

INC Summer Neuroimaging Bootcamp 2022  
Human Neuroanatomy Primer



**Justin Sipla, Ph.D**

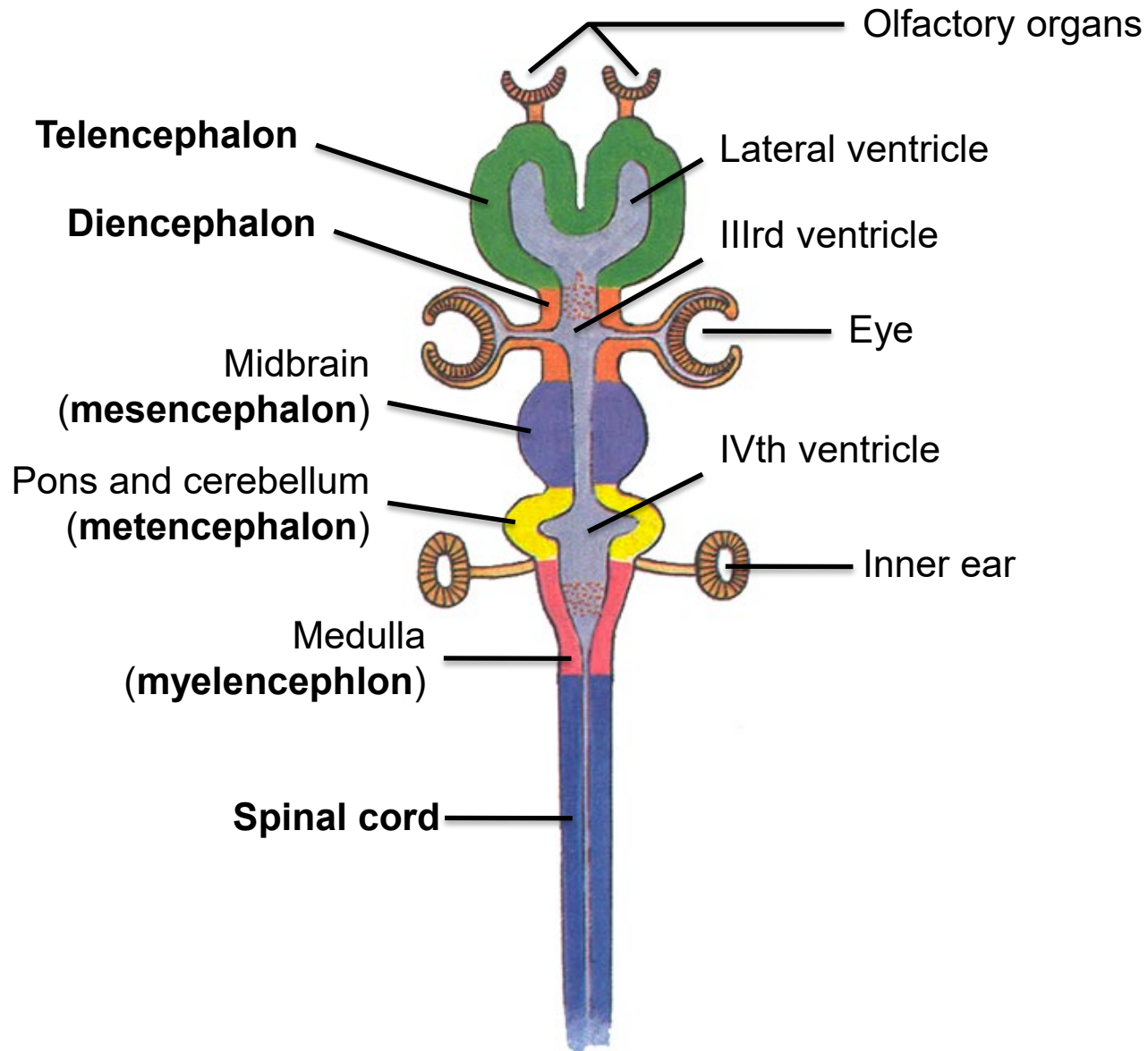
CCOM Foundational Science Co-Director  
Depts. of Anatomy & Cell Biology, Neurology

Contact:

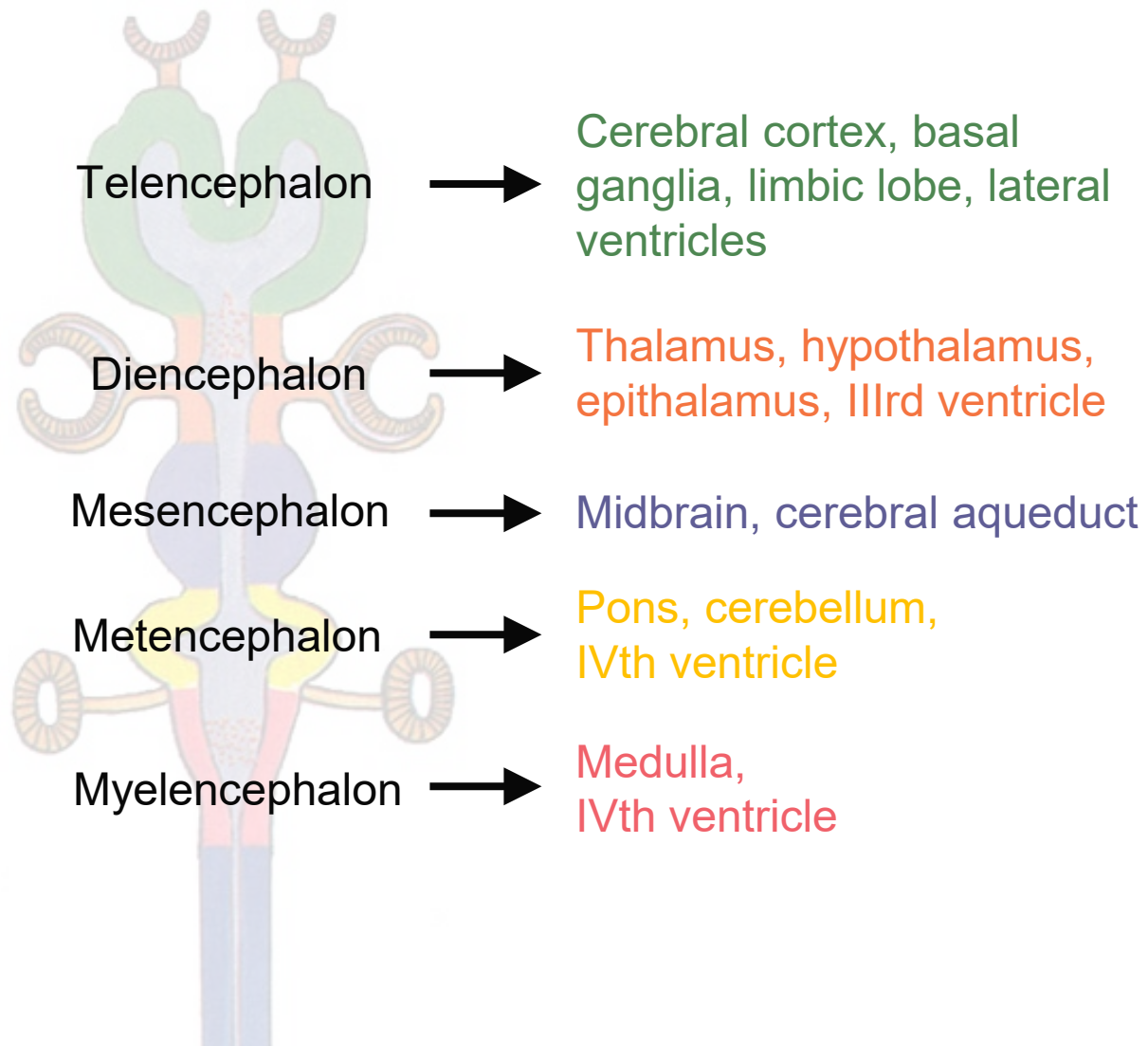
[justin-sipla@uiowa.edu](mailto:justin-sipla@uiowa.edu)

BSB 1-400-A

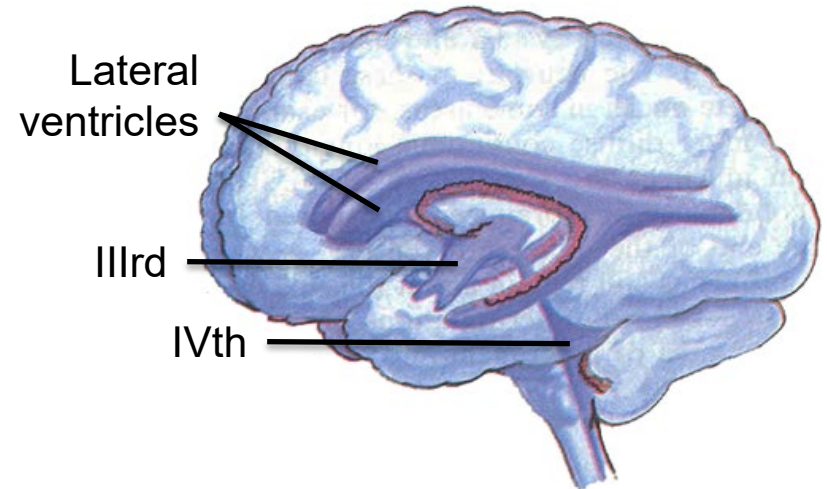
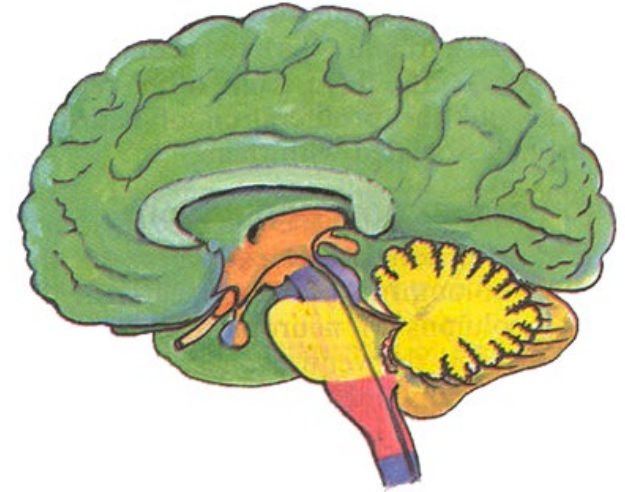
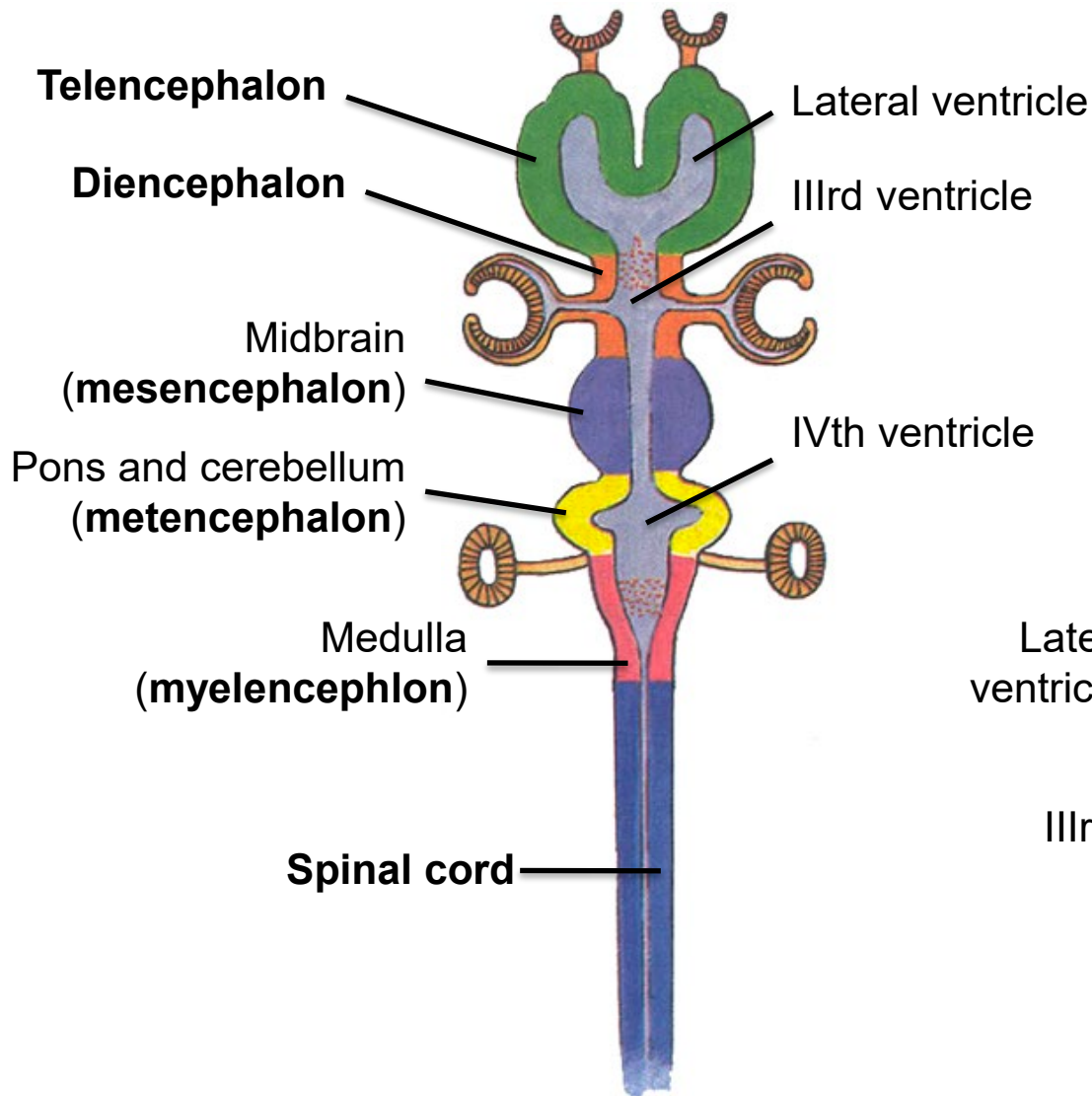
# 6 divisions of the CNS



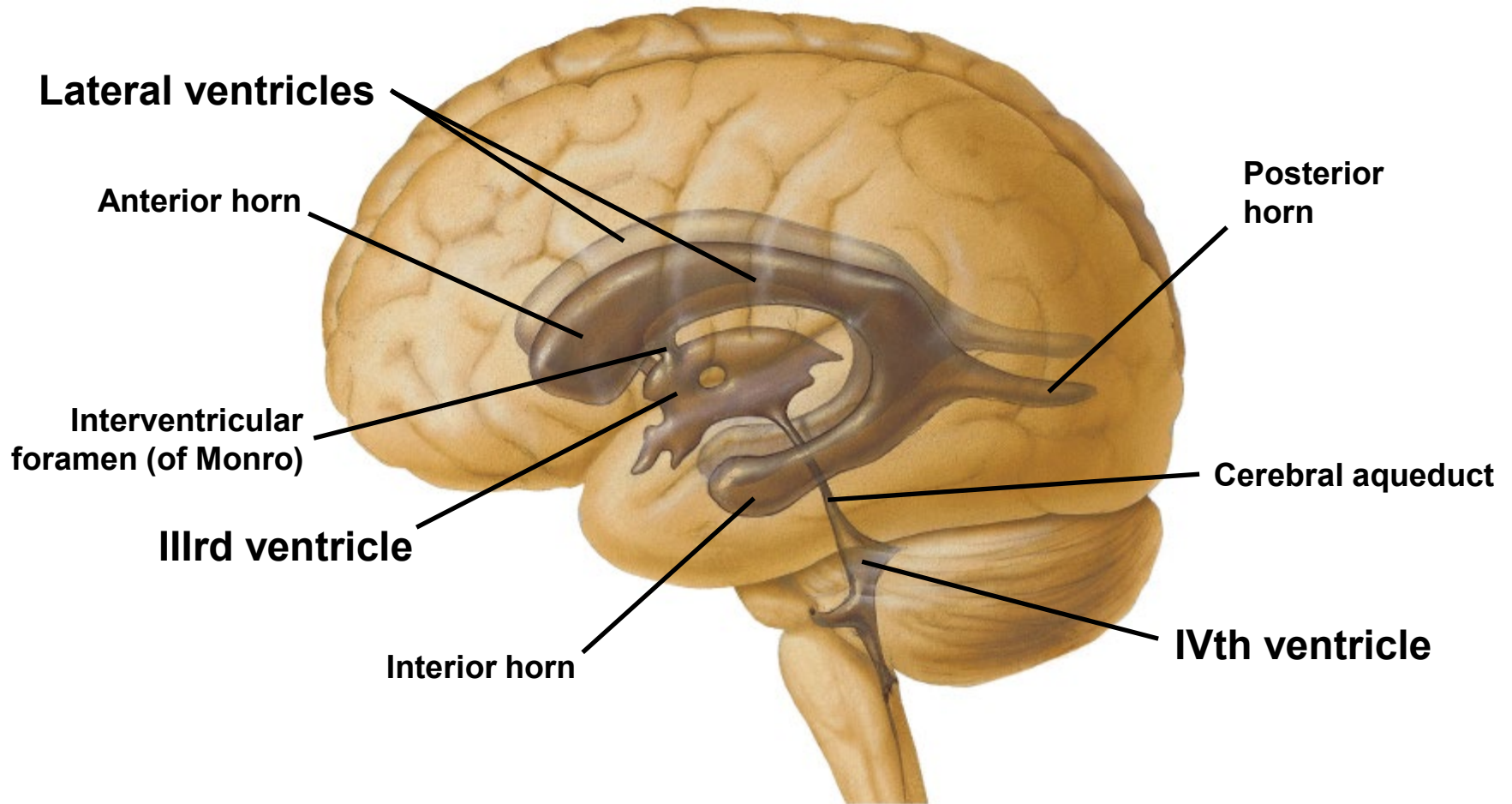
# Derivatives of neural tube regions



# 6 divisions of the CNS

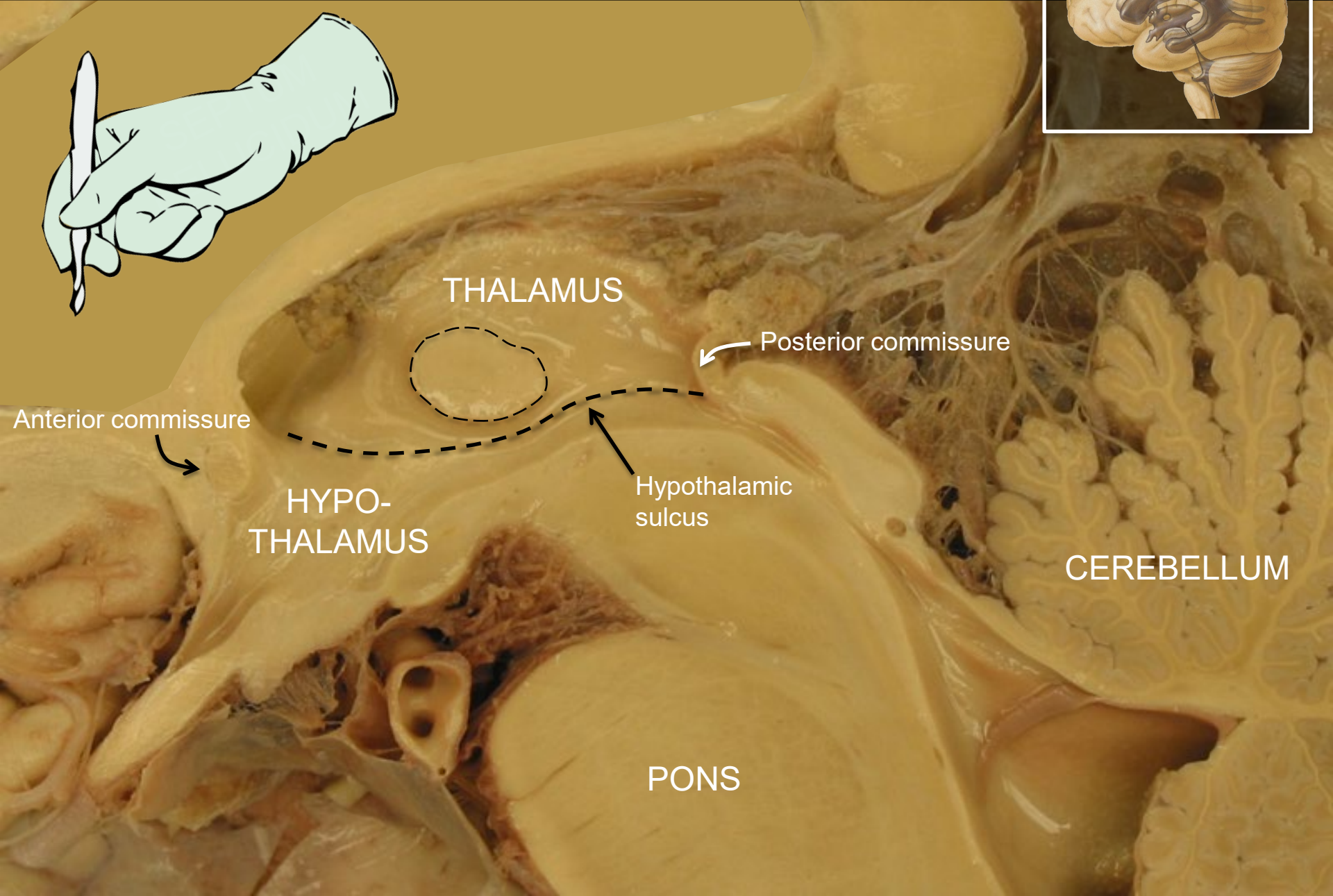


# Cerebrospinal fluid (CSF) originates in the ventricular system





# Brain ventricles



THALAMUS

Posterior commissure

Anterior commissure

HYPO-  
THALAMUS

Hypothalamic  
sulcus

PONS

CEREBELLUM

# Brain ventricles



**LATERAL  
VENTRICLE**

Interventricular  
foramen of Monro

THALAMUS

Cerebral  
aqueduct

III

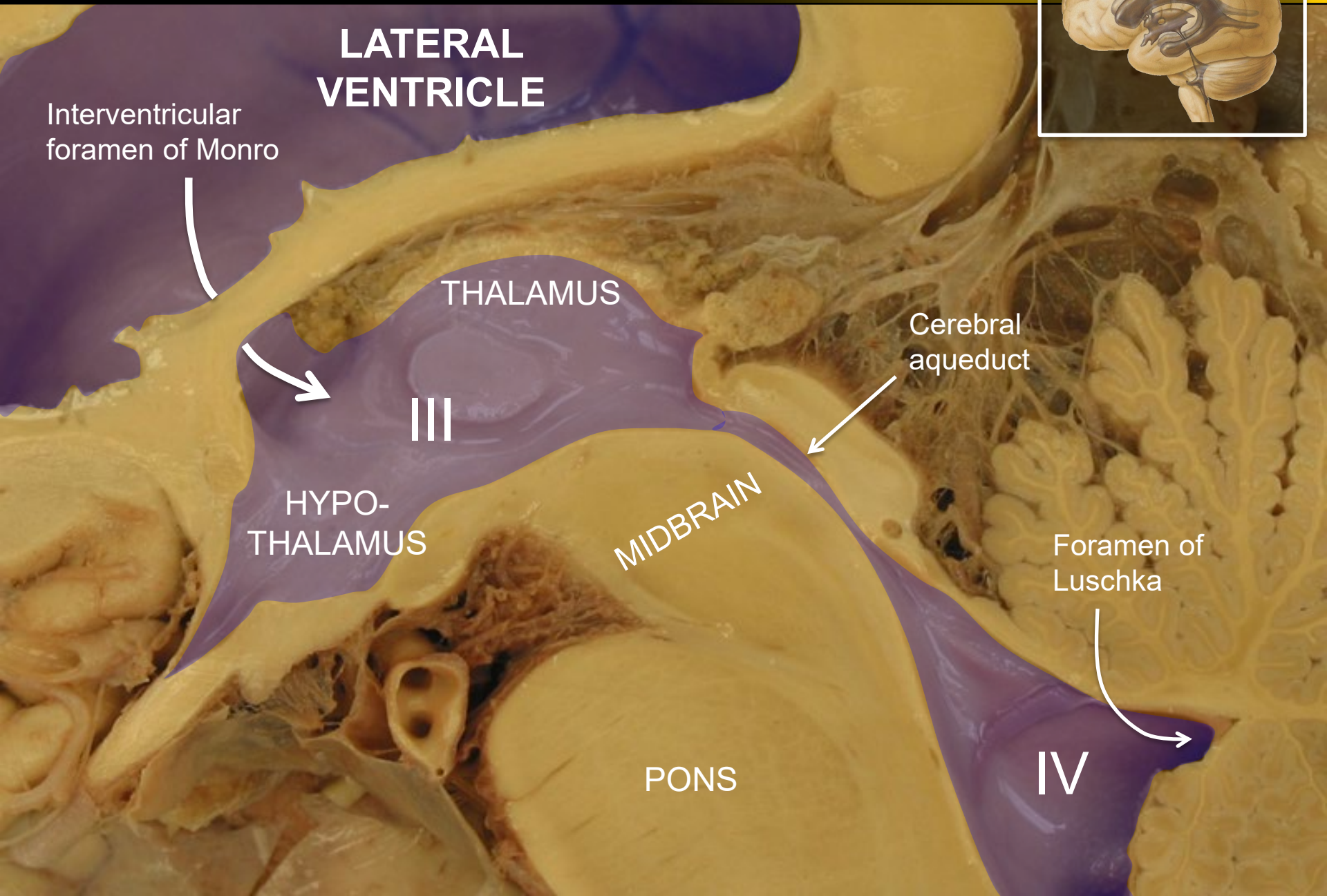
HYPO-  
THALAMUS

MIDBRAIN

Foramen of  
Luschka

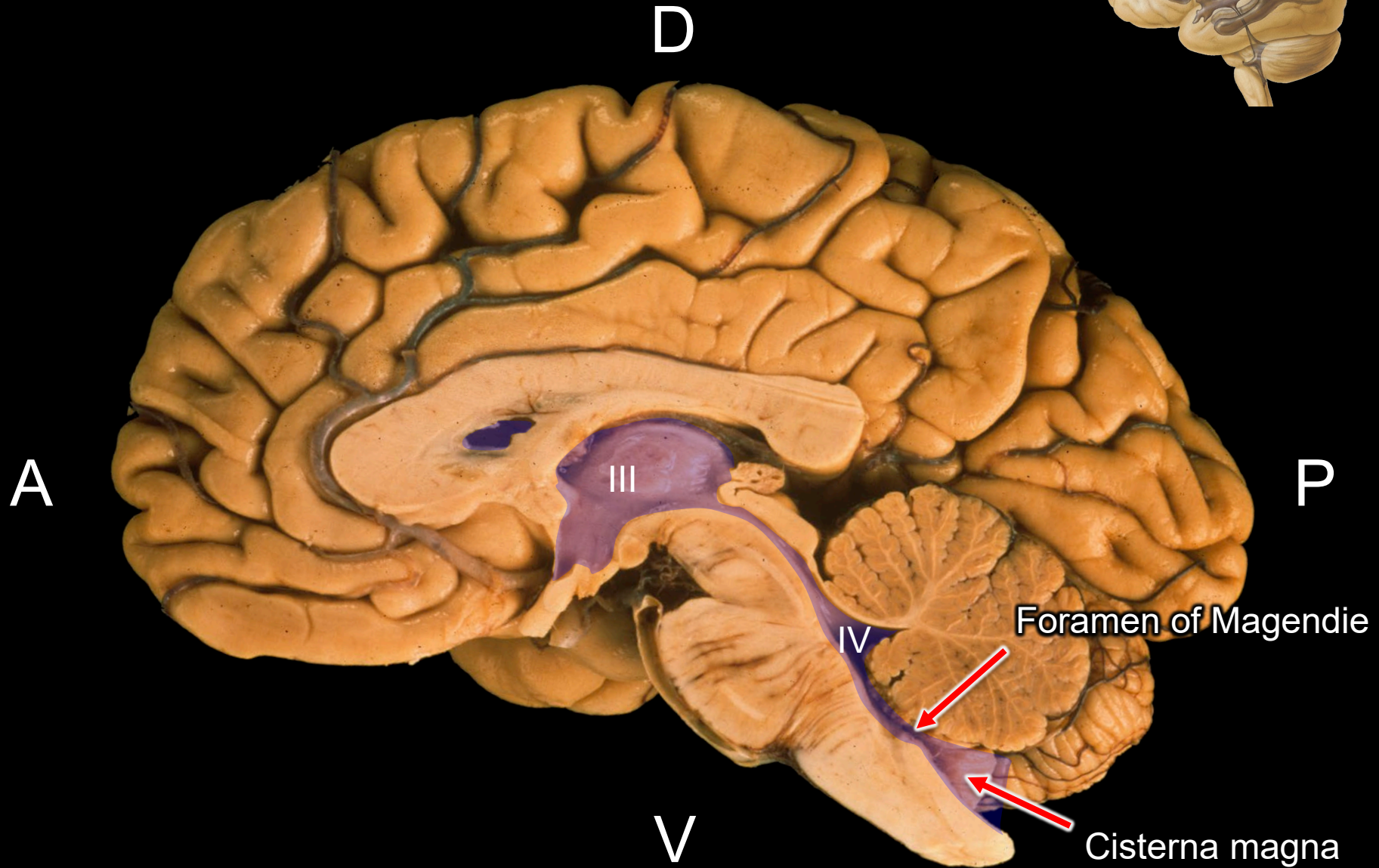
PONS

IV





# Brain ventricles



Foramen of Magendie

Cisterna magna

A

P

D

V

III

IV



# Lateral recess



Cerebral  
aqueduct

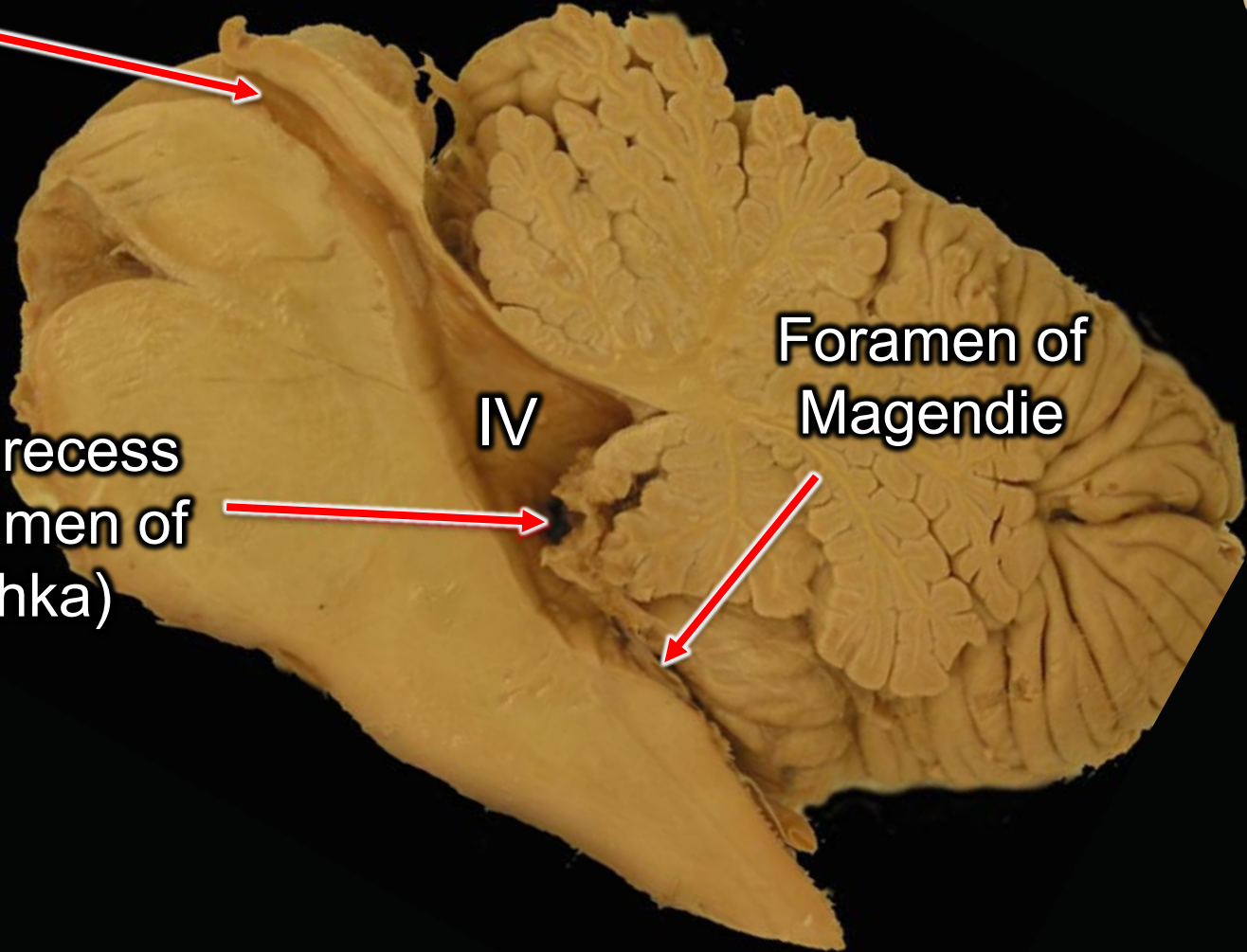


Lateral recess  
(to Foramen of  
Luschka)

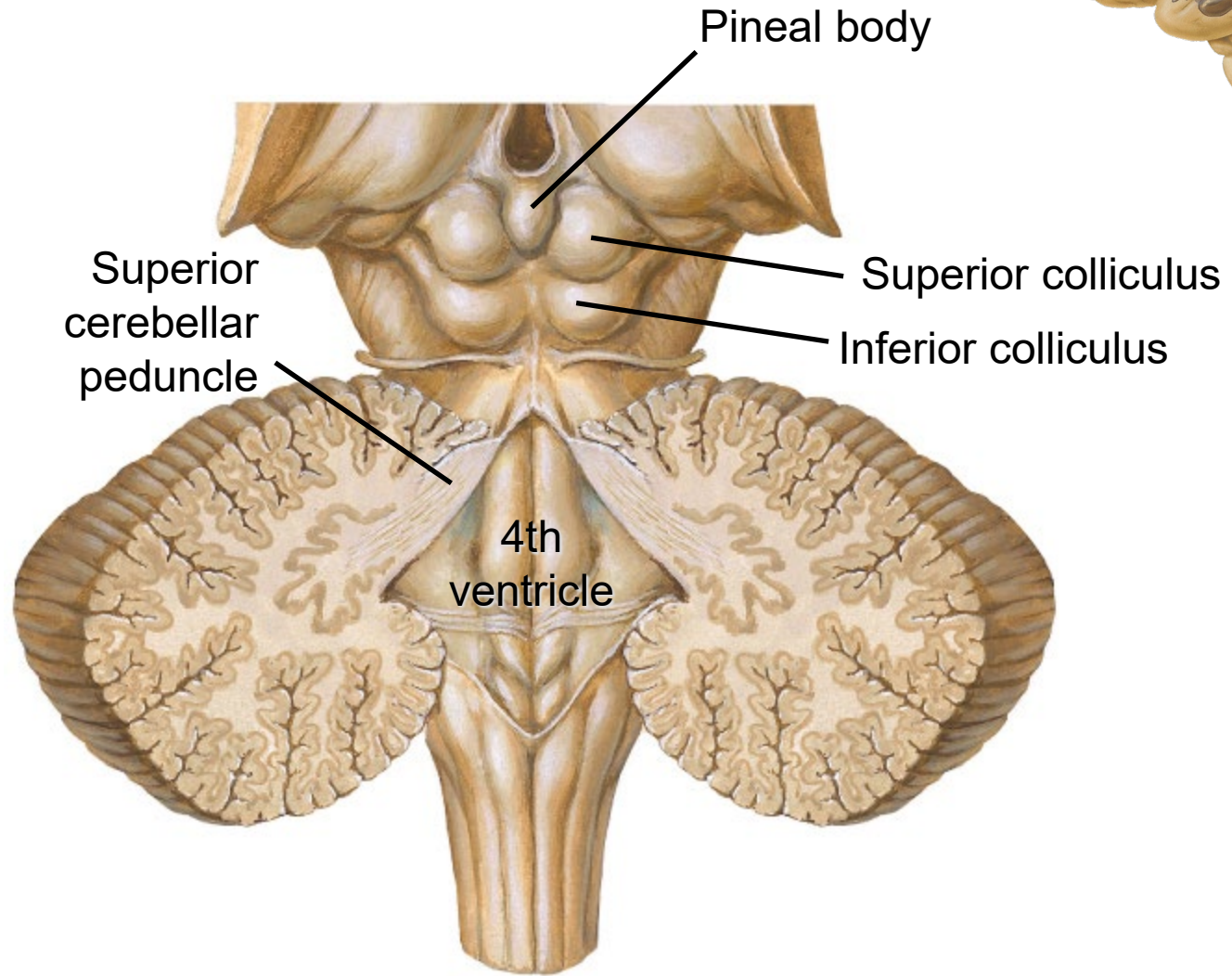


IV

Foramen of  
Magendie



# Dorsum of brainstem



Pineal body

Superior colliculus

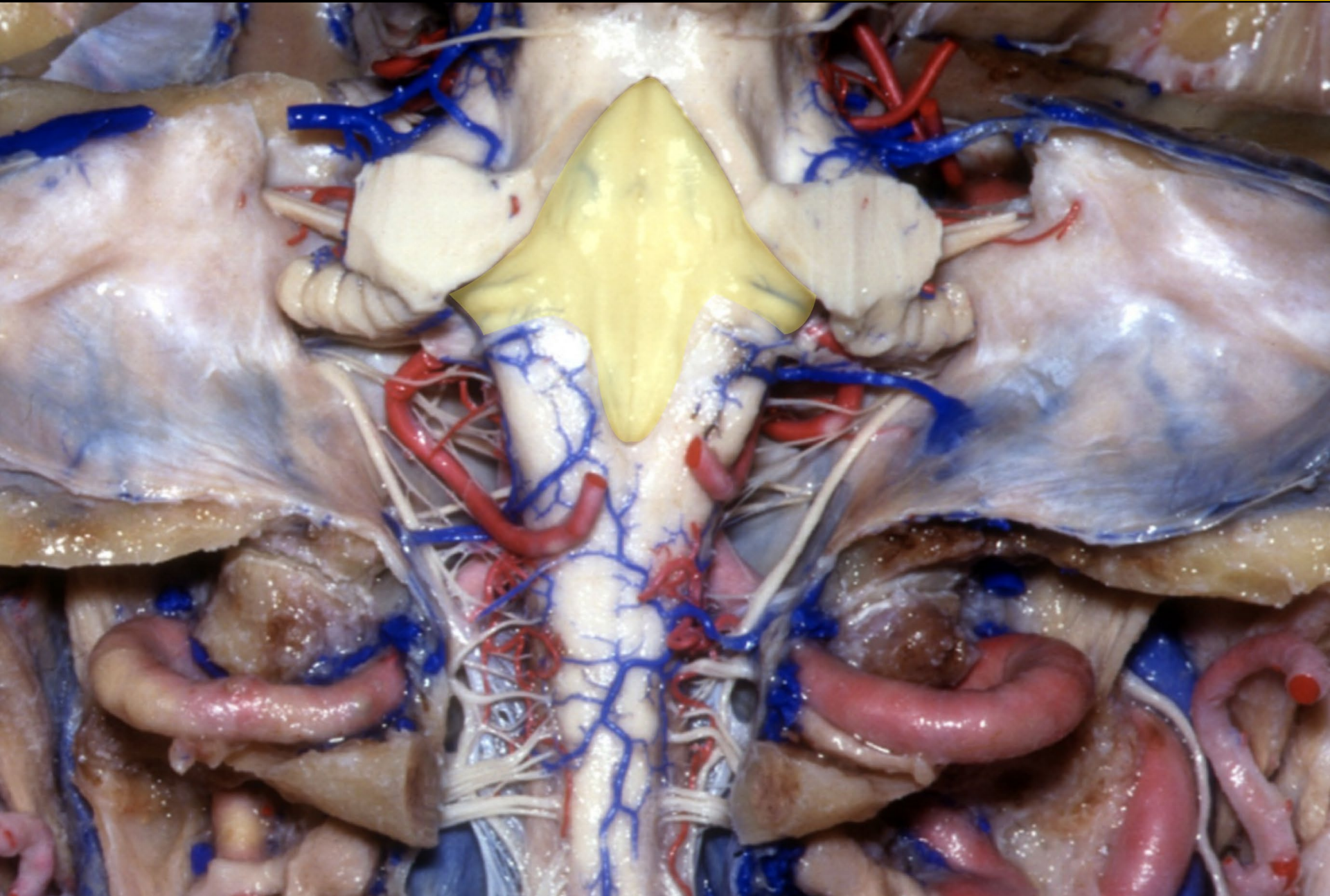
Inferior colliculus

Superior cerebellar peduncle

4th ventricle

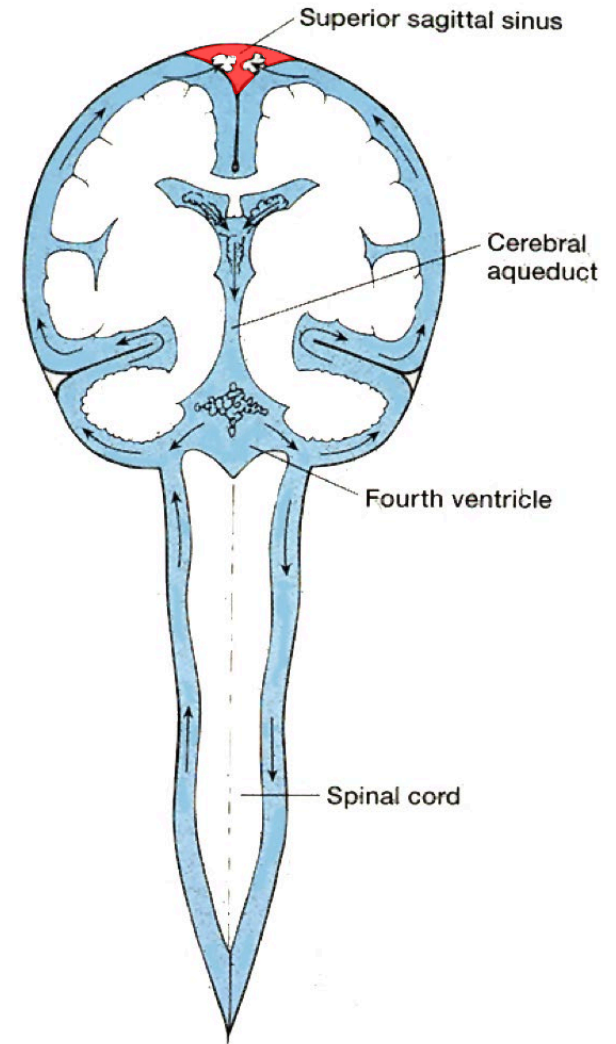
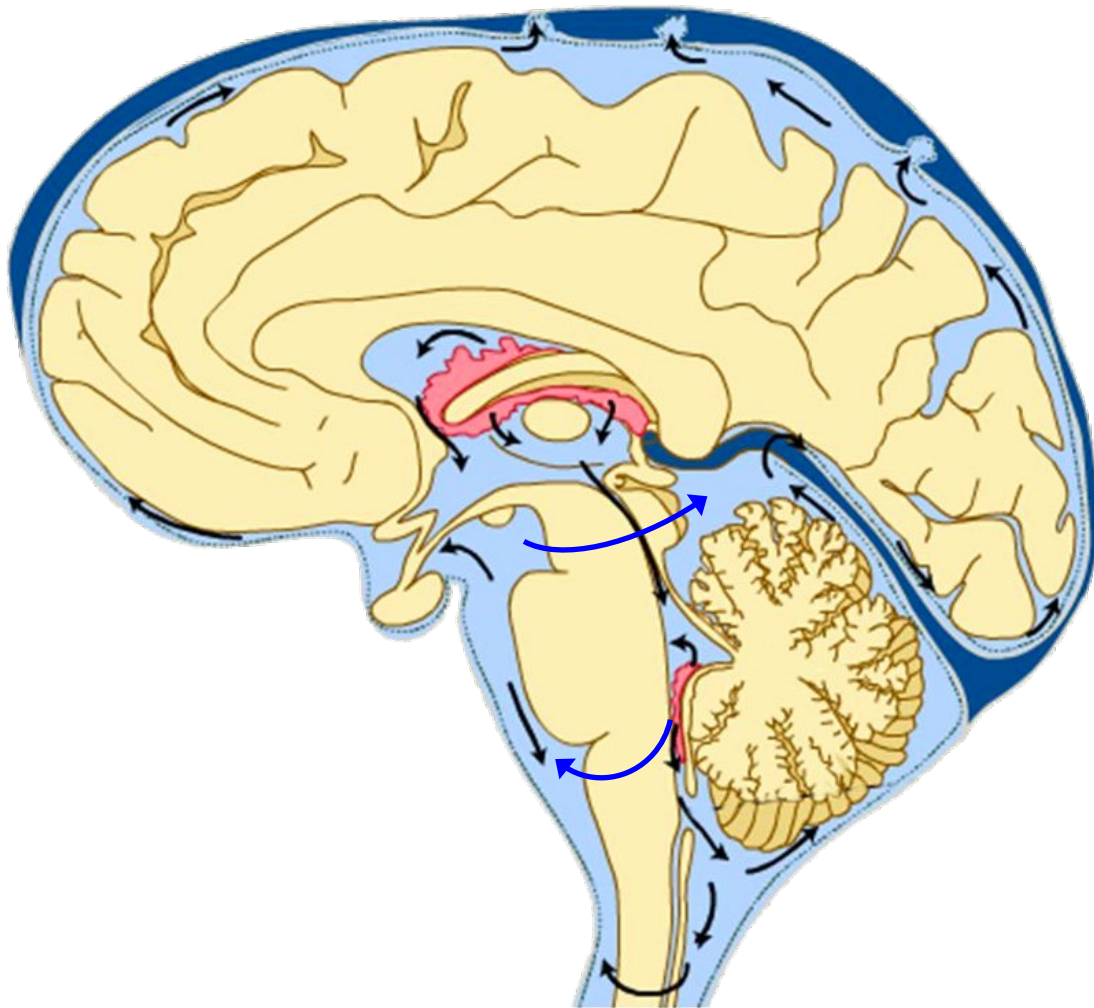


# IVth ventricle (dorsal view)





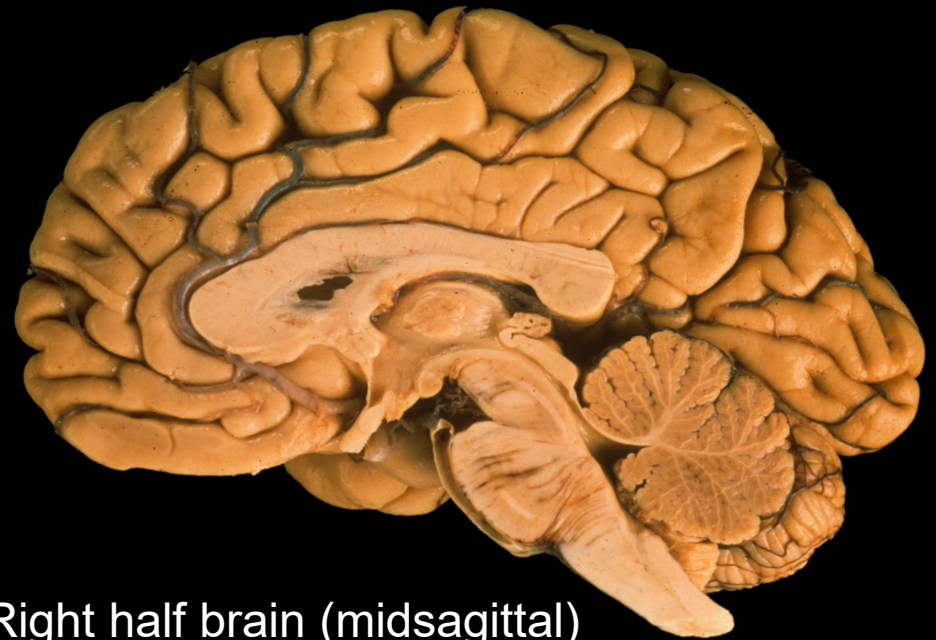
# Subarachnoid spaces



# Gross topography of the brain



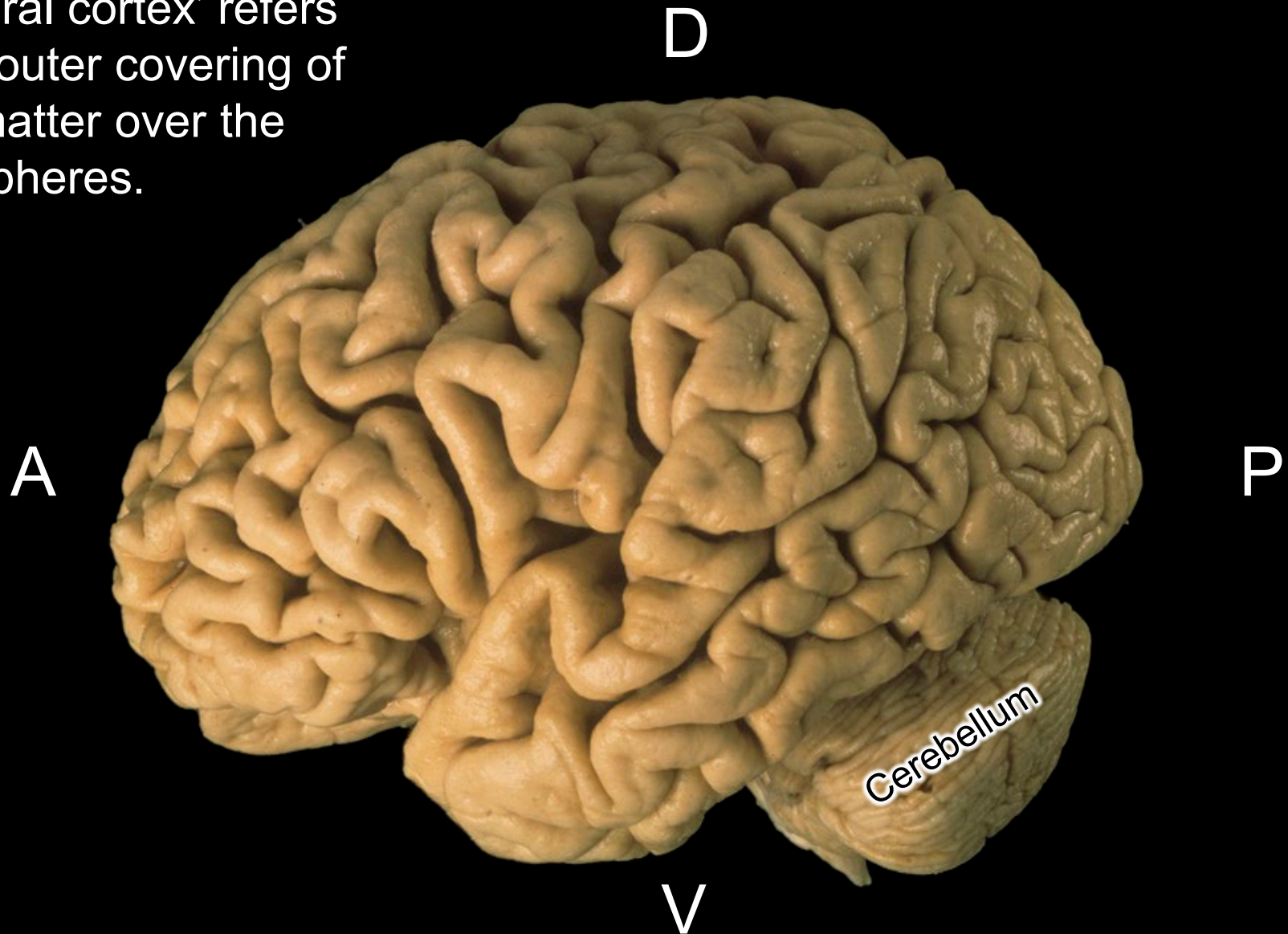
Whole brain without meninges  
(left lateral view)



Right half brain (midsagittal)

# Gross topography of the brain

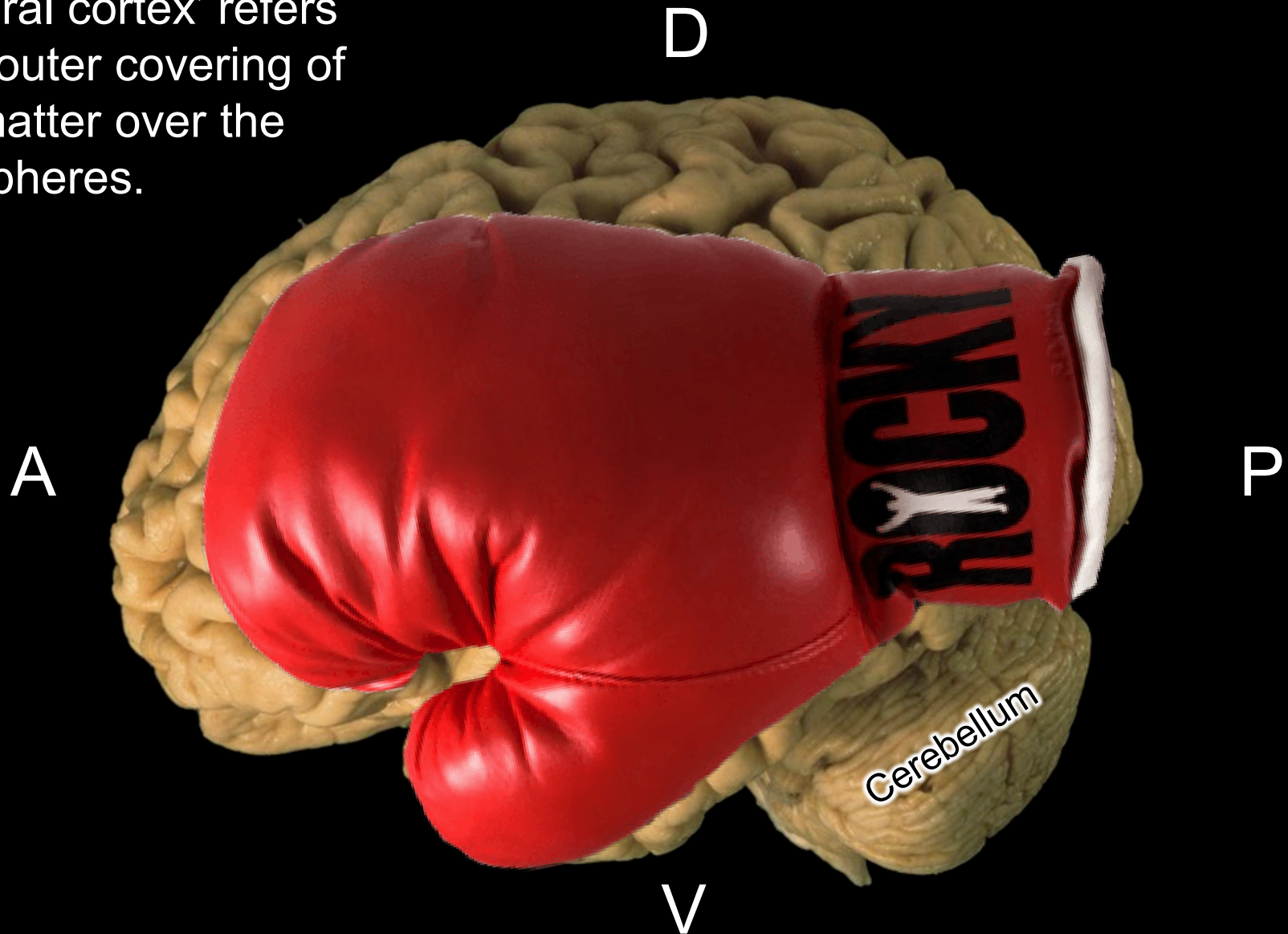
'Cerebral cortex' refers to the outer covering of gray matter over the hemispheres.





# Gross topography of the brain

'Cerebral cortex' refers to the outer covering of gray matter over the hemispheres.

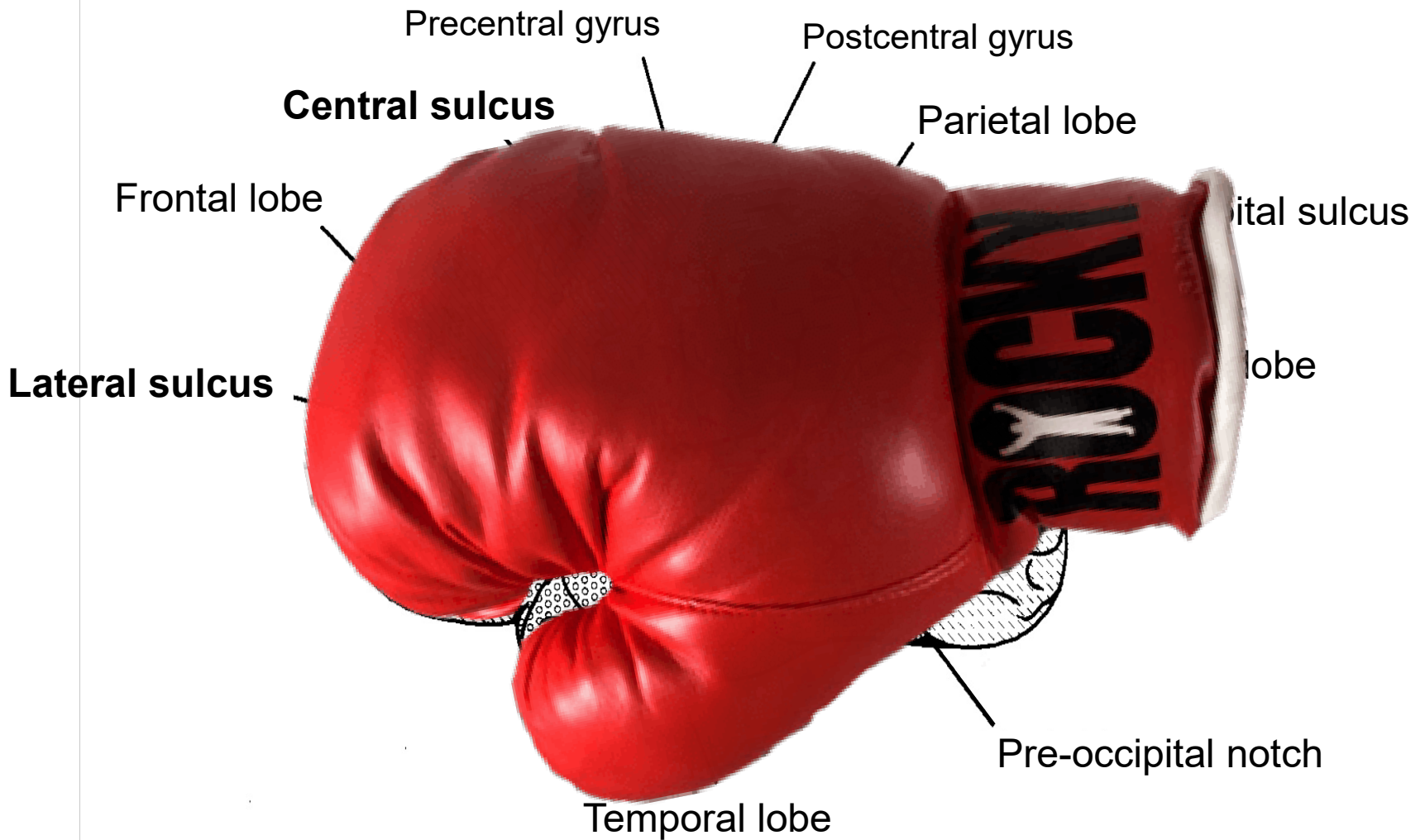


# Gross topography of the brain



# Prominent fissures

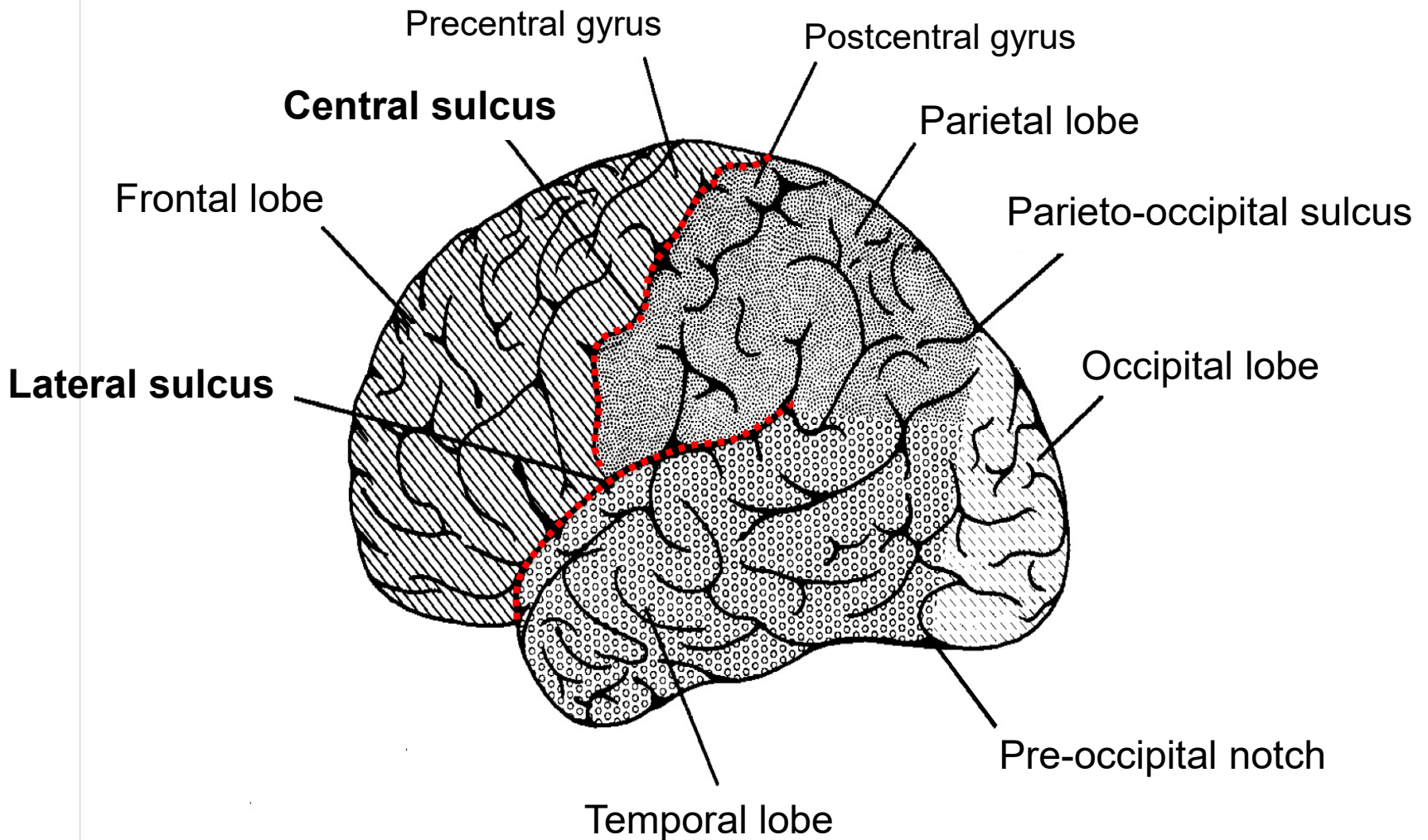
LATERAL VIEW of L hemisphere, anterior is left





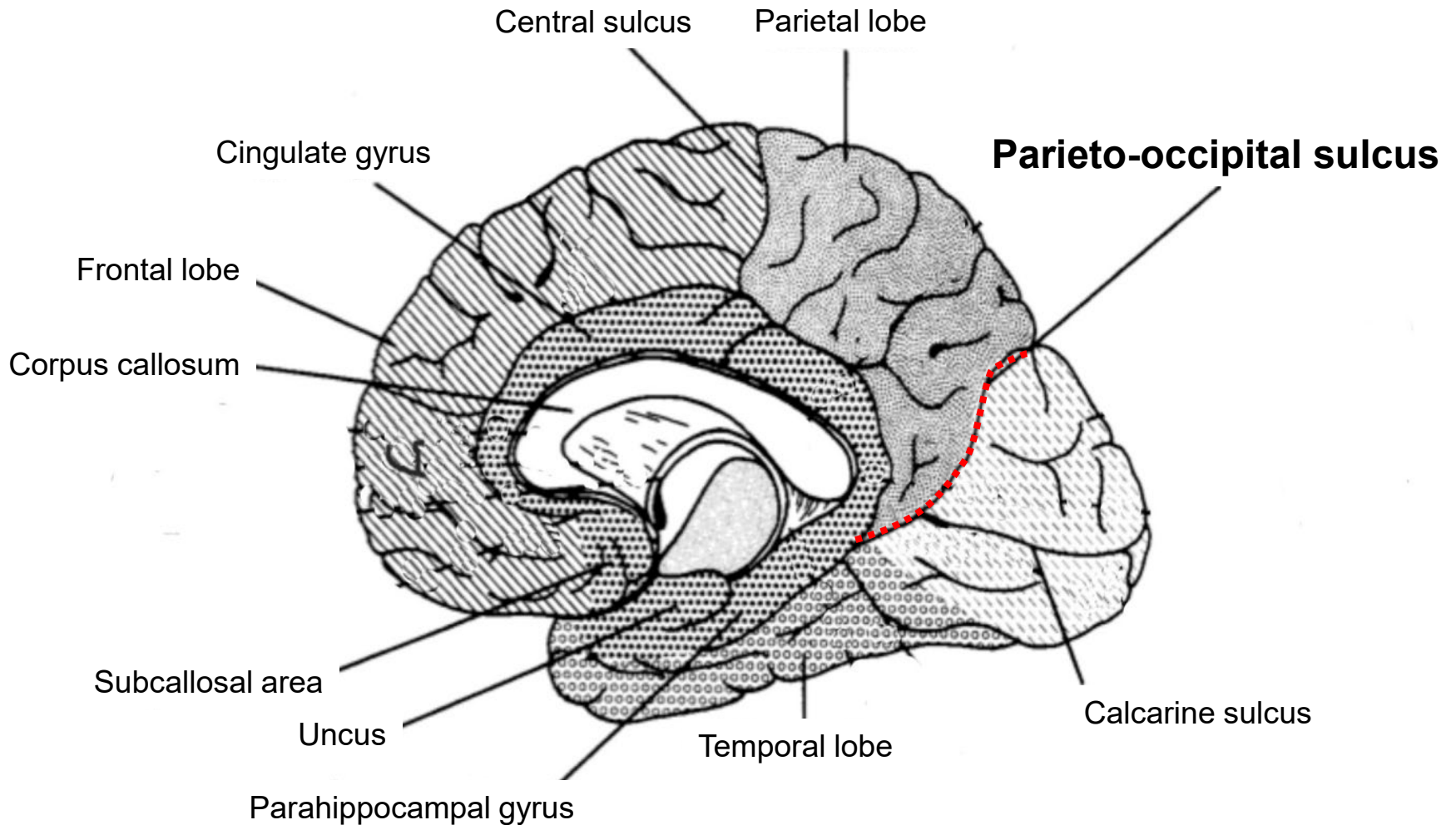
# Prominent fissures

LATERAL VIEW of L hemisphere, anterior is left



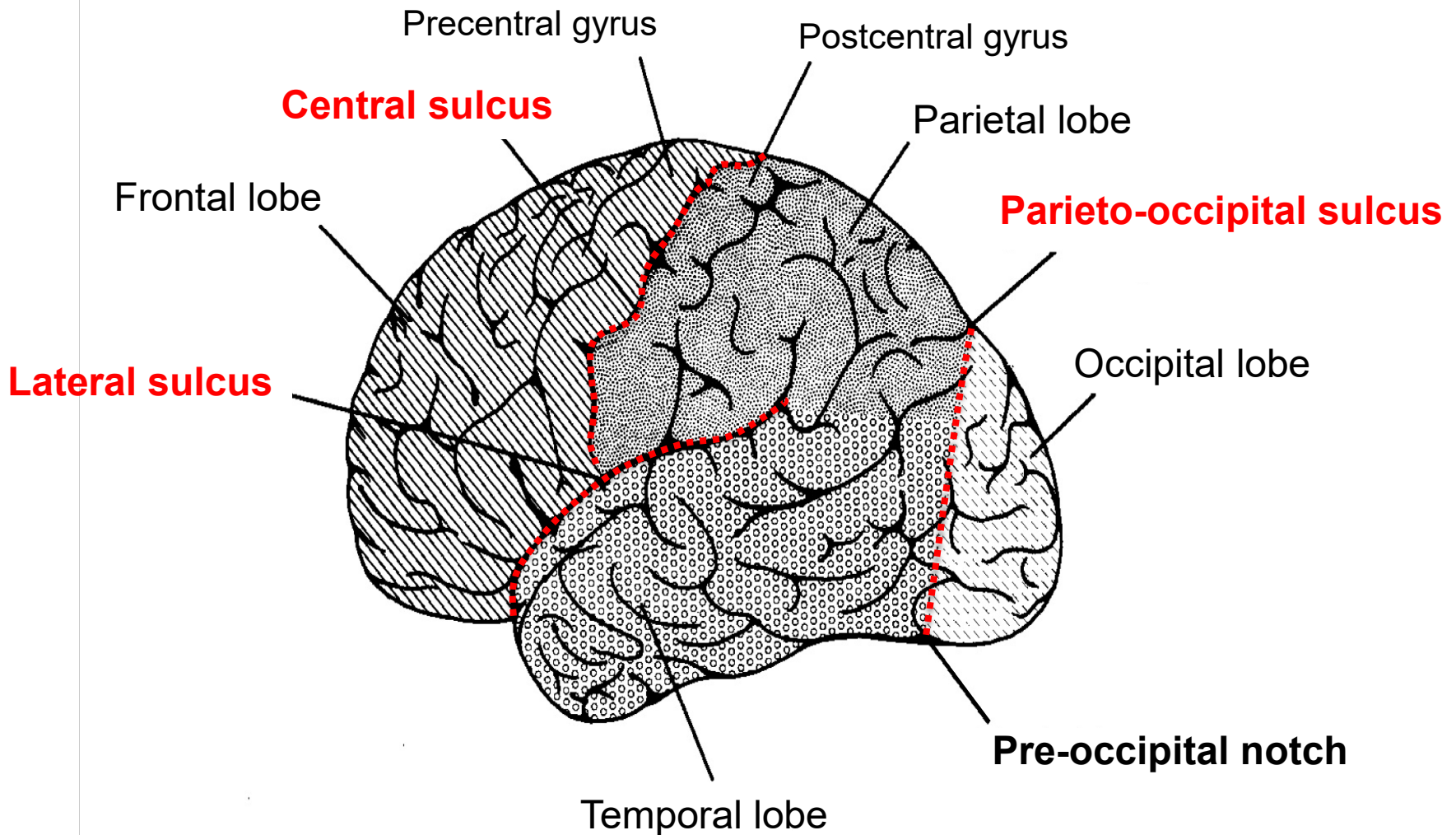
# Prominent fissures

SAGITTAL VIEW of R hemisphere, anterior is left



# Prominent fissures

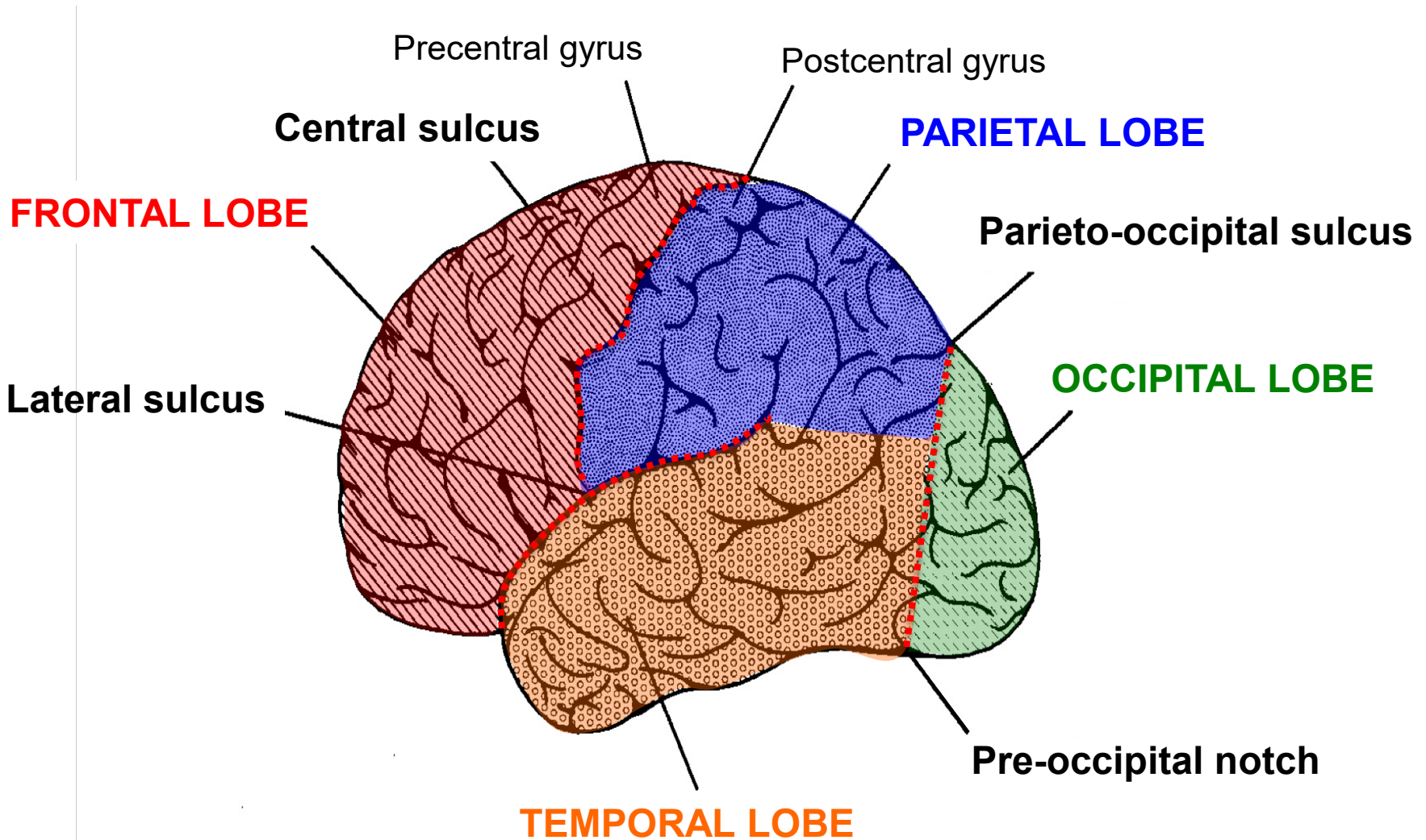
LATERAL VIEW of L hemisphere, anterior is left



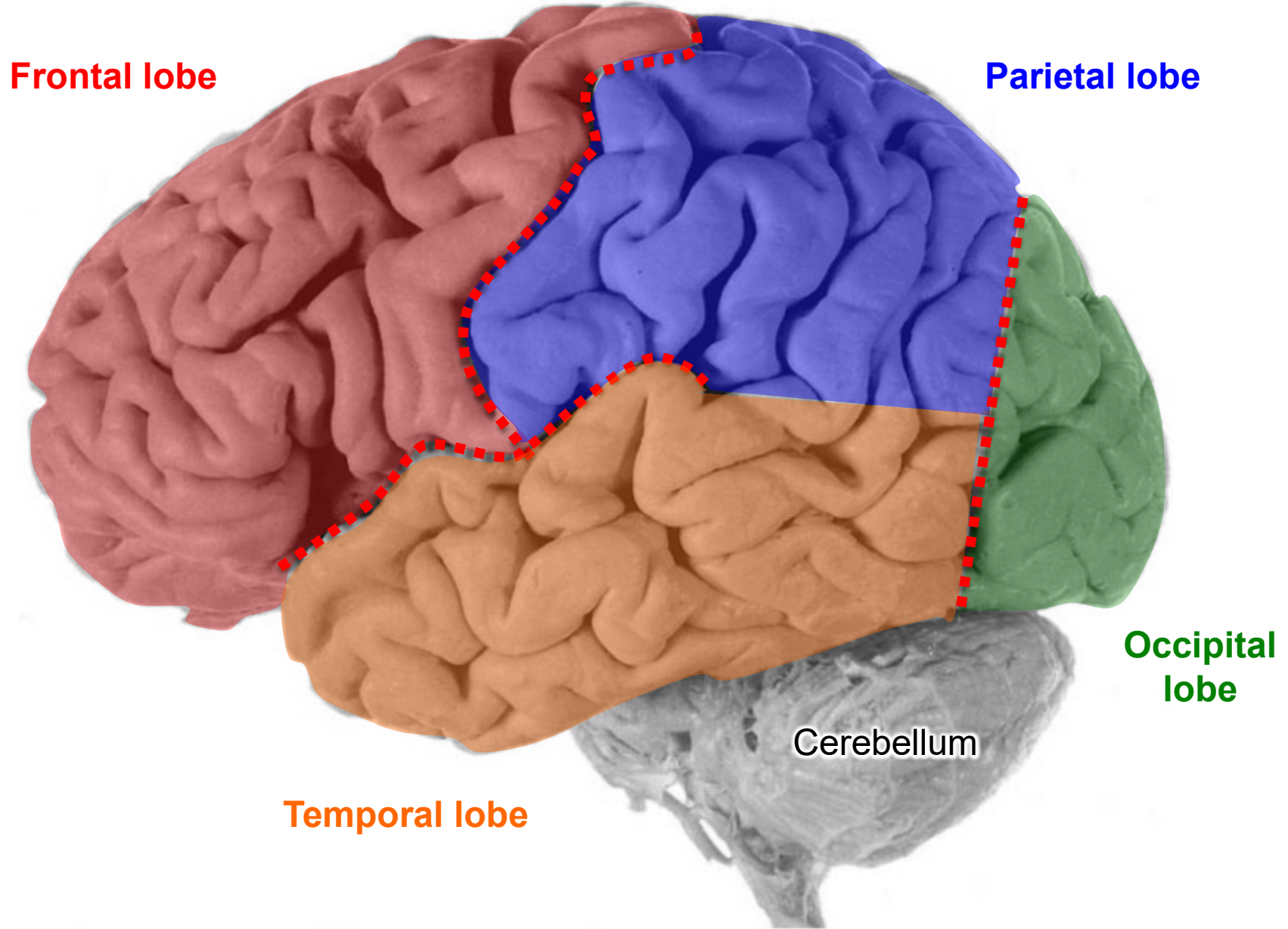


# Lobes of the brain

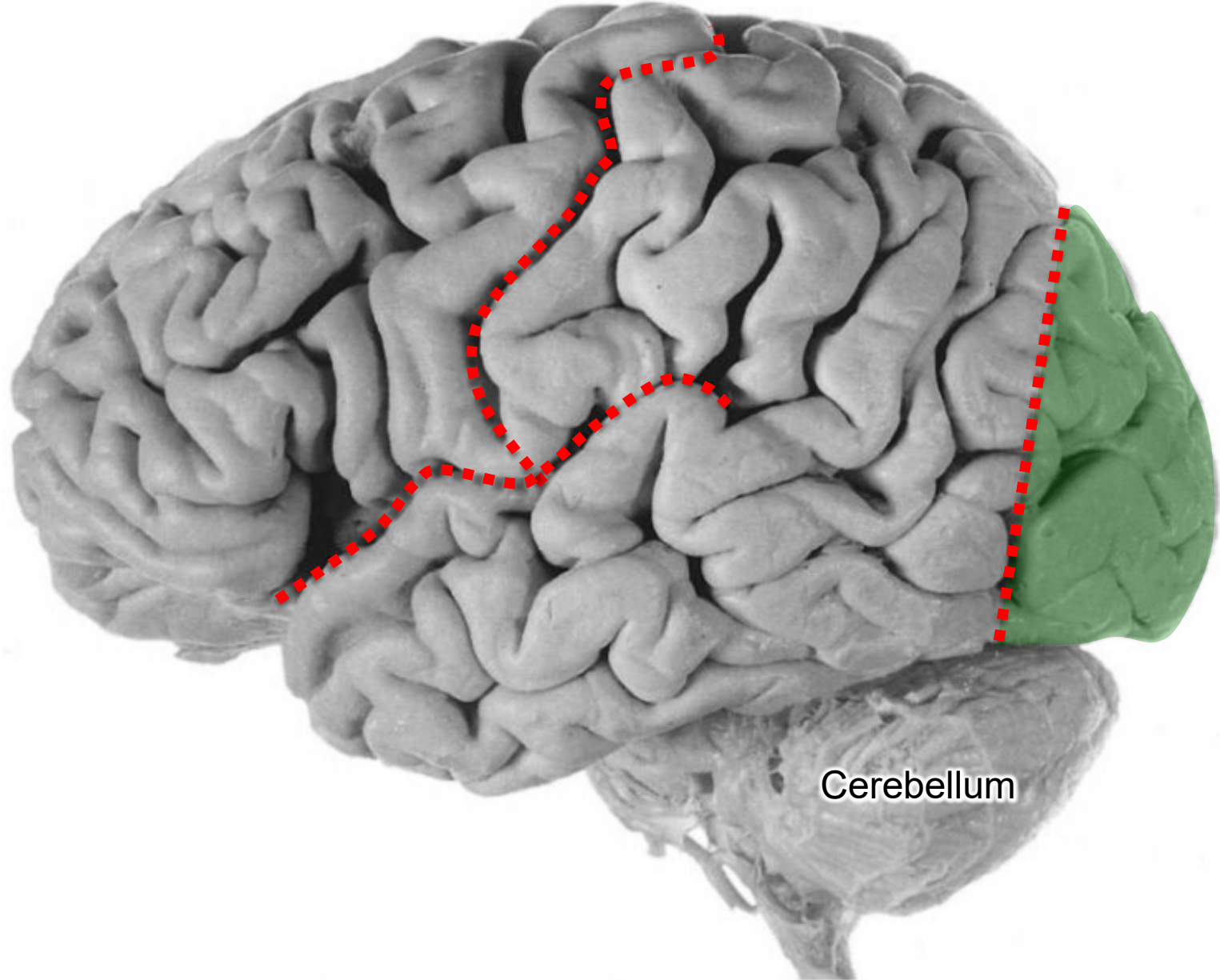
LATERAL VIEW of L hemisphere, anterior is left



# Lobes of the brain



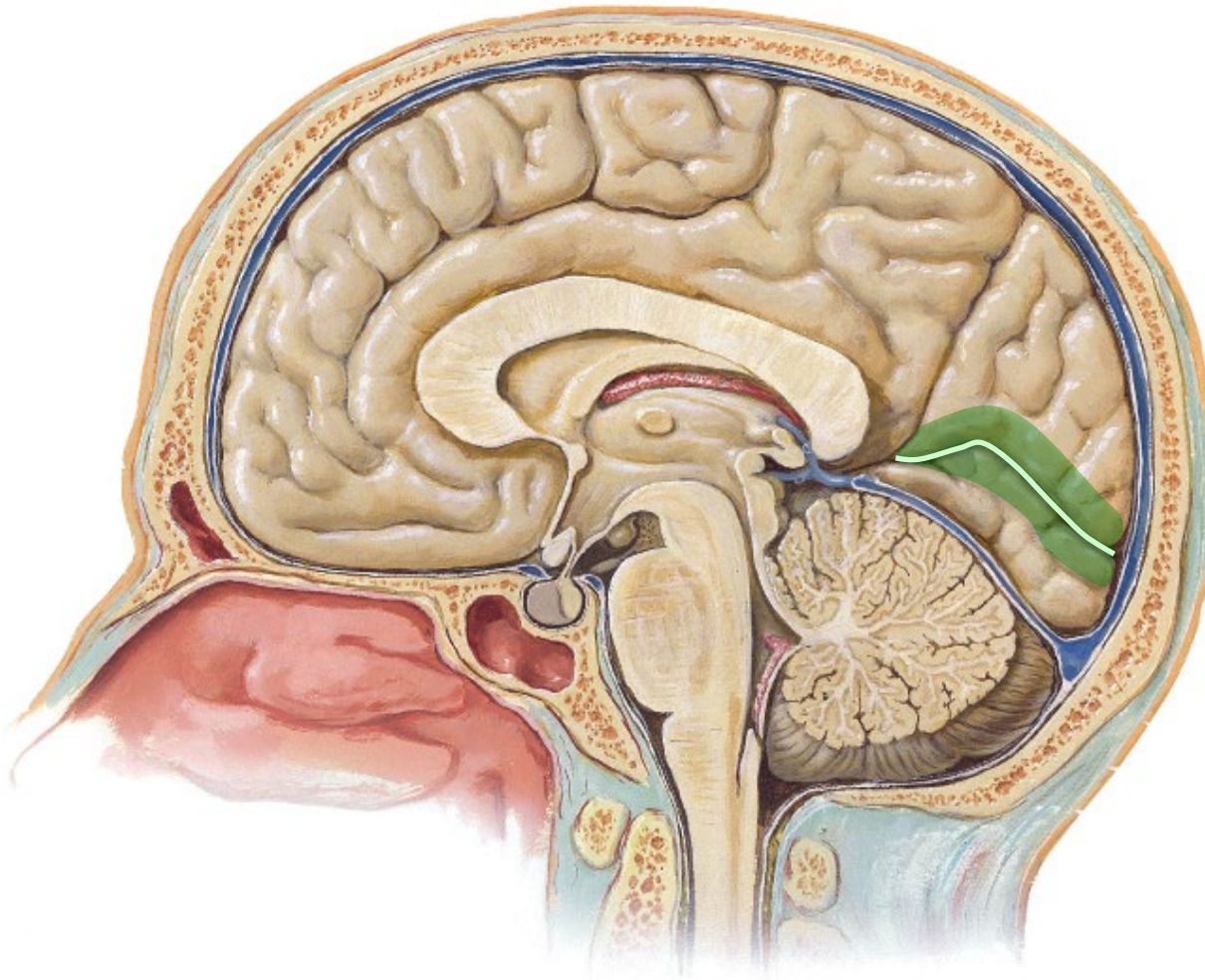
# Occipital lobe – *vision*





# Primary visual cortex (V1)

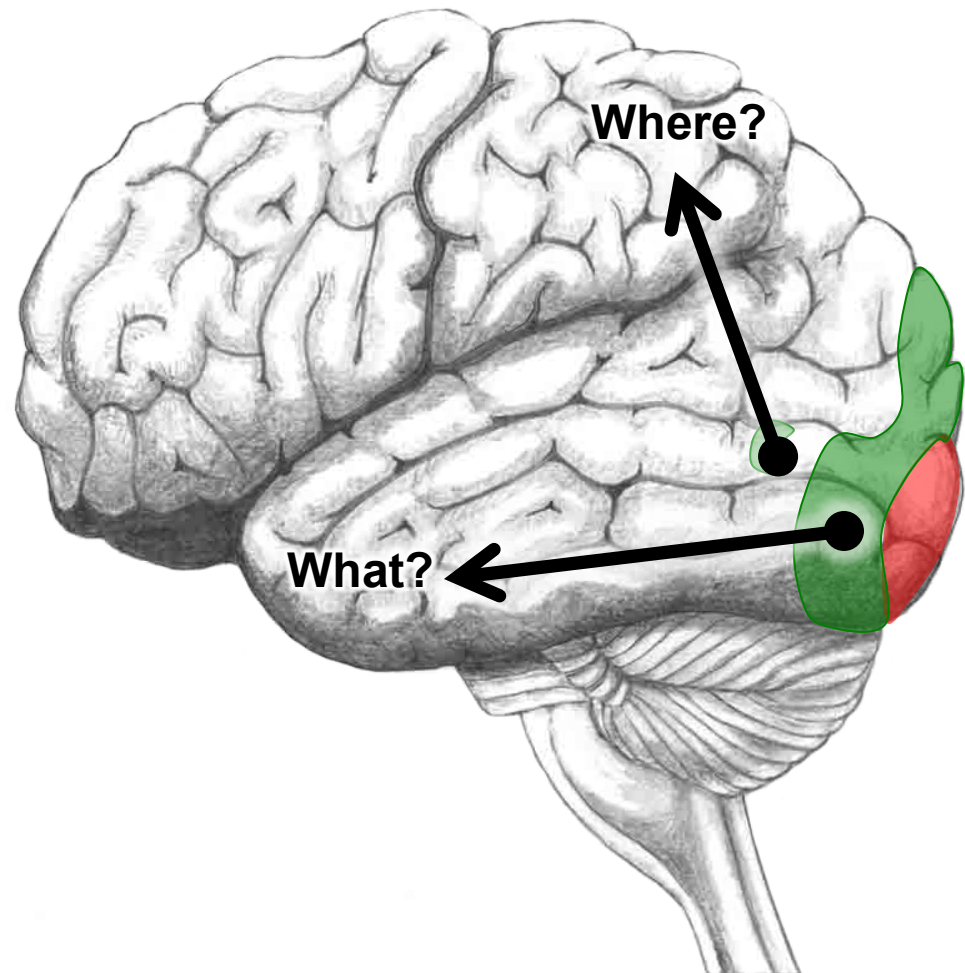
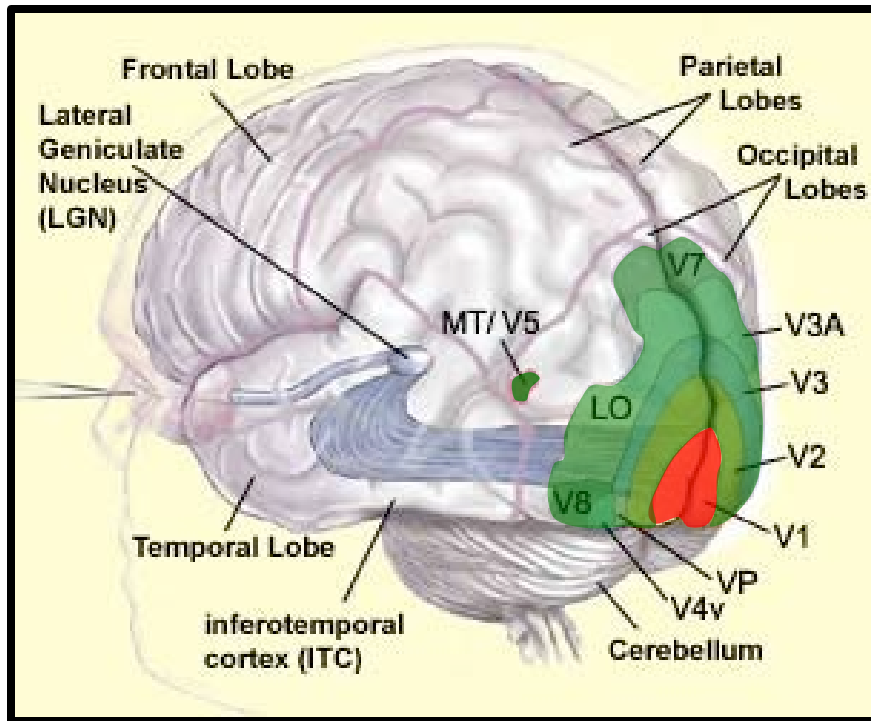
**FUNCTIONS:**  
visual processing



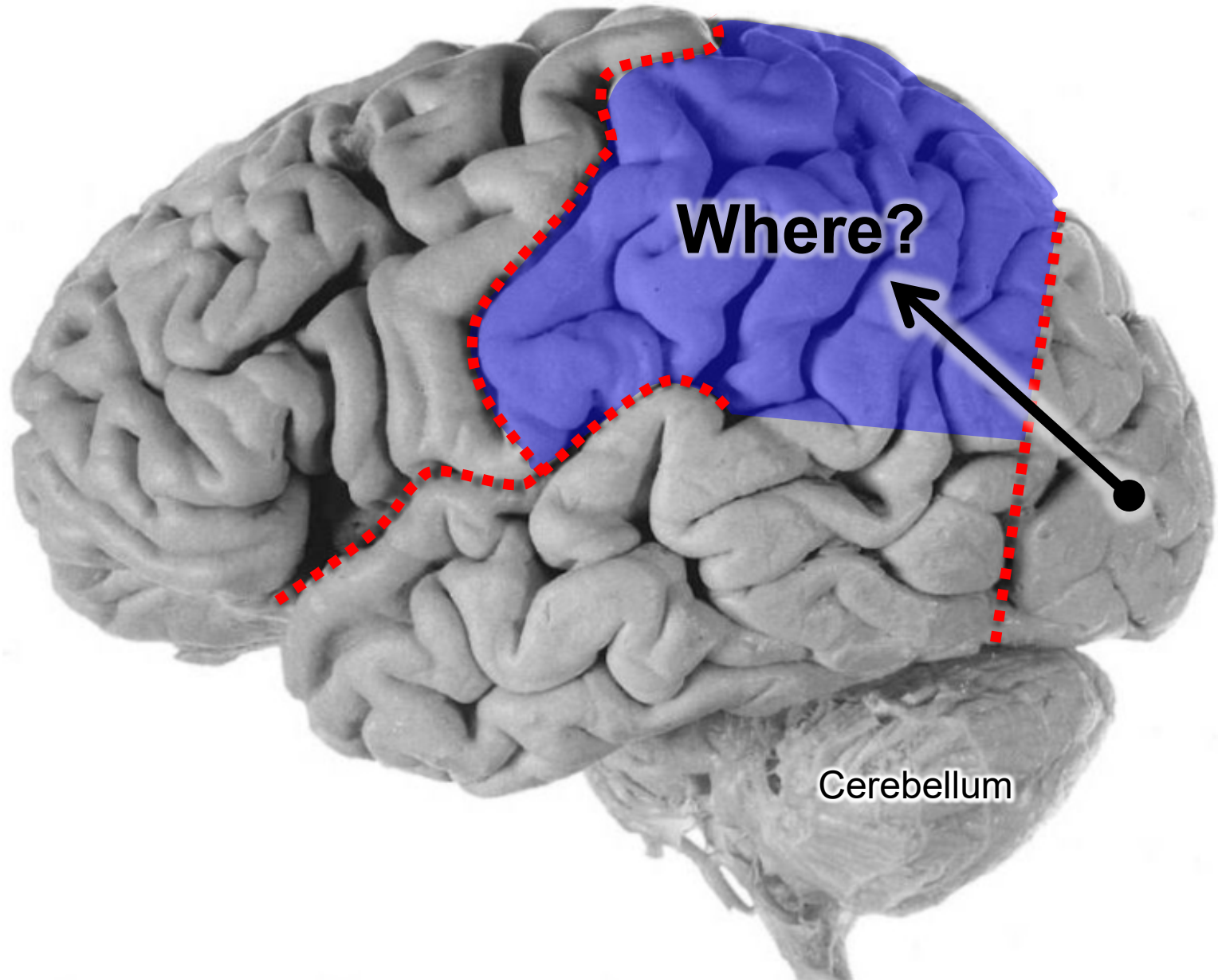
**Calcarine sulcus** –  
cortex superior and  
inferior to this sulcus  
constitutes the  
**primary visual cortex  
(V1)**

# Association visual cortex

Two major pathways extract feature information from V1: parietal “**where?**” and temporal “**what?**”



# Parietal lobe – *sensory integration*

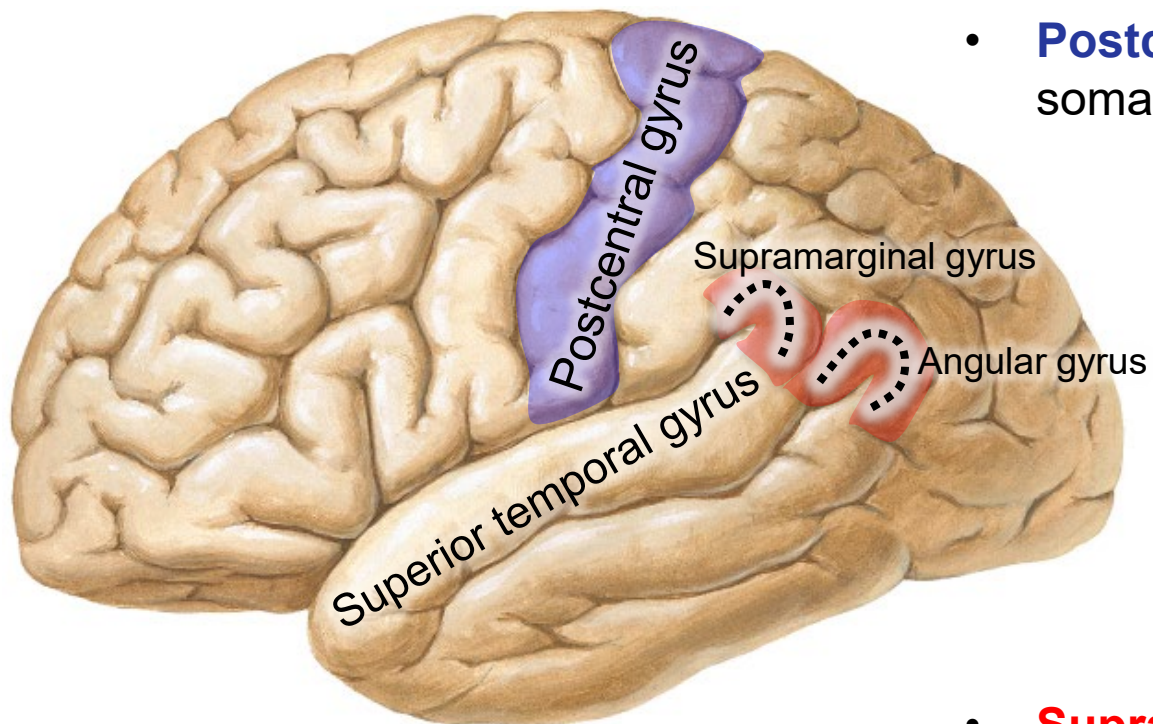




# Parietal lobe

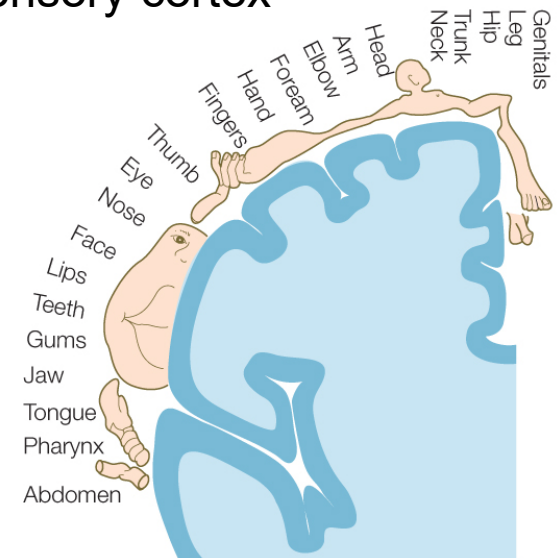
## FUNCTIONS:

Visual (*where?*) processing, sensory integration, spatial orientation, language



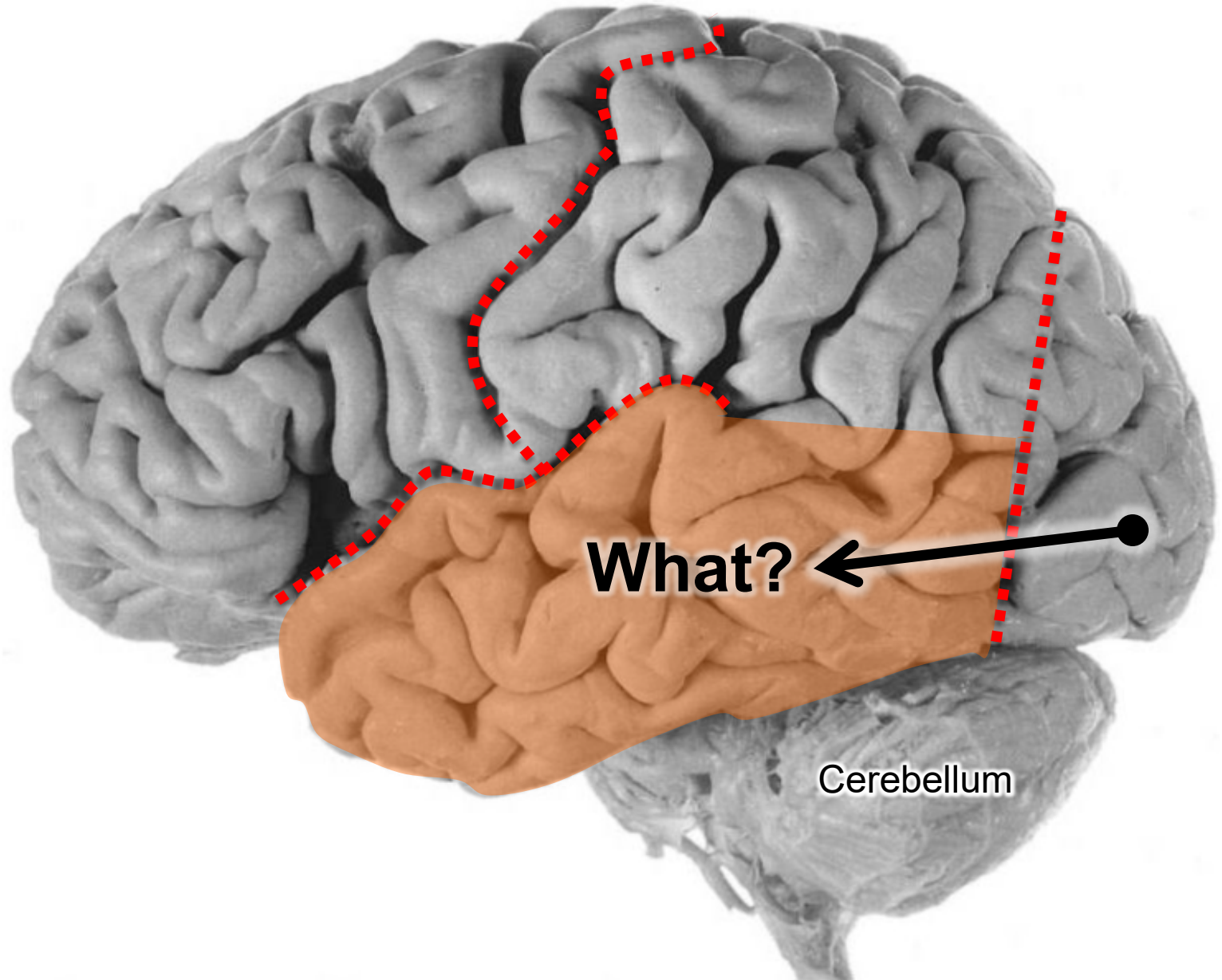
## SOME KEY FEATURES:

- **Postcentral gyrus** – primary somatosensory cortex



- **Supramarginal** and **angular gyri** – language processing on LEFT

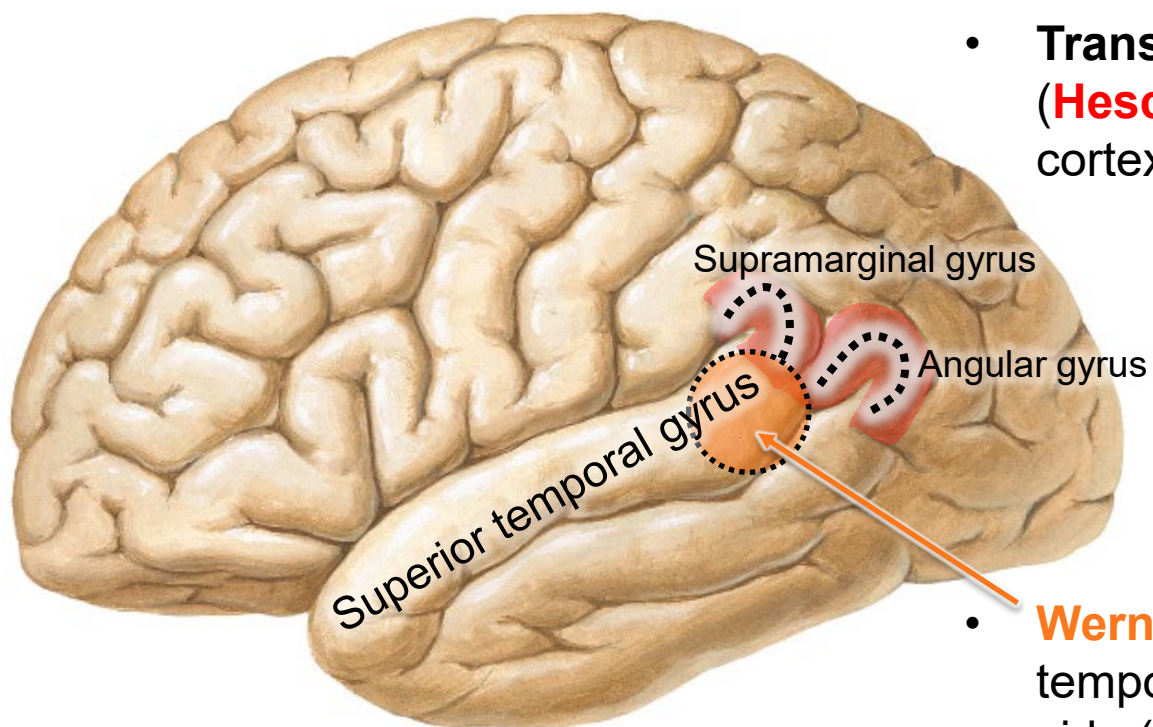
# Temporal lobe – *hearing, language, more*



# Temporal lobe

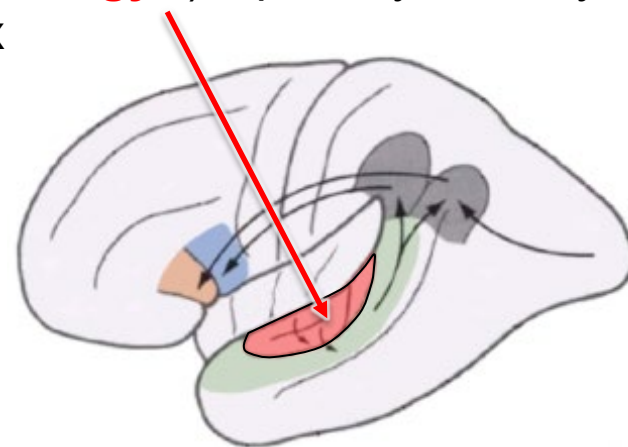
## FUNCTIONS:

Hearing, language processing, visual (*what?*) processing, memory, recognition and reaction system



## SOME KEY FEATURES:

- **Transverse temporal gyri (Heschl's gyri)** – primary auditory cortex

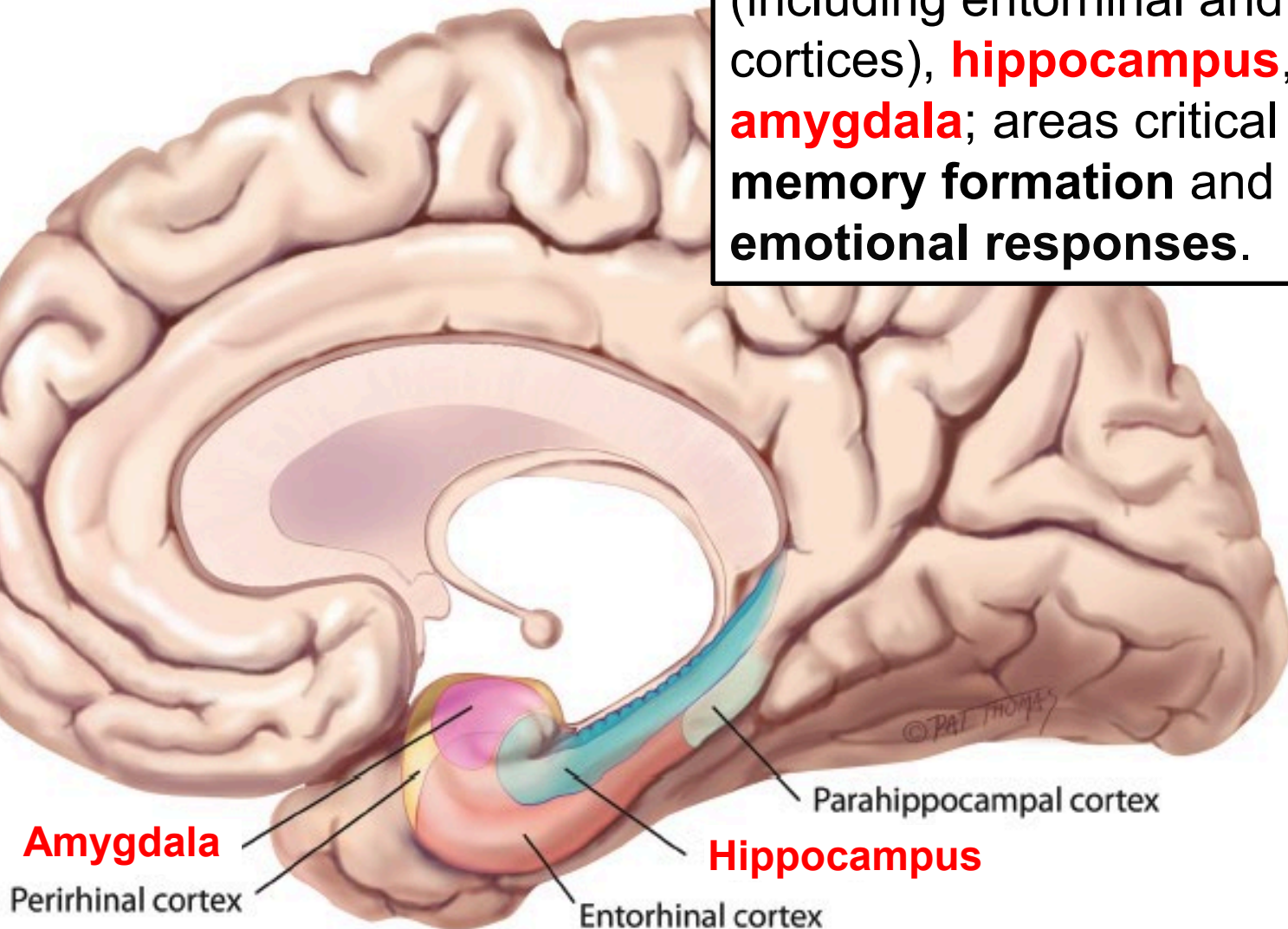


- **Wernicke's area** located in superior temporal gyrus on speech dominant side (LEFT); decodes verbal information in sound

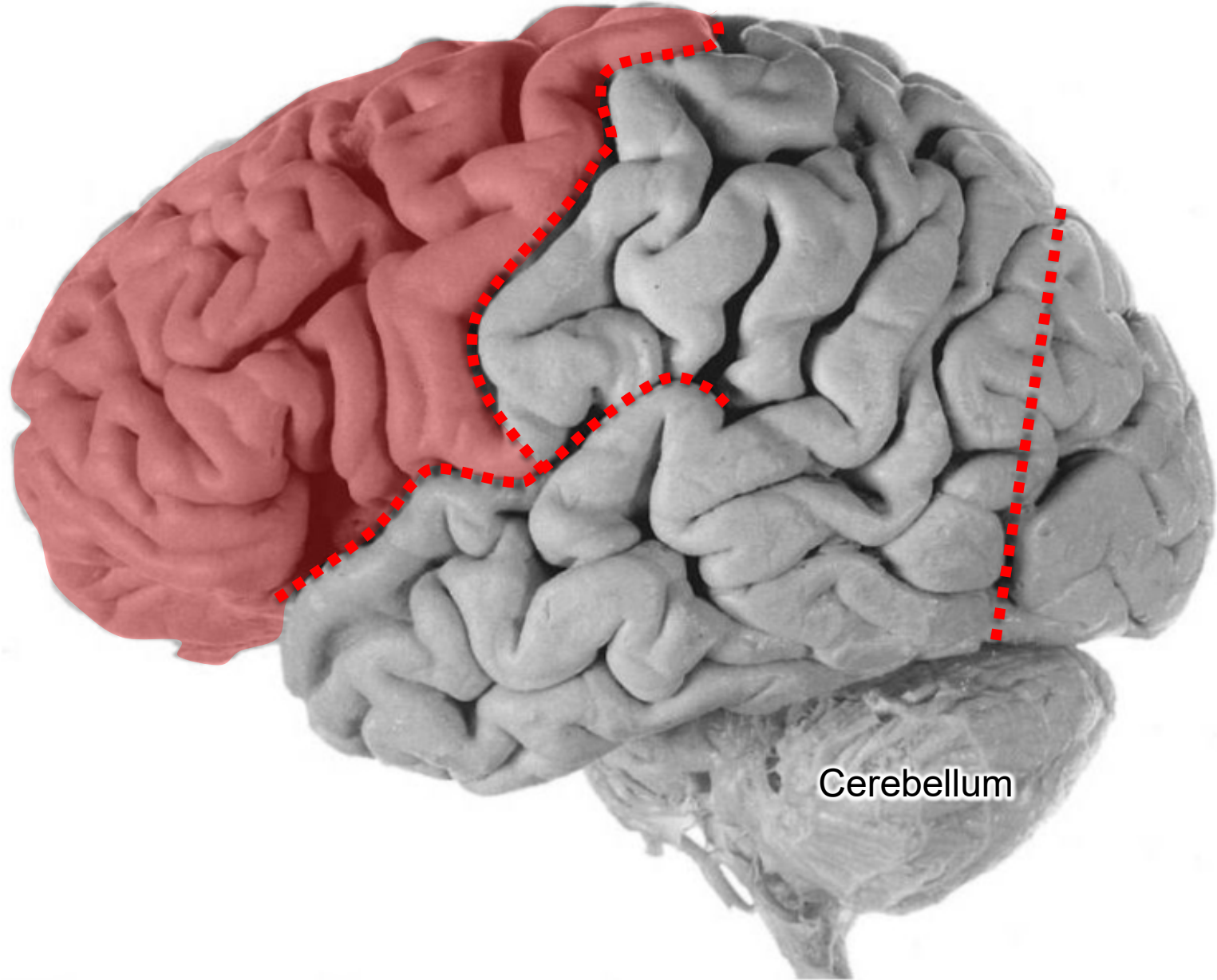


# Medial temporal lobe

Includes **parahippocampal gyrus** (including entorhinal and perirhinal cortices), **hippocampus**, and **amygdala**; areas critical for **memory formation** and **emotional responses**.



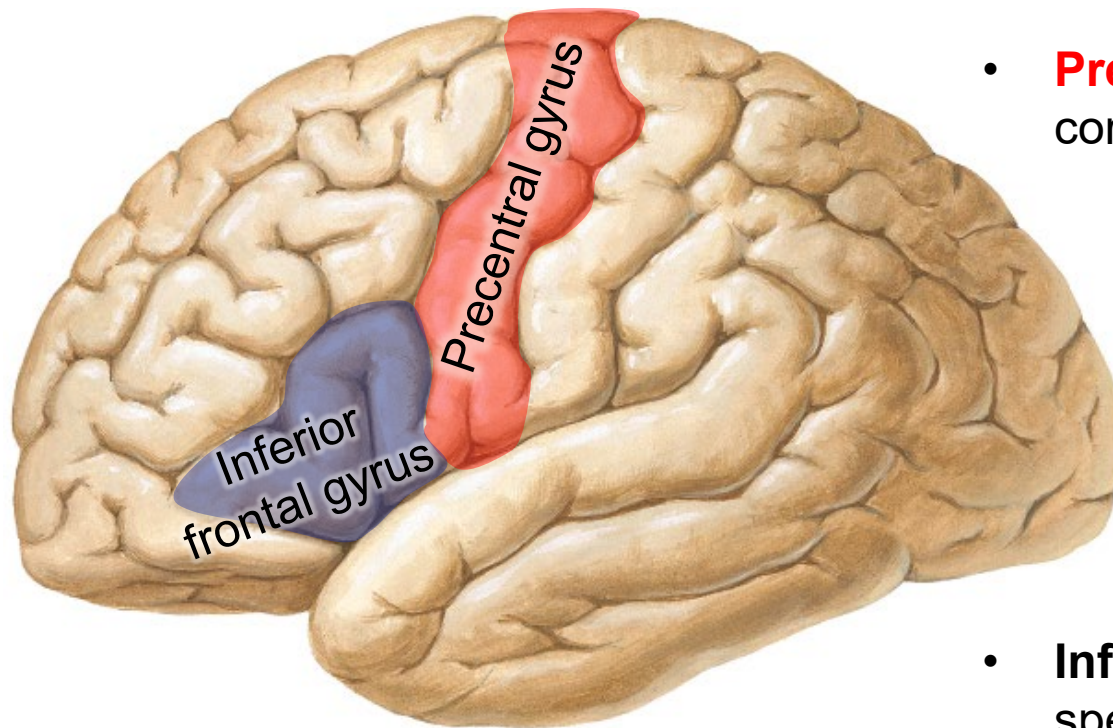
# Frontal lobe – *executive and motor control*



# Frontal lobe

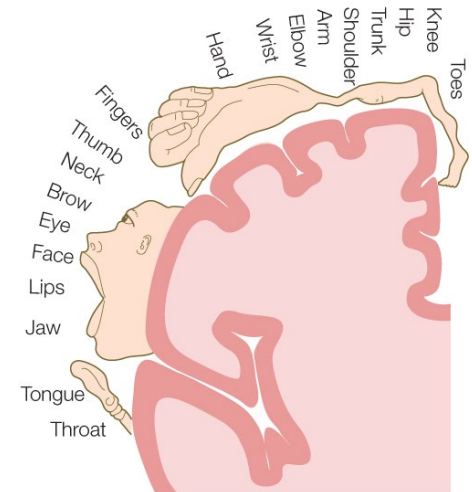
## FUNCTIONS:

Intelligence, personality, motivation, executive control, motor command



## SOME KEY FEATURES:

- **Precentral gyrus** – primary motor cortex

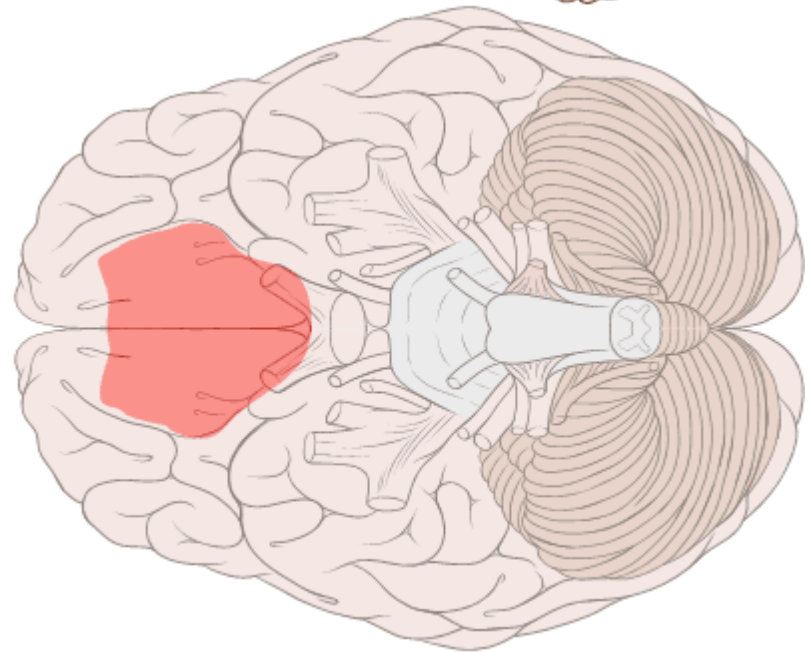


- **Inferior frontal gyrus** – on the speech dominant (usually left) side, contains **motor speech area (Broca's area)**

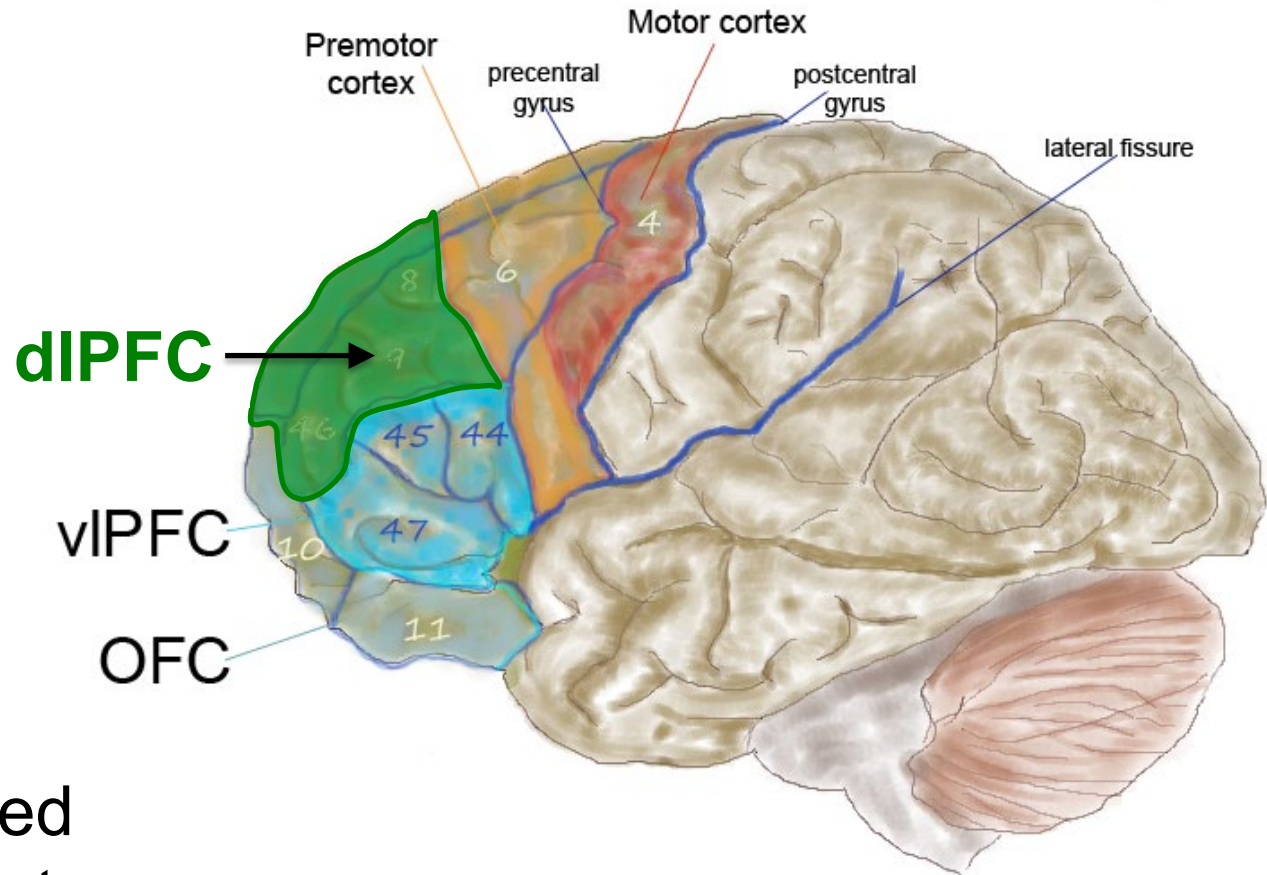


# Ventromedial prefrontal cortex (vmPFC)

**vmPFC** generates the **valence** or **'emotional charge'** of each experience



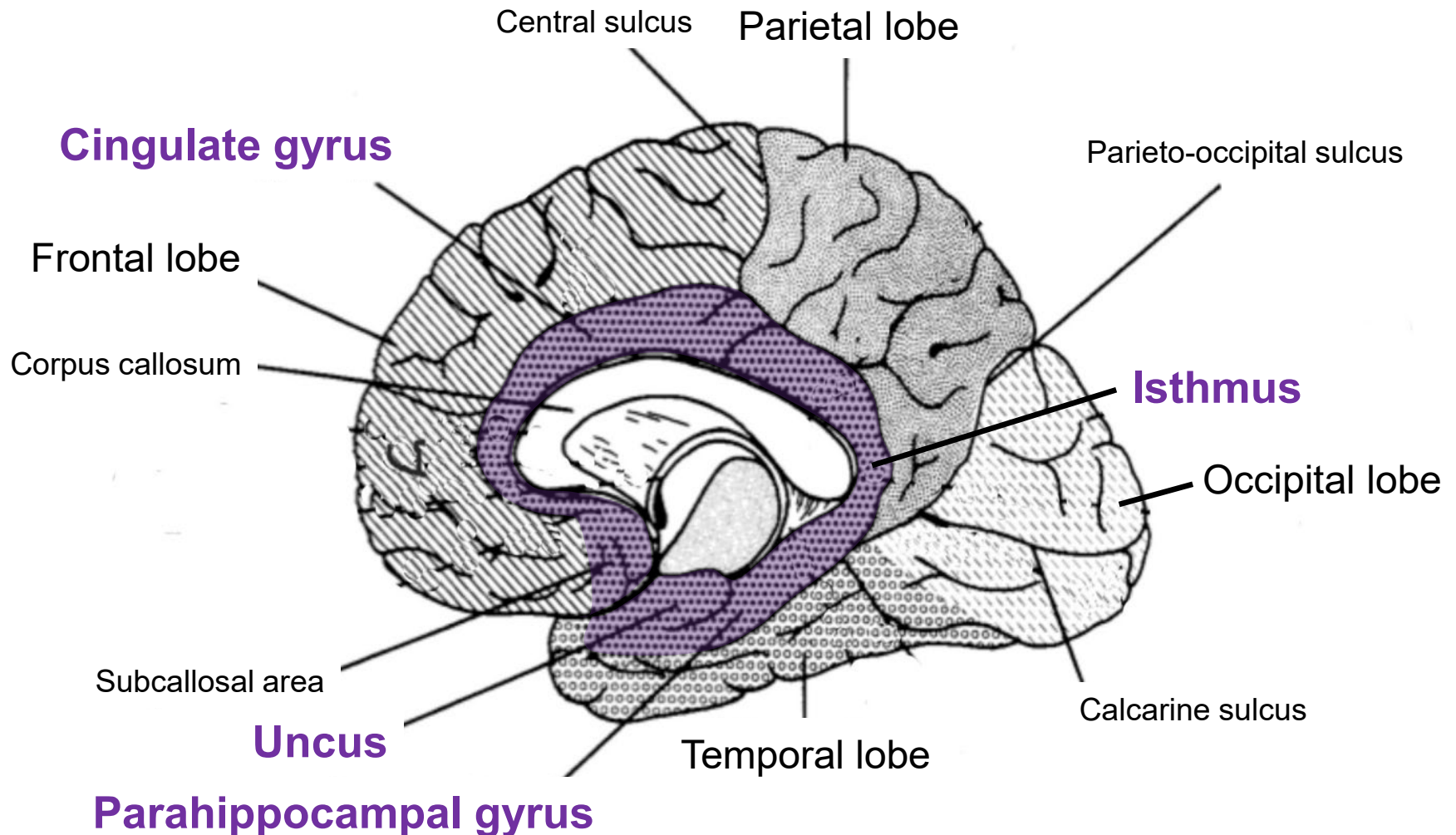
# Dorsolateral prefrontal cortex (dIPFC)



**dIPFC** is concerned with how to interact with stimuli via **decision making** and **working memory**

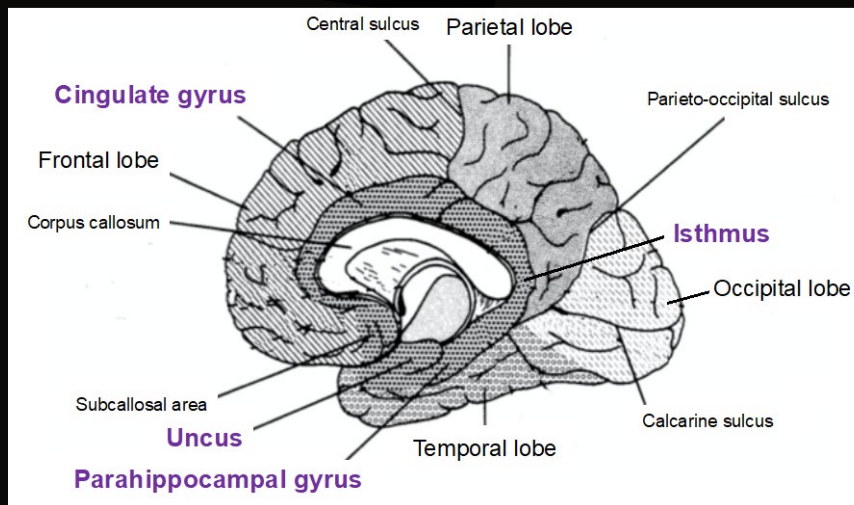
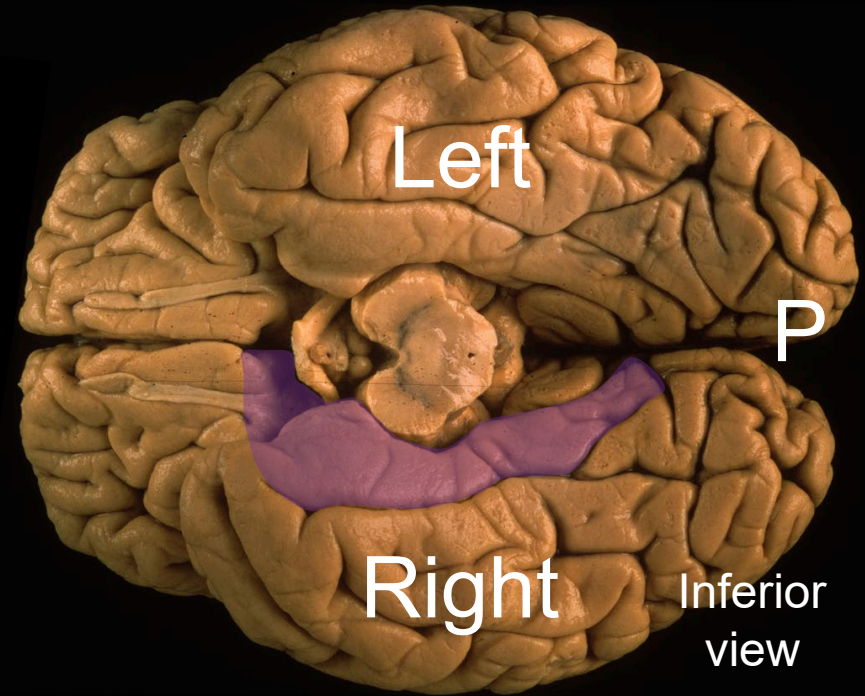
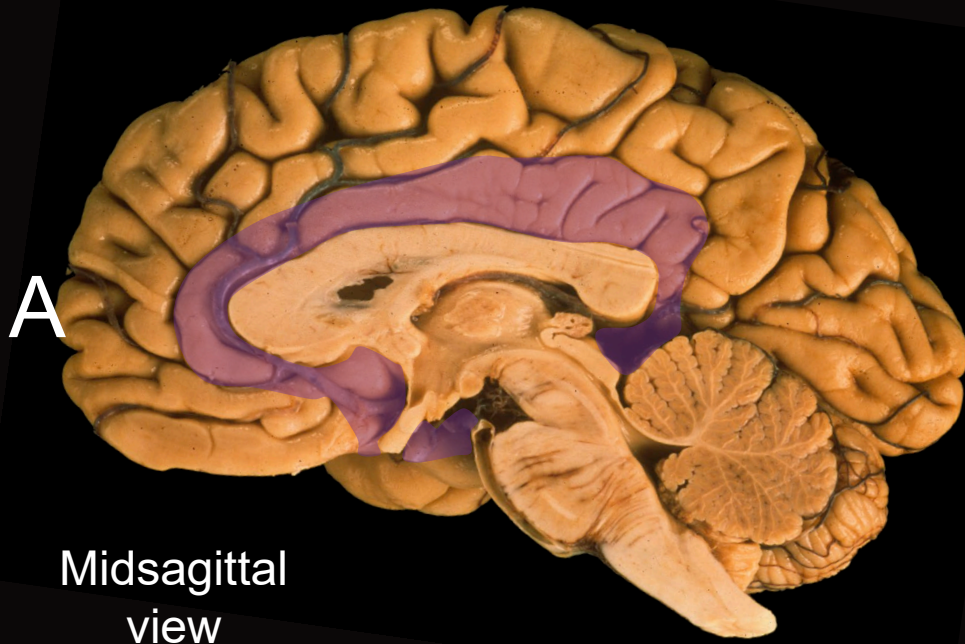
# So-called “limbic lobe”

SAGITTAL VIEW of R hemisphere, anterior is left





# Parts of the limbic lobe

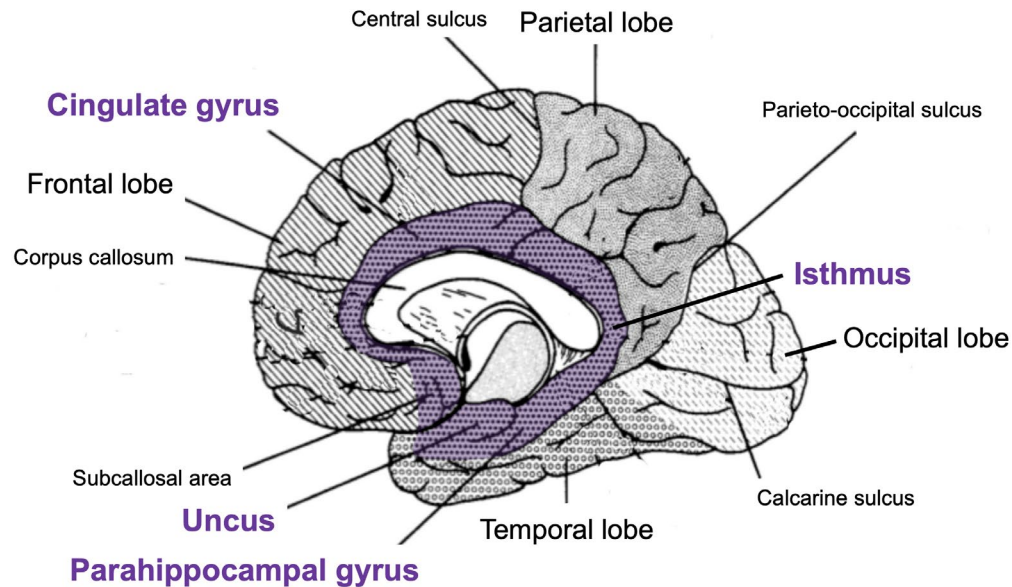


# So-called “limbic lobe”

## FUNCTIONS:

associated with emotions,  
basic drives, memory, smell

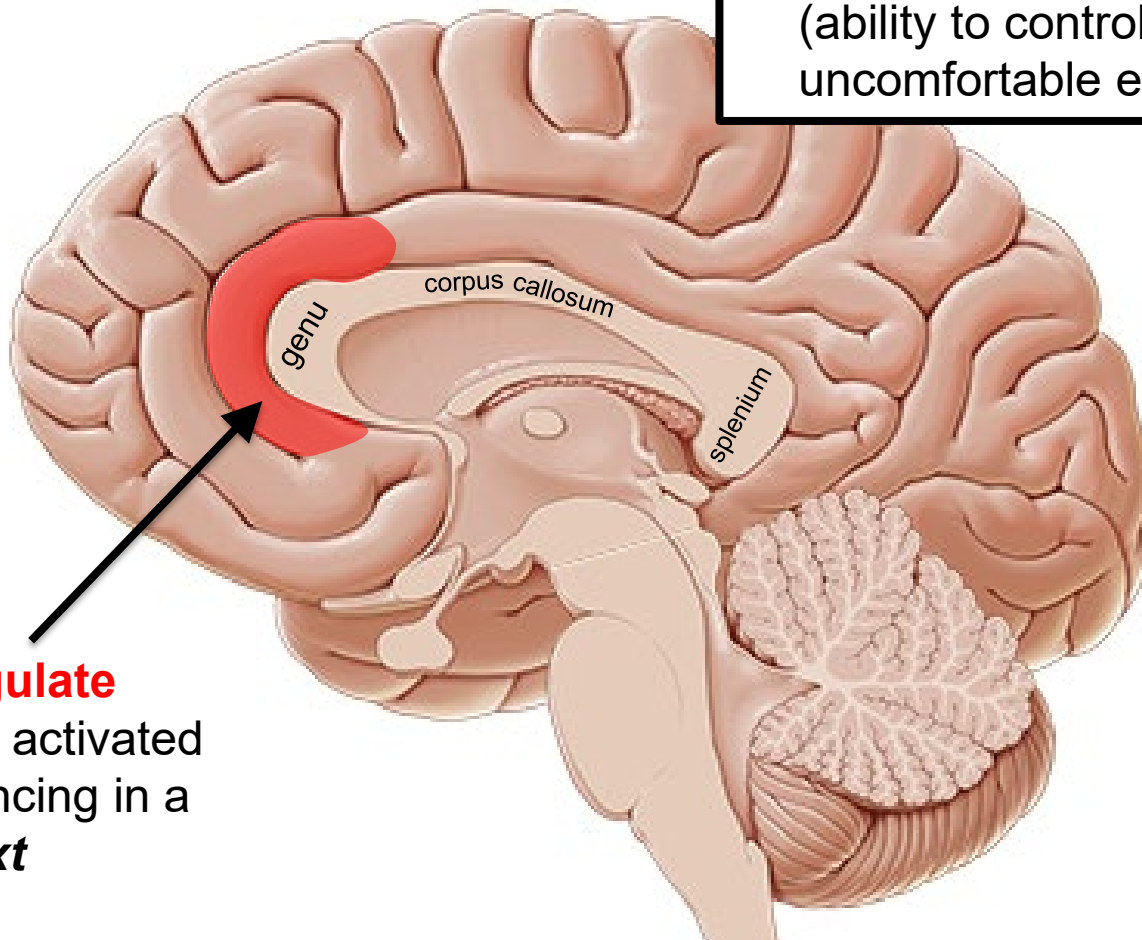
## SOME KEY FEATURES:



- **Cingulate gyrus** – involved with emotion formation and processing, learning, and memory
- **Uncus** – part of olfactory cortex (smell)
- **Parahippocampal gyrus** – surrounds **hippocampus** (in medial temporal lobe); role in memory encoding and retrieval; united with cingulate gyrus at **isthmus**

# Cingulate cortex and self-referencing

- Connections to both “emotional” limbic system and “cognitive” prefrontal cortex
- Major role in integration of circuits for **affect regulation** (ability to control/manage uncomfortable emotions)

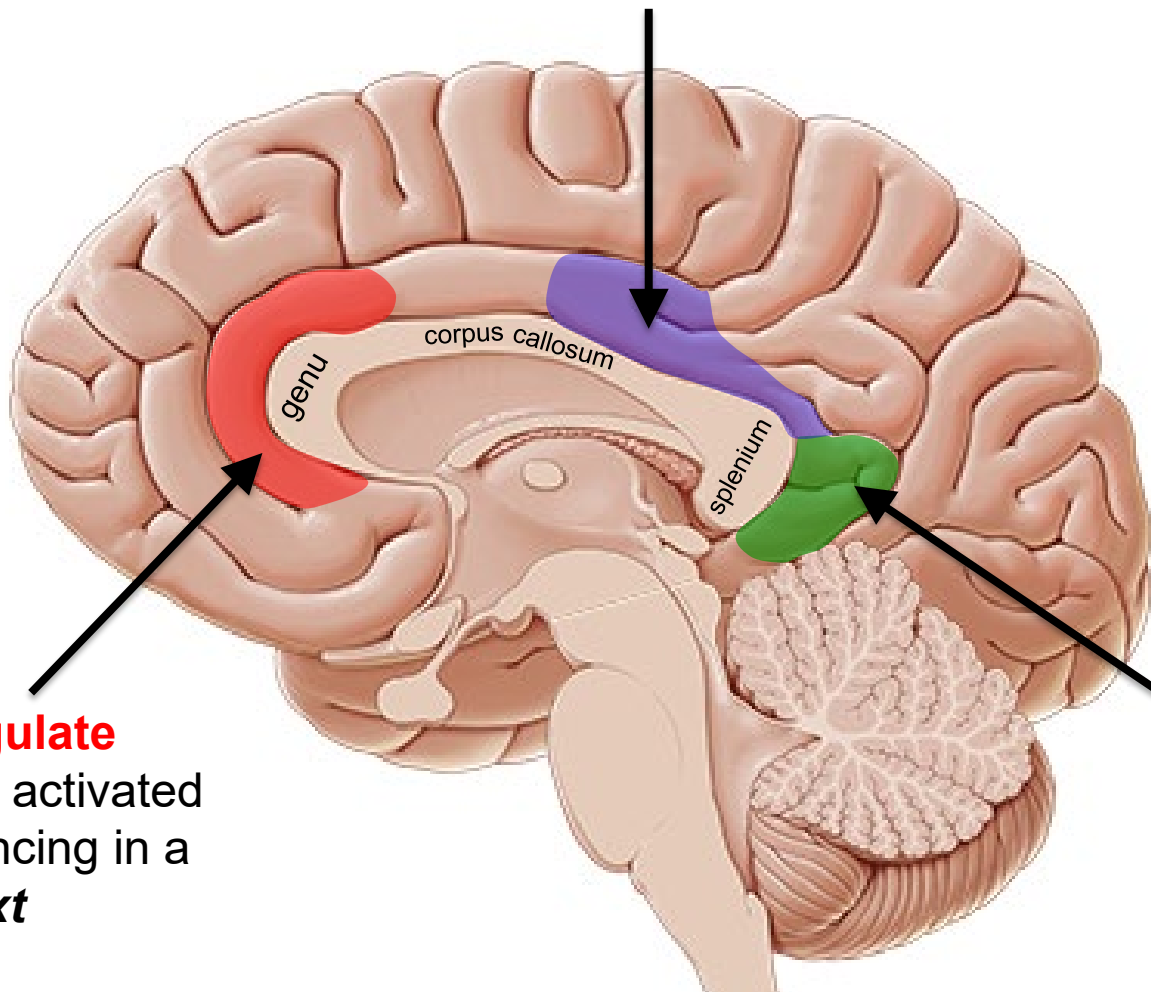


**Anterior cingulate cortex (ACC)** activated by self-referencing in a **social context**



# Cingulate cortex and self-referencing

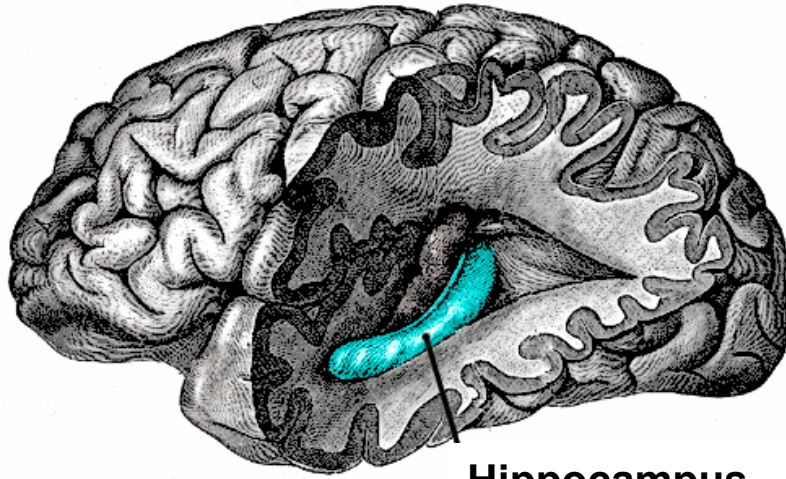
**Posterior cingulate cortex (PCC)** activated by self-referencing in a *spatial context*



**Anterior cingulate cortex (ACC)** activated by self-referencing in a *social context*

**Retrosplenial cortex** highly engaged during navigation tasks

# Hippocampus (limbic component)



Hippocampus

## **FUNCTIONS:**

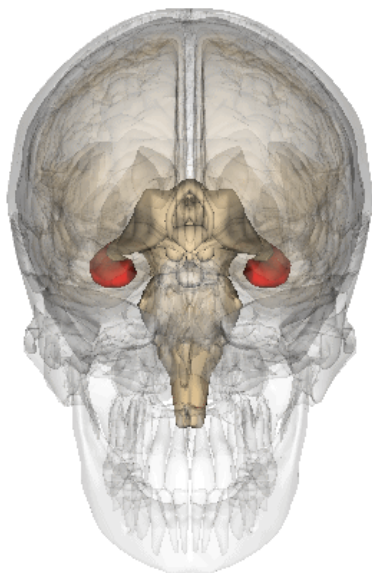
prominent role in **memory formation** and **retrieval**;  
*hub in corticohippocampal system*



# Hippocampus (limbic component)



Hippocampus



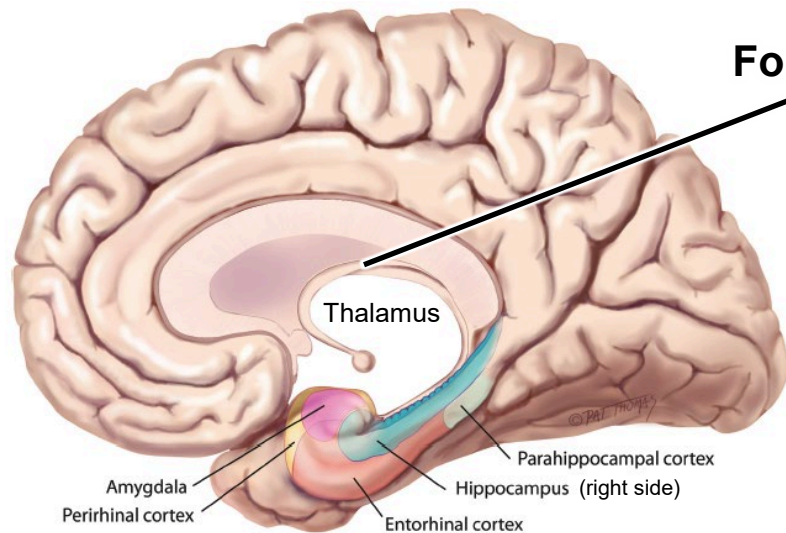
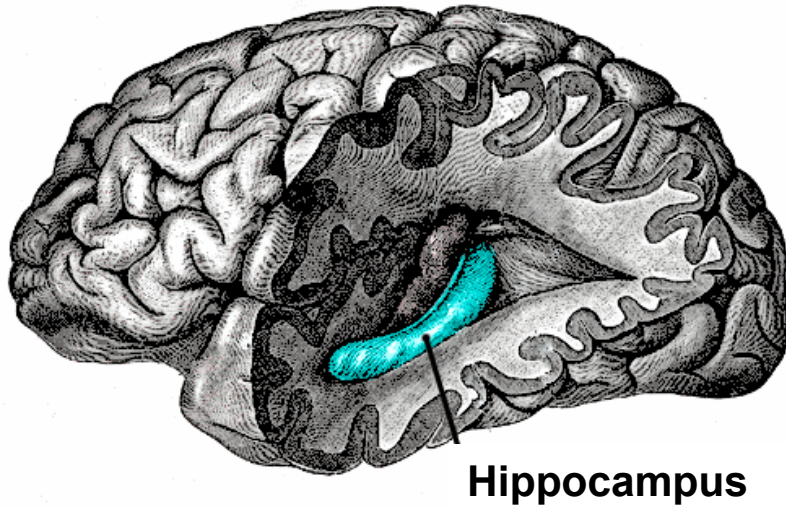
Formed by complex folding of most medial edge of telencephalon



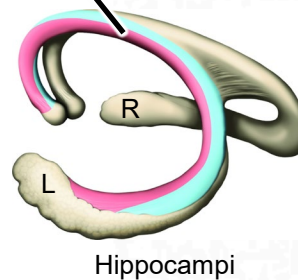


# Hippocampus (limbic component)

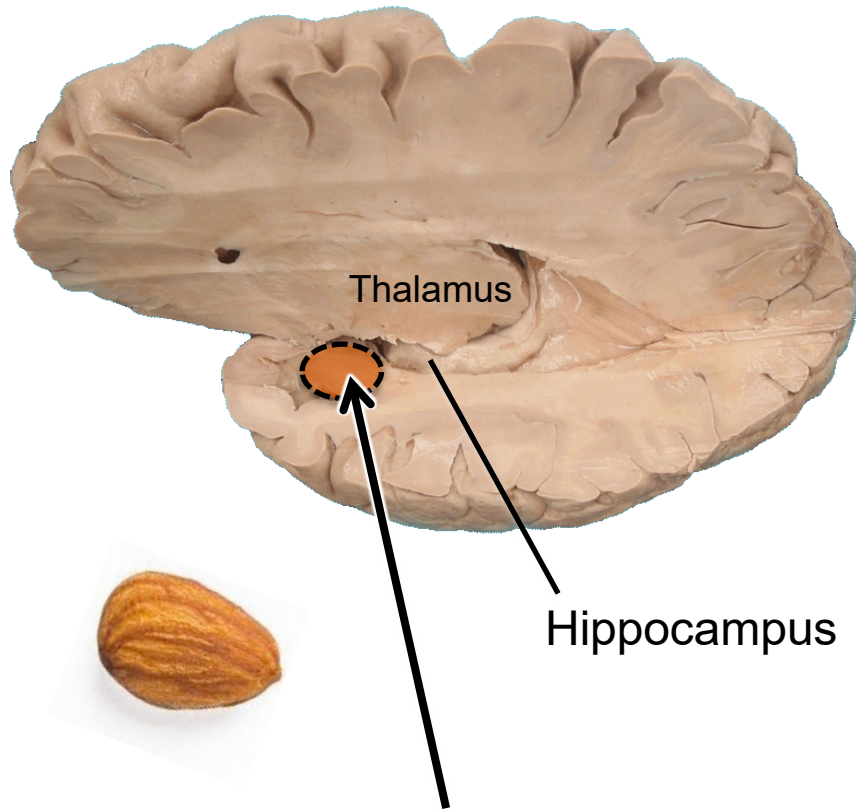
Formed by complex folding of most medial edge of telencephalon



Fornix



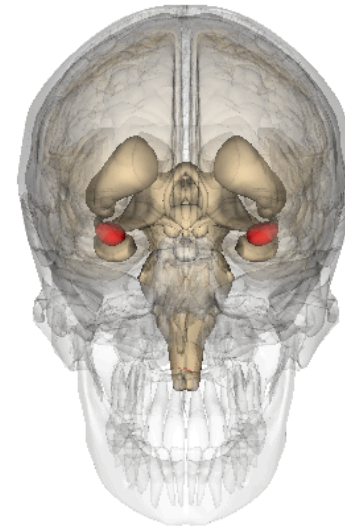
# Amygdala (limbic component)



**Amygdala:** almond-shaped complex of nuclei clustered in antero-medial temporal lobe, anterior to hippocampus

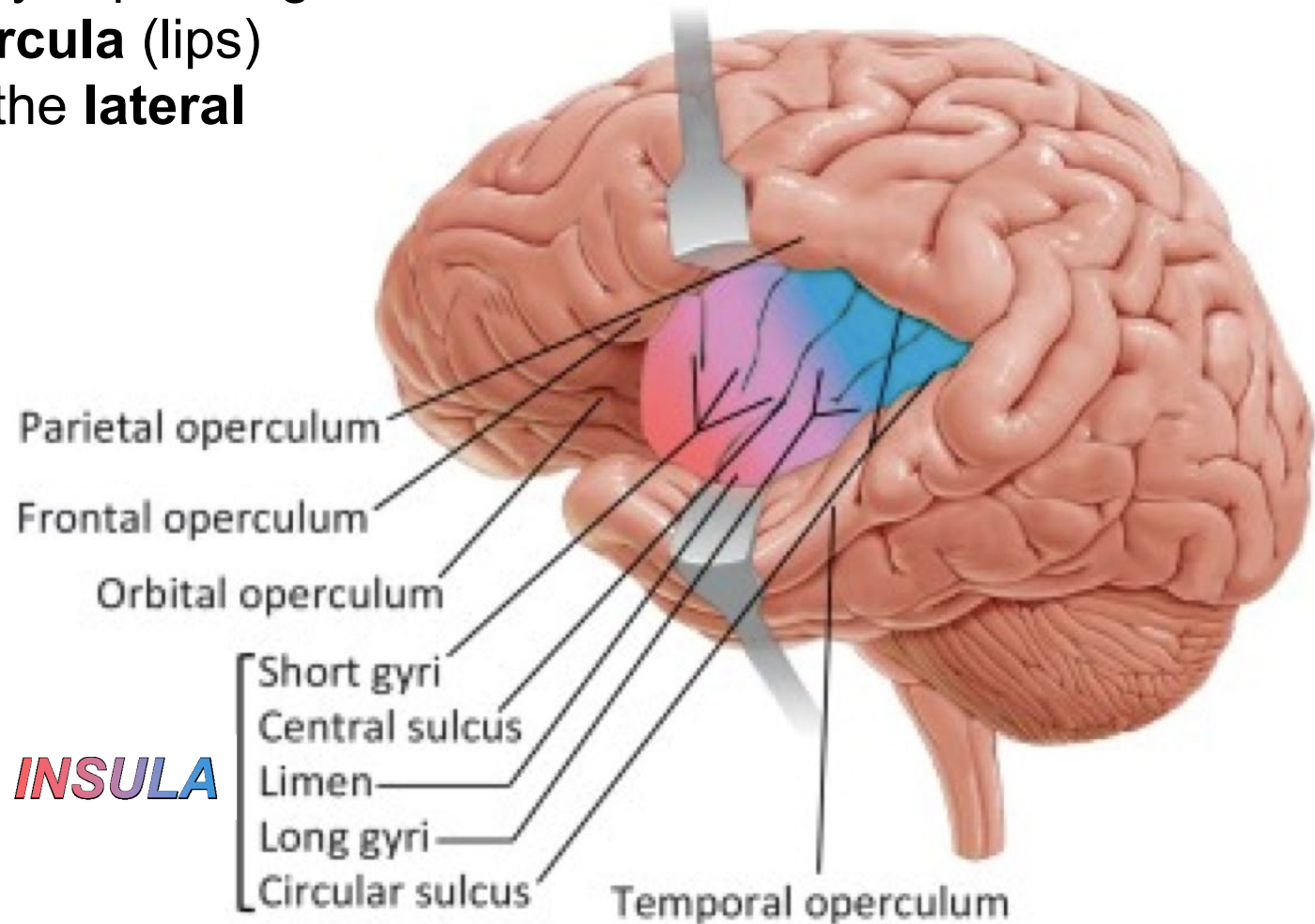
## **FUNCTIONS:**

important for recognizing and reacting to challenges confronted in the environment; major roles in **associative learning** and **generation of emotions**; *hub in corticolimbic system*



# Insula (limbic component)

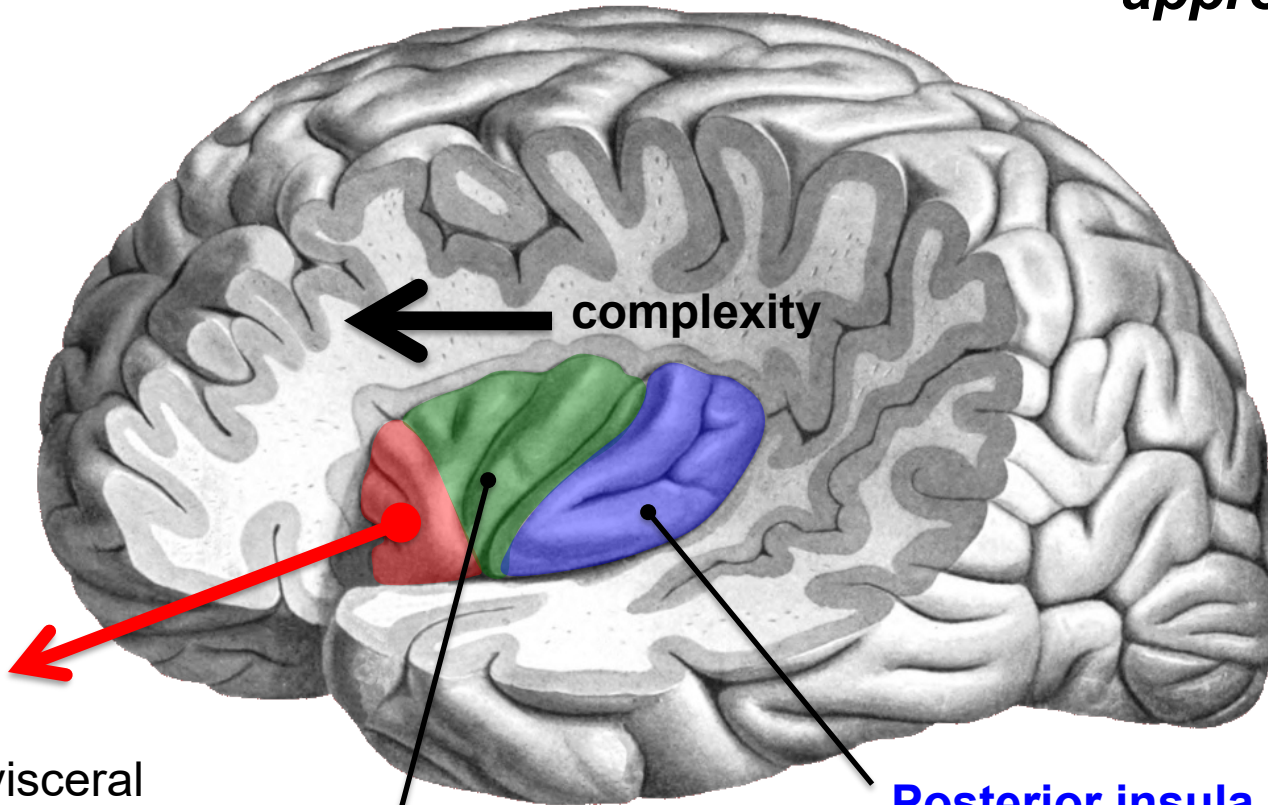
Visible by separating the **opercula** (lips) around the **lateral fissure**





# The insula is “primary interoceptive cortex”

*...locations highly approximated!*



Determines subjective intensity of visceral signals, presents to other limbic cortices

## Mid-insula

- Polymodal integration
- Sensory representation of viscera

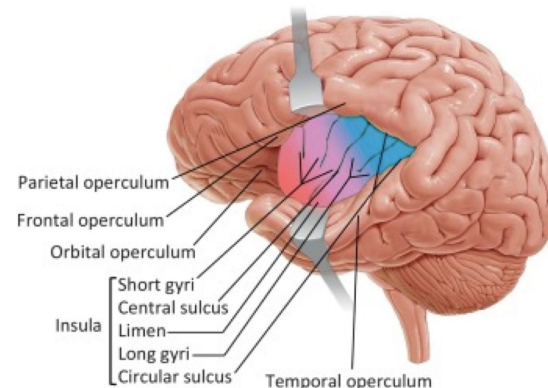
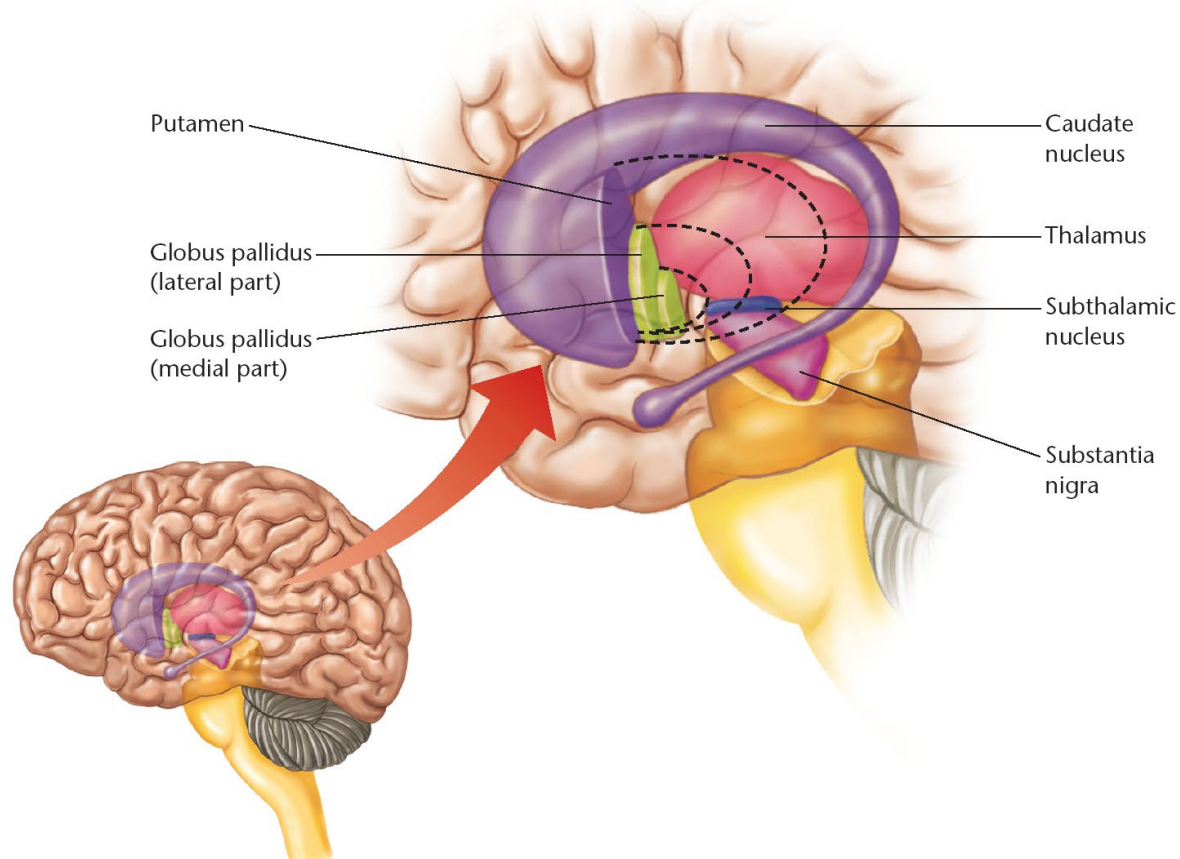
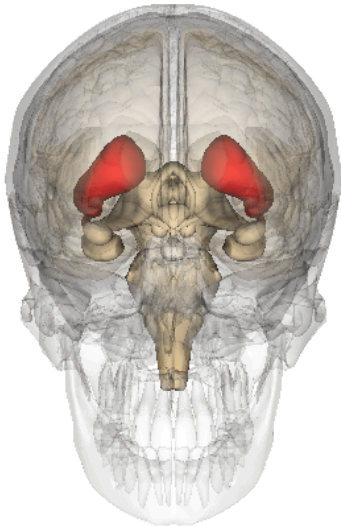
## Posterior insula

- Interoceptive awareness of our bodily state
- *E.g.*, internal temperature, sexual arousal, visceral pain, ANS changes

# Basal “ganglia” in deep telencephalon

## **FUNCTIONS:**

activates and coordinates internally generated movements (**action selection**); consolidation of *procedural memory*

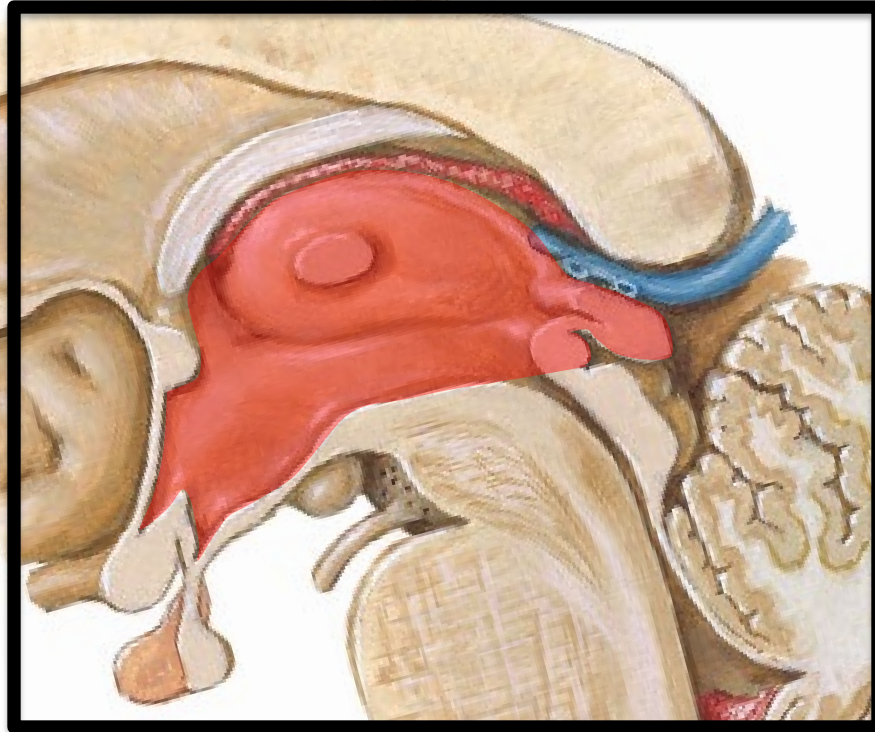


*Located deep to the insula*

# Diencephalon in sagittal section

←Anterior

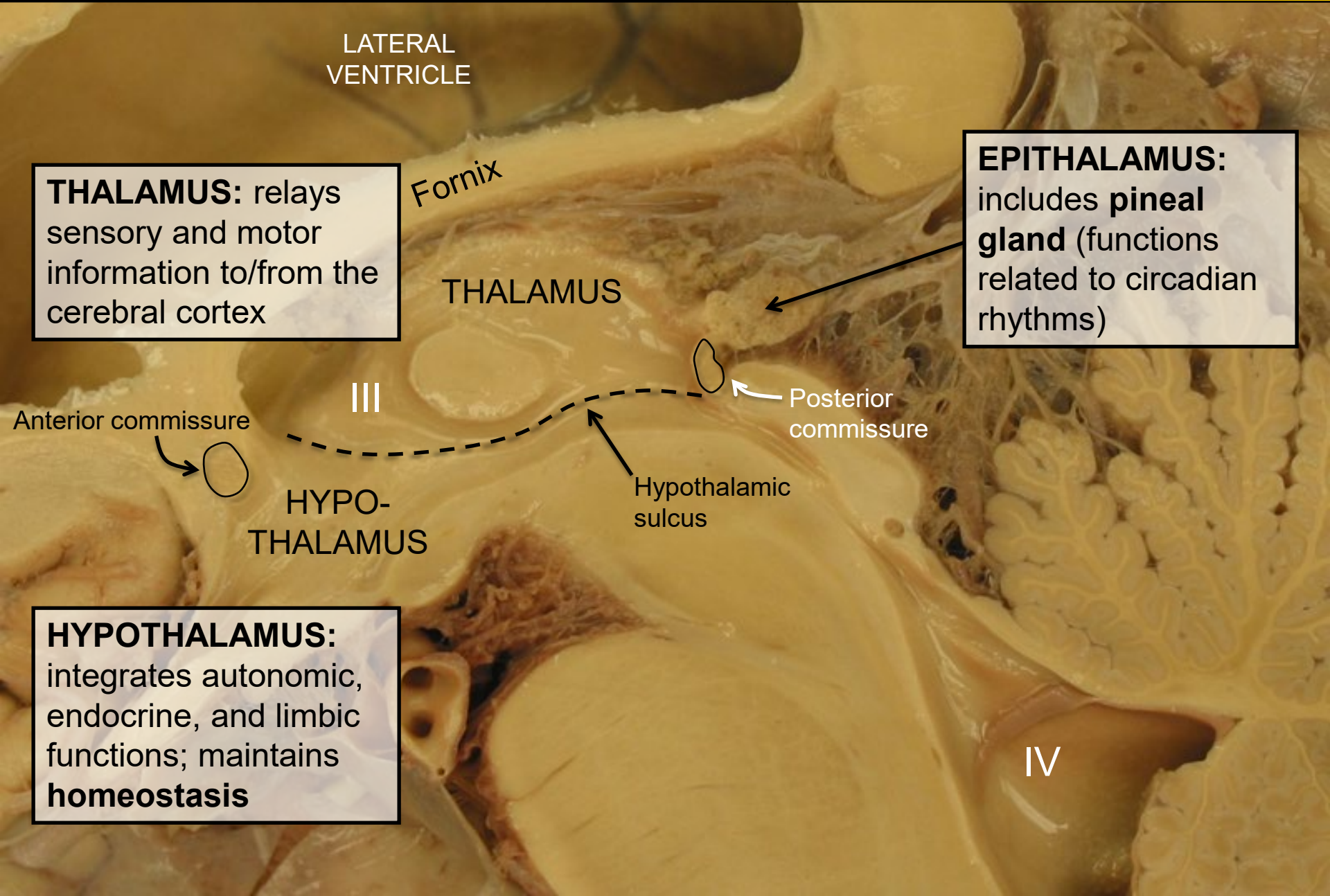
("interbrain")



Area demonstrated  
on next slide



# Diencephalon (sagittal section)



LATERAL  
VENTRICLE

**THALAMUS:** relays sensory and motor information to/from the cerebral cortex

Fornix

THALAMUS

**EPITHALAMUS:** includes **pineal gland** (functions related to circadian rhythms)

III

Anterior commissure



HYPO-  
THALAMUS

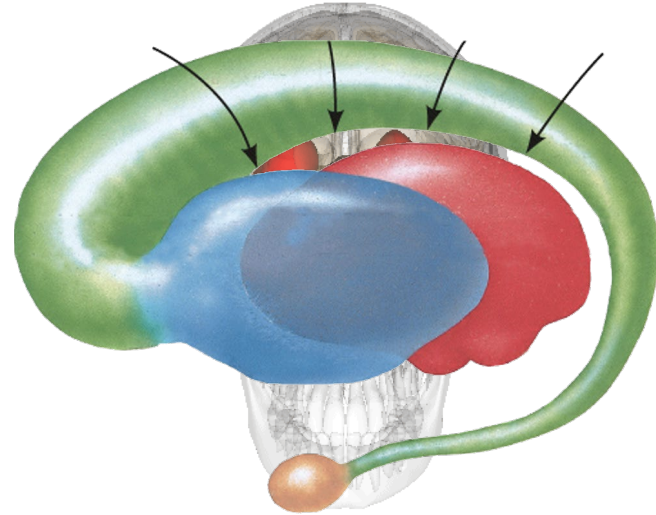
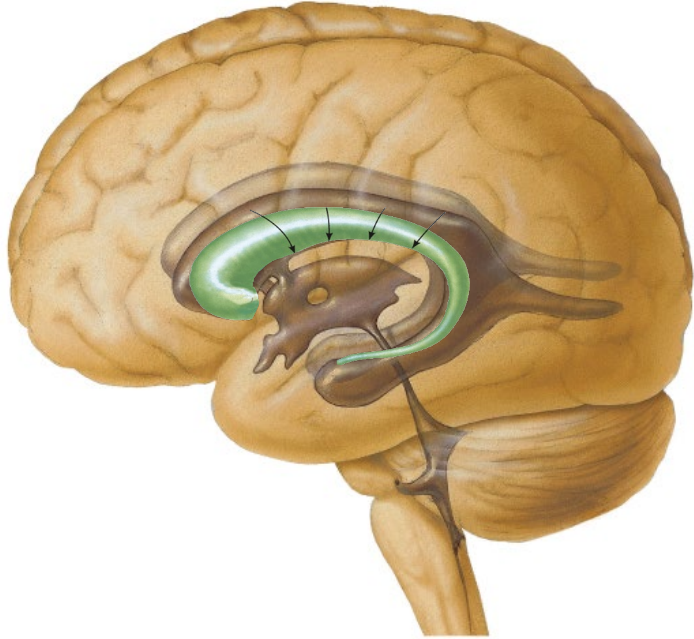
Hypothalamic  
sulcus

Posterior  
commissure

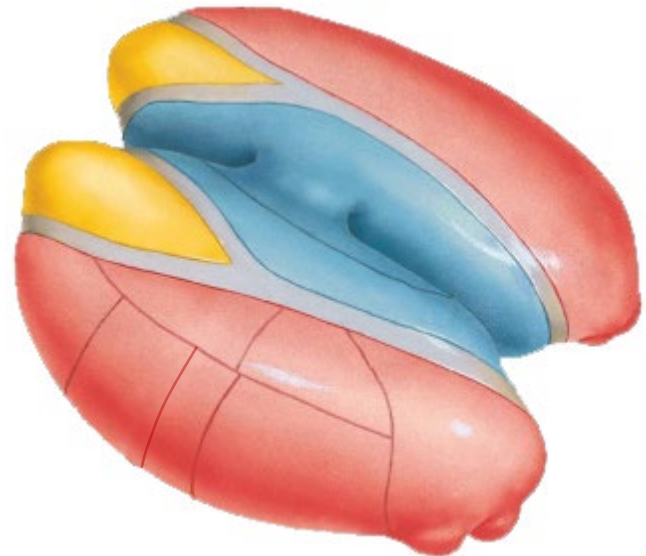
**HYPOTHALAMUS:** integrates autonomic, endocrine, and limbic functions; maintains **homeostasis**

IV

# Complex 3D structures to identify in 2D

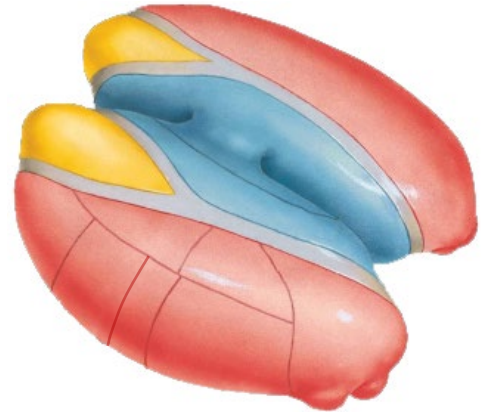
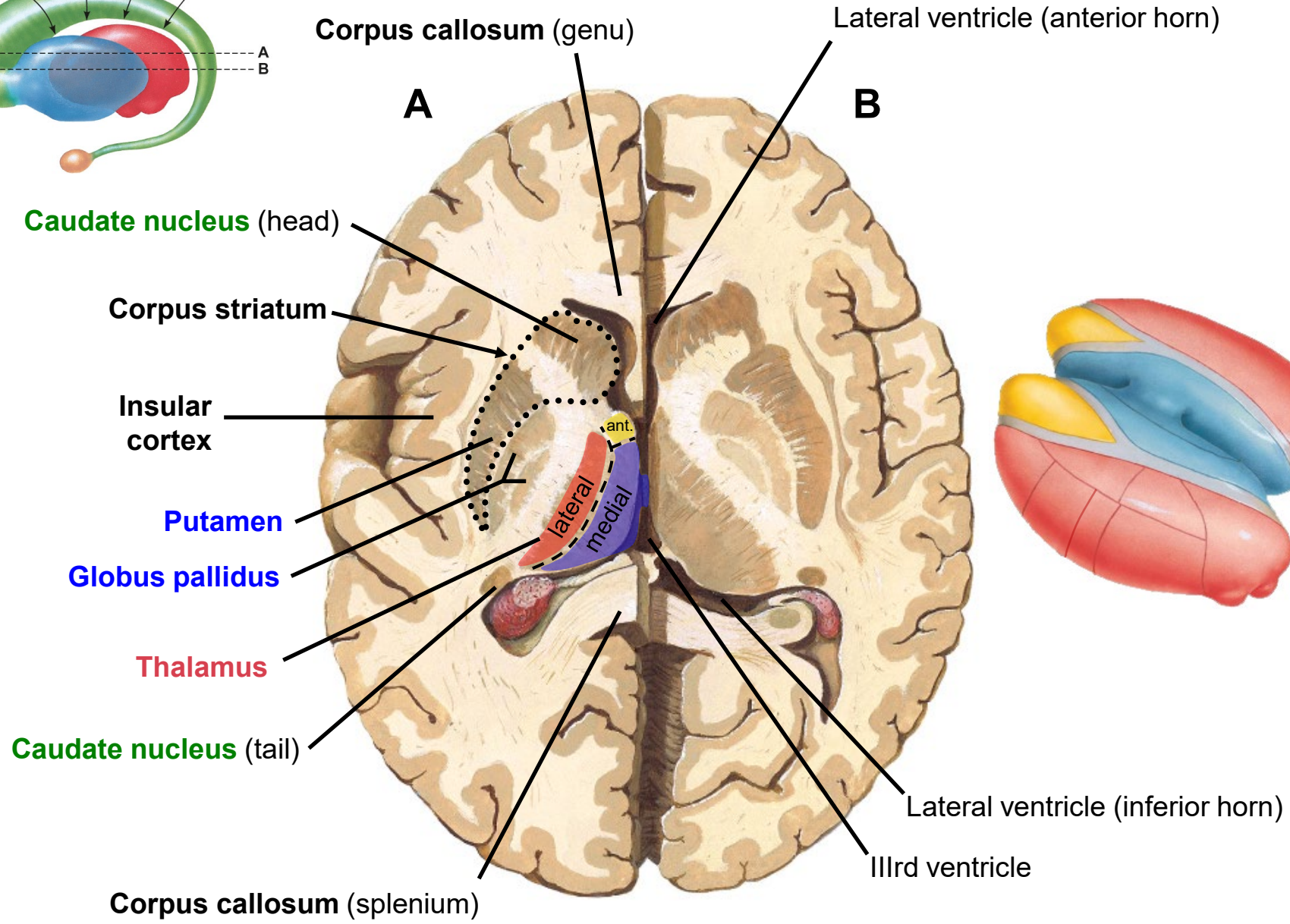
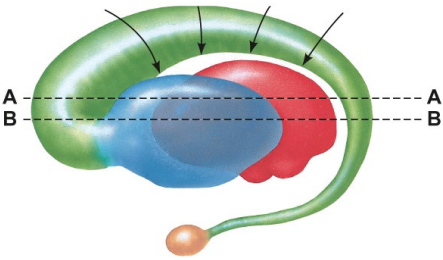


Thalamus



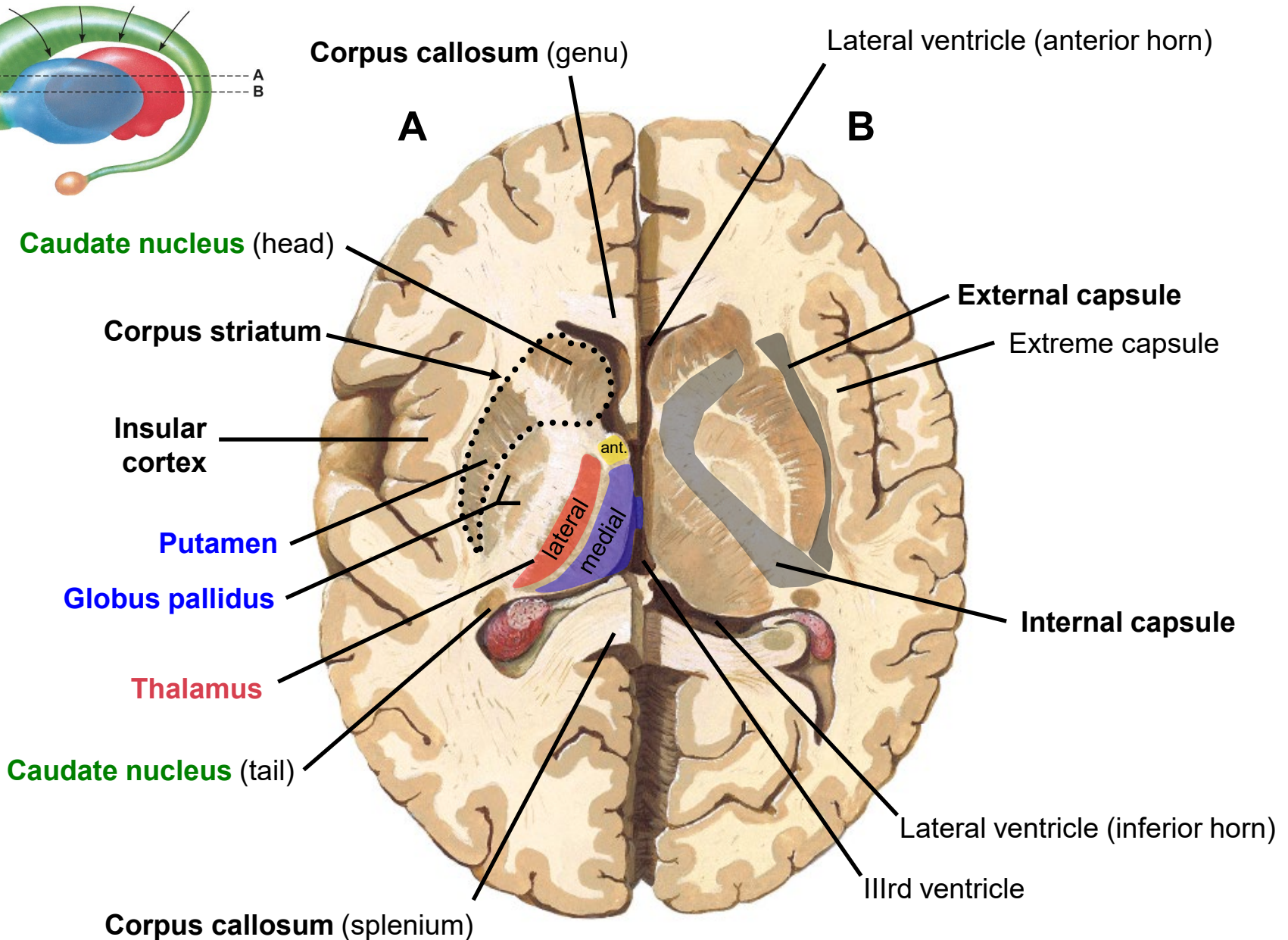


# The “basal ganglia” and thalamus





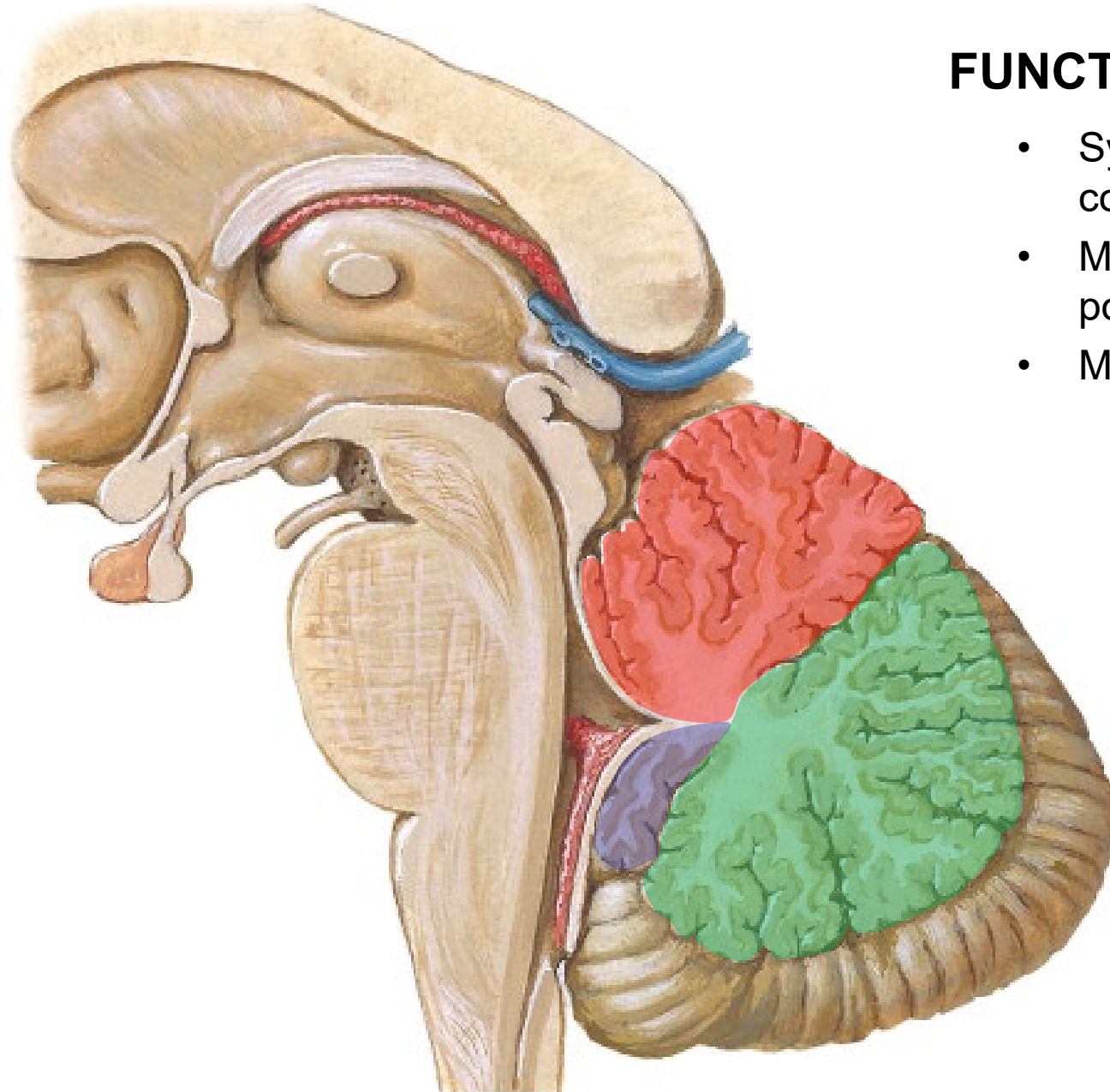
# Internal capsule



# The cerebellum (“little brain”)

## FUNCTIONS:

- Synergizes and corrects movement
- Maintains upright posture
- Maintains muscle tone



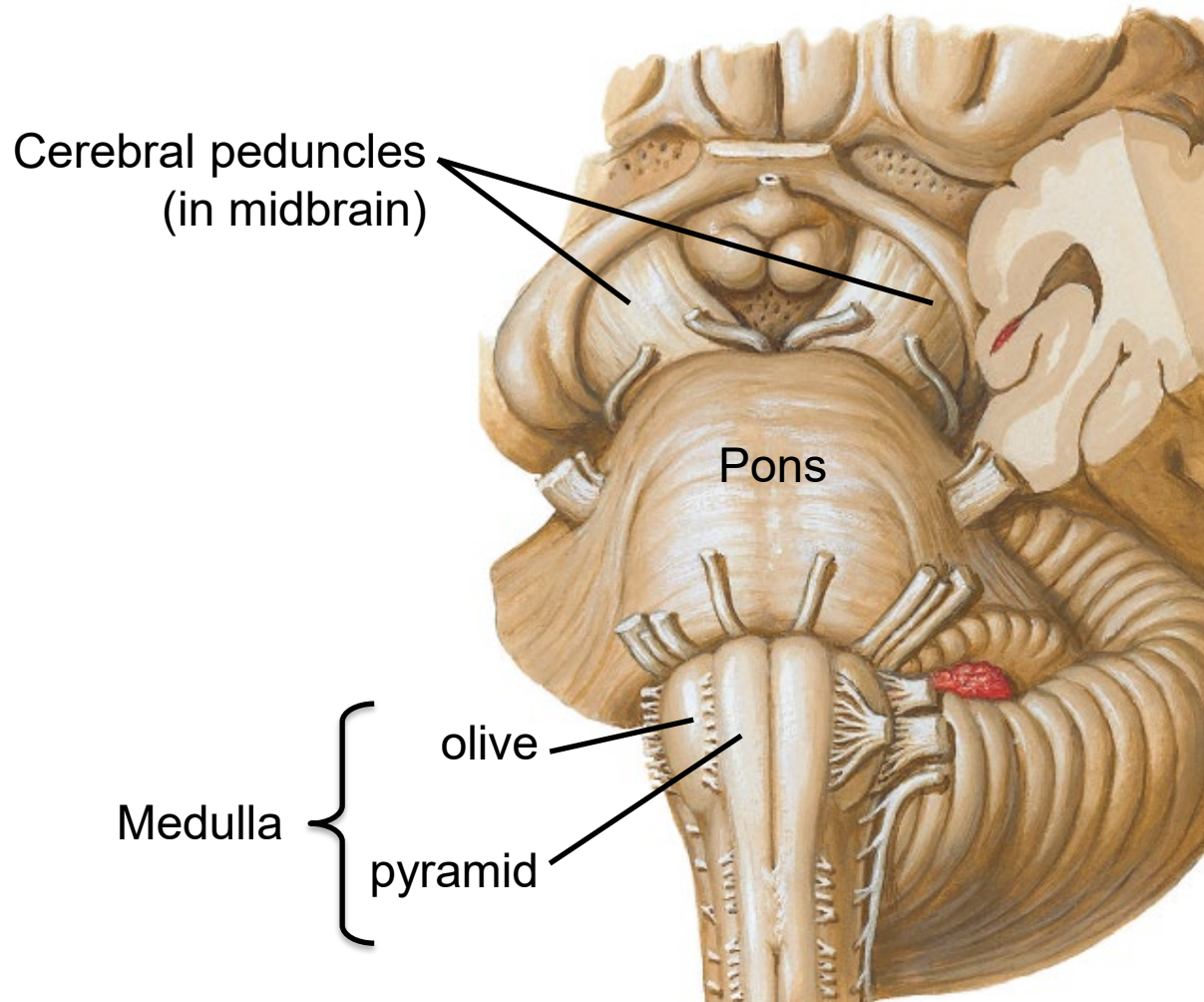
 **Anterior lobe**

 **Posterior lobe**

 **Flocculonodular lobe**

# Brainstem

Ventral view

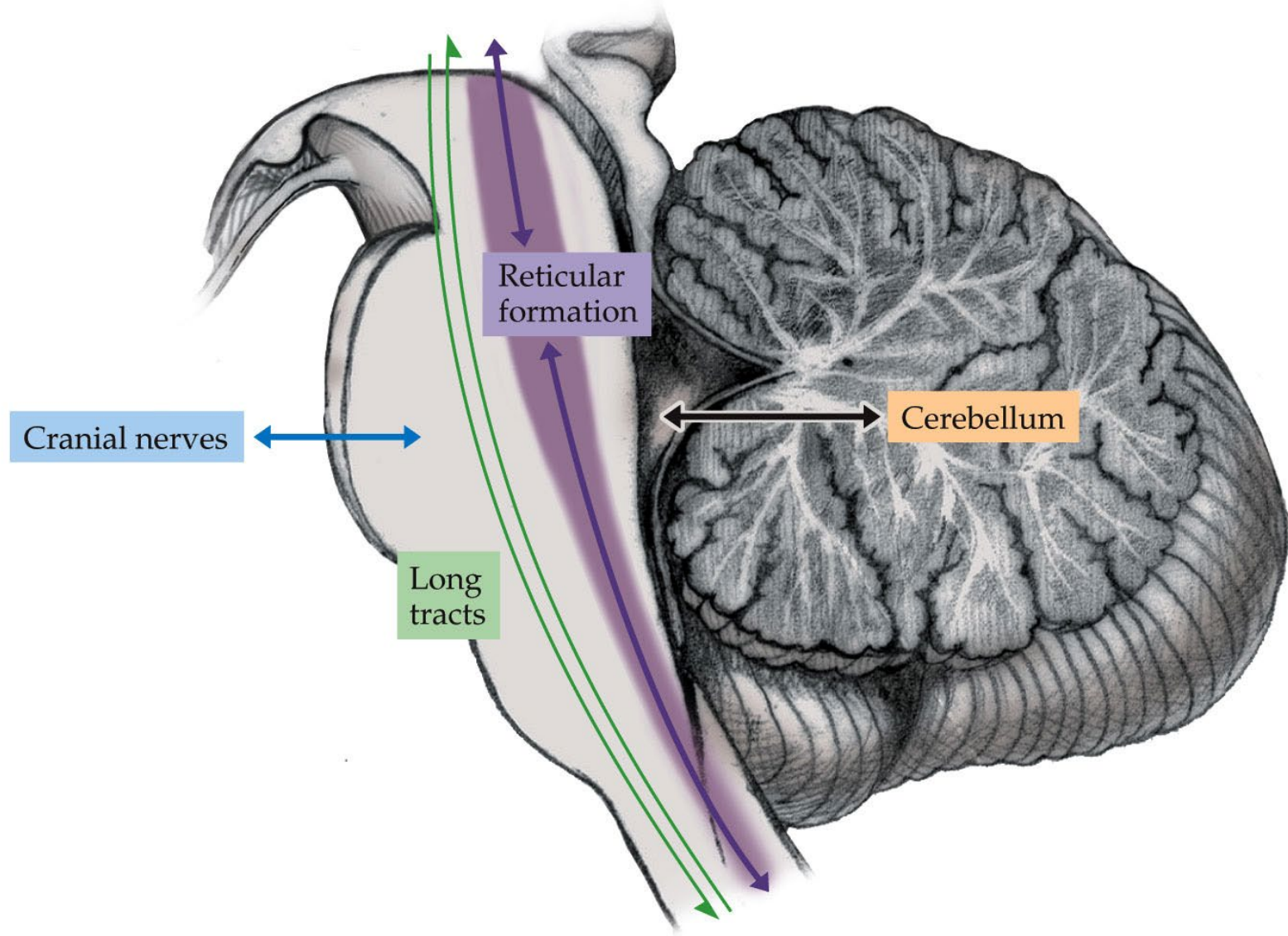


## **FUNCTIONS:**

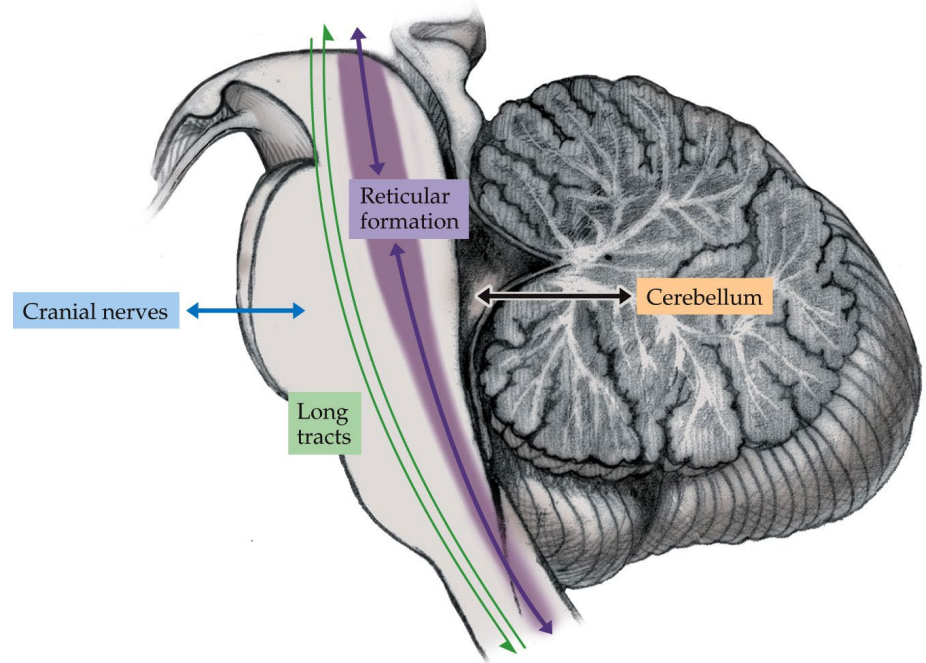
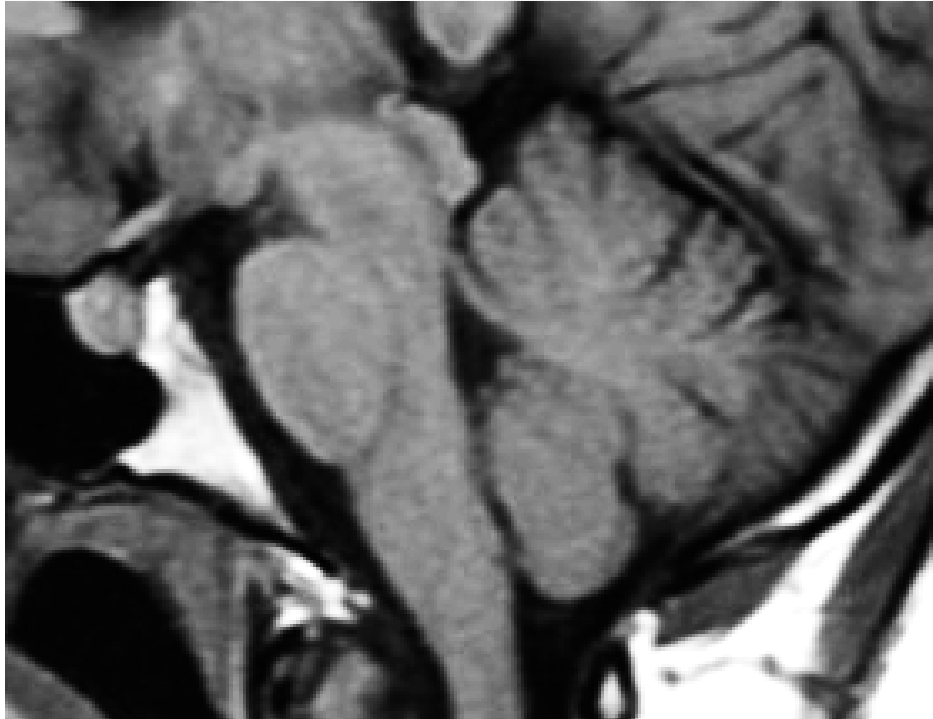
- Cranial nerve function
- Regulation of cardiac and respiratory function
- Regulates CNS
- Maintains consciousness
- Regulates sleep cycle



# Brainstem – the big picture



# Brainstem – the big picture





# Questions?

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