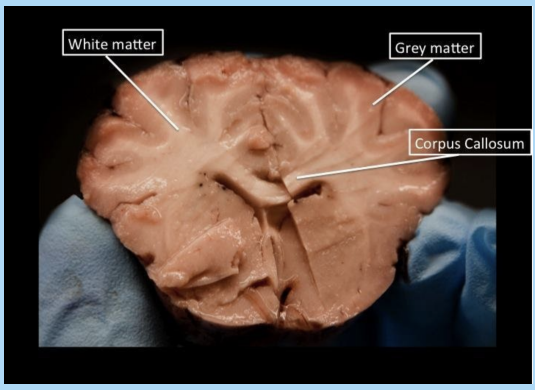
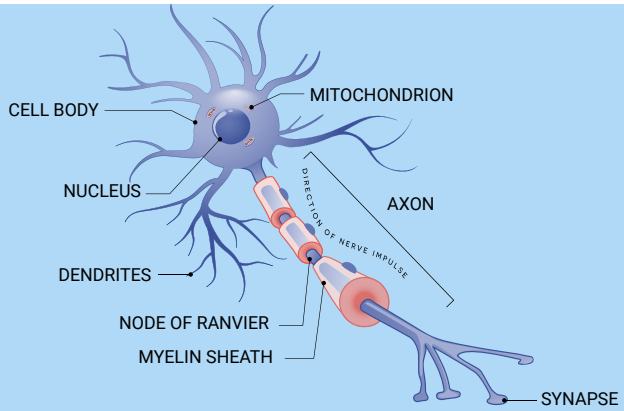
It's important to note, however, the simplistic left-brain / right-brain assumptions, often portrayed in the media, crumble when further inspected. For example, it is often assumed that creativity is a right-brain phenomenon, whereas analytical thinking is a left-brain one. In reality, the two sides of the brain work together as a network to produce complicated behaviors such as creativity and analytical thinking.

NEURON DETAILS

White & Grey Matter: Can you see the difference between grey and white matter? Sometimes it's hard to see in a fixed brain. White matter consists of axons (the long fiber section of a neuron). Axons are surrounded by a fatty substance called the myelin sheath. The myelin sheath allows neurons to communicate very quickly and is responsible for the white color of this tissue. Grey matter consists of neuron cell bodies and branching dendrites (the tentacle-like extensions that bring electrical signals from other cells to the cell body). Upon dissection, this tissue is grey in color.





HOMEOSTASIS

The concept of homeostasis in the brain and body is an important one. Homeostasis refers to the tendency of an organism or a cell to regulate its internal conditions. Your body has a goal to remain at homeostasis. Various mechanisms are at play in your brain to keep your body at homeostasis following a change in normal conditions or a perturbation. The brain uses a system of feedback controls to sense shifts in normal conditions and send signals throughout the brain and body to react appropriately.

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For example, when you exercise, your muscles increase heat production, causing your internal body temperature to increase. Your brain must detect and respond to this change in order to remain at homeostasis. Your brain usually responds by initiating negative feedback loops to oppose the stimulus that has caused your body to veer from homeostasis. Therefore, when your body temperature exceeds the normal temperature, your sensory neurons will detect the change, and the brain will respond by triggering your sweat glands to activate. Sweating causes you to cool off and return to a normal body temperature.

The cerebrospinal fluid is also critical for homeostasis. The cerebrospinal fluid is contained and flows within the ventricles and also in the space between the arachnoid and pia meninge layers. The space between these meninge layers is termed the subarachnoid space. The cerebrospinal fluid protects the brain by acting like a cushion that buffers the impact of a harmful blow to the head. This flow of fluid is also important for excretion of waste. When unwanted, potentially harmful molecules build up in the brain, the cerebrospinal fluid helps to eliminate them.

COMPARATIVE NEUROANATOMY

One method to understanding the relationship between brain anatomy and function is to compare the neuroanatomy of different species. By assessing the differences and similarities in brain structures and their adaptive functions across animals, it's easier to understand the relative significance of each area within an organism.

For instance, dog brains have a more wrinkled cortex compared to many other animals. This wrinkling allows more brain cells to fit into their skulls. Dogs are quick learners and social animals that tend to live in packs in the wild. These characteristics may contribute to a more developed cortex.

Visually inspecting the brains of different organisms side by side can give us insight about species behavior and survival. For instance, let's look at the similarities and differences between human, sheep, and bat brains.

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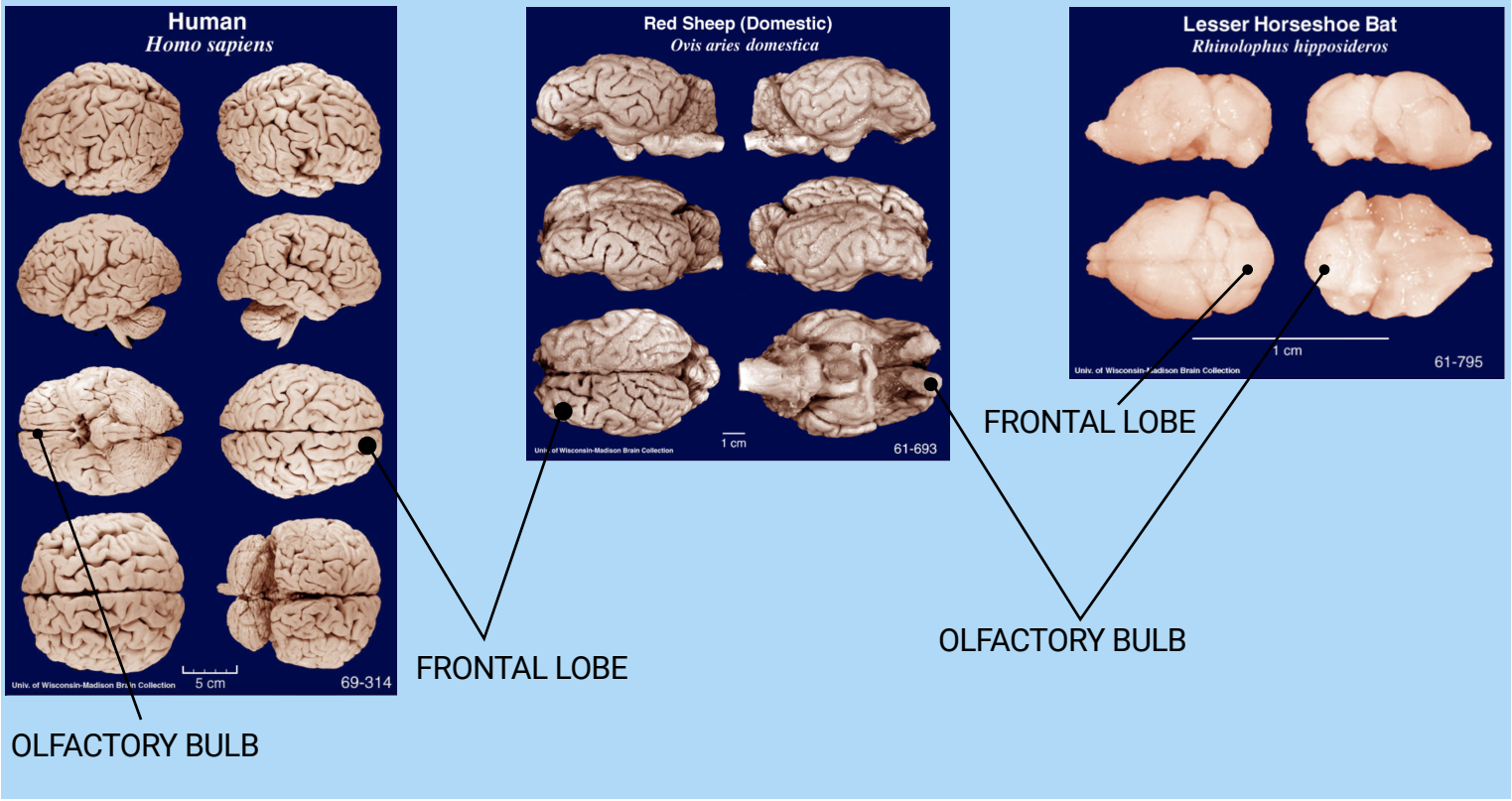

Here, all of the brains have similar structures because they are all mammals. Yet, there are differences as well. The human and sheep brains have lots of wrinkles. This allows more brain cells to fit into their skulls. This may contribute to a more developed cortex in these two animals versus the bat, suggesting these animals may be more equipped to handle high order processing.

Further, the frontal lobe in humans is far more developed than that of sheep or bats. A highly-developed frontal lobe is associated with attributes such as emotional regulation, problem-solving, and impulse control, to name a few.

Finally, humans rely more on their sense of sight than their sense of smell. The opposite is true for many other mammals. Because of this, humans have relatively small olfactory bulbs, while other mammals, who rely more heavily on the sense of smell to interact with their environment, have larger, more developed olfactory bulbs. We see this here when comparing the olfactory bulbs of the human versus the sheep and bat brains.

SHEEP BRAIN DISSECTION

PROCEDURE

[1] Each student reads 9th-12th grade Dana Foundation fact sheet, "How Does the Brain Work?"

[2] Briefly introduce the exercise and give the necessary background information from the accompanying PowerPoint presentation (slides 1-8). Hand out Neuroanatomy Quick Definitions Guide for quick reference (see pages 10 & 11 of lesson plan).

[3] Split up the class into groups based on how many preserved sheep brains are available (recommend 4-5 students per group).

[4] Set up trays or plates, dissection tools, and hand out lab glasses and gloves (slide 9).

- The gloves and glasses protect our hands and eyes from the preservative chemical used to fix the sheep brain.

[5] Go over the dissection tools students will be given and how they will be used (slide 9):

- The brain must always remain on the dissection tray or plate.
- The scissors will be used to remove the dura mater covering the brain before starting the dissection.
- The scalpel will be used for cutting the brain in half after viewing the external structures. It will also be used to cut a slice of the brain to view the white and grey matter.
- The forceps will be used to point out structures and remove any debris.

[6] Reiterate that extreme caution needs to be taken when handling the brain (slide 9).

[7] Go over safety information when using sharp tools (slide 9).

[8] Complete the sheep brain dissection using the accompanying PowerPoint presentation.

- Have students watch the YouTube video, "Sheep Brain Dissection," (slide 10) as they carefully use the scissors to remove the dura mater covering the brain.
- Have students identify exterior brain structures and the lobes (slides 11 & 12).
  - Have the students turn their brains facing up, as viewed in slide 11. Note the pituitary gland, olfactory bulb, and optic chiasm.
  - Discuss lobes, sulci, gyri, cerebellum, and brain stem after turning the brain back over as viewed in slide 12.

SHEEP BRAIN DISSECTION

PROCEDURE

- Students should use the scalpel to cut the brain along the longitudinal fissure, including the cerebellum. Make sure students do not hold the brain in their hands while cutting.
- Left and right hemispheres can now be separated and laid on the dissection tray so the inner structures are exposed.
- Have students identify internal brain structures (slide 13).
    - Discuss the corpus callosum, thalamus, hypothalamus, midbrain, pons, and medulla (slide 13).
- Have students cut off a small sliver of the brain to identify the white and grey matter (slide 14).
- Appropriately discard brain specimens and clean the tools and trays.
- Students must wash their hands with soap after class is concluded (5 minutes).

ADDITIONAL RESOURCES

- Follow the link for a full sheep brain dissection video: **https://www.youtube.com/watch?v=y7gEWzPqm94**
- A collection of neuroscience puzzles and fact sheets for kids in grades K-12 that are available for download (PDF): **www.dana.org/educators/**

The Sheep Brain Dissection Lesson was originally developed by the University of New England Center for Excellence in the Neurosciences and has been adapted by Elizabeth Weaver, M.S., and Katie Partrick, M.S., for the Dana Foundation.

SHEEP BRAIN DISSECTION

NEUROANATOMY QUICK DEFINITIONS GUIDE

Brain stem
The brain stem includes the midbrain, pons, and medulla. This region controls things required to live, including breathing, heart rate, and blood pressure. It also processes sensory information and influences brain regions involved in higher order processing.

Cerebellum
This structure plays an important role in motor control. It contributes to coordination, balance, precision and accurate timing of movement.

Corpus Callosum
A thick band of fibers joining the two halves of the brain.

Frontal Lobe
The frontal lobe controls conscious thought, executive thinking, decision-making, and movement. This part of the brain may be more developed in humans than in most other animals. If you damage this, you will have trouble working socially and creatively, with emotional regulation, and may experience impairments with movement, depending on the part of the lobe that is damaged.

Grey Matter
A tissue of the brain consisting of neuron cell bodies and branching dendrites (the tentacle-like extensions that bring electrical signals from other cells to the cell body). Upon dissection, this tissue is grey in color.

Gyrus
A fold or curve on the surface of the brain.

Hypothalamus
Below the thalamus, coordinates the autonomic nervous system and the activity of the pituitary gland. The pituitary gland controls thirst, hunger, and body temperature.

Medulla
A part of the brain stem that is a continuation of the spinal cord. This section of the brainstem controls several basic functions such as swallowing, breathing, and heart rate.

Meninges
Three membranes around the brain that provide protection and support, known as the Dura mater, Arachnoid mater, and Pia mater. Dura mater is the outermost and is extremely tough. Arachnoid mater is between the Dura and Pia mater. Pia mater is the innermost and delicate layer that lies very tightly to the surface of the brain. Important for protecting your brain and keeping it from hitting your skull.

Midbrain
A part of the brain stem that contributes to visual and auditory systems as well as some body movement. A part of the midbrain called the substantia nigra produces the neurotransmitter dopamine. Degeneration of this region occurs in Parkinson's Disease.

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NEUROANATOMY QUICK DEFINITIONS GUIDE

Occipital Lobe
This lobe is responsible for the sense of sight. Damage to this lobe can produce hallucinations and blindness.

Olfactory Bulb
Neural structure responsible for olfaction, or our sense of smell.

Optic Chiasm
The optic nerves carry signals from the eyes to the brain. The optic chiasm is where the optic nerves from each eye cross. Because the optic nerves cross at the optic chiasm, visual information from the right eye sends signals to the left side of the brain and visual information from the left eye sends signals to the right side of the brain!

Parietal Lobe
This lobe plays important roles in integrating sensory information from various senses (touch, smell, taste, sight, hearing). It is also responsible for visual spatial processing.

Pituitary Gland
A pea-sized organ that serves as the "master gland" and is responsible for secreting hormones throughout the body.

Pons
A part of the brain stem that connects the cerebral cortex to the medulla. It has several functions including controlling autonomic functions, arousal, and relaying information.

Sulcus
A groove or crevasse on the surface of the brain, creating the gyri.

Temporal Lobe
This lobe controls our sense of hearing and is important for language because it processes sound.

Thalamus
Relays information regarding senses and pain to other parts of the brain. Commonly known as the "gateway in and out of the cortex."

Ventricles
Cavities in the brain where cerebrospinal fluid (fluid that encases and cushions the brain and spinal cord) is produced.

White Matter
A tissue of the brain consisting of axons (the long fiber section of a neuron). Axons are surrounded by a fatty substance called myelin sheath. Myelin sheath allows neurons to communicate very quickly and is responsible for the white color of this tissue.