Neuroanatomy Bootcamp 1

Lab 1

January 5, 2024 - Dr. Krebs (*claudia.krebs@ubc.ca*)

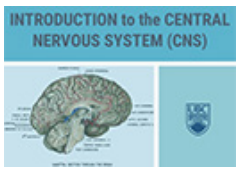
Objectives

1. Apply the anatomical planes of orientation as you look at the CNS specimens and cross-sectional imaging studies.
2. Describe the major surface markings of the forebrain and brainstem.
3. Identify major sulci and gyri on the surface of the brain.
4. Identify the five cerebral lobes and define their boundaries in general terms.
5. Describe the location/organization of the gray matter and the white matter in the CNS in general terms.
6. Relate the three meningeal layers and the spaces between them to common pathologies that can be found in these real and potential spaces.
7. Explain the organization of the ventricular system and the location of its component parts as well as the circulation of CSF.

Resources

Below are the e-tutorials, videos and web resources for this lab - click the green buttons to access them.

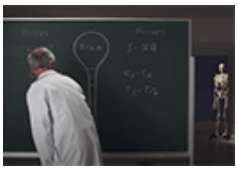
Intro to CNS (Module)



Meninges (Module)

Herniation (Module)

Intro to CNS (Video)



Web Syllabus & Links

*This icon located throughout the lab manual indicates **checklist items**!*

** NOTE: Interactive PDFs are best viewed on desktop/laptop computers - functionality is not reliable on mobile devices **

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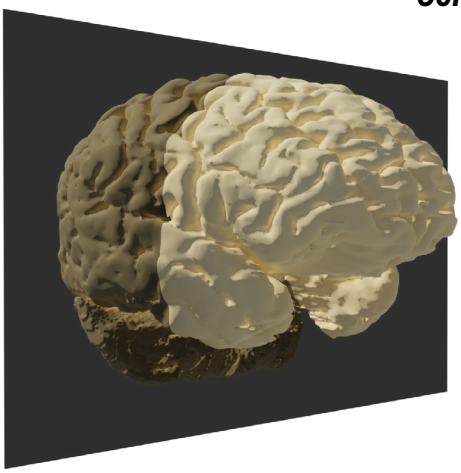
Orientation in the CNS

Planes of Orientation

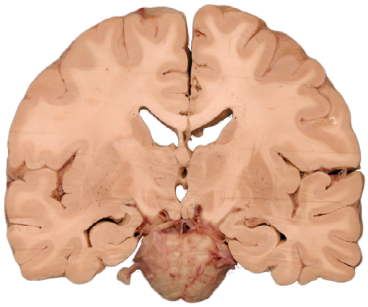
- Coronal
- Horizontal
- Sagittal

Directions

- Caudal - Rostral
- Dorsal - Ventral
- Superior - Inferior
- Anterior - Posterior

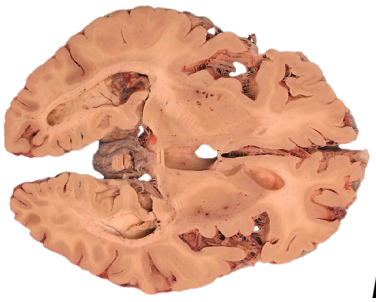


Coronal

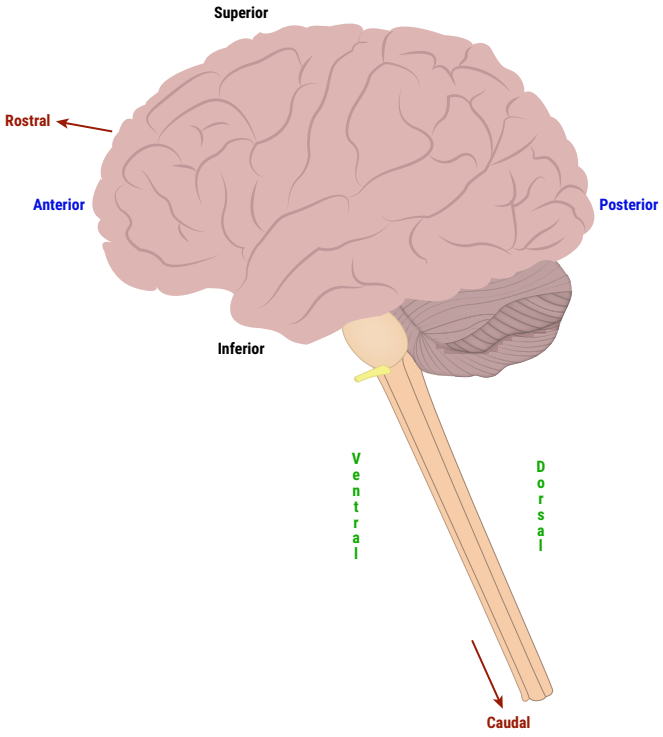


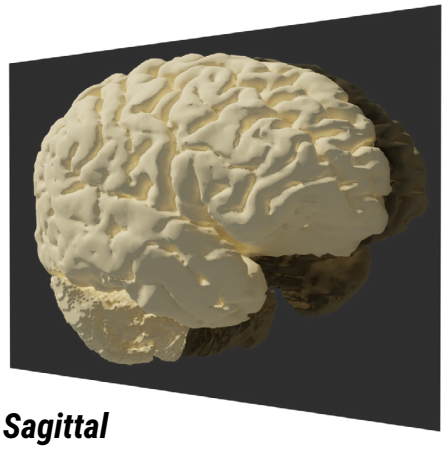
Coronal Sections (Web)

Horizontal Sections (Web)

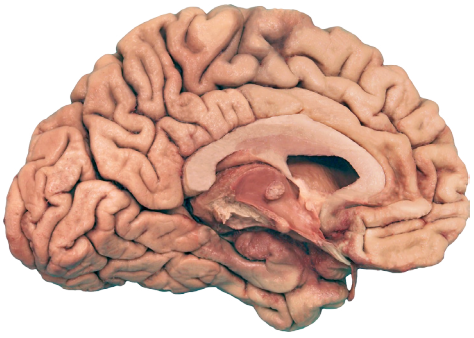


Horizontal





Sagittal



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Gross Anatomy of the CNS

Surface Anatomy

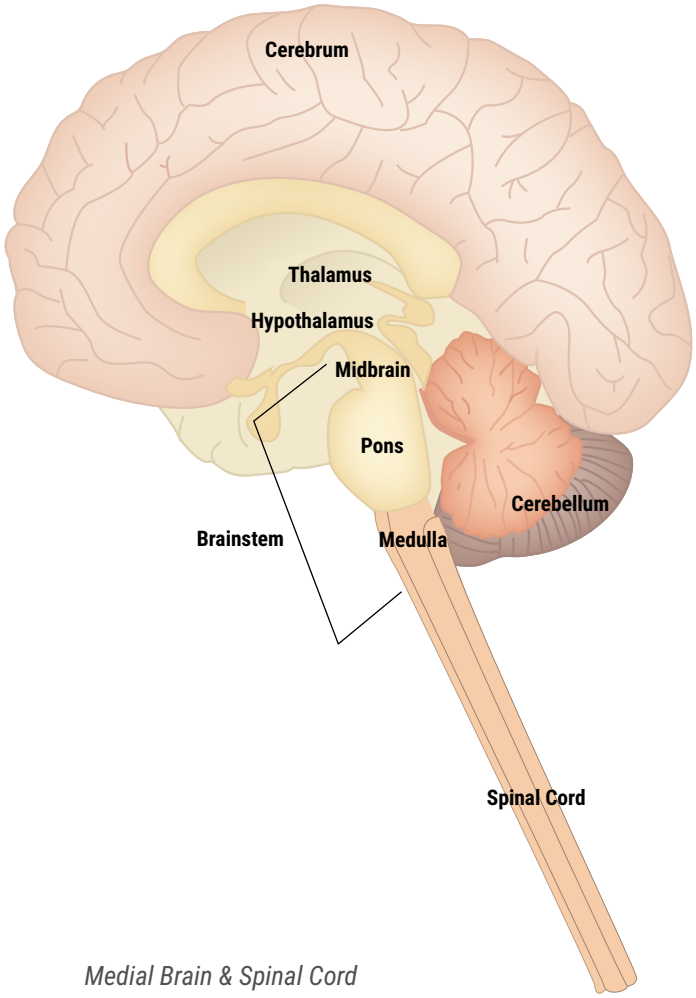
- Gyrus = ridge
- Sulcus = groove between ridges
- Fissure = deep sulcus ('fissure of Sylvius')

Brain

- Forebrain
  - Telencephalon
    - cerebrum
    - limbic structures
    - basal ganglia
  - Diencephalon
    - thalamus
    - hypothalamus
    - subthalamus

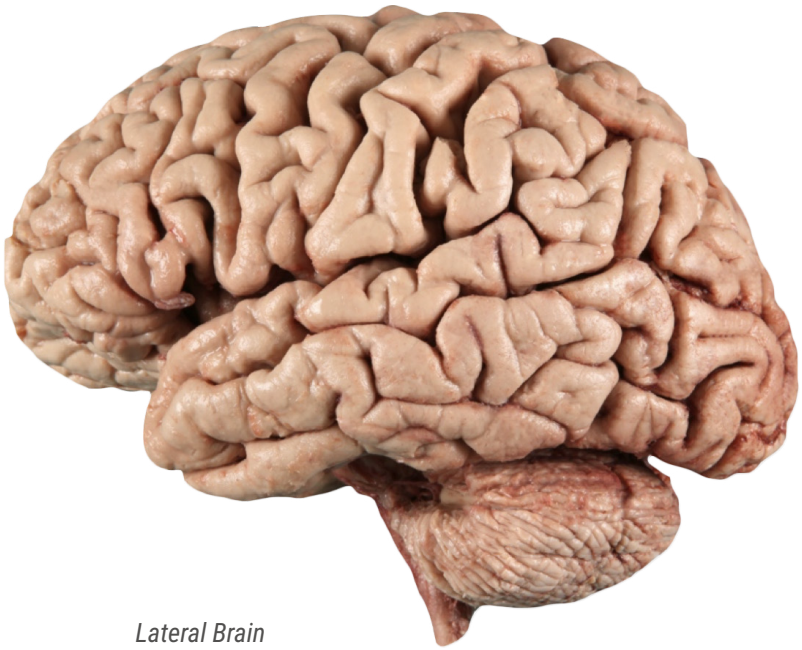
Whole Brain (3D)

Half Brain + Brainstem (3D)



Medial Brain & Spinal Cord

Superior Brain



Lateral Brain

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Spinal Cord

- Cervical
- Thoracic
- Lumbar
- Sacral

Brainstem

- Midbrain
- Medulla
- Pons

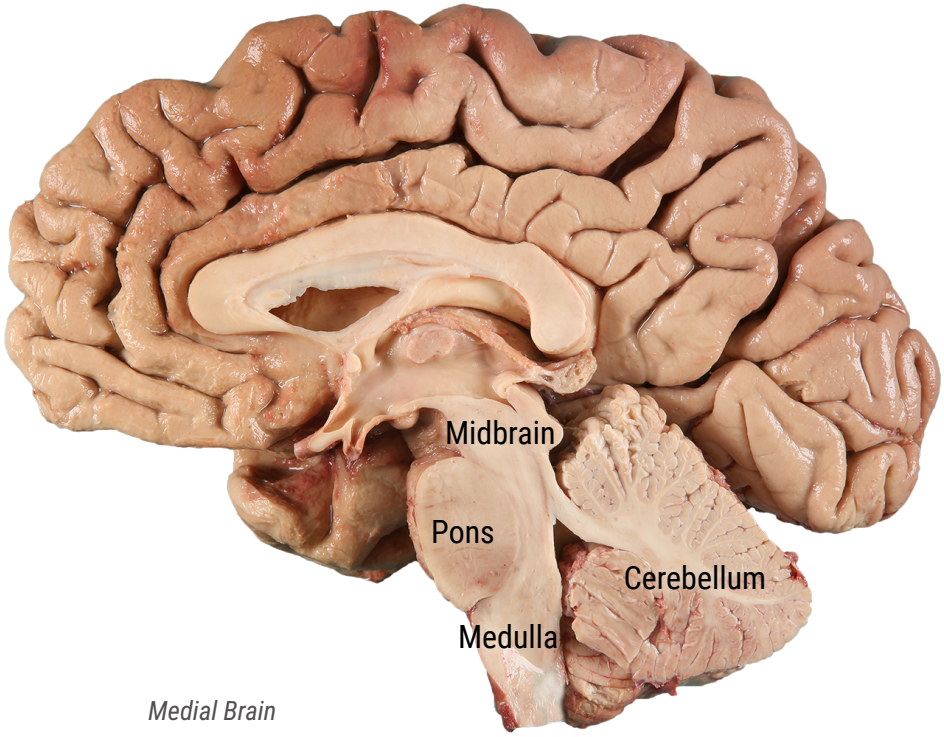
Cerebellum

Brainstem (3D)

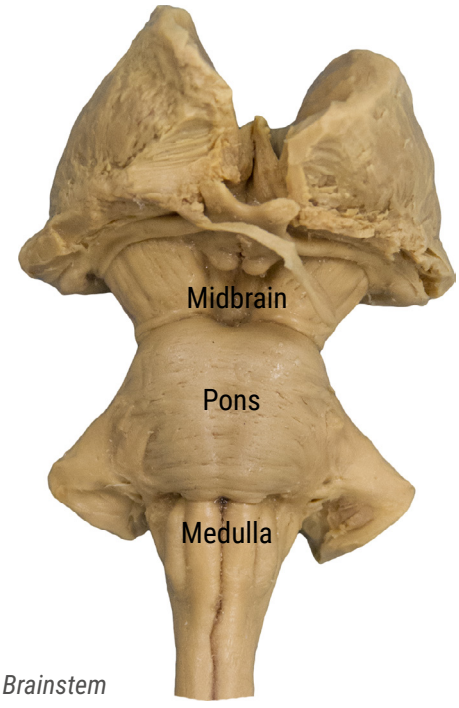
Cerebellum (3D)

Brainstem + Cerebellum (3D)

Spinal Cord in situ



Medial Brain



Anterior Brainstem

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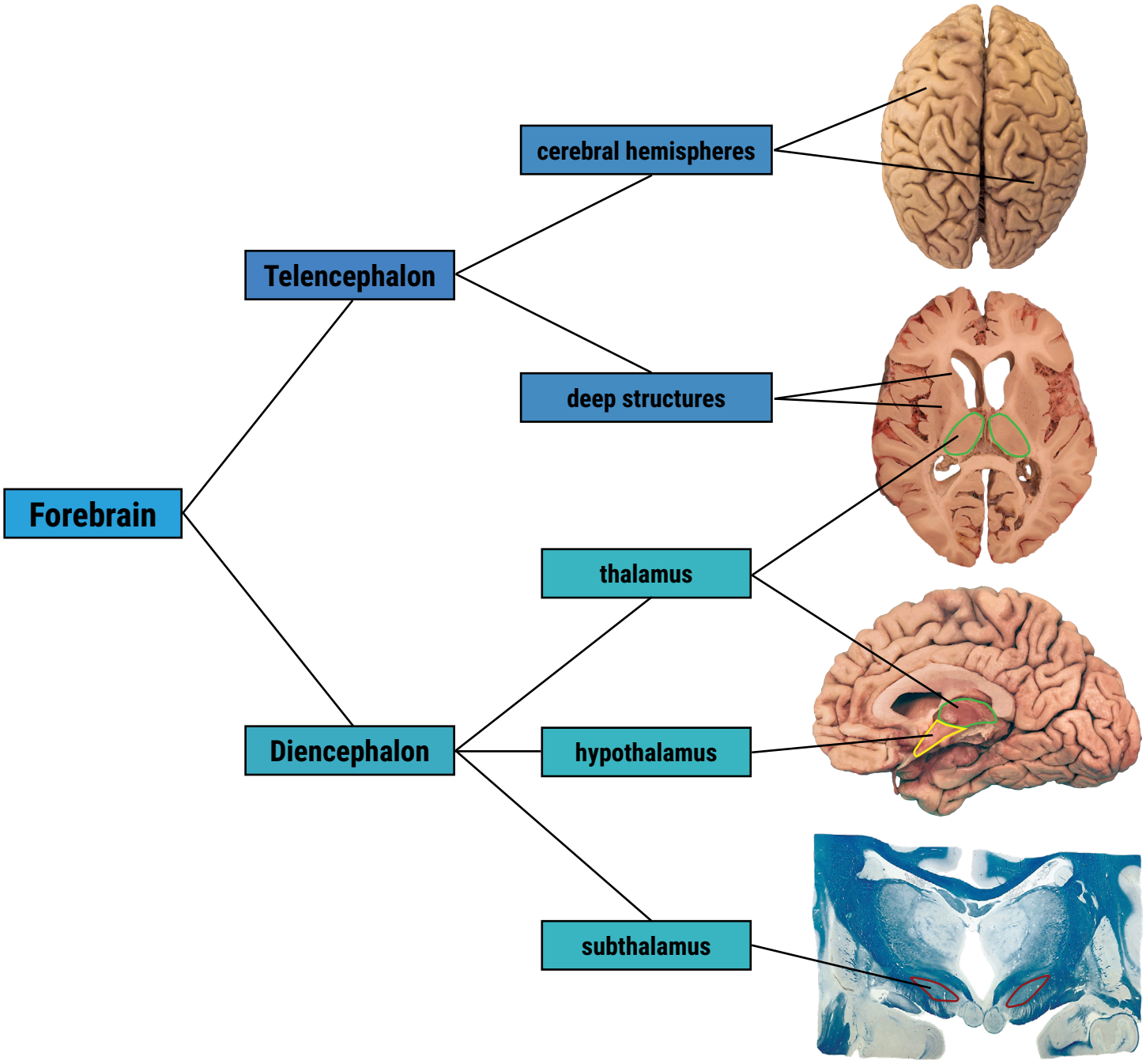
The Forebrain

The forebrain is comprised of the **telencephalon** and the **diencephalon**.
We will first examine the surface anatomy and then explore some of the deep structures.



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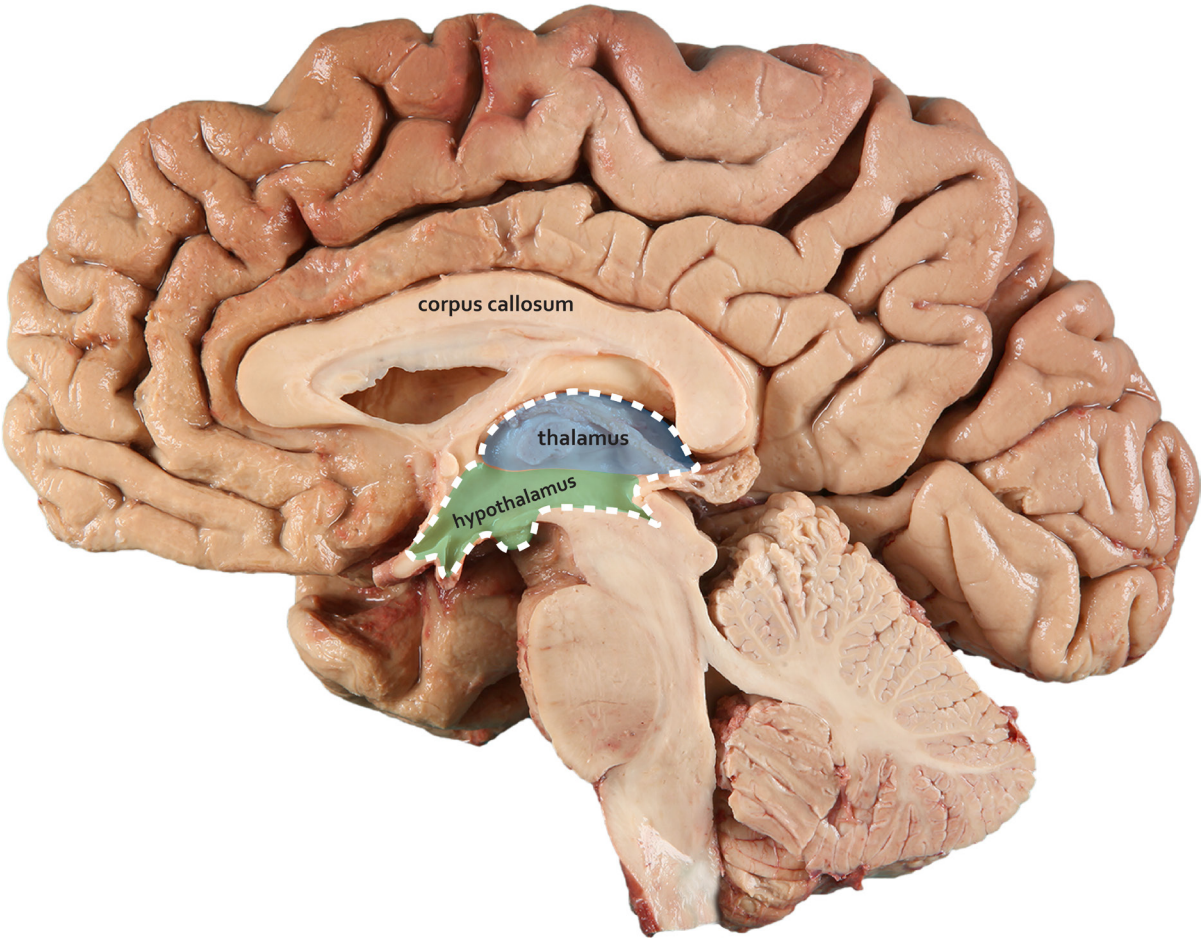

Diencephalon in Medial Brain

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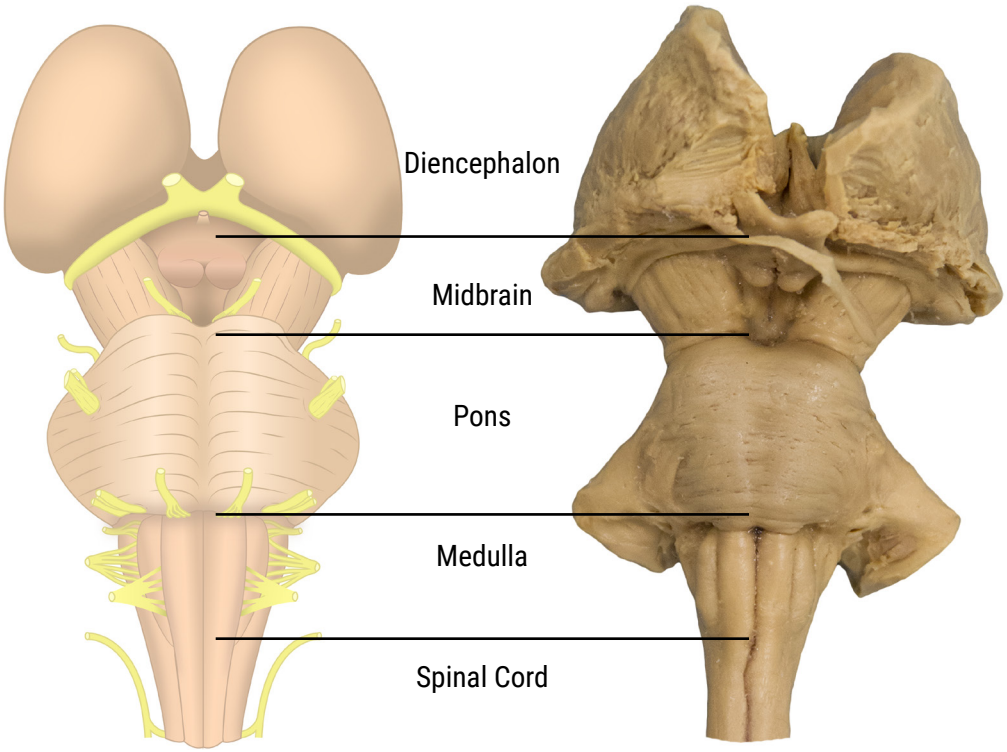
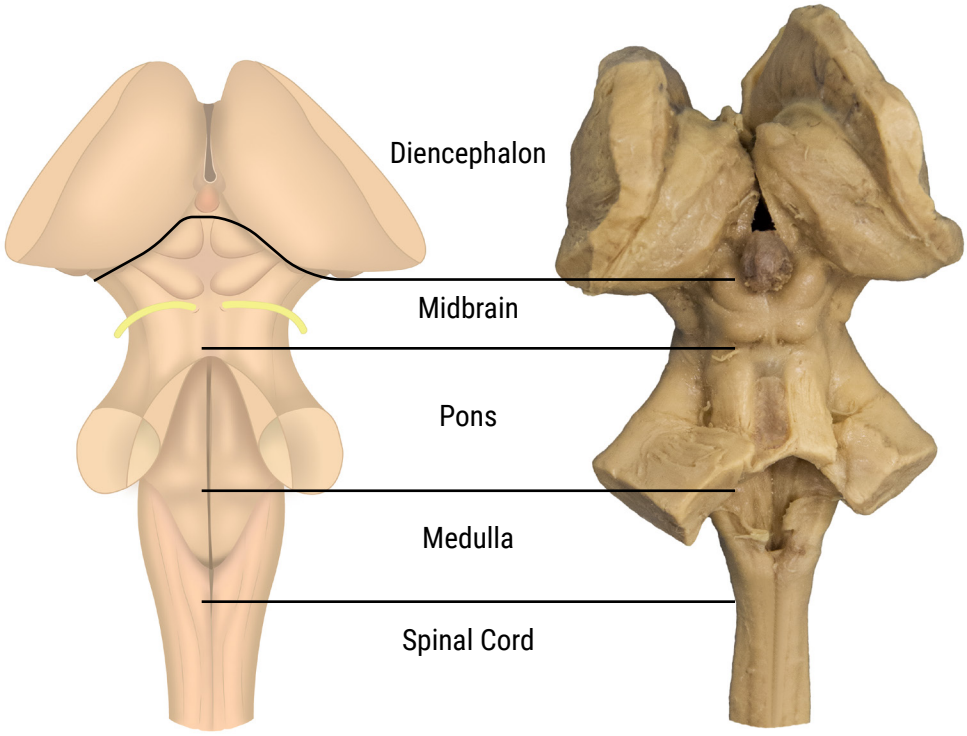
Brainstem

Identify the following:

- ◯ Midbrain
- ◯ Pons
- ◯ Medulla



Anterior Brainstem



Posterior Brainstem

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Surface Anatomy of the Forebrain

Identify the following structures of the brain:

a) Major Sulci & Gyri

- ◯ Longitudinal fissure
  - separates the 2 cerebral hemispheres
- ◯ Central sulcus
  - separates frontal and parietal lobes
- ◯ Lateral fissure
  - separates frontal and parietal lobes from temporal lobe
- ◯ Parieto-occipital sulcus
  - on medial surface, separates occipital lobe from parietal / temporal lobes
- ◯ Calcarine fissure
  - on medial surface in occipital lobe
- ◯ Precentral gyrus
  - anterior to central sulcus
  - primary motor area
- ◯ Postcentral gyrus
  - posterior to central sulcus
  - primary somatosensory area

General approach to surface anatomy of the brain:

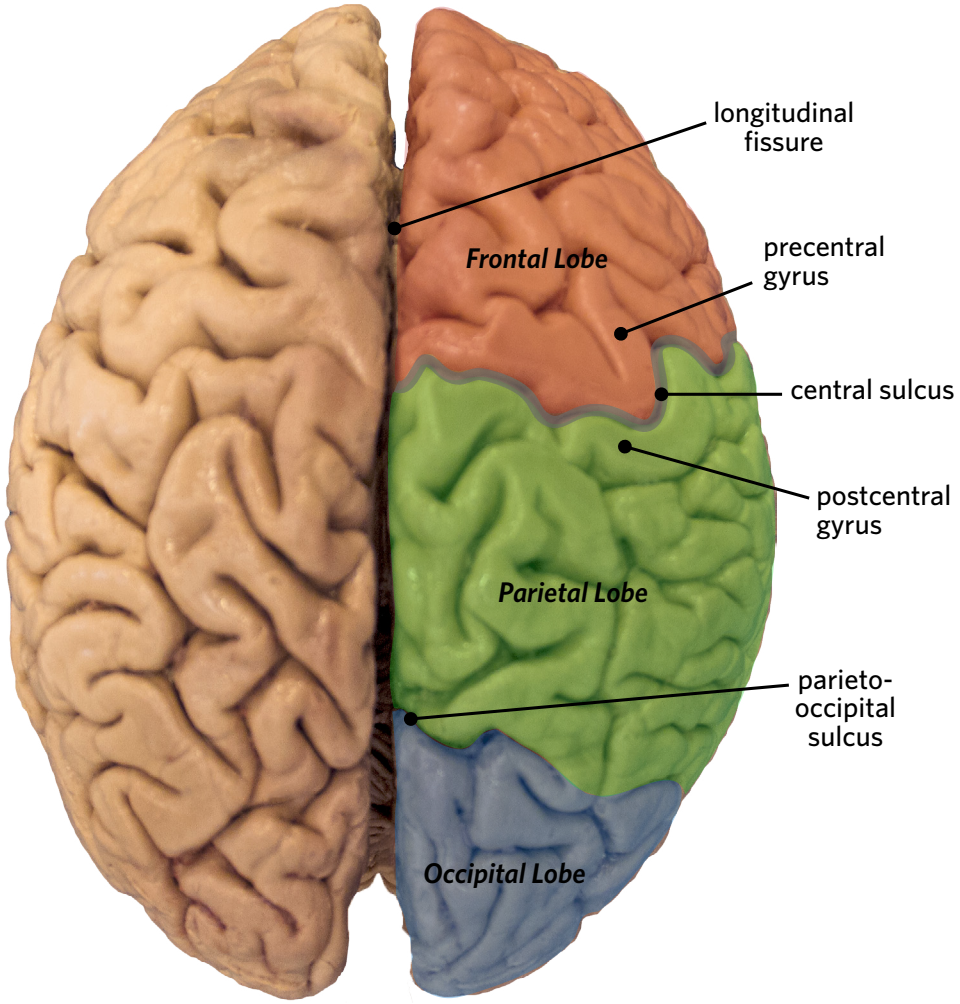
- Look for the major sulci first (eg. central sulcus)
- Define gyri based on these landmarks

b) Lobes

- ◯ Frontal
- ◯ Parietal
- ◯ Occipital
- ◯ Temporal
- ◯ Limbic

Hide Labels

Superior/Dorsal Cortex



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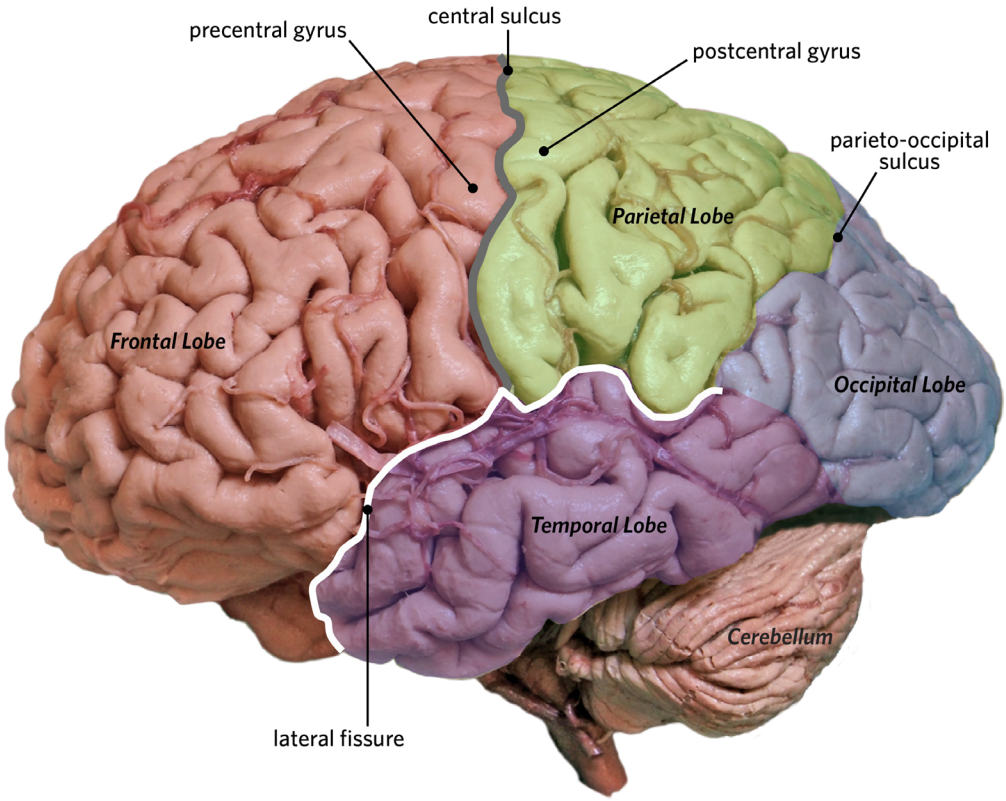
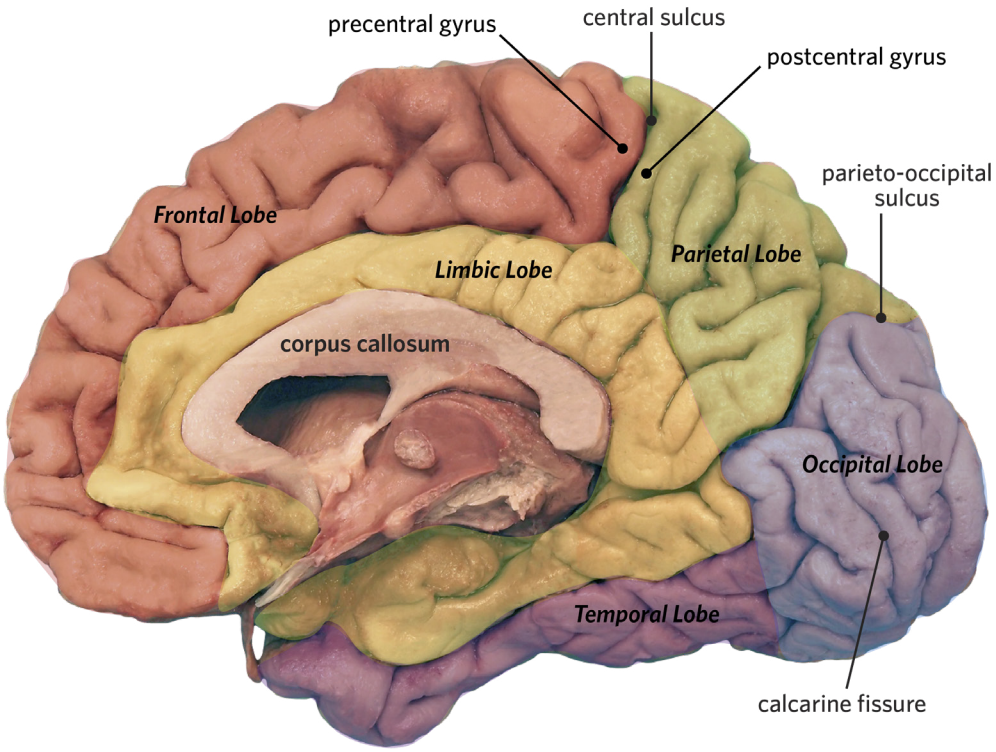
Lateral Cortex





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Medial Cortex

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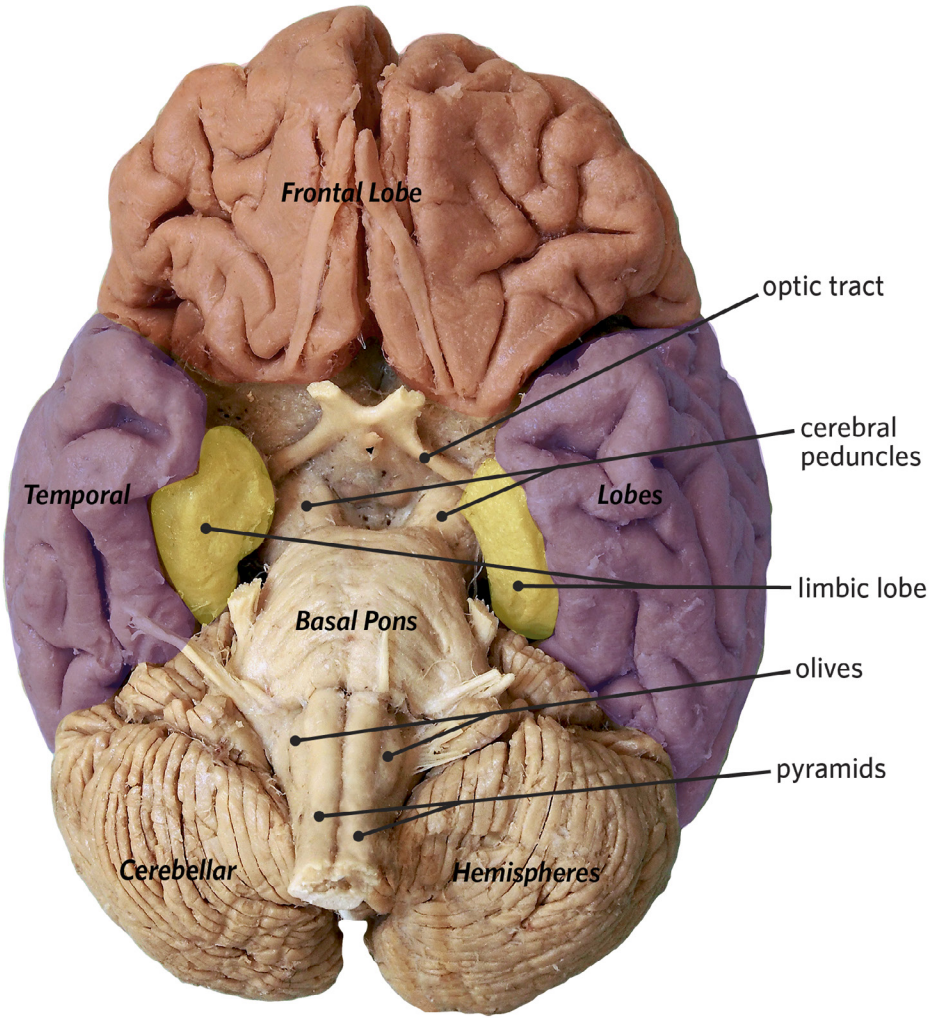

Inferior/Ventral Cortex

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Gray Matter vs. White Matter

Gray Matter:

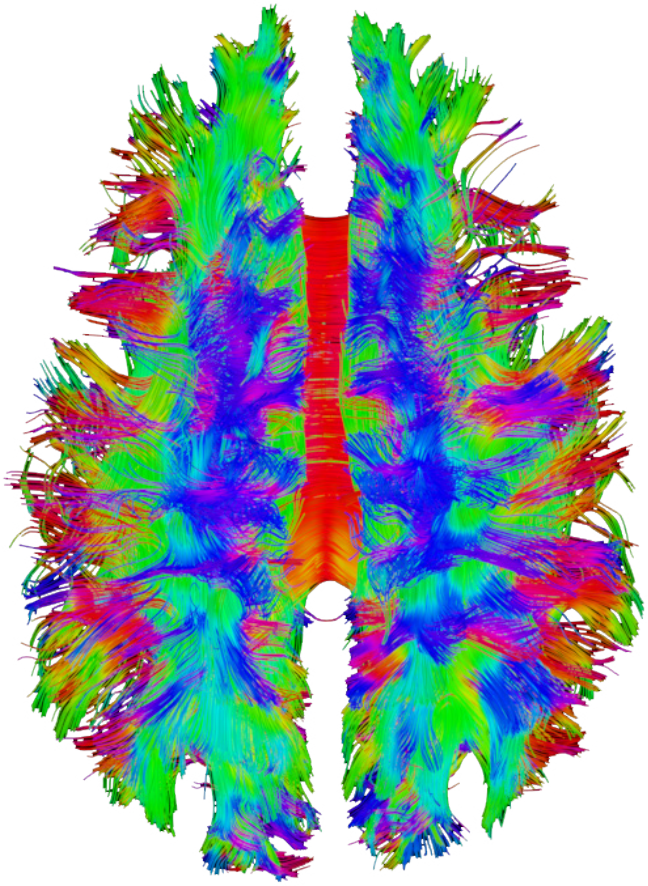
- where the nerve cell bodies reside
  - cortical layer
  - deep nuclei

White Matter:

- where the fiber tracts (axons) reside
  - connect different parts of the CNS
  - run in all directions and intermingle with each other
  - most fibers are myelinated

There are 3 types of fibers in the brain:

- **Association fibers**
- **Commissural fibers**
- **Projection fibers**

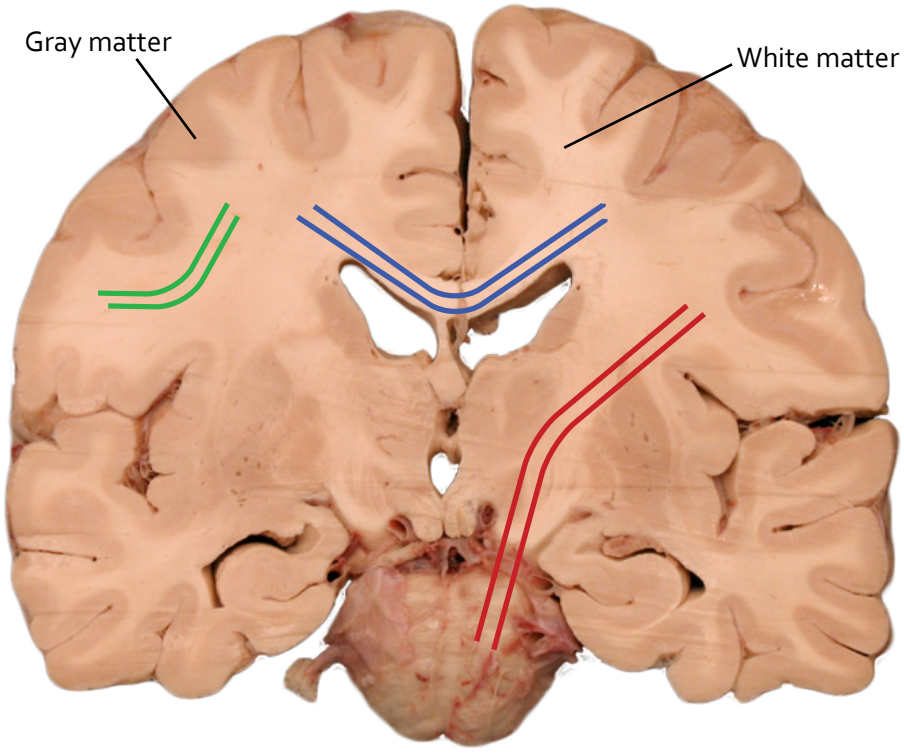


3D Rendering of Fiber Tracts in the Brain

Association fibers
are confined to the same hemisphere. Short association fibers connect cortical areas in adjacent gyri; long association fibers pass between cortical areas that are further removed from each other.

Commissural fibers
originate from cell bodies in the cortex of one hemisphere, cross the midline, and synapse with neurons in corresponding areas of cortex of the other hemisphere. The largest bundle of commissural fibers is the corpus callosum.

Projection fibers
project to and from the cortex.



Coronal Brain Section

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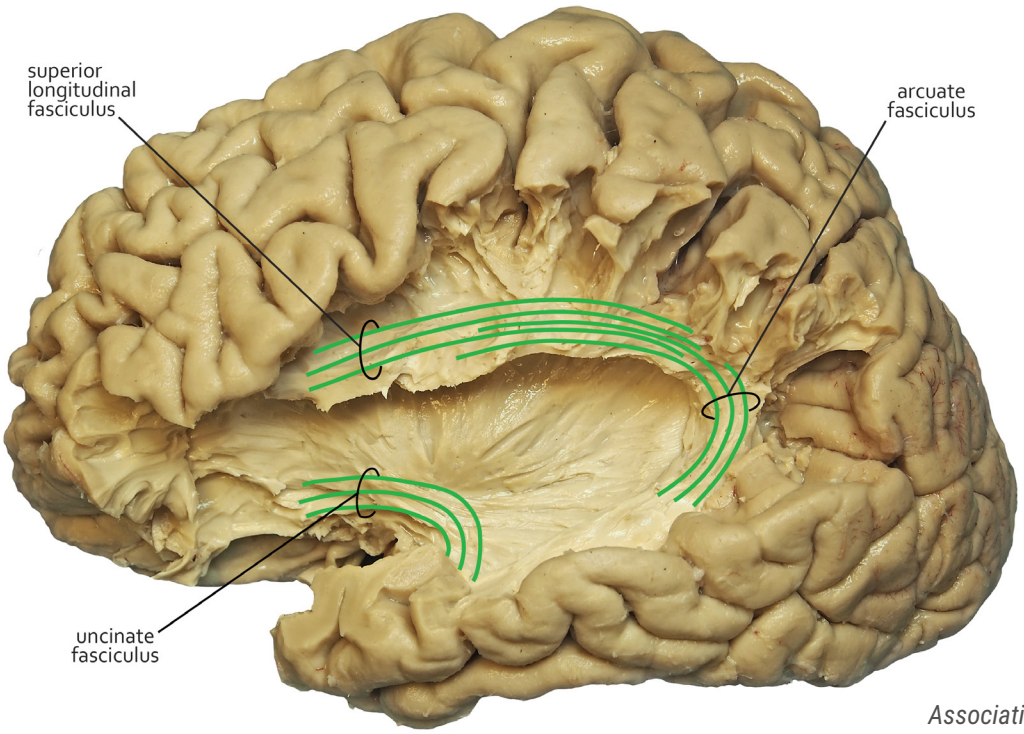


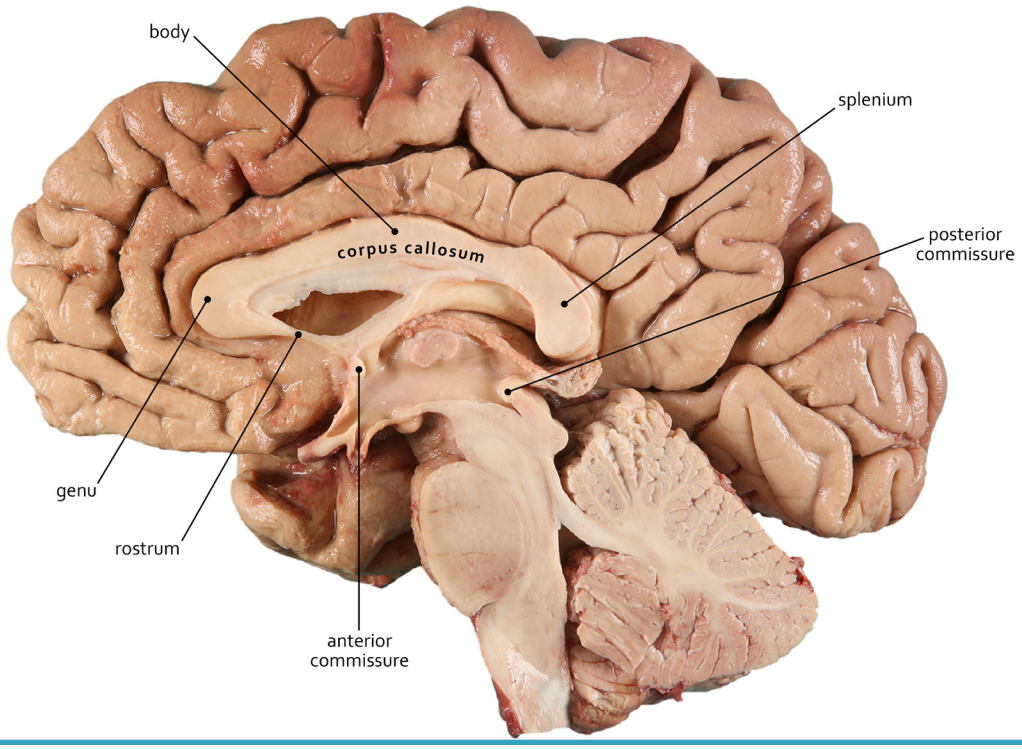
Association Fibers in Lateral Brain Dissection

Identify on brain specimens:

- ○ Cortical layer
  - on coronal and/or horizontal sections
- ○ Deep nuclei
  - find areas of gray matter deep in the forebrain
- ○ Corpus callosum
  - identify on half brains, coronal and horizontal sections
- ○ Internal capsule
  - major bundle of projection fibers

Coronal Sections (Web)

Horizontal Sections (Web)



Medial Brain

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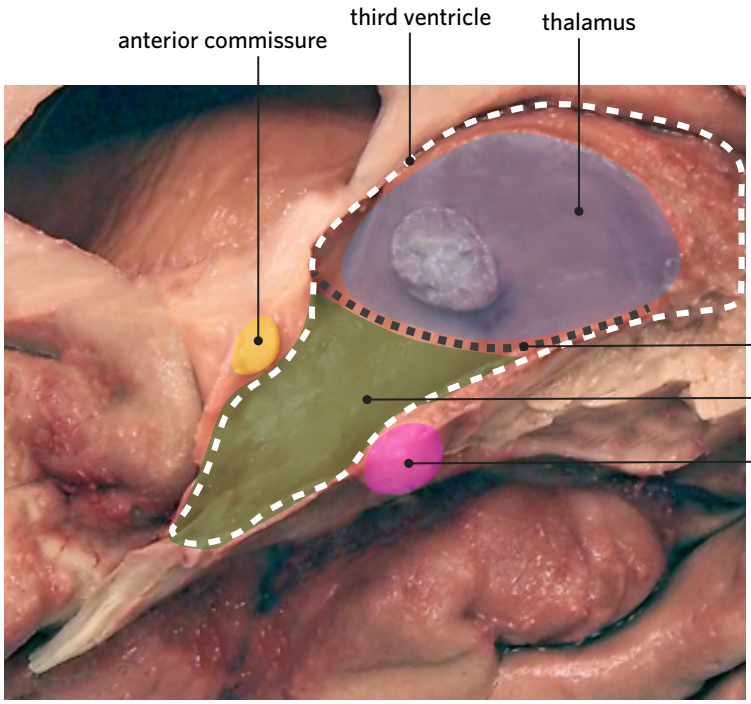
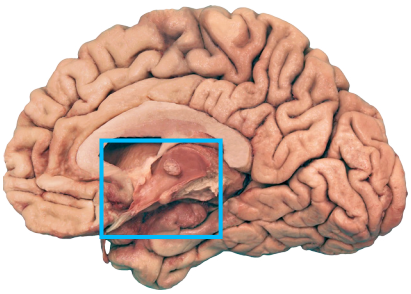
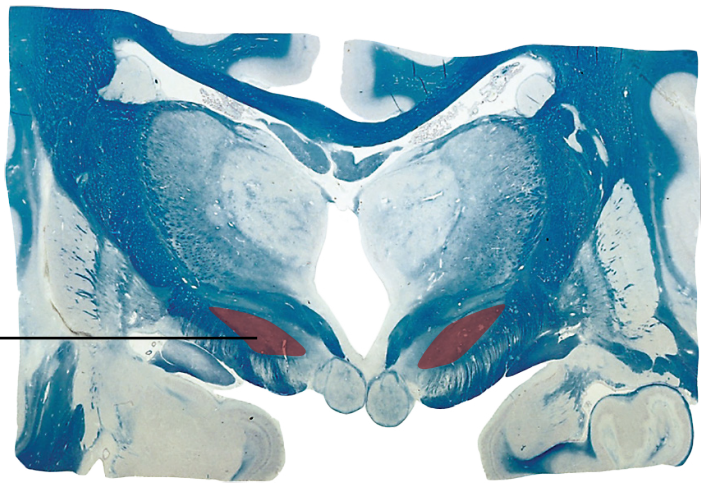
Deep Structures of the Forebrain

Diencephalon *(everything with 'thalamus' in the name)*

- **Thalamus**
  - gatekeeper to the cerebral cortex
  - 2 thalami, egg-shaped masses of gray matter that border the 3rd ventricle
- **Hypothalamus**
  - located under the thalamus
  - involved in control of autonomic and endocrine function
  - influences emotional and motivational aspects of behaviour
- **Subthalamus**
  - located inferior and lateral to the thalamus
  - involved in modulation of voluntary motor activity







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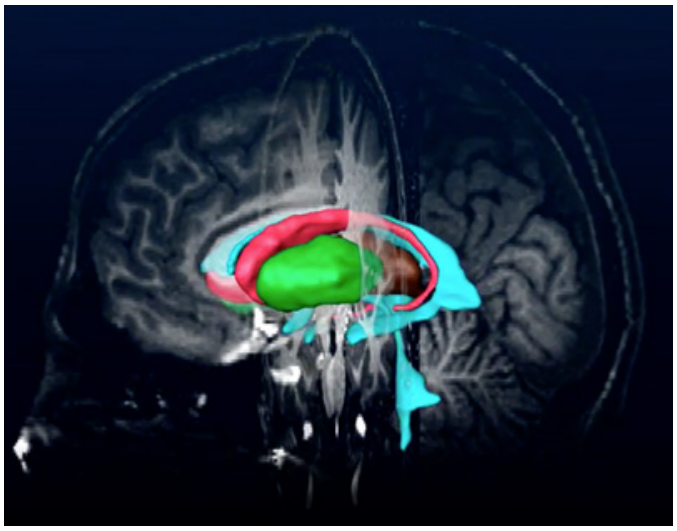
Basal Ganglia

- gray matter deep within the cerebral hemispheres
- involved in modulation of voluntary motor activity

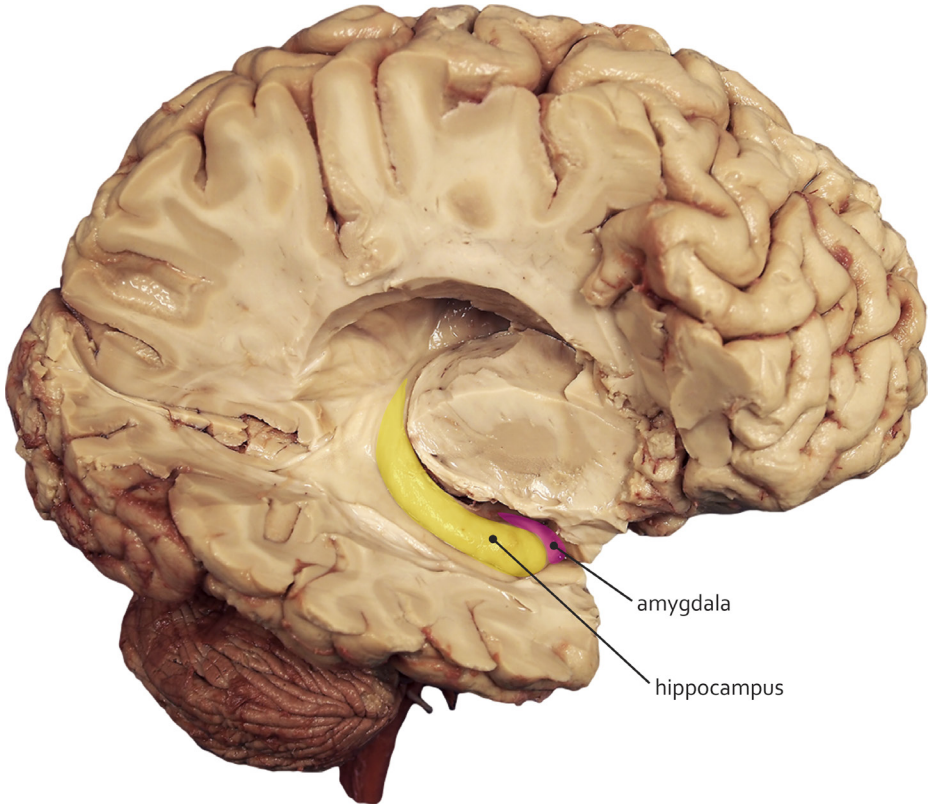


Basal Ganglia (3D)

- Thalami & Basal Ganglia - Basal Ganglia tab

Limbic Structures

- ◯ hippocampus
- ◯ amygdala



Identify the following:

On a half brain:

- ◯ thalamus
- ◯ interthalamic adhesion
- ◯ hypothalamus

On coronal & horizontal sections:

- ◯ thalamus
- ◯ deep nuclei of forebrain (as a gray matter structure)

Note:
Do not try to memorize the nuclei of the basal ganglia in this lab. It is important to understand that deep nuclei exist within the forebrain and are connected to neurons in the cortex - details will be discussed in upcoming labs.

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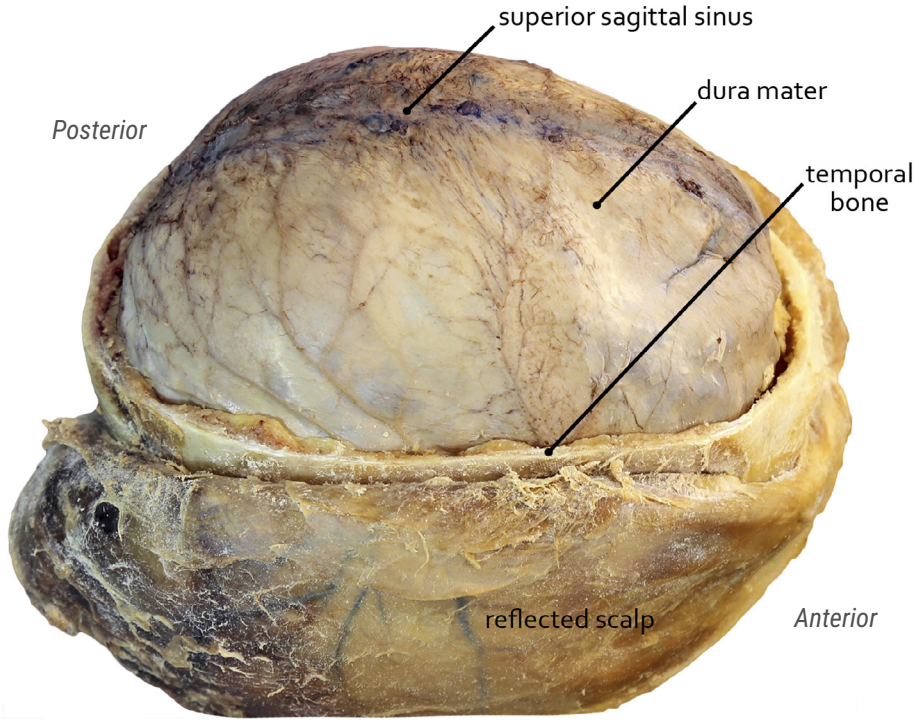
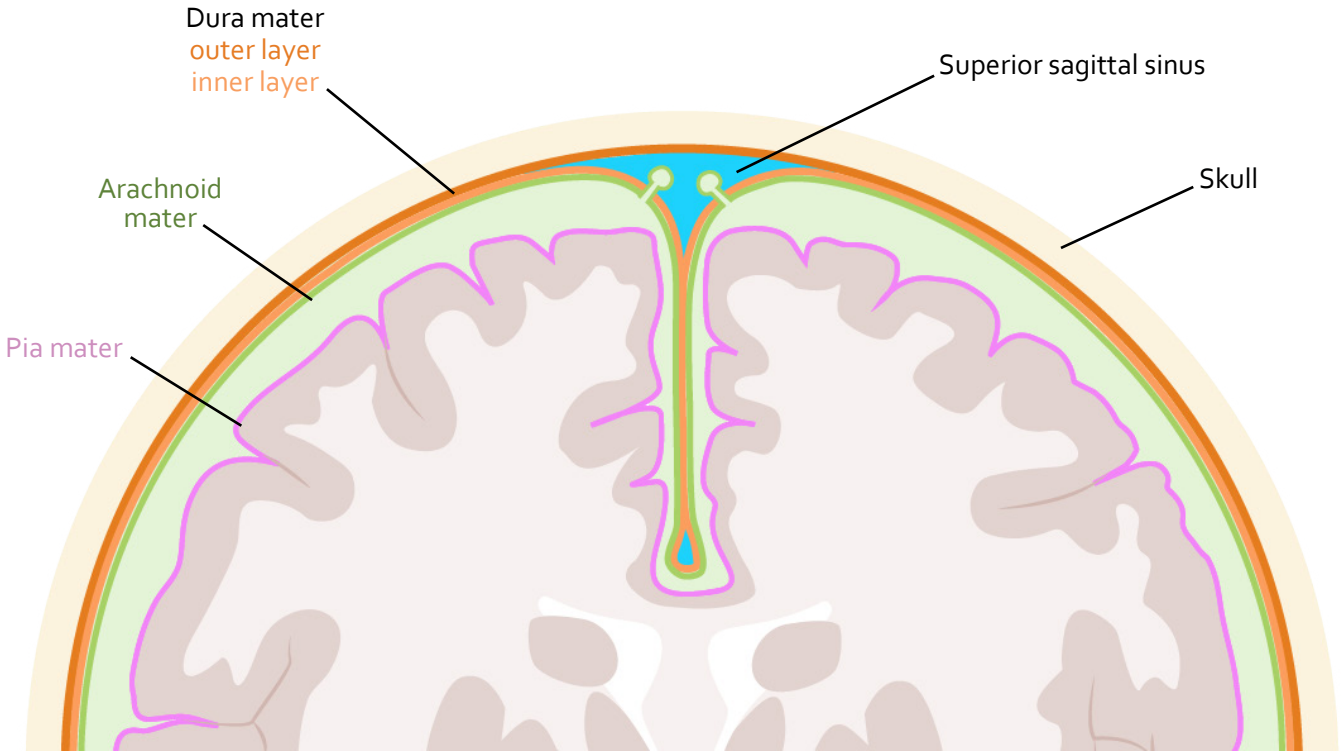
Cerebral Meninges

1. **Dura mater (2 layers)**
   - *Outer*: serves as periosteum of inner surface of skull
   - *Inner*: the meningeal dura
2. **Arachnoid mater**
   - thinner middle layer, lines the dura, bridges over sulci
   - in life, the subarachnoid space contains cerebrospinal fluid
3. **Pia mater**
   - thin, delicate innermost layer
   - adheres tightly to surface of brain, following all gyri and sulci

Note:
This is review from Gross Anatomy!



Lateral Brain With Dura Mater
B. Kathleen Alsup & Glenn M. Fox, University of Michigan Medical School, BlueLink



Meninges Schematic, Coronal Section

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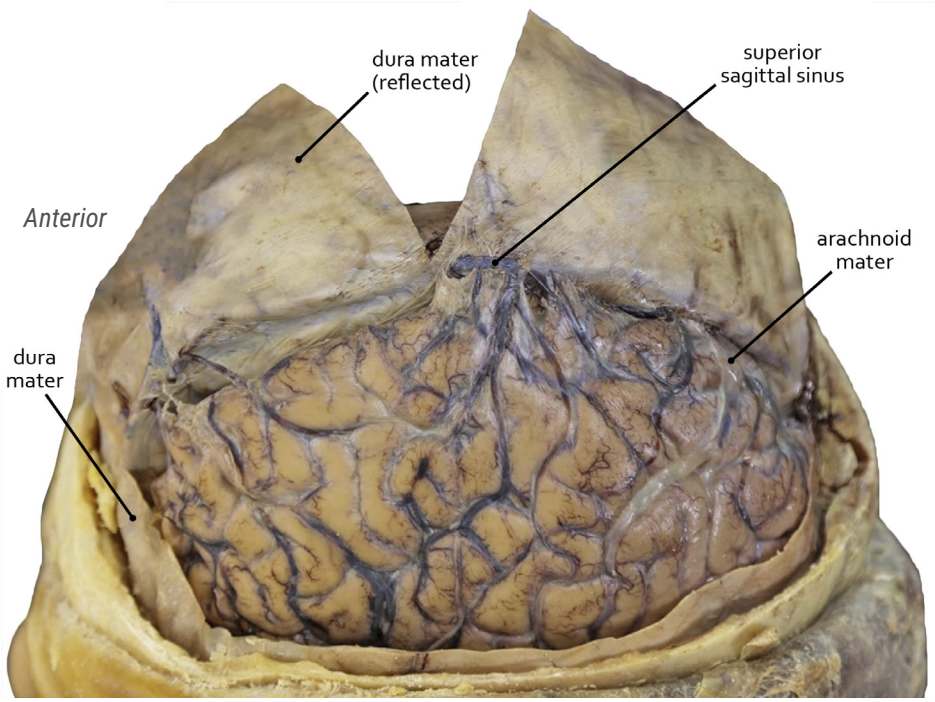

Supero-Lateral Brain
B. Kathleen Alsup & Glenn M. Fox,
University of Michigan Medical School,
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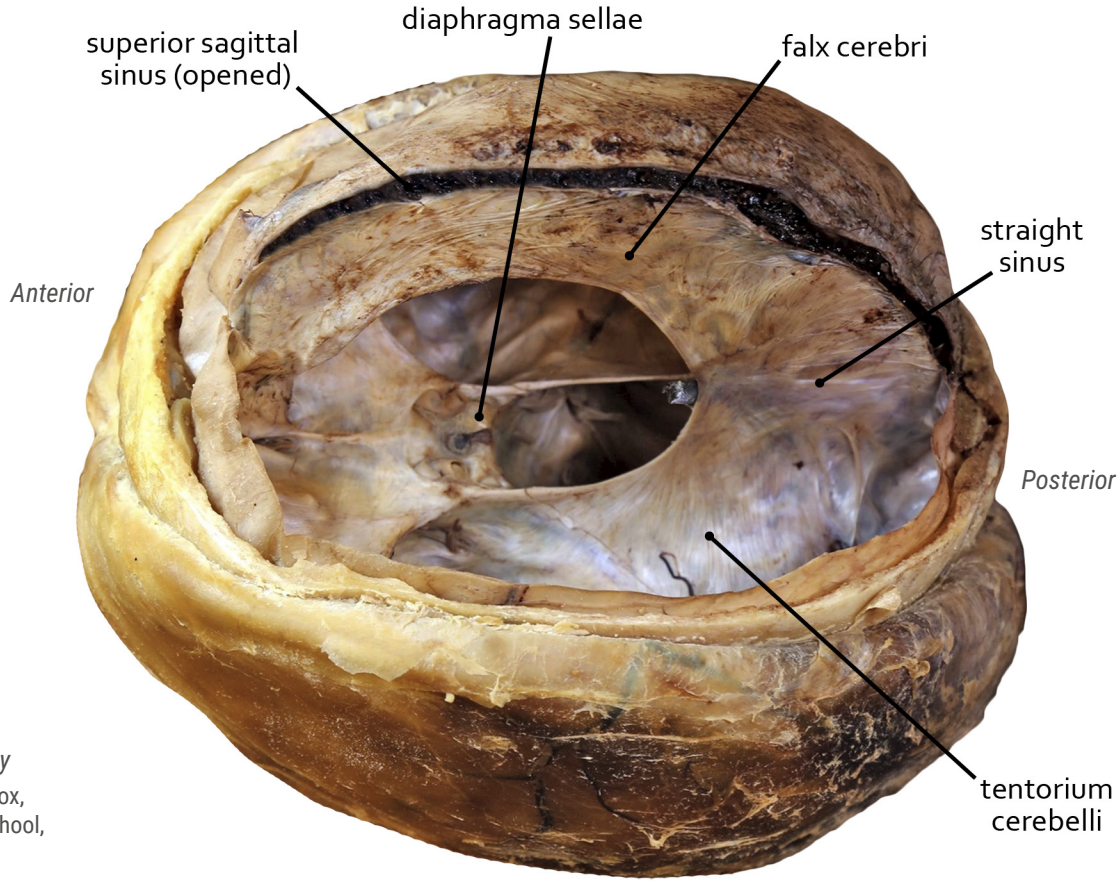
Reflections of the Dura

- **Falx cerebri**
- **Falx cerebelli**
- **Tentorium cerebelli**
- **Diaphragma sellae**



Supero-Lateral Cranial Cavity
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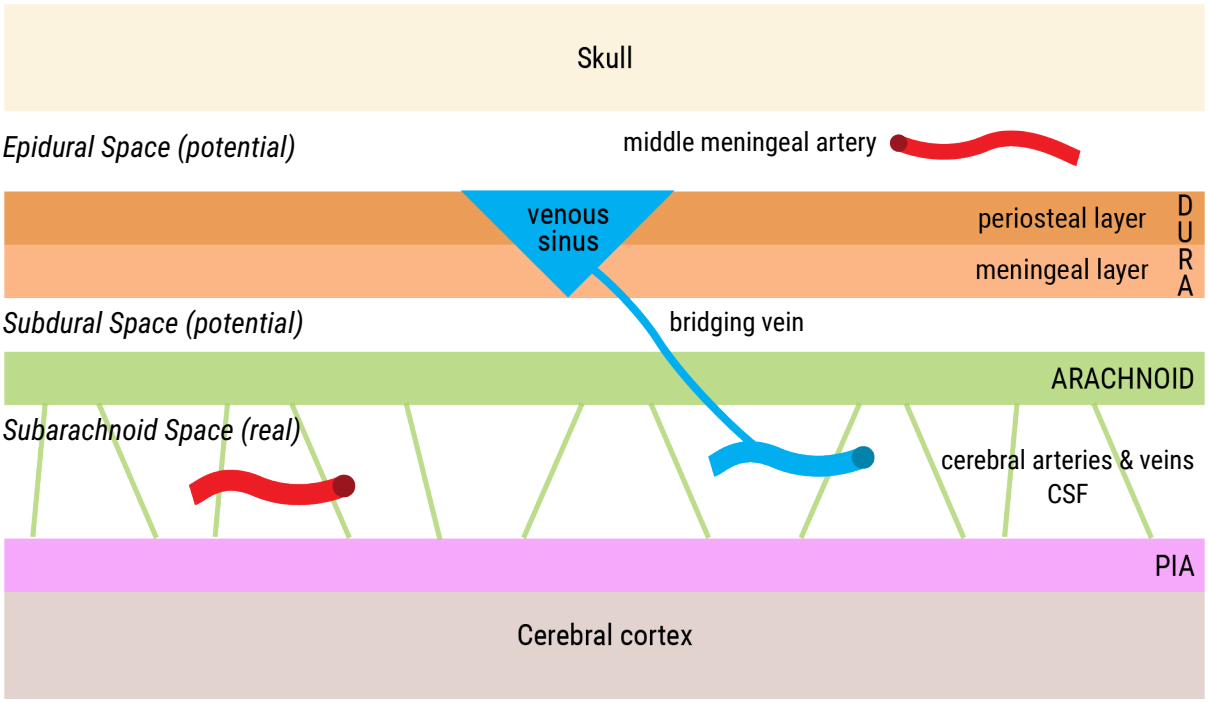
Hemi-heads Showing Dural Reflections

Meningeal Spaces (between the meningeal layers)

- **Epidural/Extradural space**
- **Subdural space**
- **Subarachnoid space**

> ***Note:***
> This is review from Gross Anatomy!



Epidural hematoma after traumatic injury to the head with a skull fracture to the middle meningeal artery, pressure of the arterial bleed separates the dura from the periosteum

Subdural hematoma when violent shaking of the head severs the veins connecting to the dural sinuses (shaken baby syndrome)

Subarachnoid hemorrhage in a hemorrhagic stroke or bleeding of an arterial aneurysm

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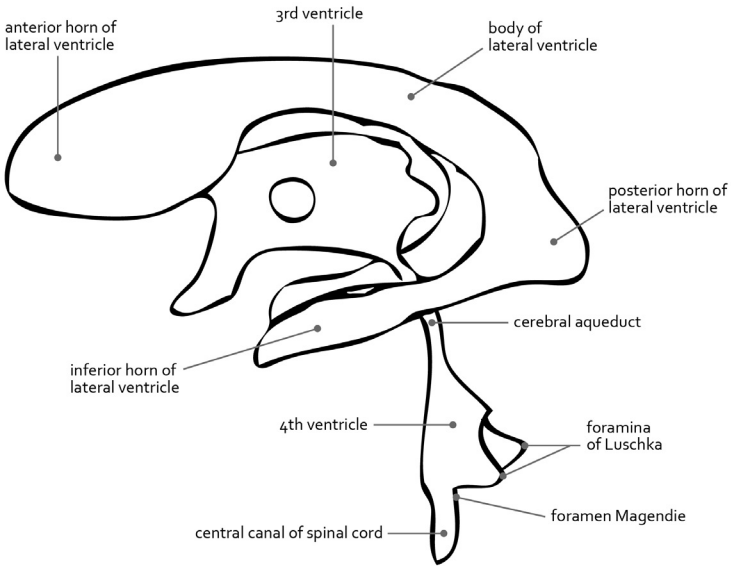
Ventricular System and Cerebrospinal Fluid (CSF)

- The **ventricles** are cavities within the CNS.
- **Cerebrospinal fluid** (CSF) is produced by the choroid plexus and circulates within the ventricles.
- The **cerebral aqueduct** connects the 3rd and 4th ventricles.
- 4th ventricle is continuous with the **central canal** of the spinal cord.
- One midline (Magendie) and two lateral (Luschka) foramina allow CSF to flow into the subarachnoid space.

Identify the following using ventricle models and brain dissections:

Ventricles (3D)

- ◯ Lateral ventricles (one in each cerebral hemisphere)
  - ◯ Body
  - ◯ Anterior horn
  - ◯ Posterior horn
  - ◯ Inferior horn
- ◯ 3rd ventricle (midline cavity between halves of the diencephalon)
- ◯ Interventricular foramen (foramen of Monro - connects each lateral ventricle with the 3rd ventricle)
- ◯ 4th ventricle (in the pons and medulla)



Sagittal View of Ventricles

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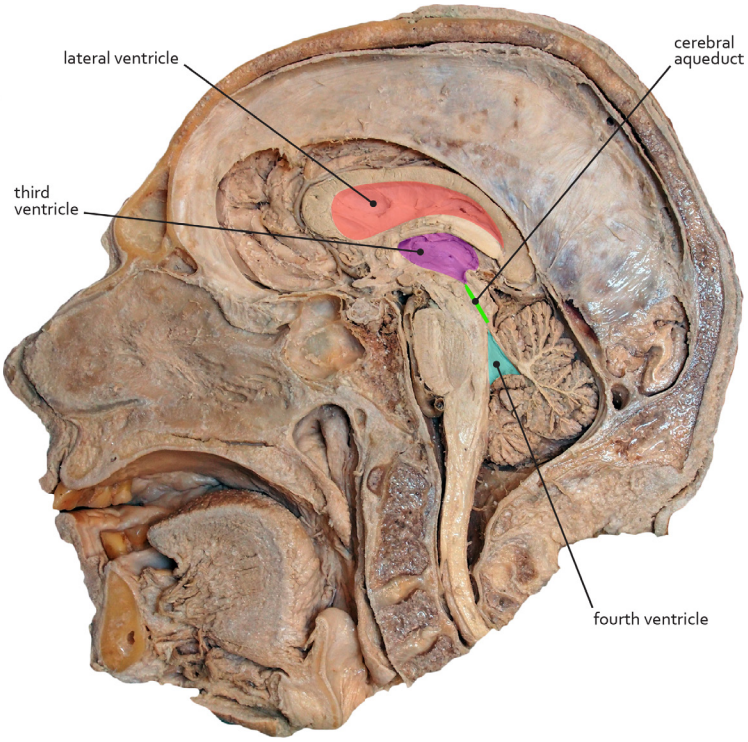

Sagittal Hemi-head

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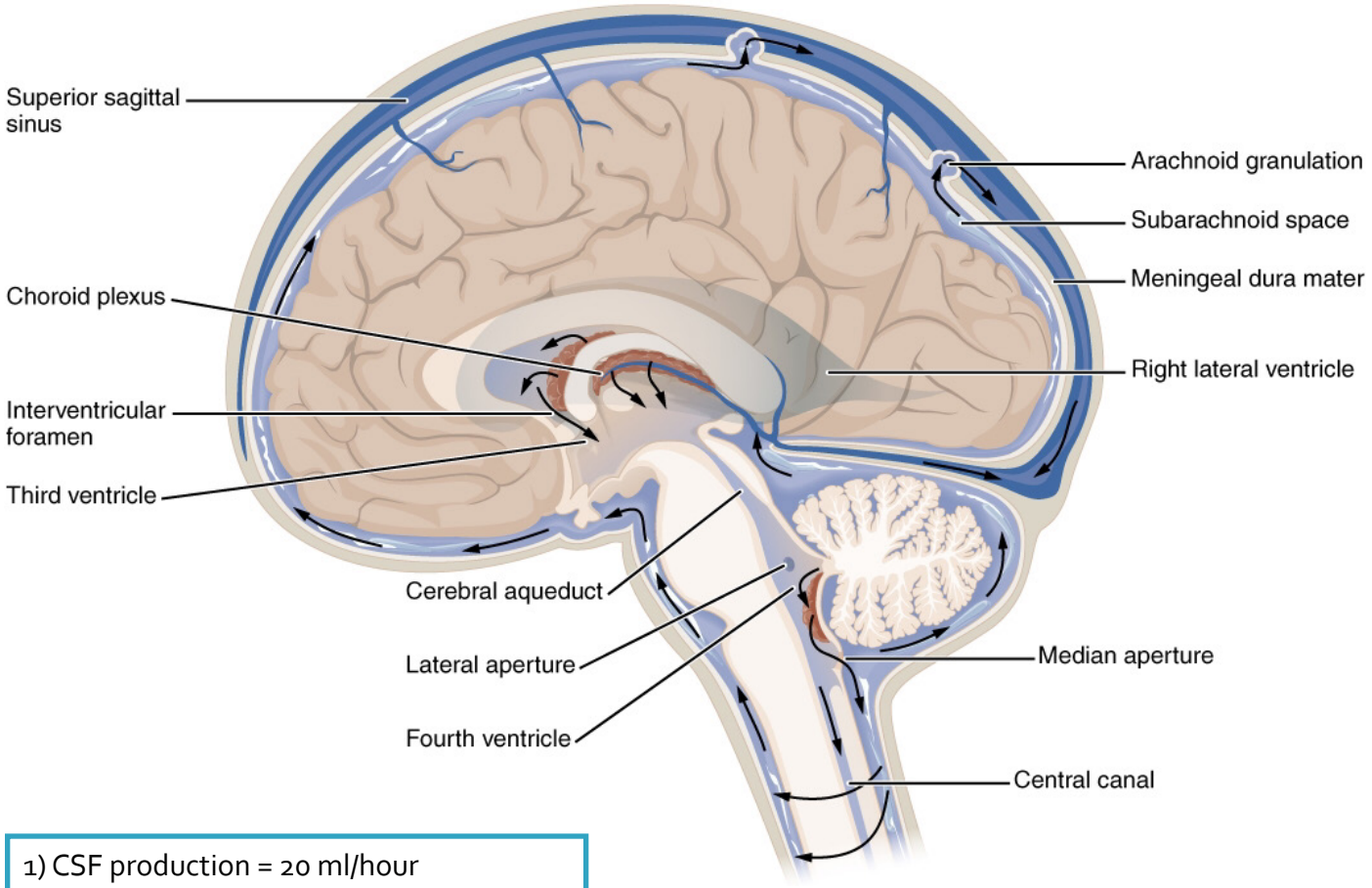
Circulation of Cerebrospinal Fluid (CSF)

- CSF is secreted by the epithelium of the choroid plexus, which is found in all 4 ventricles. The ventricles are lined with ependymal cells. At certain locations the ependyma-pia complex invaginates into the ventricles together with capillaries travelling in the subarachnoid space. Here the ependymal layer becomes a cuboidal epithelium, the choroid epithelium, and is secretory.
- CSF moves from the lateral, to the 3rd, to the 4th ventricle, pushed along by newly formed CSF.
- CSF flows into the central canal of the spinal cord, and flows out of the 4th ventricle through the 2 lateral foramina (Luschka) and 1 central foramen (Magendie) and into the subarachnoid space.
- CSF moves through the subarachnoid space until it reaches the arachnoid granulations or villi which protrude primarily into the superior sagittal sinus.
- Movement across the arachnoid villi is passive, driven by the difference in hydrostatic pressure between the CSF in the subarachnoid space and the venous blood in the superior sagittal sinus. The villi act like tiny flap valves so reverse flow is prevented if venous pressure exceeds CSF pressure.
- **Subarachnoid cisterns:** the width of the subarachnoid space varies because of the irregular contours of the brain. Regions that contain more substantial amounts of CSF are called subarachnoid cisterns.



1) CSF production = 20 ml/hour
2) CSF amount = 125-150 ml
3) Normal opening pressure = 6-20 cm H20 (up to 25 if obese)

Image: https://commons.wikimedia.org/wiki/File:1317_CFS_Circulation.jpg

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Identify the following:

On a whole brain:

- ◯ meninges (arachnoid vs. pia)
- ◯ arachnoid granulations

On a half brain:

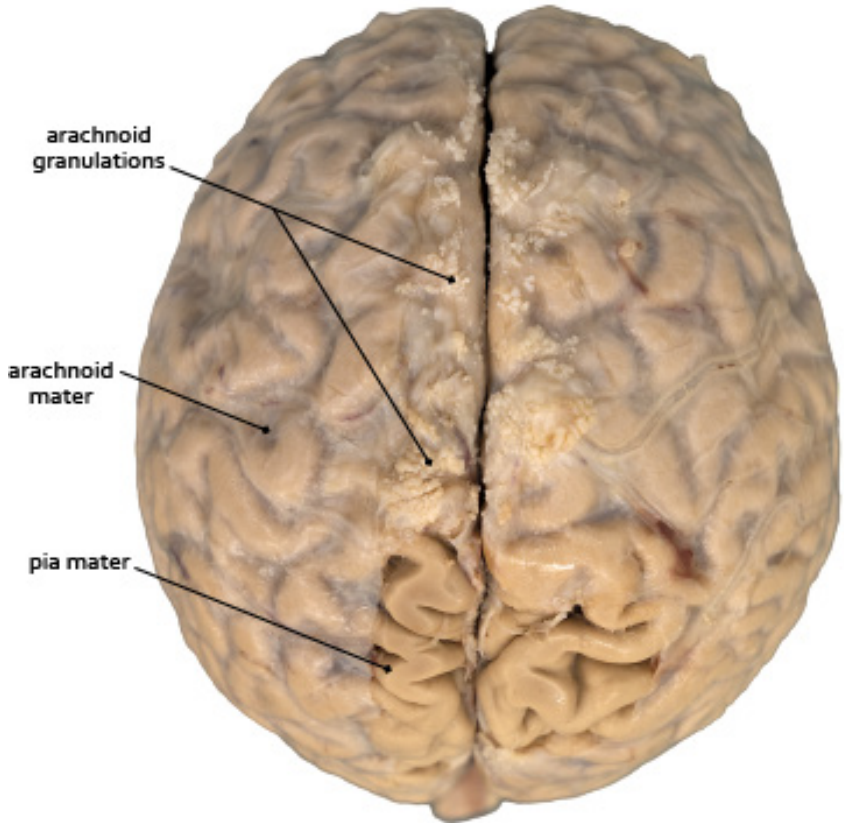
- ◯ 3rd ventricle
- ◯ 4th ventricle
- ◯ choroid plexus (possibly)

On coronal & horizontal sections:

- ◯ lateral ventricles
- ◯ 3rd ventricle
- ◯ choroid plexus

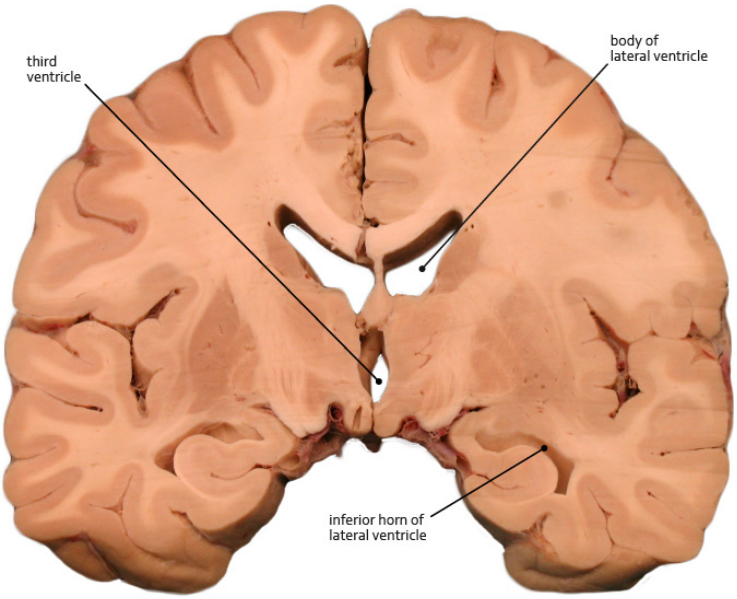
On a 3D ventricle:

- ◯ shape of ventricles
- ◯ relationship of ventricles to one another



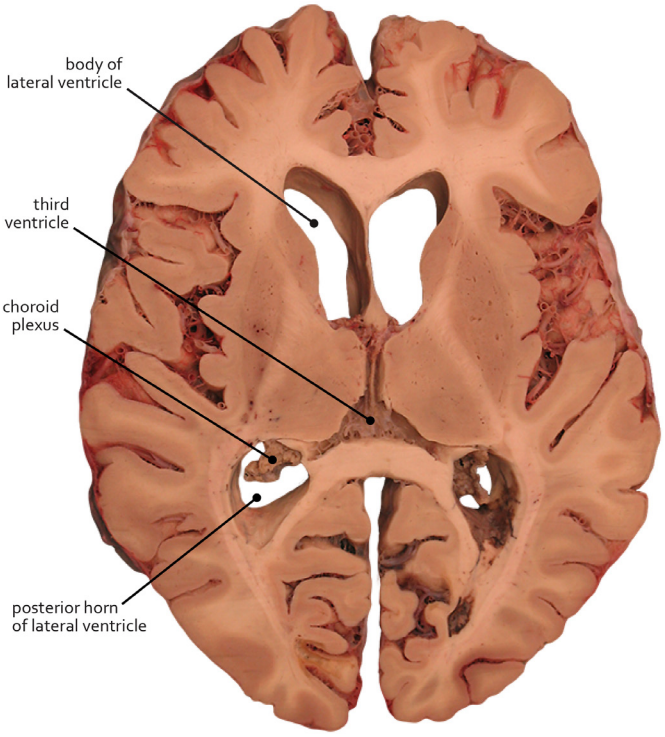
Arachnoid Granulations on Superior Brain

Ventricles (3D)



Coronal Brain Section

Hide Labels



Horizontal Brain Section

Hide Labels

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Cases

How to approach the following cases:

- list the symptoms
- hypothesize which structures are involved in the symptoms seen
- what is the area of the brain where all these pathways/nuclei/structures come together
- what level of the CNS is the lesion most likely located - peripheral, spinal cord, brainstem, diencephalon, cortex, subcortical structures (fiber tracts, deep nuclei)

Case #1

A 12-y.o. girl is watching a hockey game in the arena. The puck flies into the crowd and hits her on the head. She complains about the pain of the impact, but is otherwise OK. After the game she goes home with her parents. After a period of feeling OK she slowly starts to lose consciousness. She is brought to the hospital where a CT scan shows a skull fracture and an **epidural bleed**.

What is an epidural bleed?

What is the underlying pathology? Which vessel is most likely to have caused this problem?

Why is the "lucid interval" typical for an epidural bleed?

Case #2

A 25-y.o. woman goes to the ER complaining about a sudden start of a severe headache. In addition, she complains about pain in her neck and suspects it might be due to her posture when working on her computer. She also complains about nausea and vomiting, which she attributes to extremely hot weather conditions.

All of these symptoms developed acutely within 15 minutes and were so severe, that she came directly to the ER. A CT scan is done immediately and shows a **subarachnoid bleed**.

What is a subarachnoid bleed?

What is the underlying pathology?

RESOURCES

Websites:

Neuroanatomy | Entrada

Recommended Textbooks:

Lippincott Illustrated Reviews: Neuroscience
By: Claudia Krebs, Joanne Weinberg, Elizabeth J. Akesson, Esma Dilli
Lippincott Williams & Wilkins
ISBN 978-1-4963-6789-1

Neuroanatomy Through Clinical Cases
By: Hal Blumenfeld
Sinauer
ISBN 978-0-8789-3613-7

Neuroanatomy in Clinical Context: An Atlas of Structures, Sections, Systems, and Syndromes
By: Duane E. Haines
Wolters kluwer Health
ISBN 978-1-4511-8625-3

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