Basic Neuroanatomy

by Natalie Frederick, Margaret Gullick, and Melissa McSweeney

Objectives

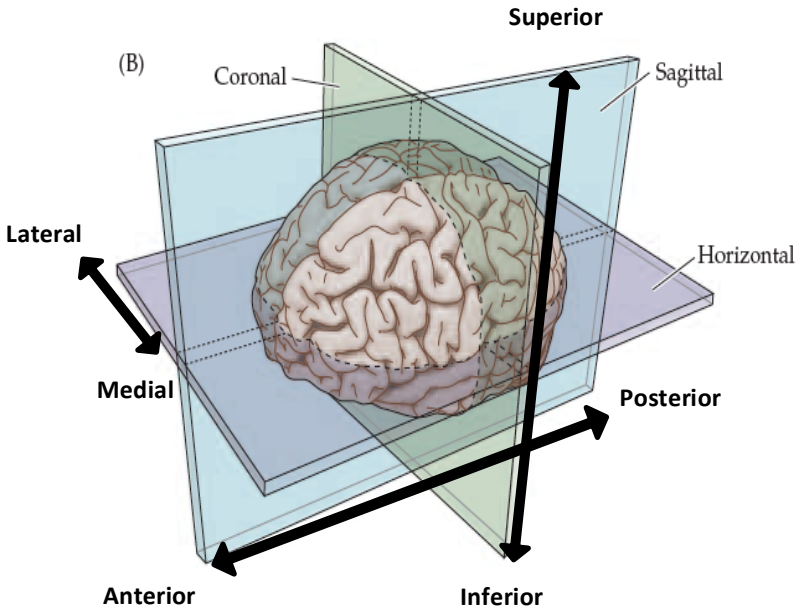
- Explore the sheep brain and identify various brain regions/structures
- Compare and contrast the sheep and human brain
- Trace the visual system pathway through the sheep brain

Background

The nervous system can be broken down into two major components: the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS is comprised of the brain and the spinal cord, while the PNS is comprised of the nerves innervating the body.

The PNS can be divided into two parts, the **autonomic** and the **somatic** nervous systems. The somatic nervous system is composed of nerves that carry sensory and voluntary motor information between the CNS and the rest of the body. It is comprised of 12 cranial and 31 spinal nerve pairs. The autonomic nervous system is largely responsible for the involuntary control of internal organs. Heart rate, digestion, and urination are just a few of the things the autonomic nervous system is responsible for. The autonomic nervous system can be further divided into the **sympathetic (**"fight or flight") and the **parasympathetic (**"rest and digest") systems.

The human brain can be divided into three parts, the **cerebrum**, **cerebellum** and **brainstem**. When describing the nervous system directional terms are used: **anterior** (towards the nose), **posterior** (towards the back of the head)**, superior** (towards the top of the head), **inferior** (towards the base), **medial** (towards the midline) and **lateral** (towards the ears). There are also three common ways the brain can be cut: **coronal** (in the plane of the face), **sagittal** (in the plane of the longitudinal fissure) and **horizontal** (parallel to the ground). Neuronal cell bodies form **gray matter** and their myelinated axonal projections make up the **white matter**.



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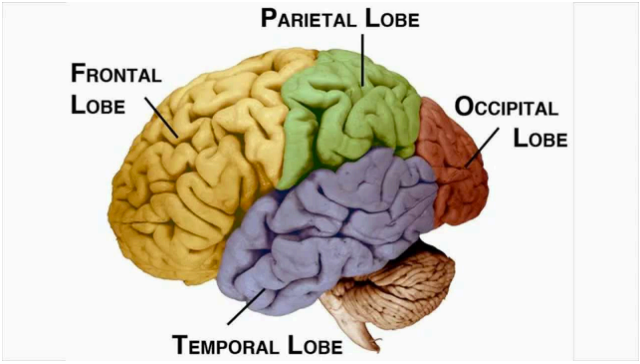
The cerebrum is the last part of the brain that has developed evolutionarily. It can be divided into two hemispheres along the longitudinal fissure. The surface of the cerebrum is folded and convoluted, creating **gyri** and **sulci.** Gyri are the ridges on the surface of the brain and sulci are the grooves between the ridges. Fissures are deep sulci. The cerebrum can be divided into four lobes: **frontal**, **parietal**, **occipital** and **temporal**. The two hemispheres of the cerebrum are connected by the **corpus callosum**.



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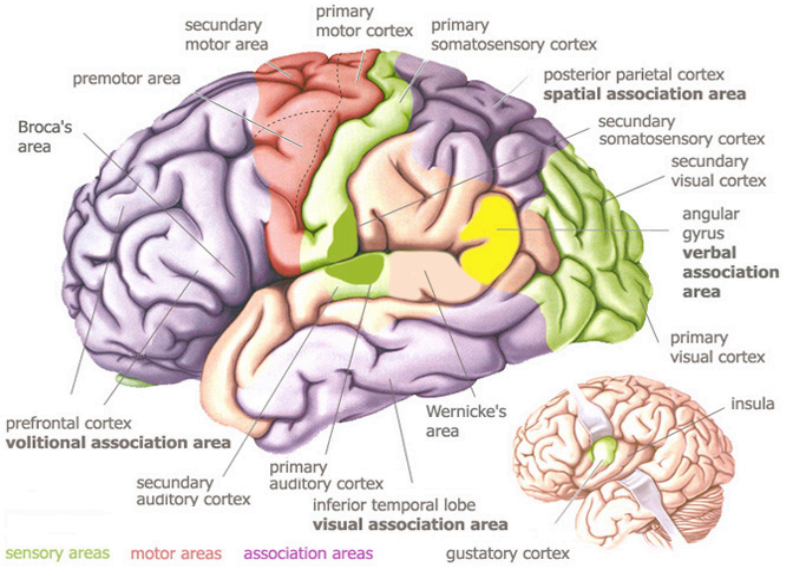
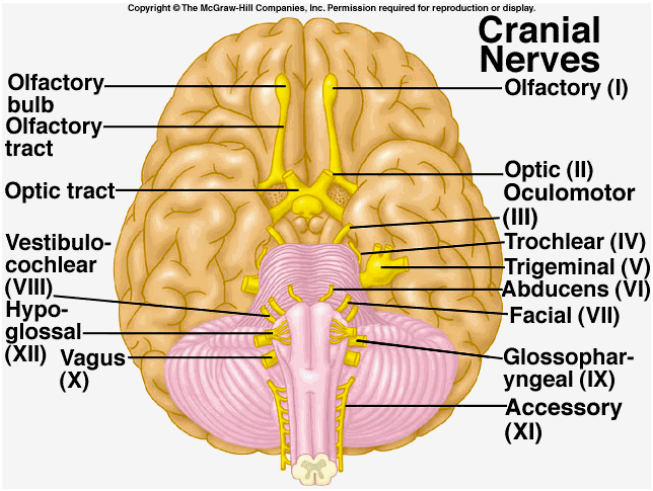
Functional Anatomy

The frontal lobe is the area anterior of the central sulcus and superior to the lateral fissure. The frontal lobe contains four general functional areas; the primary motor cortex, premotor and supplementary motor areas, Broca's area, and the prefrontal cortex. Primary motor cortex contains many of the neurons that control motor function while premotor and supplementary motor areas aid in the initiation of voluntary movements. Broca's area, usually only located in the left hemisphere, is an area associated with the production of written and spoken language. The majority of the frontal lobe is comprised of the prefrontal cortex and is involved in executive functioning, e.g. personality, insight and foresight.



The parietal lobe lies posterior to the central sulcus, anterior to the parieto-occipital sulcus and preoccipital notch, and superior to the lateral fissure. The parietal lobe contains the **primary somatosensory cortex**, which is the initial processing area for touch, language association areas, and spatial orientation areas. The temporal lobe lies inferior to the lateral fissure. **Primary auditory cortex** is located in the temporal lobe along with **Wernicke's area** that is important for language comprehension. Parts of the medial temporal lobe are associated with the limbic system, e.g. the **hippocampus** (important for memory formation) and the **amygdala** (fear recognition). Higher order visual processing also occurs in the temporal lobe. The occipital lobe is the most posterior part of the cerebrum and where visual inputs are initially processed.

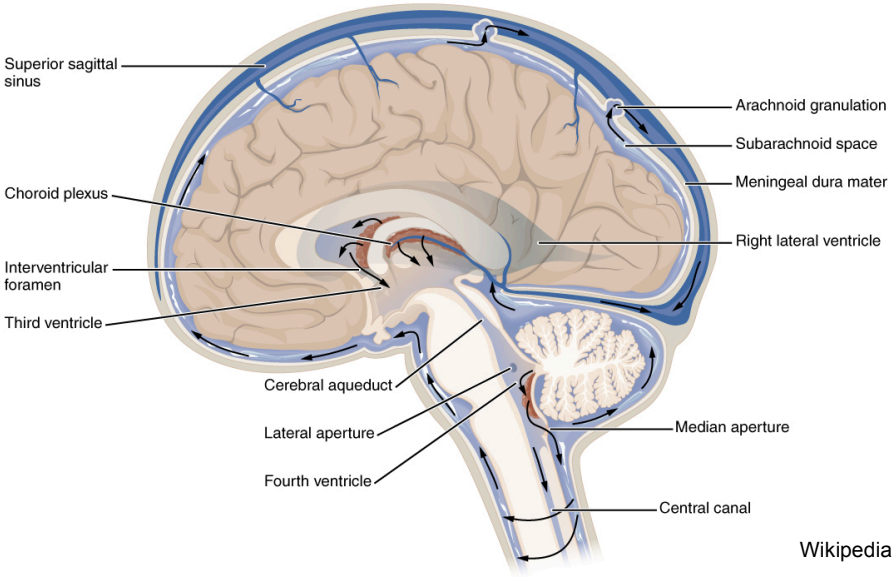
On the inferior surface of the brain are the 12 cranial nerves (CN). These nerves emerge directly from the brain, rather than the spinal cord. CN I (olfactory) relays information about smell. CN II (optic) carries visual information from the eyes to the brain. CN III (oculomotor), IV (trochlear), and VI (abducens) innervate muscles that move the eye. CN V (trigeminal) carries sensory information from the face, and CN VII (facial) innervates muscles of the face and the tongue (both taste and movement). CN VIII (vestibulocochlear) carries auditory and balance information. CN IX (glossopharyngeal), X (vagus), XI (accessory), XII (hypoglossal) innervate the viscera, shoulders, tongue and throat relaying both motor and sensory information.



Supporting Structures

The CNS receives its blood supply from the internal carotid and vertebral arteries. Branches of these arteries supply the entire brain and from a structure called the **circle of Willis**, which ensures a

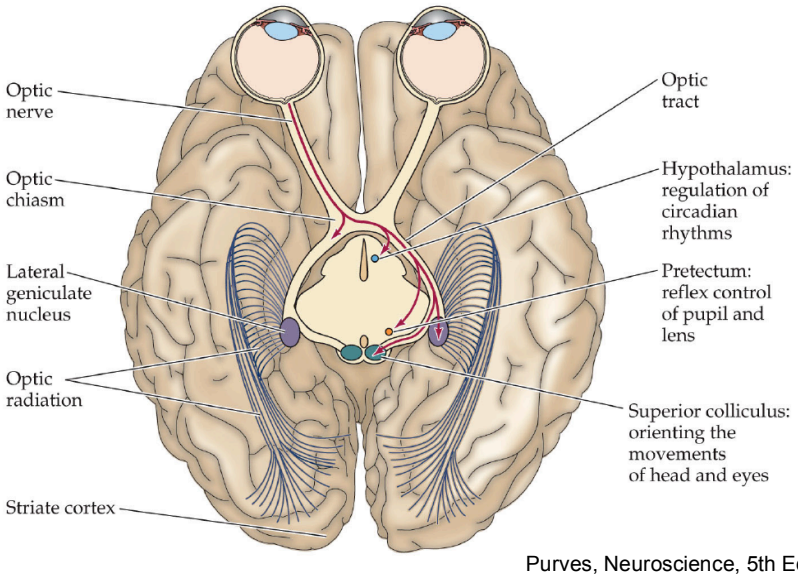
redundancy of blood supply. Cerebrospinal fluid (CSF) is produced by choroid plexus, which lines the ventricles of the brain. The majority of the CSF is produced in the **lateral ventricles** located deep within each hemisphere. The CSF then travels through the interventricular foramen of Monro to the **3rd ventricle**, which lies along the midline of the brain. CSF leaves the 3rd ventricle through the **cerebral aqueduct** and enters the **4th ventricle**, which is also a midline structure anterior to the cerebellum. CSF leaves the brain by the lateral or median apertures and circulates in the subarachnoid space of the meninges to surround the entire brain and spinal cord. CSF is reabsorbed into the blood system through arachnoid granulations into the dural venous sinuses. CSF provides nutrients, buoyancy and protection for the brain and spinal cord.



Wikipedia

The Visual System

Light falls on the retina at the back of the eye. The retina contains photoreceptor cells (rod and cones) that are sensitive to light. Axons from neurons in the retina are bundled together to form the **optic nerve** (cranial nerve II). Before entering the brain, axons from the nasal side of the retina cross to the opposite side in the **optic chiasm,** while temporal retinal axons remain on the same side**.** This allows for the right visual field to be processed on the left side of the brain and vice versa. After the optic chiasm the axons travel to the **lateral geniculate nucleus** (LGN) of the **thalamus**. The thalamus is considered the gateway to the cerebrum and most sensory information passes through the thalamus before processing in the cerebrum. The LGN consists of six layers and each layer only receives input from one eye. The LGN contains a retinotopic map therefore a given point in the visual field is represented by a column of cells running through all six layers of the LGN. From the LGN, visual information travels through the **optic radiations** to the **primary visual cortex** located in the occipital lobe. Primary visual cortex is also arranged in a retinotopic manner and it acts to process visual information and distribute it to other cortical areas. Information about movement in the visual field is processed in the parietal lobe, and information about what and object is processed in the temporal lobe.



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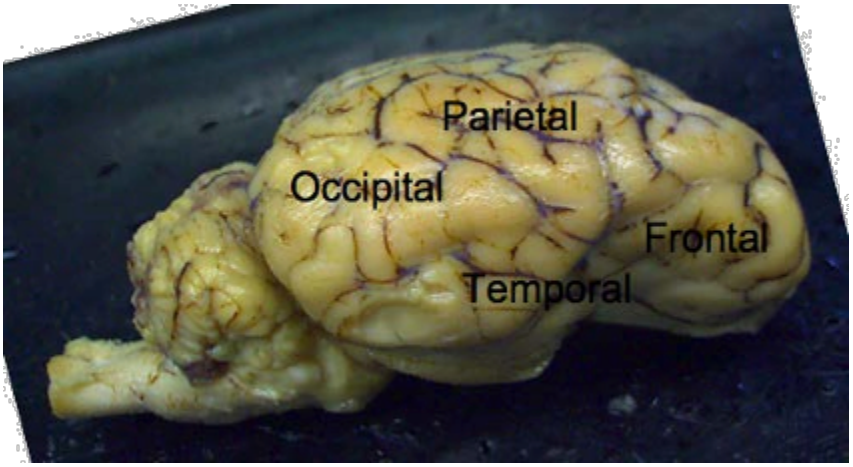
Sheep Brain Dissection

Materials

- Sheep brains
  - www.carolina.com, Item # 228704, Cost: $14/sheep brain
- Knife
- Gloves
- Dissecting tray or lunch tray with paper towels

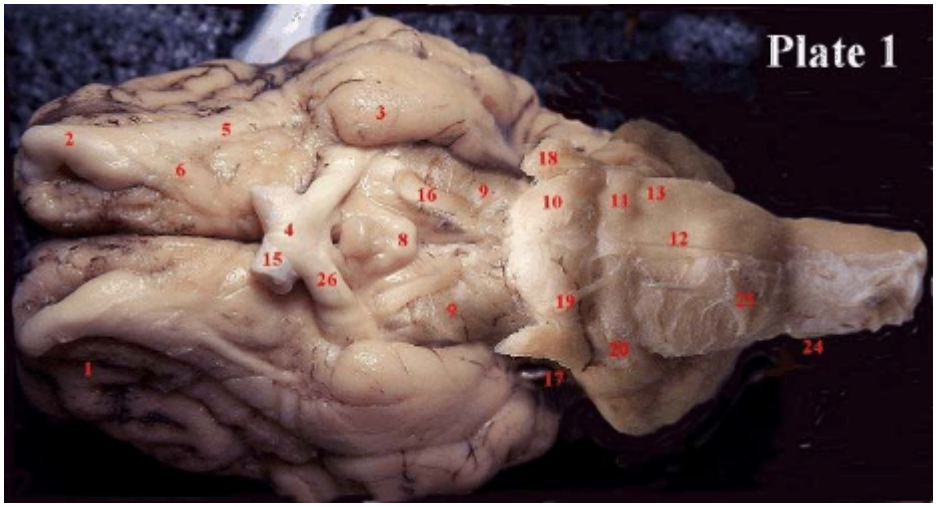
Procedure

1. Have the students identify sulci and gyri on a whole brain
2. Identify the lobes and regions of the brain: cerebrum, cerebellum, brainstem, frontal lobe, parietal lobe, occipital lobe, and temporal lobe.



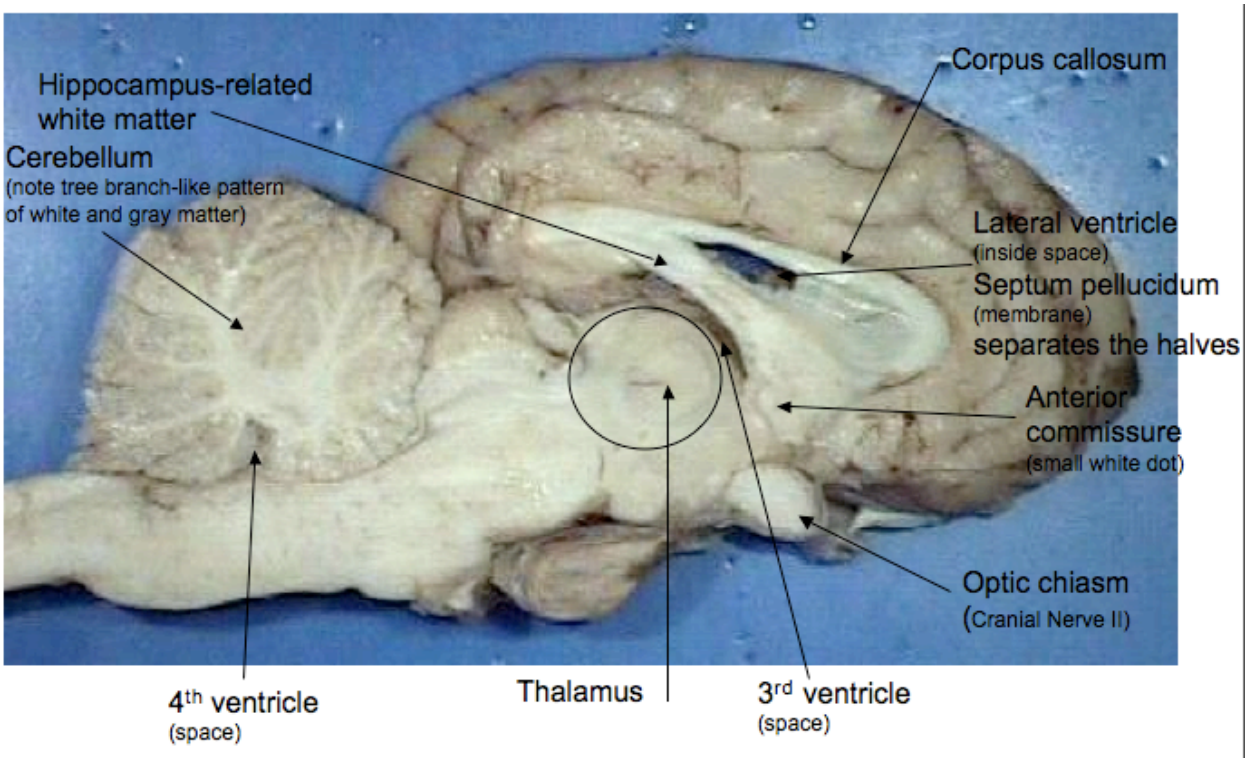
3. Have the students gently pull apart the two hemispheres of the cerebrum and peer into the longitudinal fissure to see the corpus callosum.

4. Flip the brain over (inferior side up) and identify as many cranial nerves as possible (not all will be visible): olfactory bulb (2) and tract (5,6), optic nerve (15), oculomotor nerve (16), trochlear nerve (17), trigeminal (18), abducens nerve (19), facial nerve (20), vestibulocochlear nerve (21), glossopharyngeal nerve (22), vagus nerve (23), accessory nerve (24), and hypoglossal nerve (25).

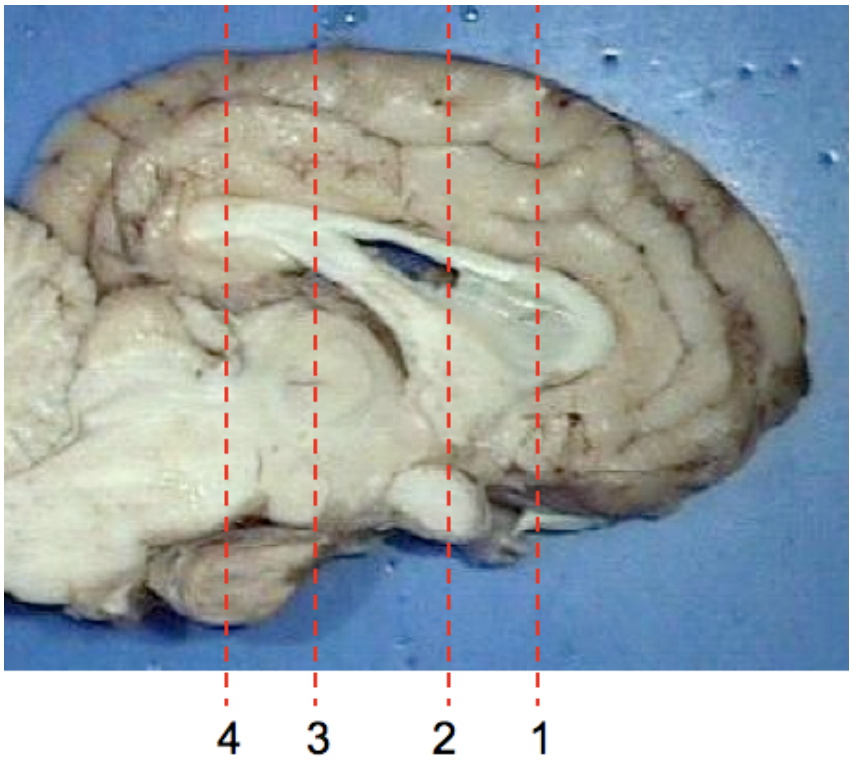


5. Cut along the longitudinal fissure through the corpus callosum and brainstem in one smooth motion (sawing back and forth will destroy the brain tissue)

6. Have the students identify structures on the medial surface of the brain: corpus callosum, thalamus, limbic lobe, cerebellum, pons, brainstem, optic chiasm and ventricles (lateral ventricle may be covered by septum pellucidum)

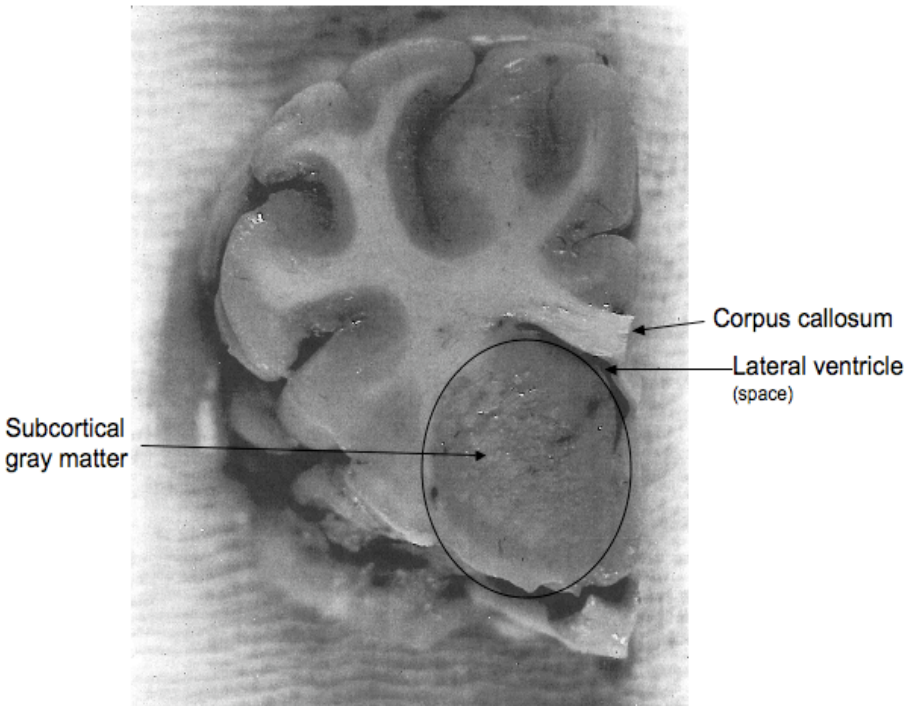


7. Take the left hemisphere and cut coronal sections as shown below

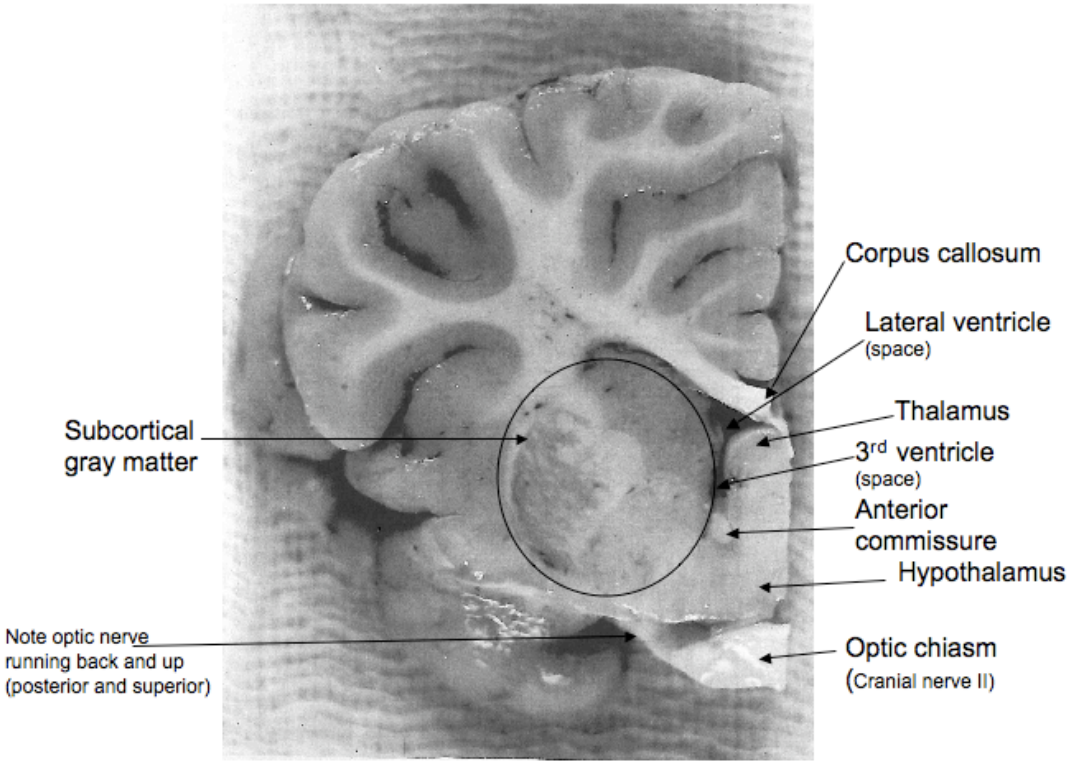


8. Have the students identify various structures in the coronal sections

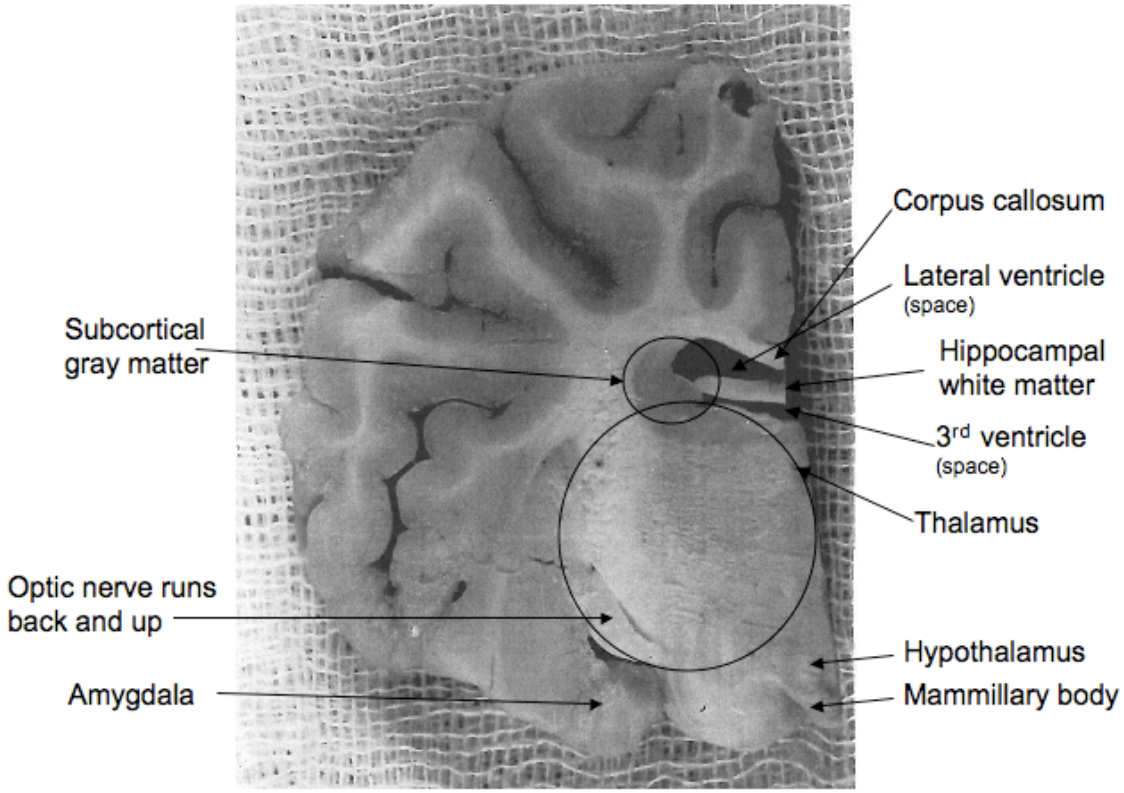
First coronal cut:
Note the contrast of gray matter and the white matter core; Note space between corpus callosum and subcortical structures (lateral ventricle)



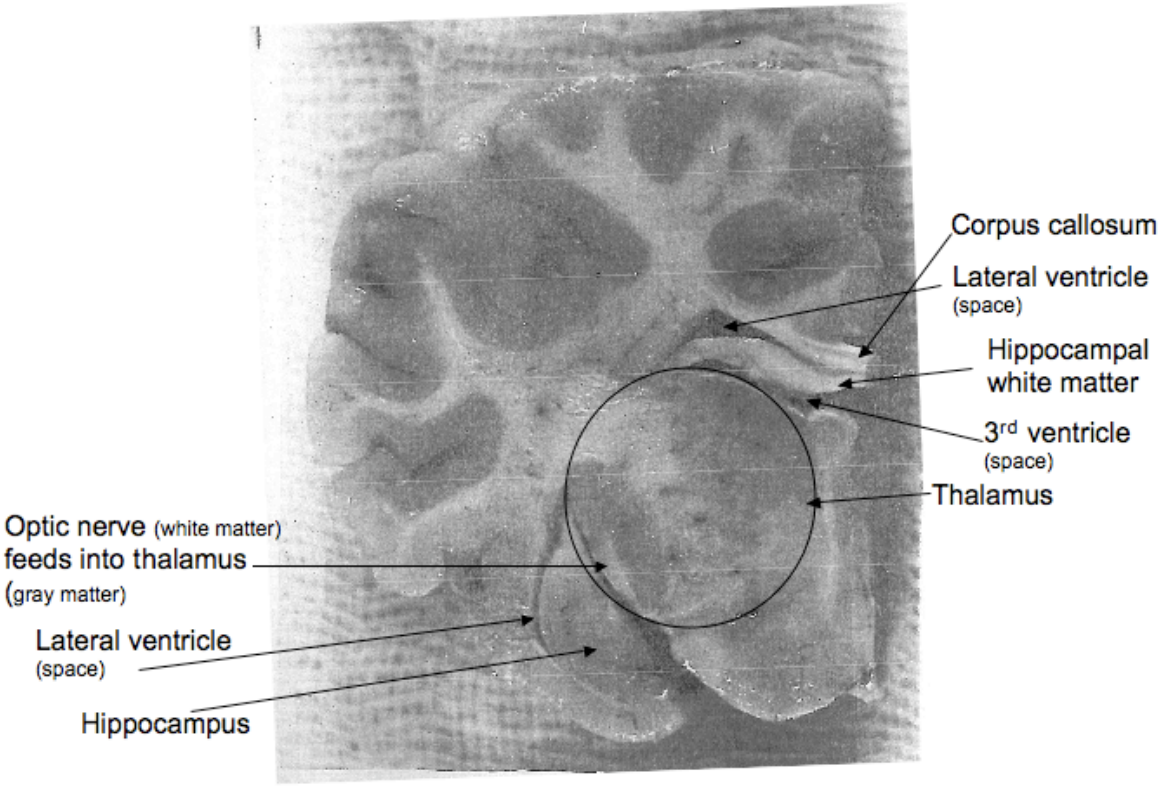
Second Coronal Cut



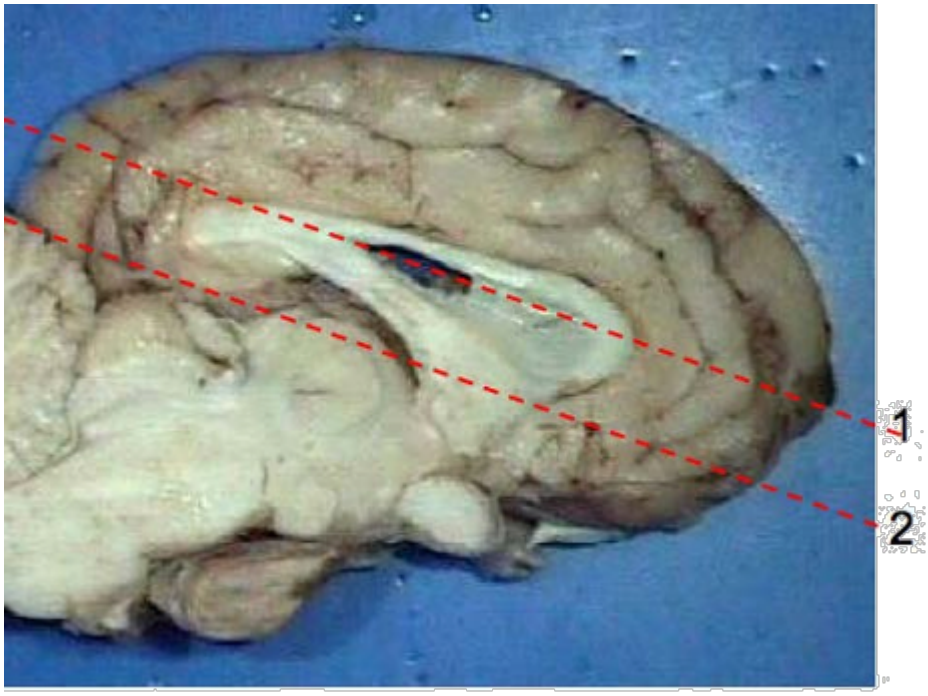
Third Coronal Cut



Fourth Coronal Cut

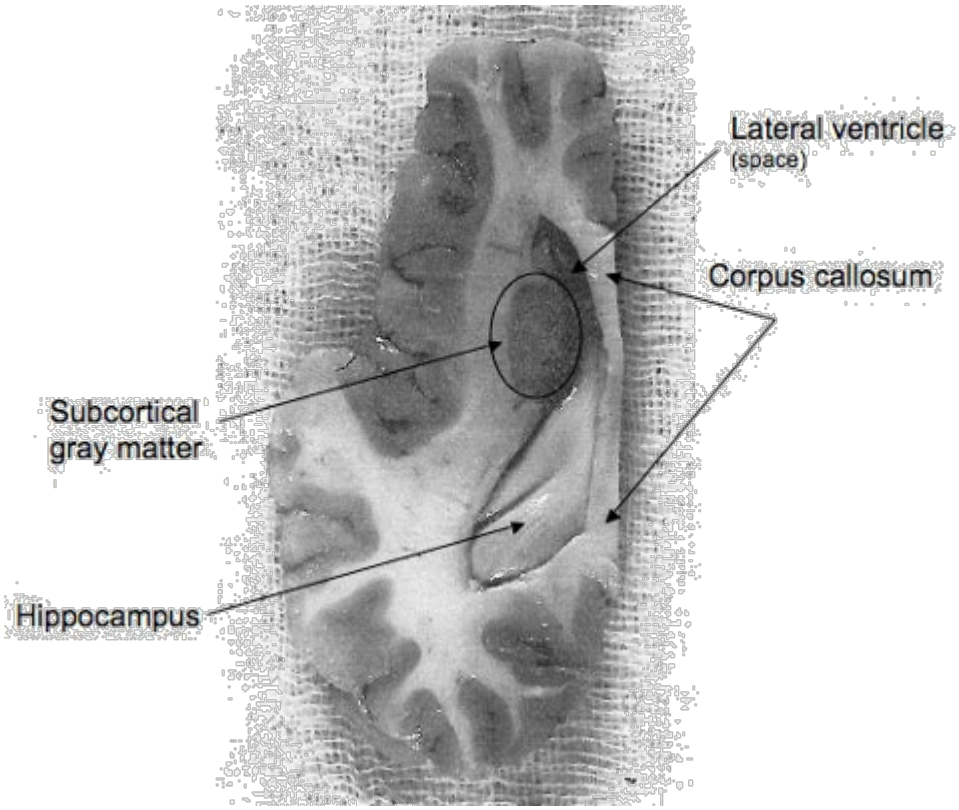


9. Now make horizontal cuts with the right hemisphere as shown below

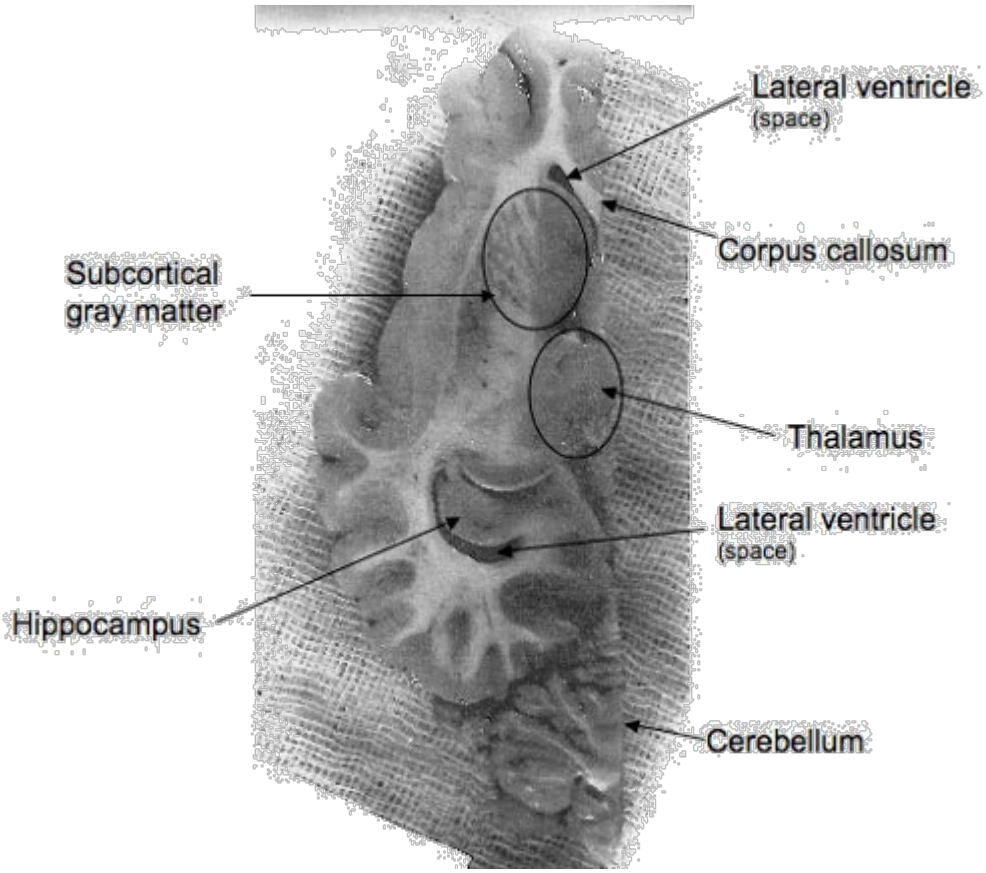


10. Have the students identify various structures in the horizontal sections:

First Horizontal Cut



Second Horizontal Cut



11. Finally, have the students trace the visual pathway through the brain starting with the optic nerve (optic nerve -> optic chiasm -> optic tract -> thalamus -> occipital lobe).

Questions

- Is there an advantage to having different discrete functional locations in the brain?
- What is the purpose of the sulci and gyri?
- If you are blind how do you think the visual cortex differs from a “seeing” person?
- In what ways do a human and sheep brains differ?
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- What is the benefit for having the two hemispheres separate and only connected by the corpus callosum?

Additional Resources

More information about sheep brain dissections:
http://portal.psy.uoguelph.ca/faculty/peters/labmanual/PrintSheepBrain.html
http://serendip.brynmawr.edu/hhmi/fridayslab/neuroanatomy.html

Human brain atlas:
https://www.msu.edu/~brains/brains/human/index.html

Scientific education supplies:
http://www.carolina.com/
https://www.wardsci.com/