UNIVERSITÀ DEGLI STUDI DI TRIESTE

DEPARTMENT OF MEDICINE, SURGERY AND HEALTH SCIENCES

NEUROLOGY UNIT

Course of
Human Neuroanatomy

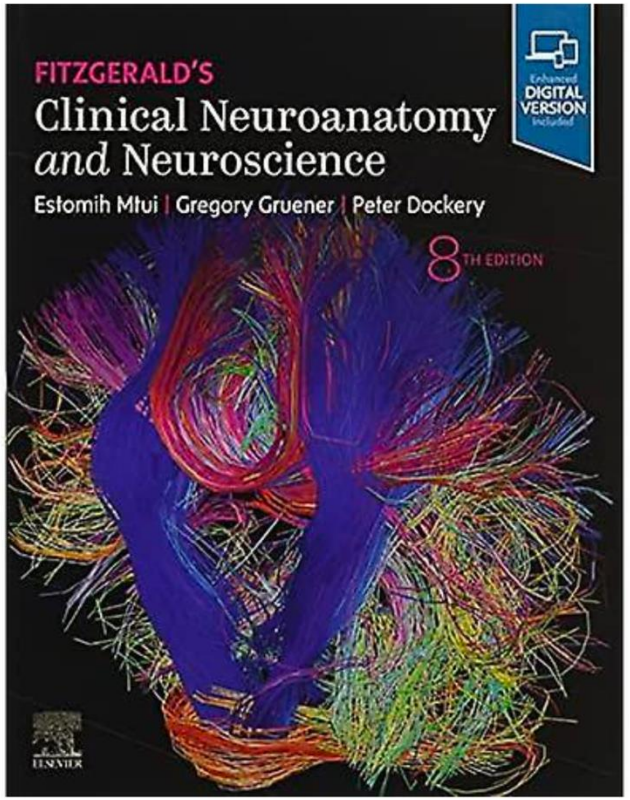
Master of Neuroscience, University of Trieste
2026-27

Dr. Federica Palacino

Structure of the course

- 24 hours divided in 6 lessons

- Textbook to use:



Fitzgerald's
Clinical Neuroanatomy and Neuroscience

Author: E. Mtui, G. Gruener and P. Dockery

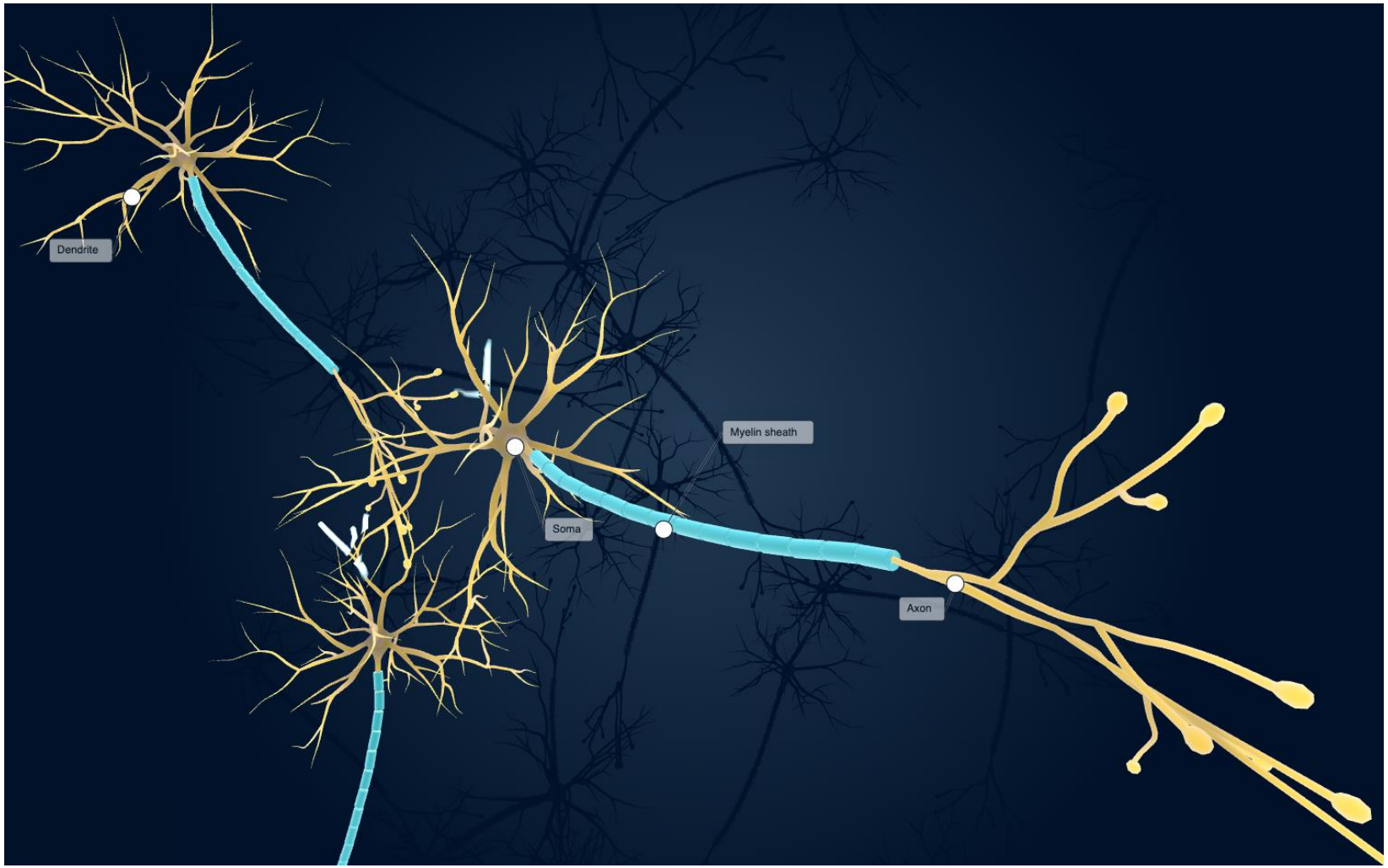
ELSEVIER, 2020, 8th Edition

Program of the course

- Introduction to the course
- Embryology
- Micro and Macrostructure of the Nervous System
- Spinal Cord
- Brainstem
- Sensorimotor integration patways
- Basal ganglia
- Sense organs
- Autonomic nervous system
- Cerebellum
- Telencephalon
- Cranial Nerves

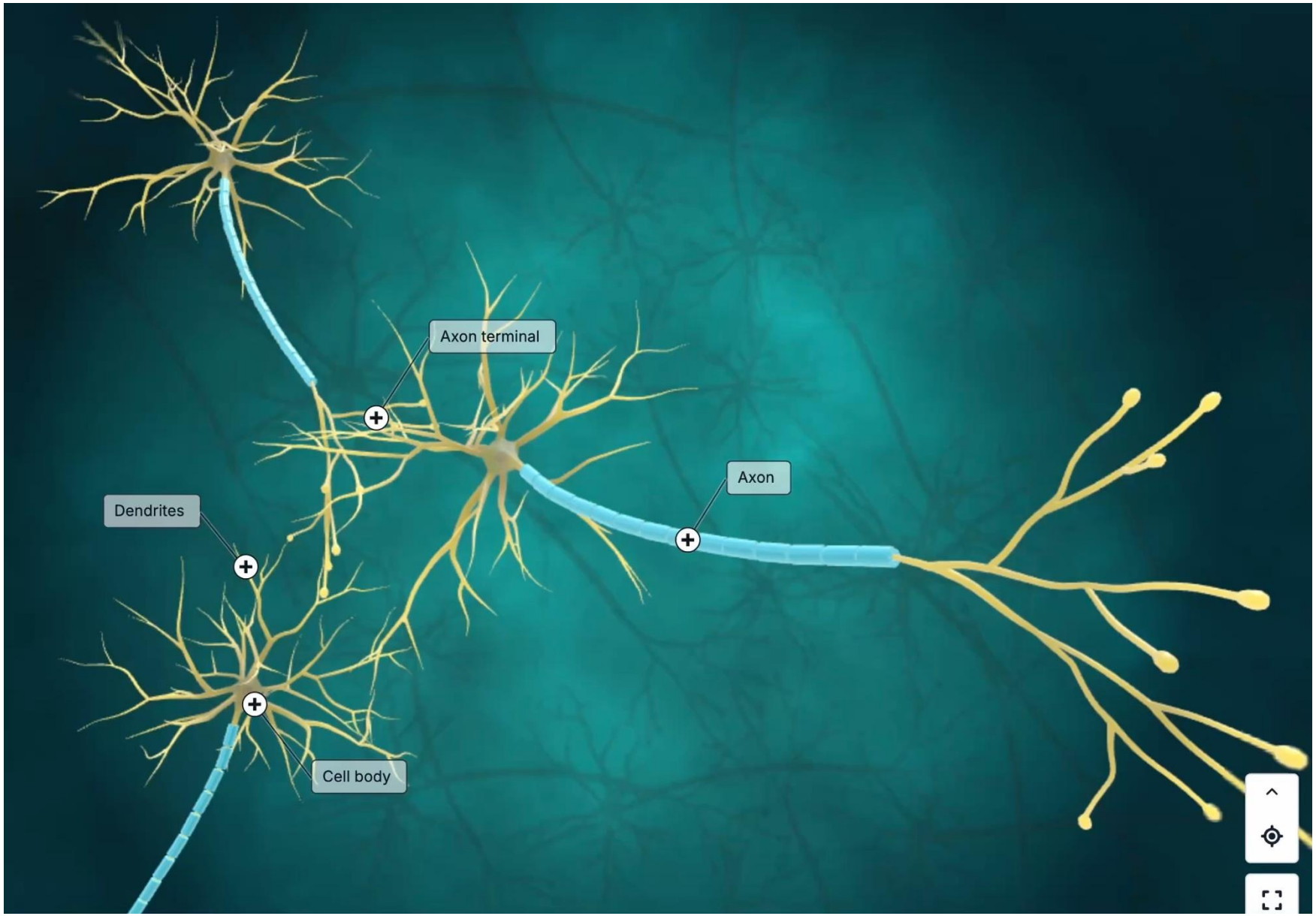
Neurons

The fundamental structural and functional units of the Nervous System



- Soma (cell body): contains the nucleus and receives signals from the environment and surrounding cells
- Dendrites: receives electrical and chemical signals from other cells
- Axon: conducts electrical signal along the cell
- Axon terminal: transmits electrical and chemical signals to other cells
- Neurons pass electrical signals from one cell to another at the synapse

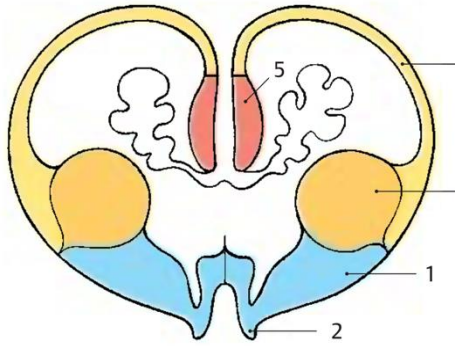
Neurotransmitters



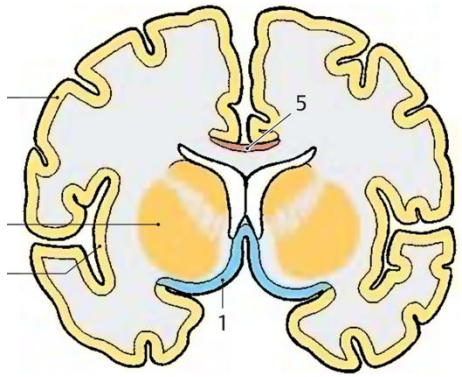
What is Neuroanatomy?

Neuroanatomy studies the organization of the nervous system at multiple levels

Developmental organization

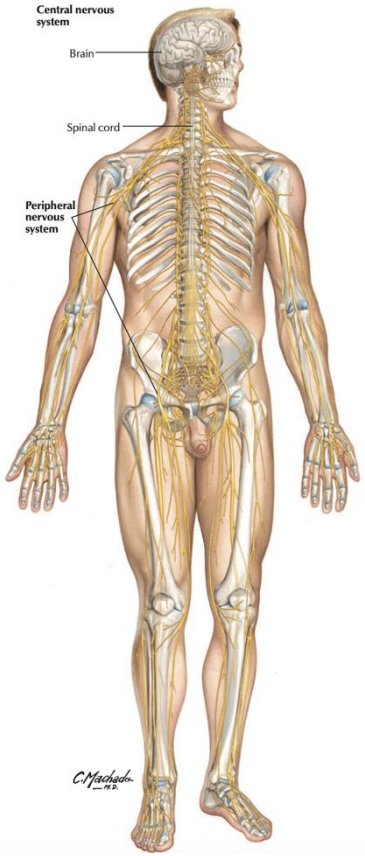


A Embryonic brain

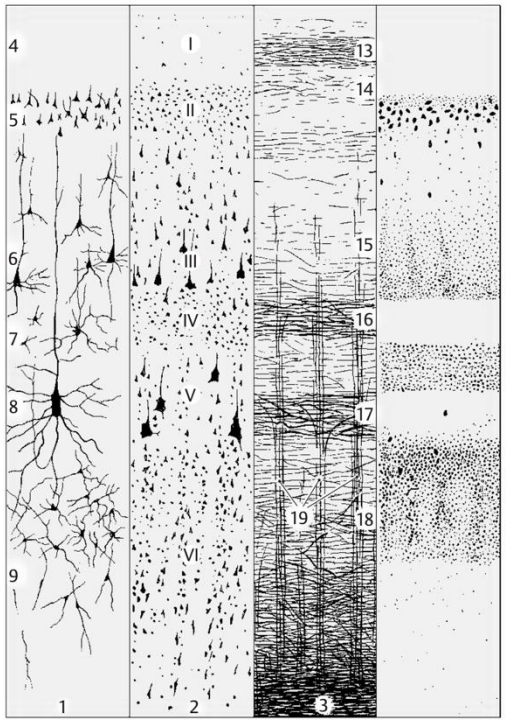


B Adult brain

Macrostructure



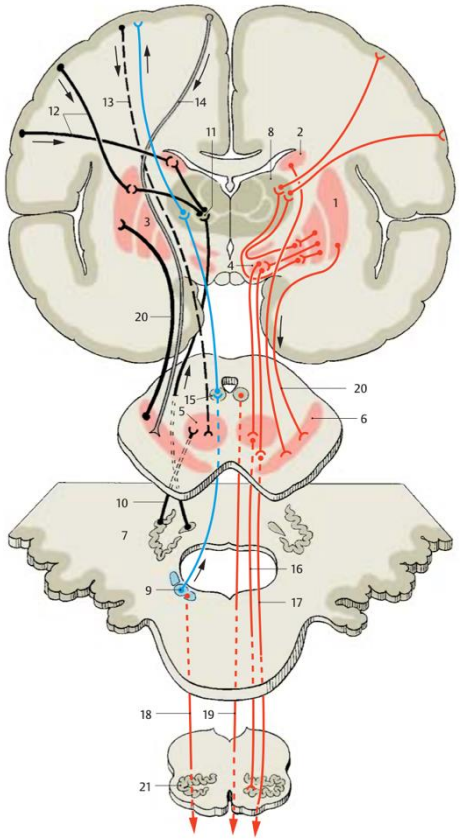
Microstructure



A Layers of the neocortex: 1, silver impregnation; 2, cellular staining; 3, myelin staining (according to *Brodmann*)

B Pigment staining

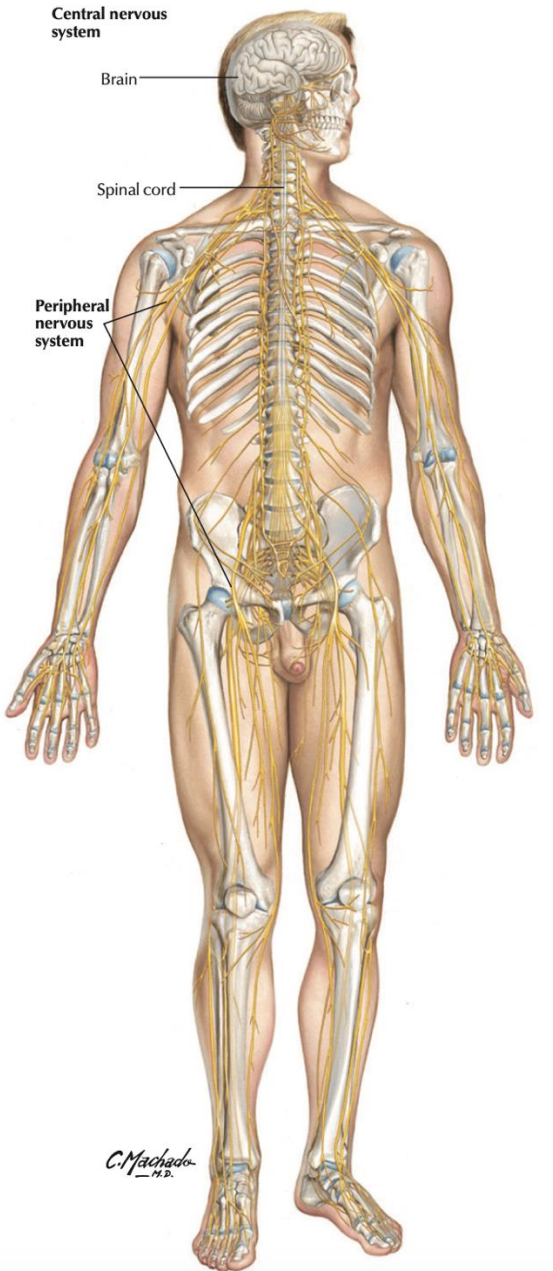
Structural-functional organization



What is Neuroanatomy?

Structure constrains **Function**

Nervous system: Structural organisation



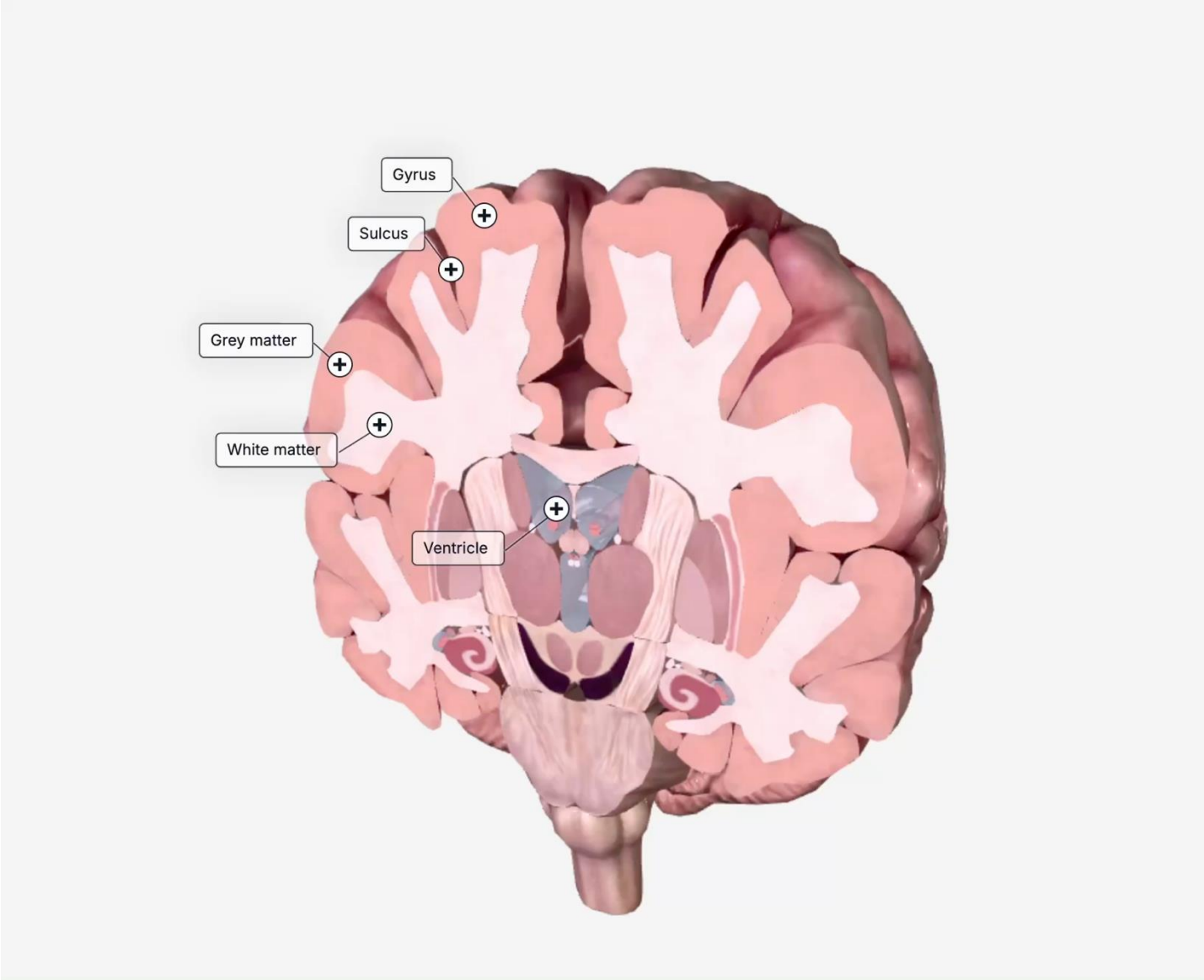
The Central Nervous System (CNS) is the site of integration and processing. It is made of:

- Brain
- Spinal cord

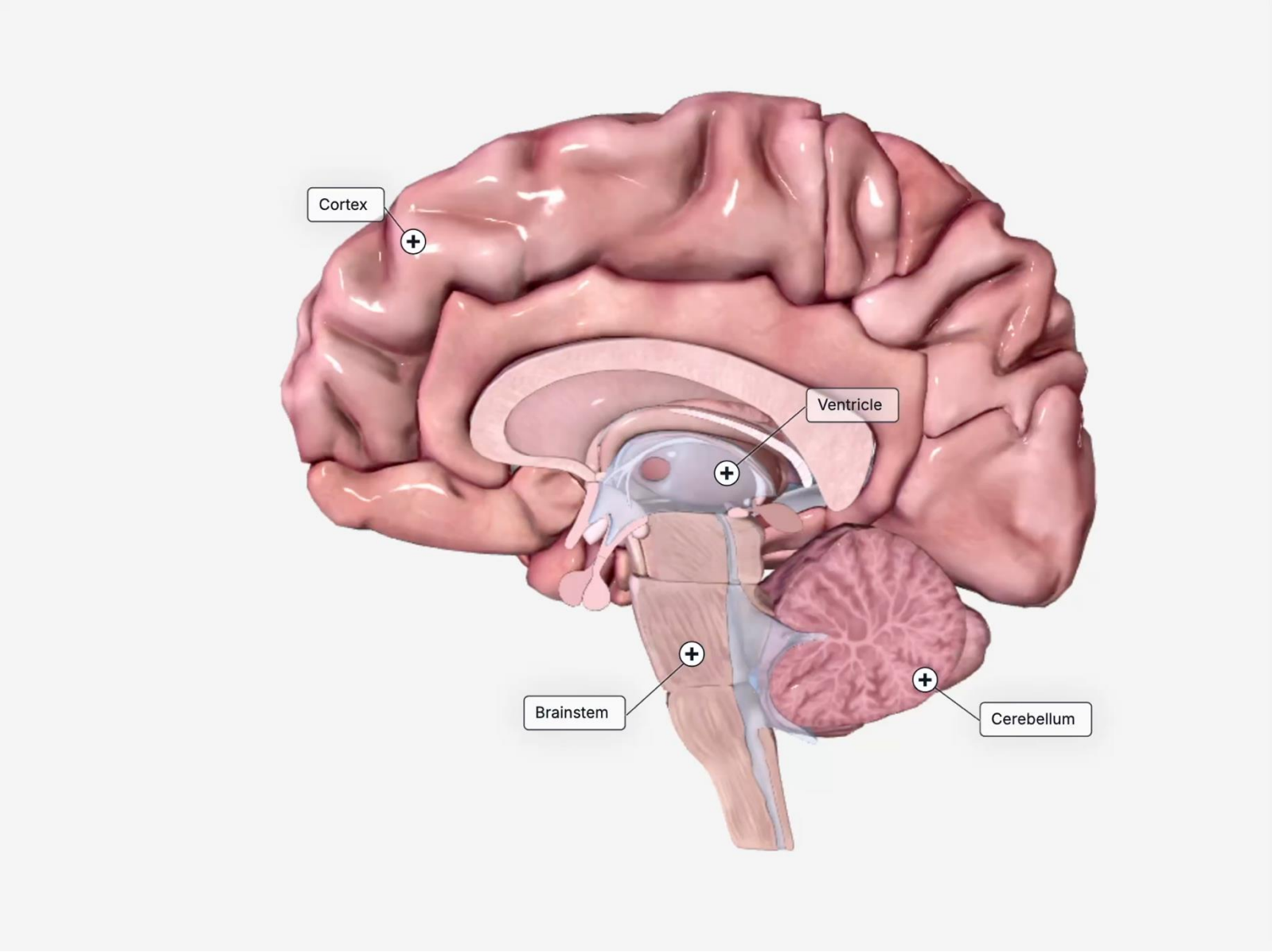
The Peripheral Nervous System (PNS) connects the body to the CNS. It is made of:

- Cranial nerves (12 pairs)
- Spinal nerves (31 pairs)
- Ganglia
- Peripheral nerves

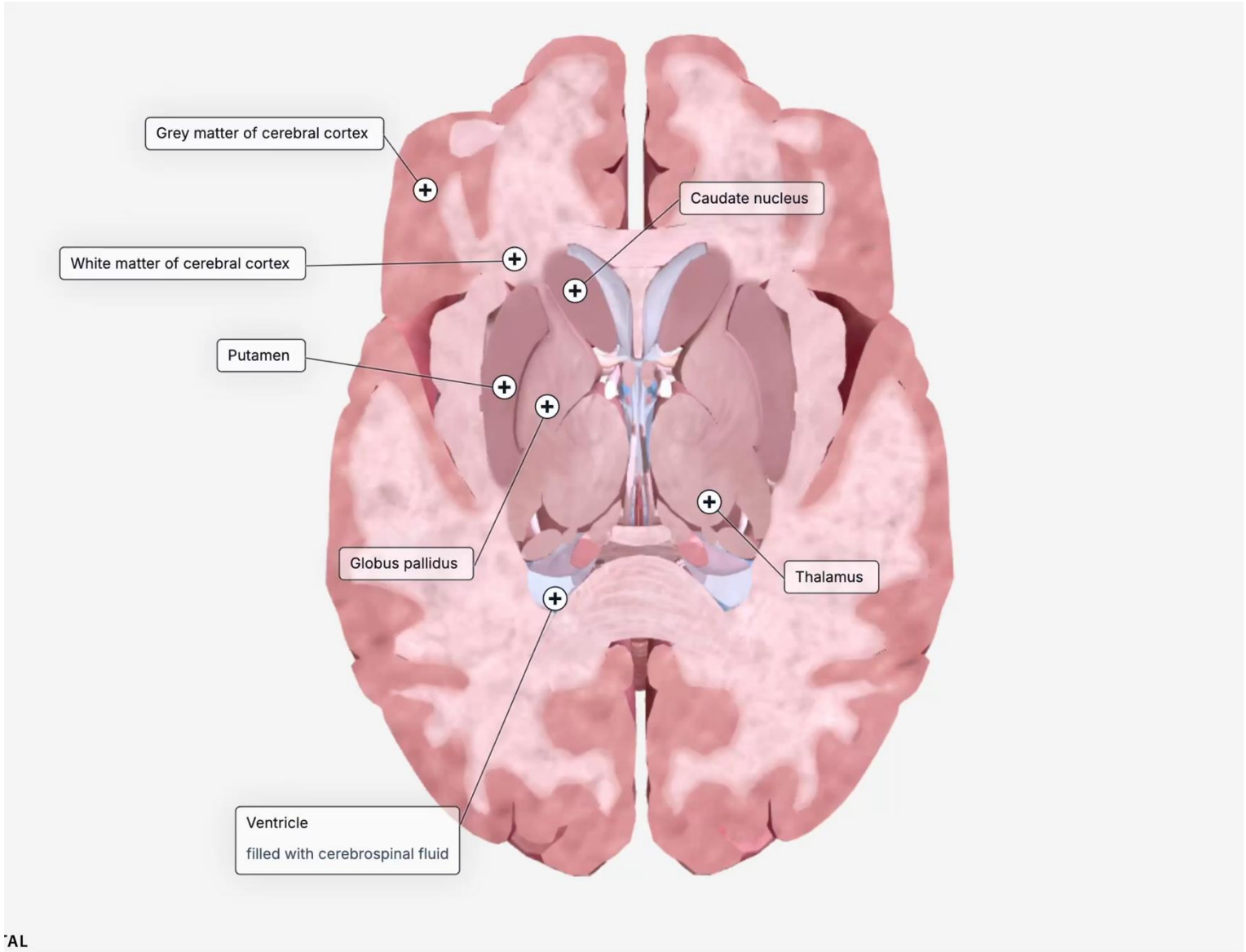
Brain coronal view



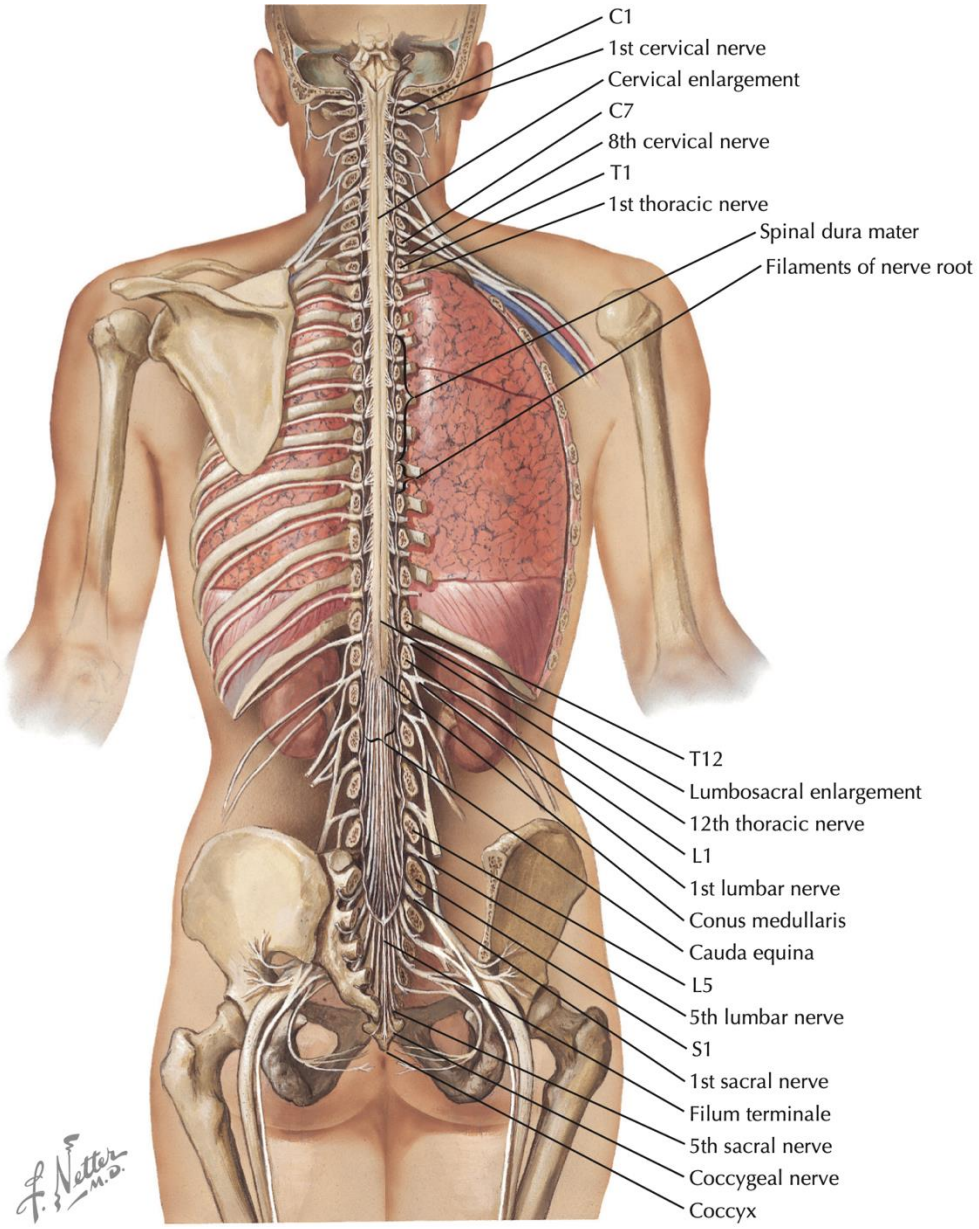
Brain: sagittal view



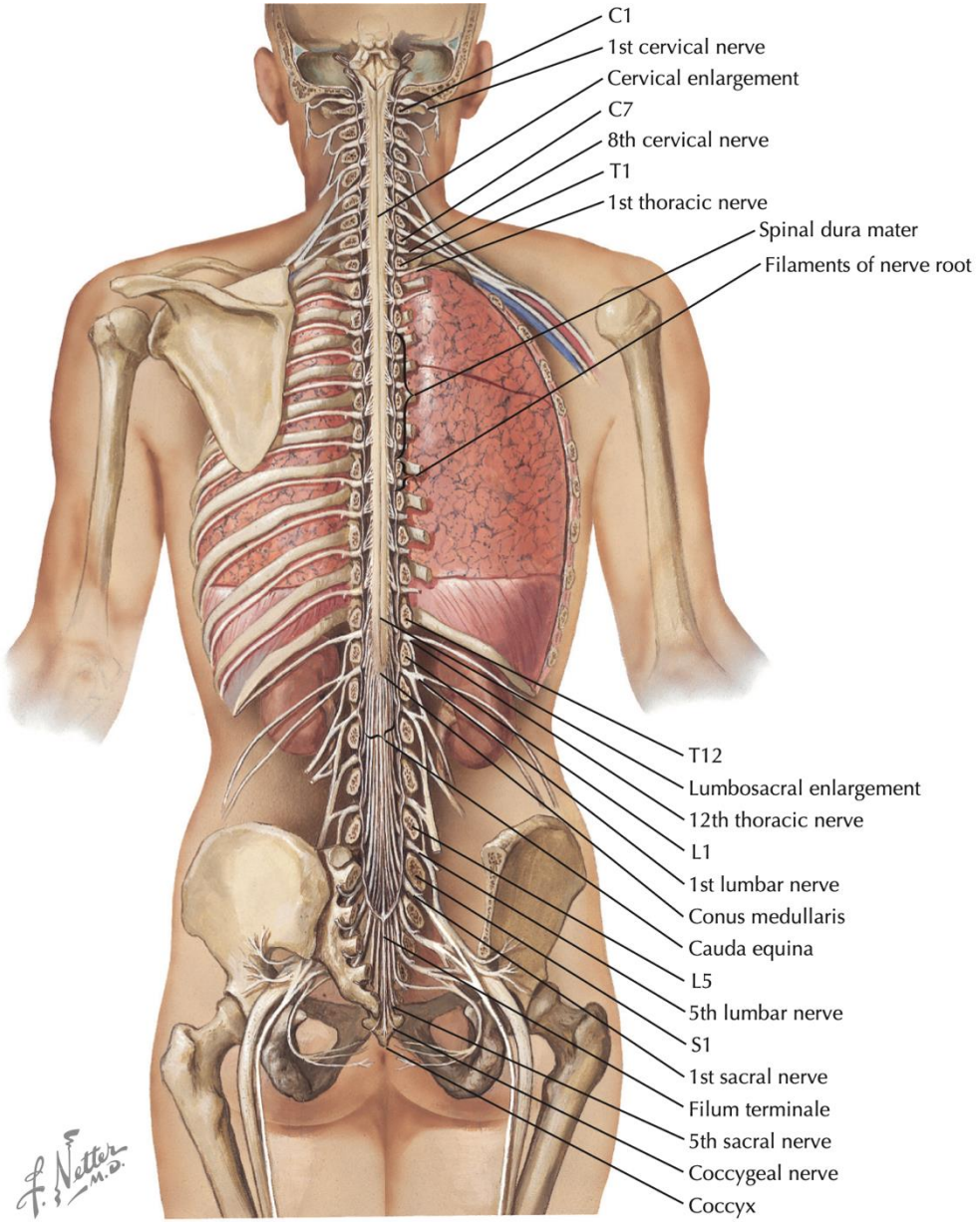
Brain: axial view

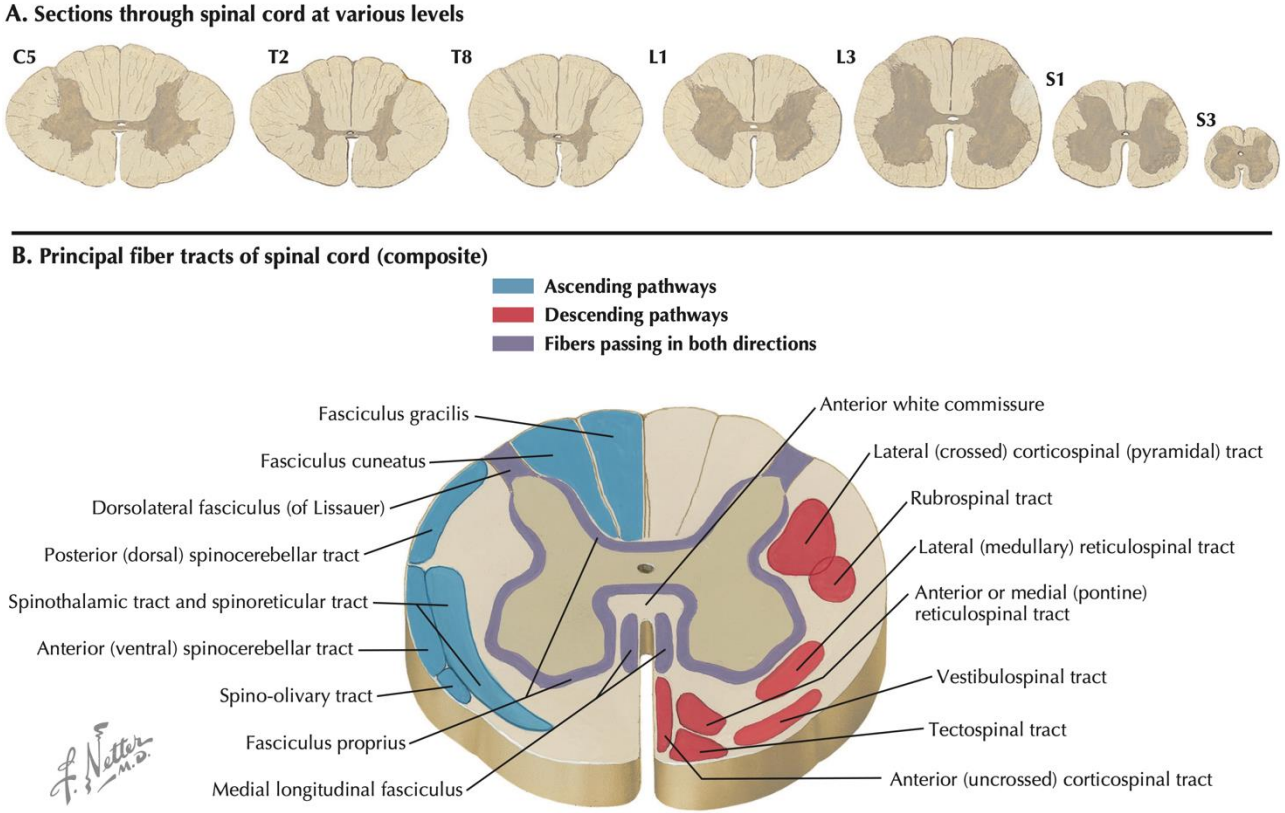


Spinal cord


C1
1st cervical nerve
Cervical enlargement
C7
8th cervical nerve
T1
1st thoracic nerve
Spinal dura mater
Filaments of nerve root
T12
Lumbosacral enlargement
12th thoracic nerve
L1
1st lumbar nerve
Conus medullaris
Cauda equina
L5
5th lumbar nerve
S1
1st sacral nerve
Filum terminale
5th sacral nerve
Coccygeal nerve
Coccyx
F. Netter M.D.

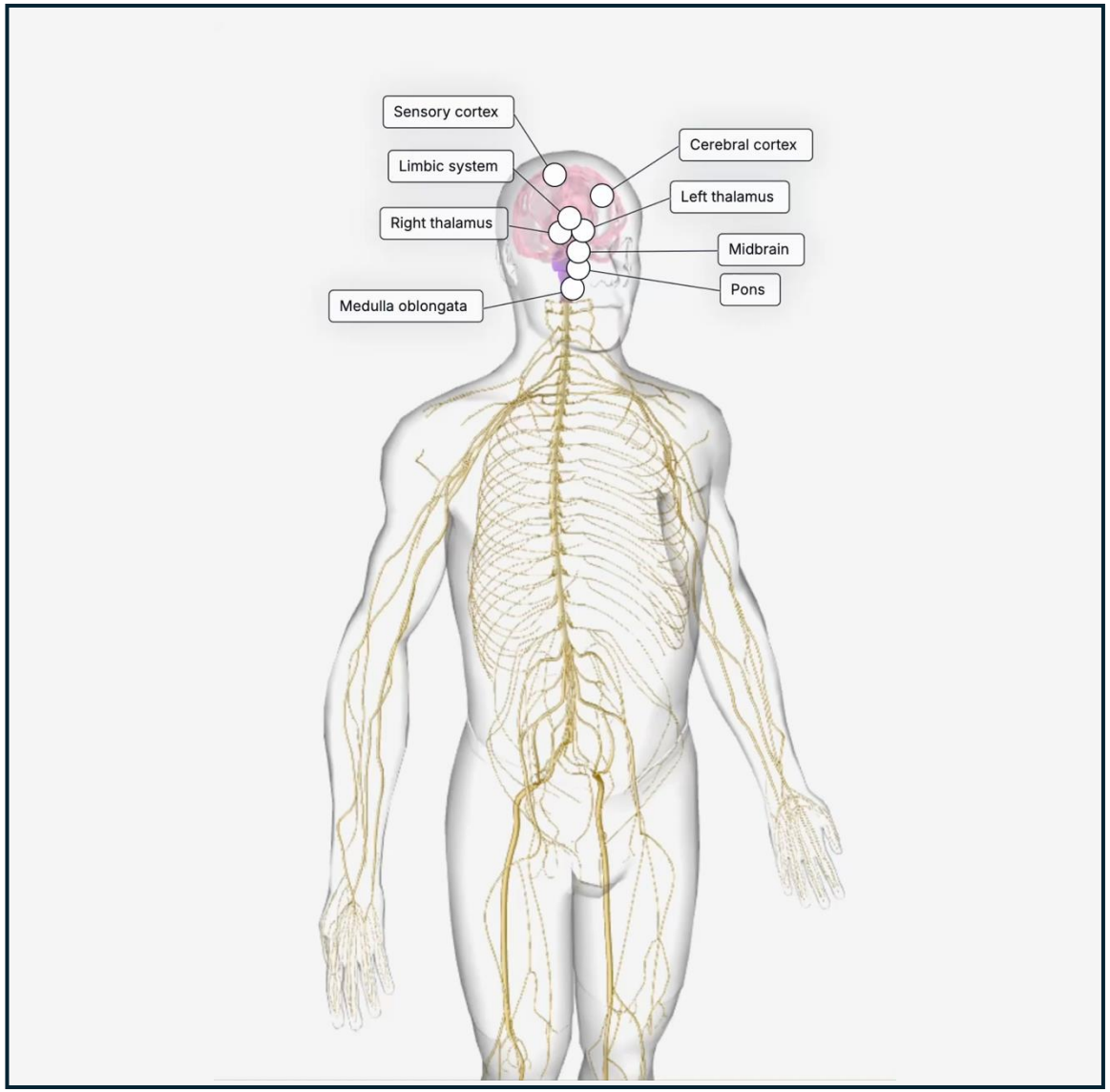
Spinal cord


C1
1st cervical nerve
Cervical enlargement
C7
8th cervical nerve
T1
1st thoracic nerve
Spinal dura mater
Filaments of nerve root
T12
Lumbosacral enlargement
12th thoracic nerve
L1
1st lumbar nerve
Conus medullaris
Cauda equina
L5
5th lumbar nerve
S1
1st sacral nerve
Filum terminale
5th sacral nerve
Coccygeal nerve
Coccyx
F. Netter M.D.

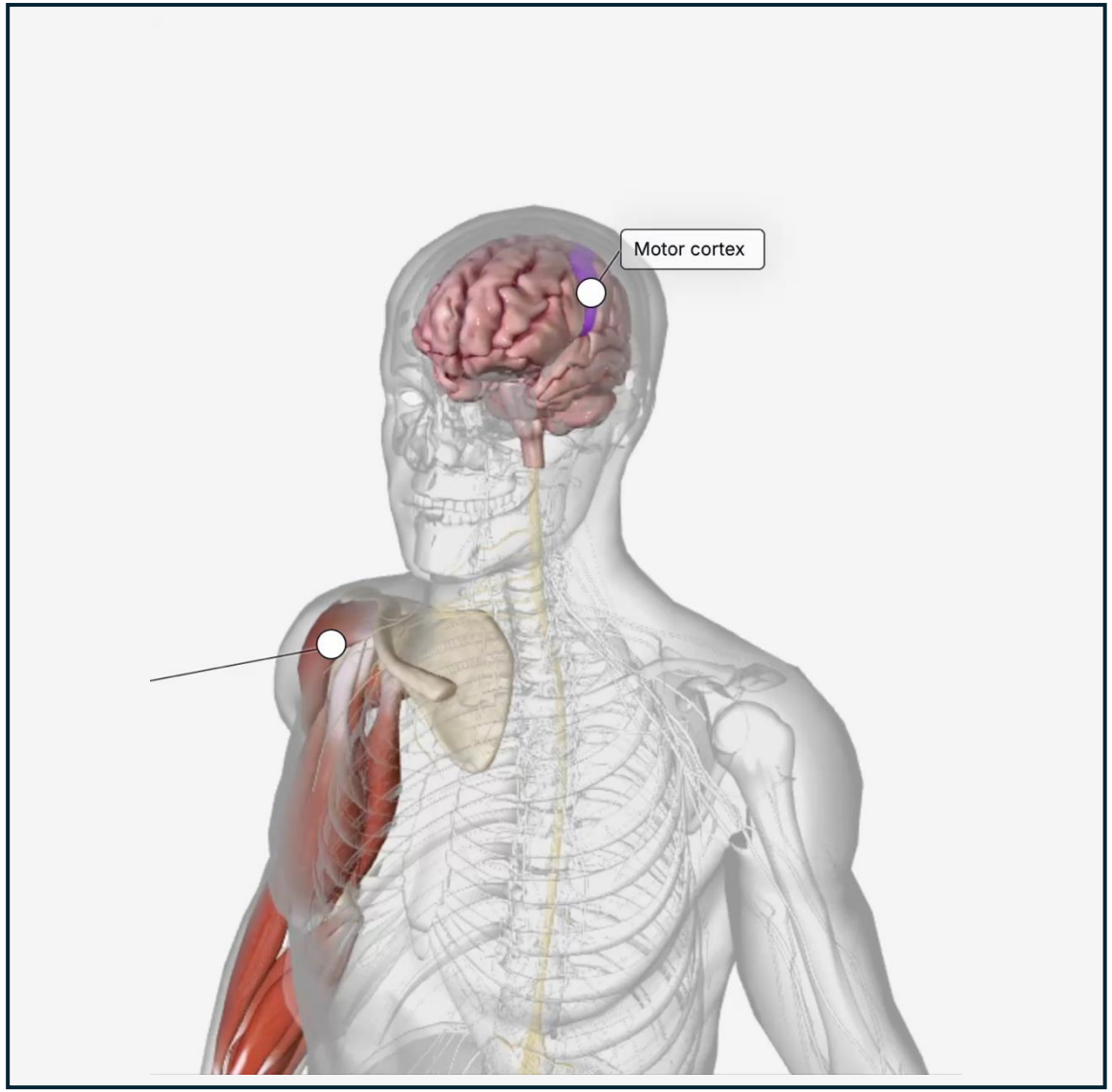

A. Sections through spinal cord at various levels
C5
T2
T8
L1
L3
S1
S3
B. Principal fiber tracts of spinal cord (composite)
Ascending pathways
Descending pathways
Fibers passing in both directions
Fasciculus gracilis
Fasciculus cuneatus
Dorsolateral fasciculus (of Lissauer)
Posterior (dorsal) spinocerebellar tract
Spinothalamic tract and spinoreticular tract
Anterior (ventral) spinocerebellar tract
Spino-olivary tract
Fasciculus proprius
Medial longitudinal fasciculus
Anterior white commissure
Lateral (crossed) corticospinal (pyramidal) tract
Rubrospinal tract
Lateral (medullary) reticulospinal tract
Anterior or medial (pontine) reticulospinal tract
Vestibulospinal tract
Tectospinal tract
Anterior (uncrossed) corticospinal tract
F. Netter M.D.

Nervous system: Functional organisation (I)

Sensory system

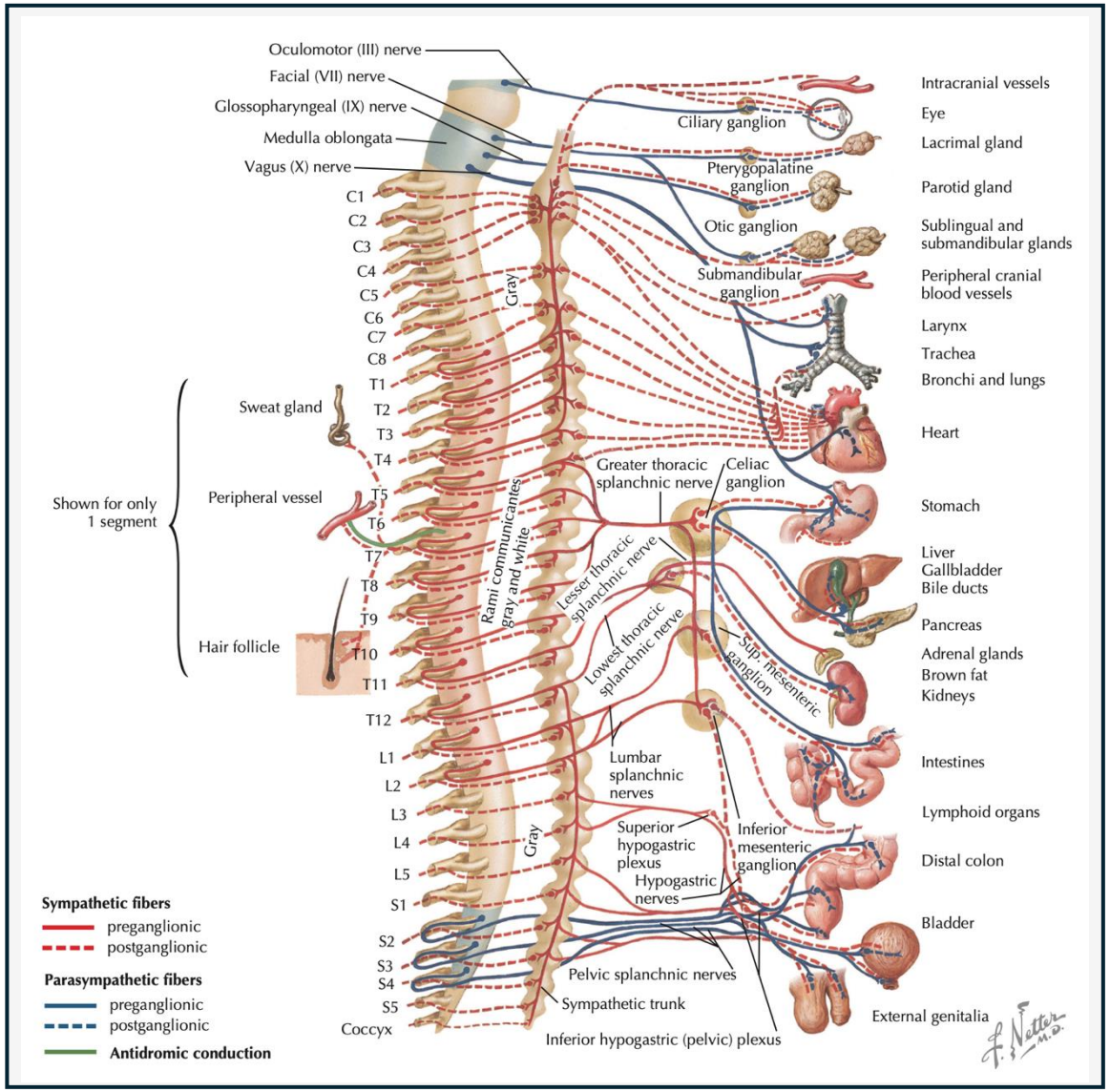


Motor system

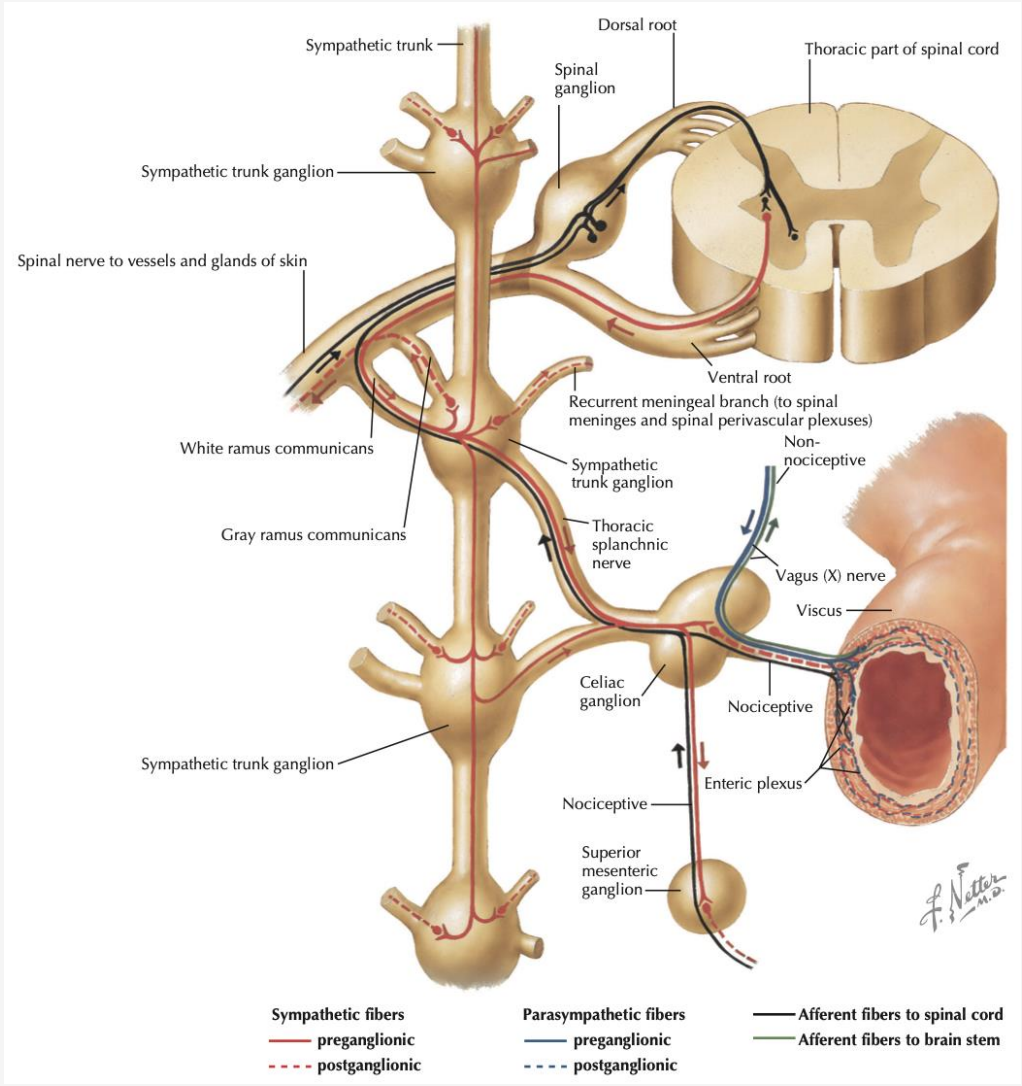


Nervous system: Functional organisation (II)

Autonomic system



Somatic system



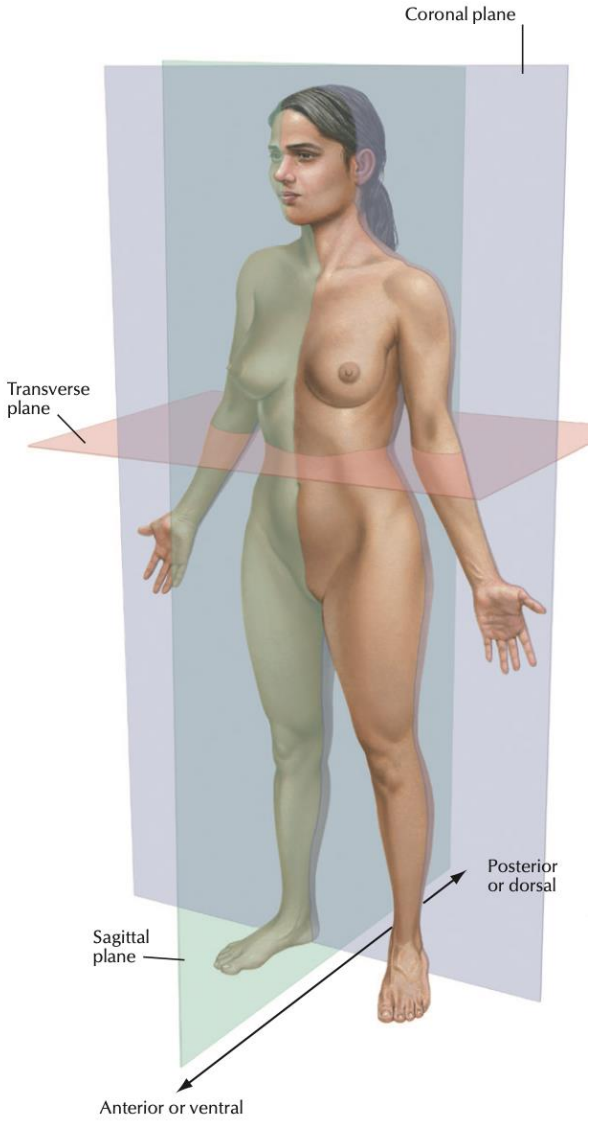
How is Neuroanatomy?

Neuroanatomy is **predictive**.

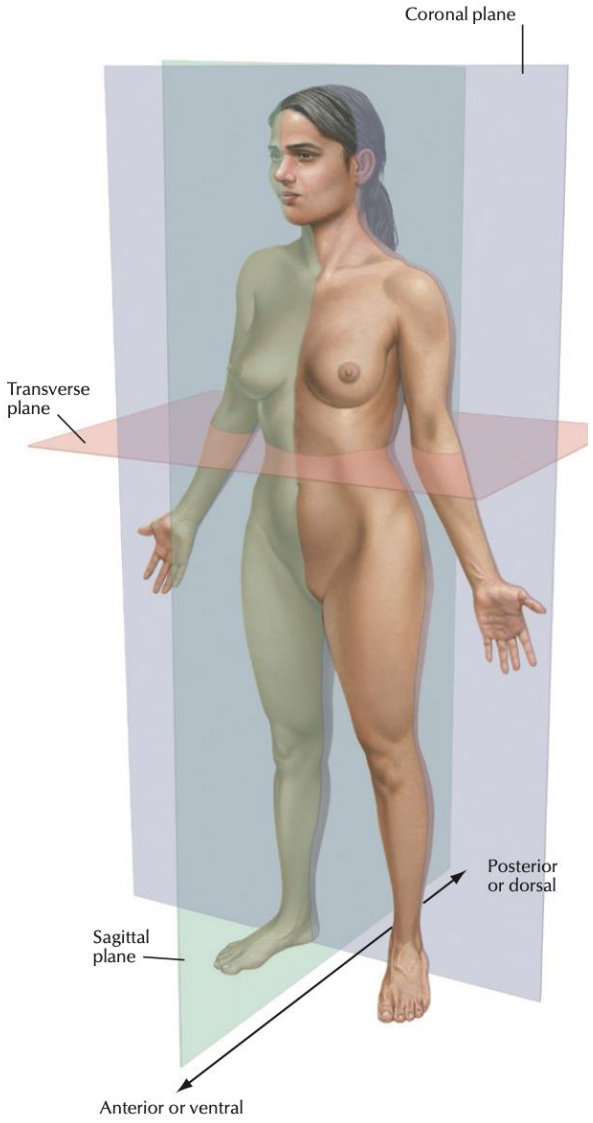
Lesions localize
Symptoms follows anatomy

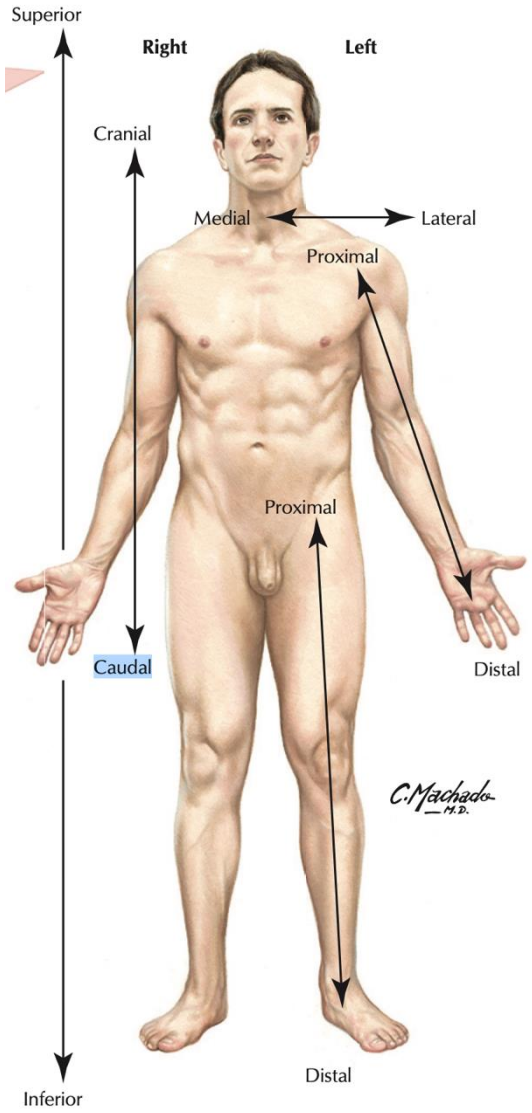
Neuroanatomy allows us to predict:
the clinical picture from the lesion
and conversely, to infer the lesion from the clinical picture.

Anatomical Terminology



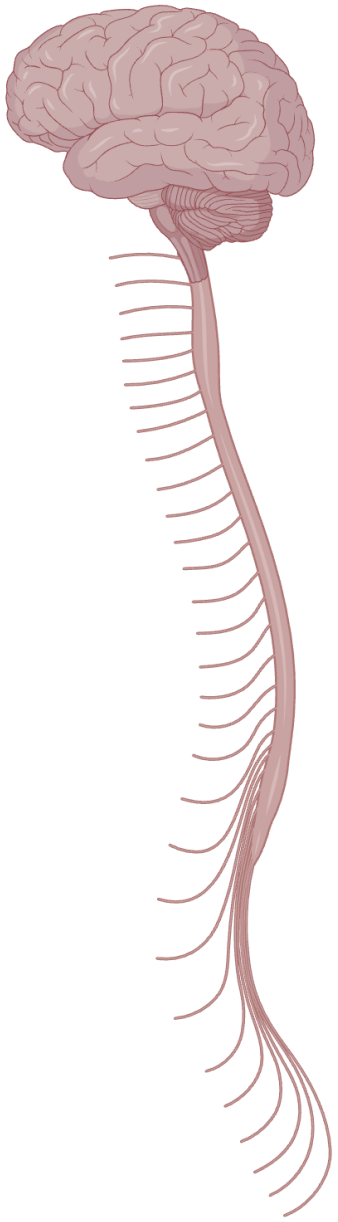
Anatomical Terminology





- Rostral or Cranial means toward the front.
- Caudal means toward the tail.
- Dorsal refers to the back side.
- Ventral refers to the belly side.
- Medial means toward the midline.
- Lateral means away from the midline.
- Proximal means toward the centre of the body.
- Distal means away the centre of the body.
- Ipsilateral means on the same side.
- Contralateral means on the opposite side.

Anatomical Terminology



Terminology problem:

In the telencephalon, dorsal = superior and ventral= inferior.

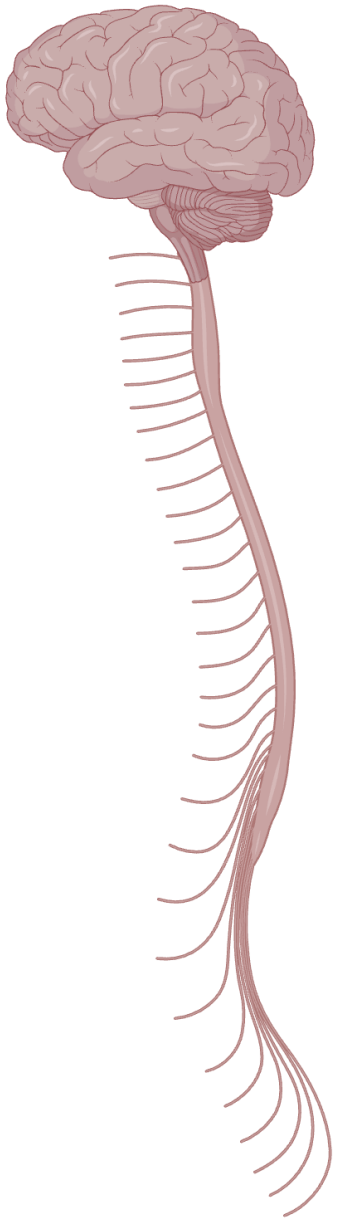
In the spinal cord, dorsal = posterior and ventral= anterior.

This problem arises because

- In the spinal cord, the neuraxis is straight,
- In the forebrain, these relationships change, because of the cephalic flexure, a developmental bending of the neural tube at the level of the midbrain.

This shift in orientation is not arbitrary. It is **embryological**.

Anatomical Terminology



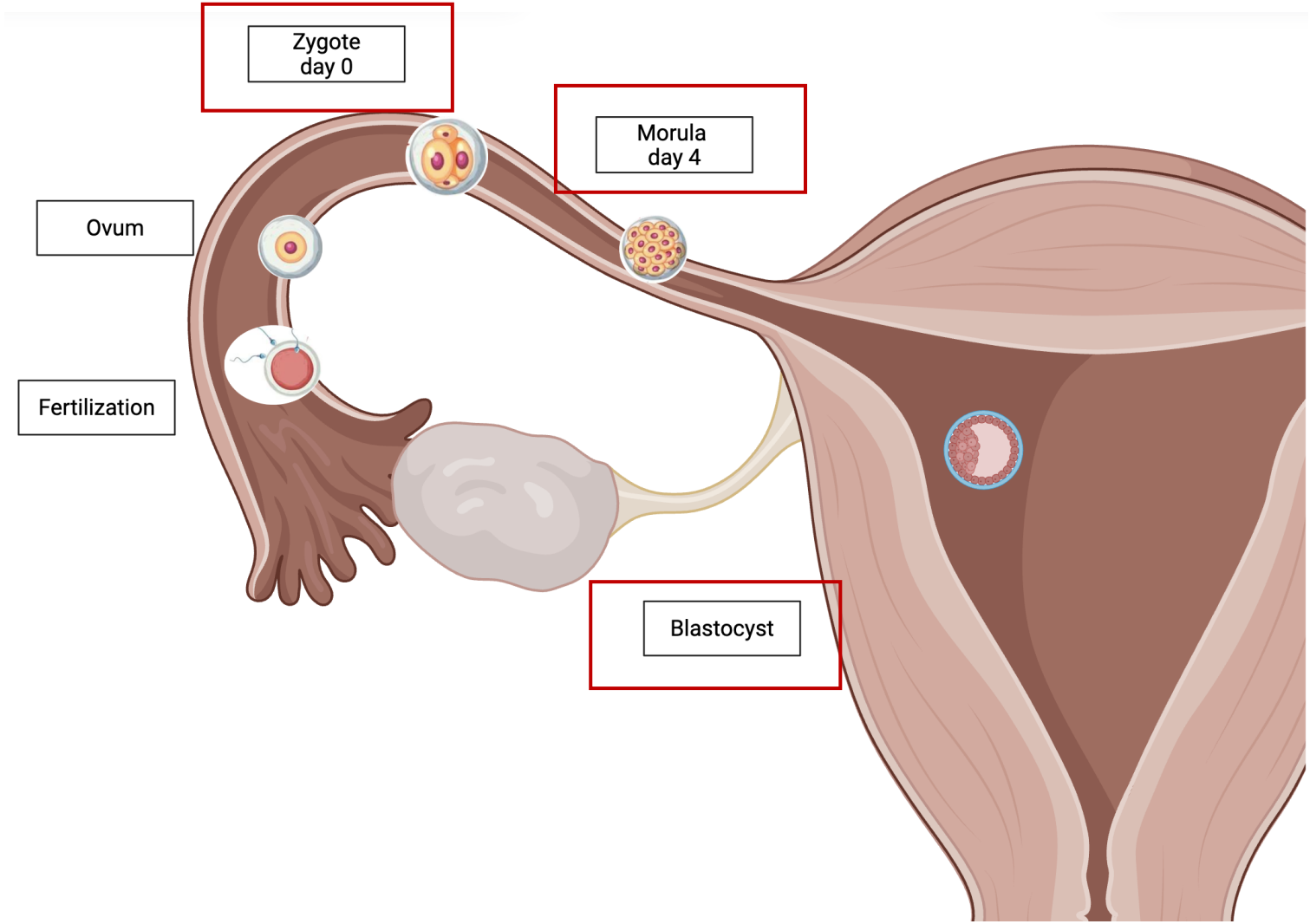
If you understand development, everything becomes coherent.

Development explains **adult organization**

Many features of adult neuroanatomy appear complex or even counterintuitive, until you understand their embryological origin.

Development of Nervous System

Human fertilisation and embryonic development

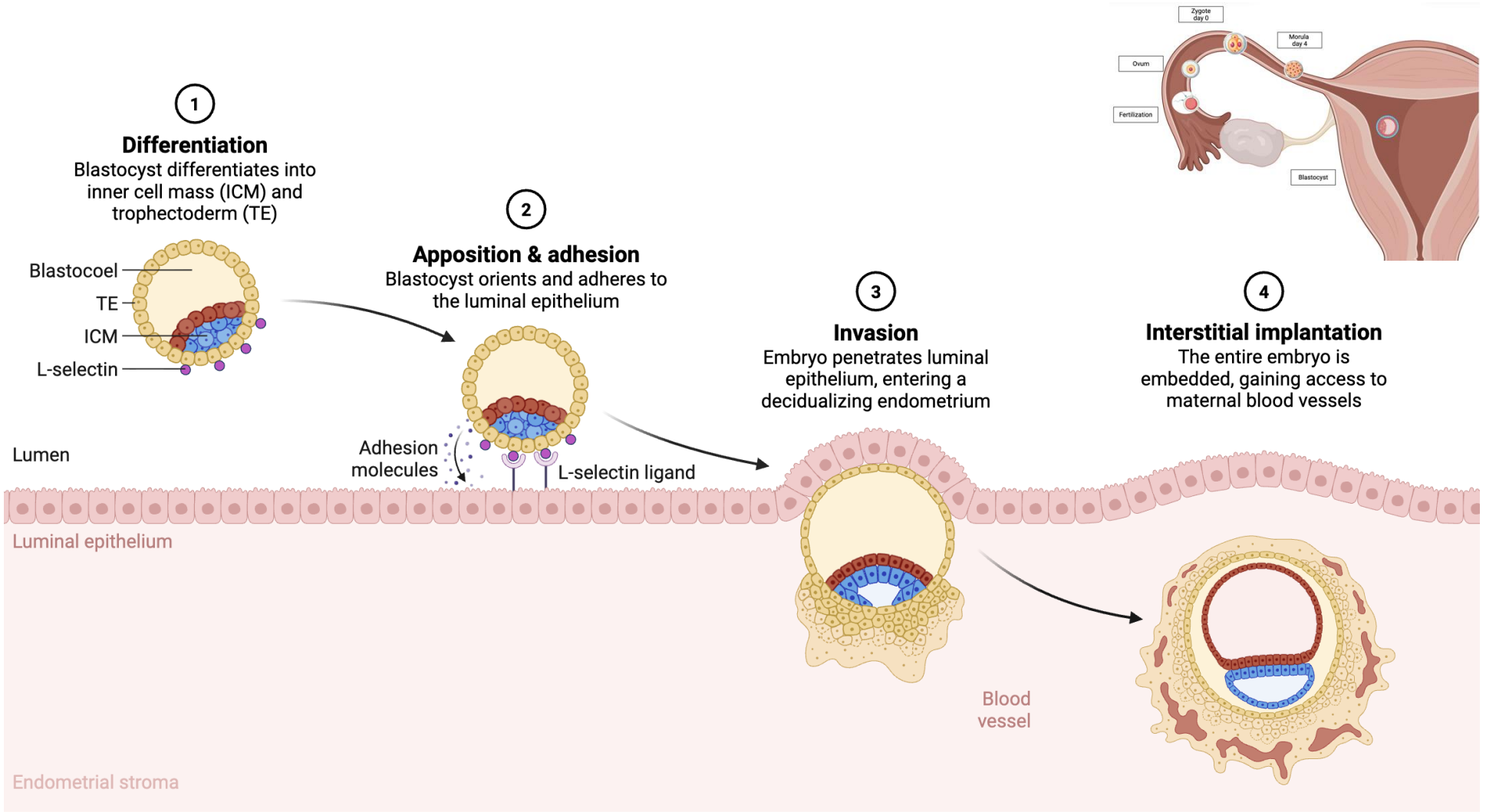


Morula stage

Blastula stage

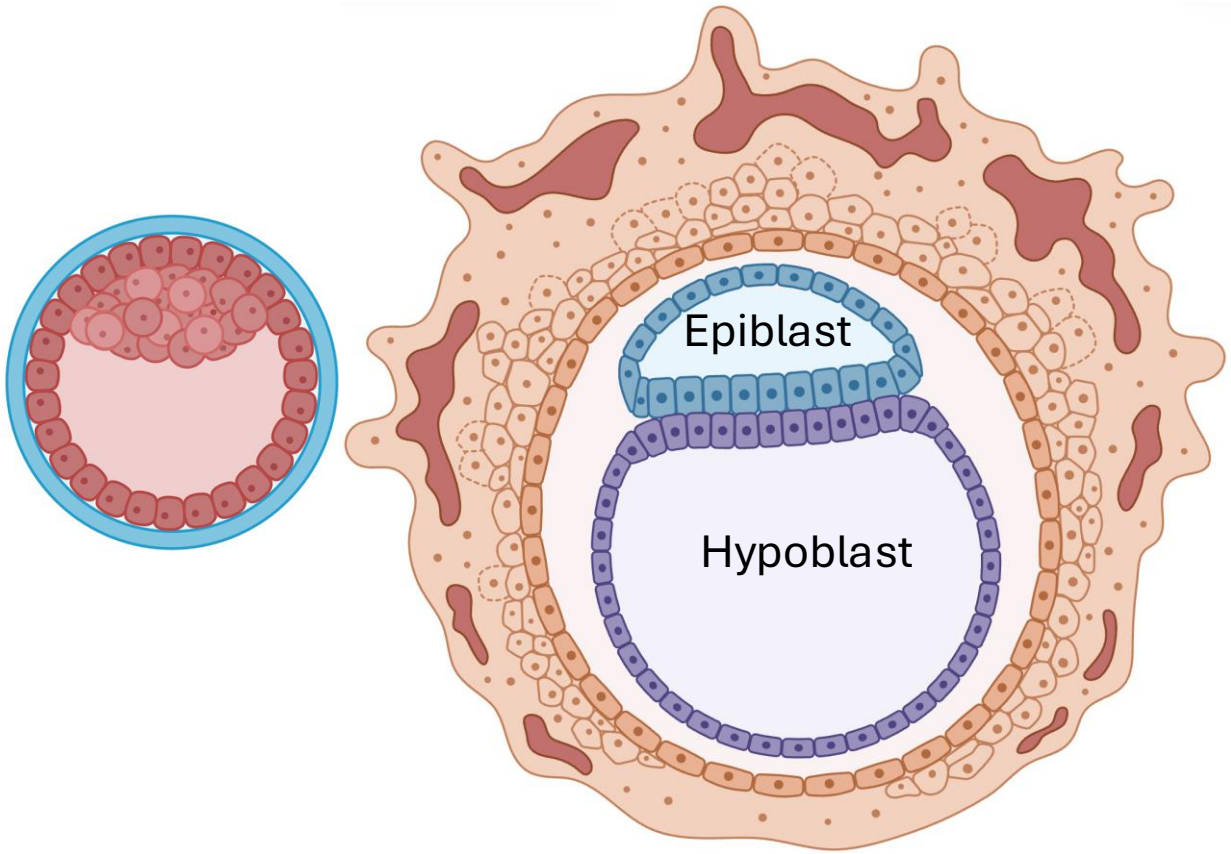
Development of Nervous System

Blastula stage



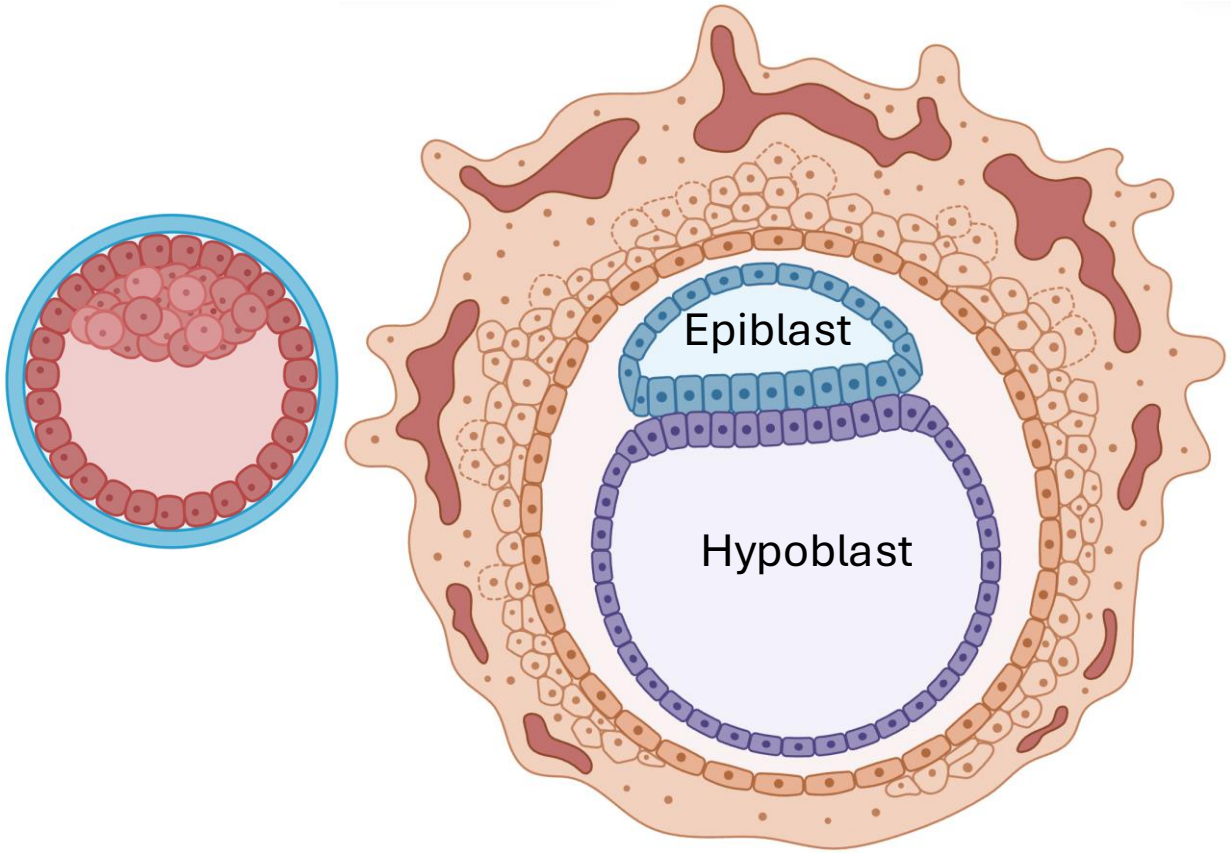
Development of Nervous System

Blastula stage

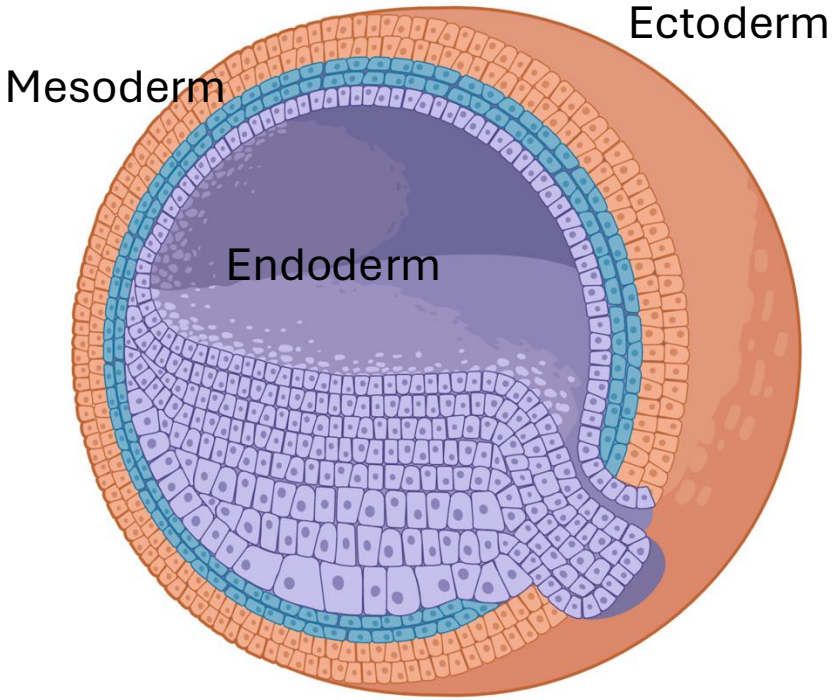


Development of Nervous System

Blastula stage

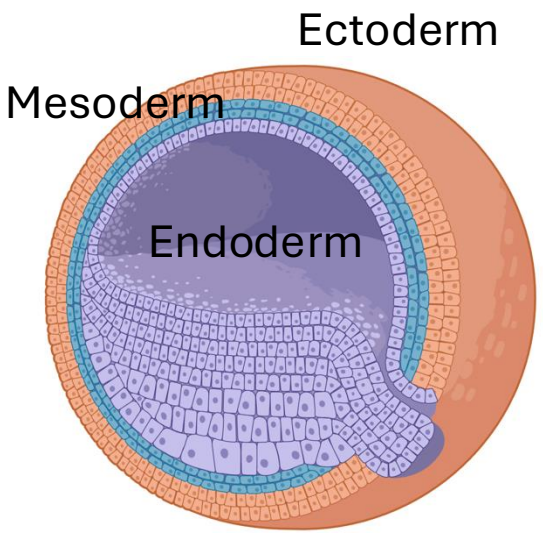


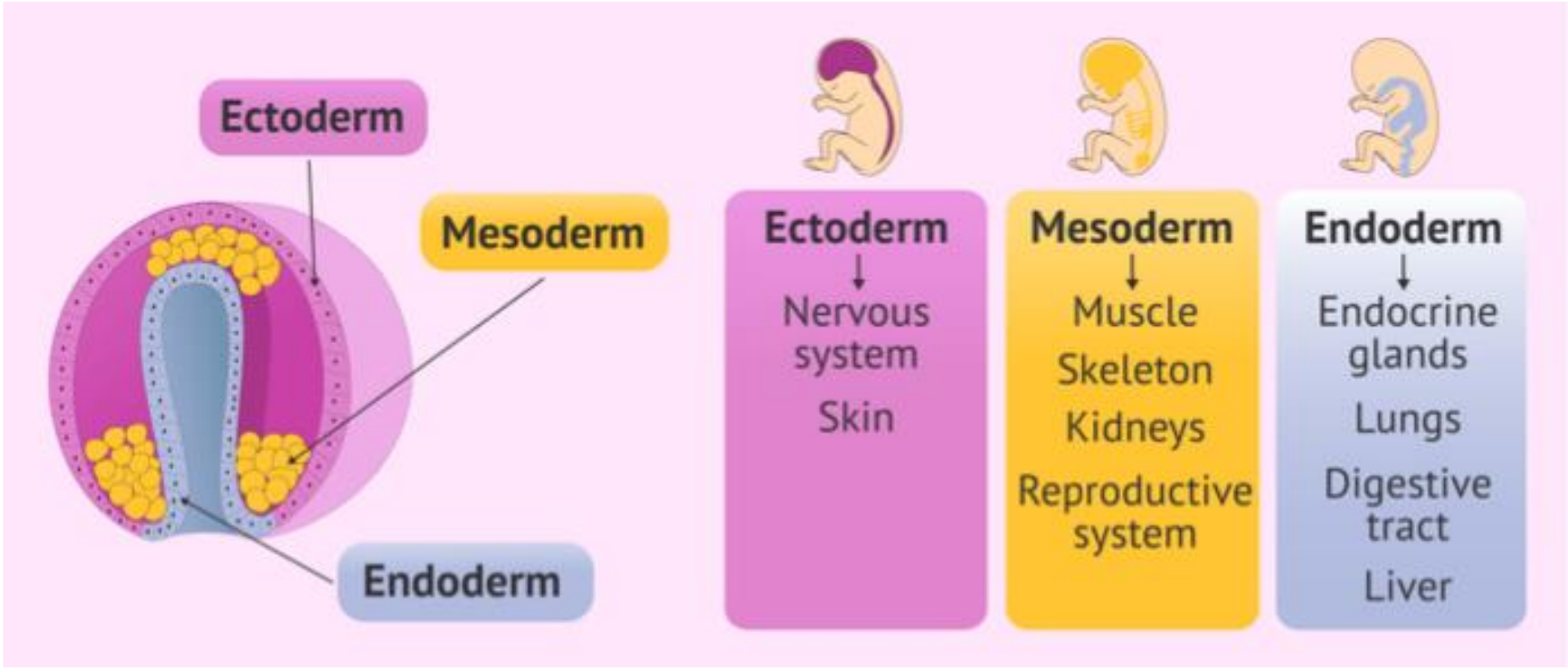
Gastrula stage



Development of Nervous System

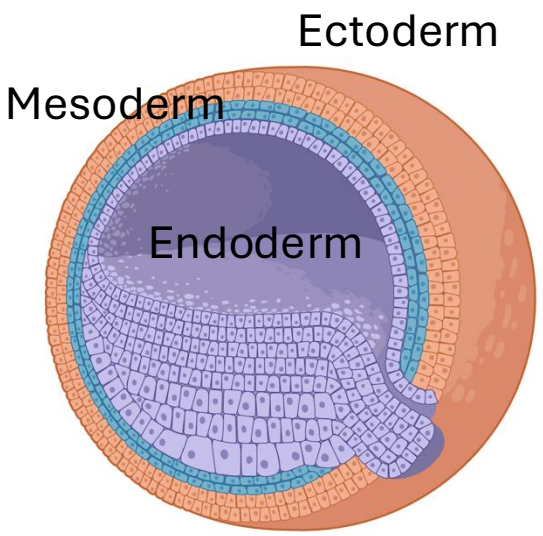
Gastrula stage

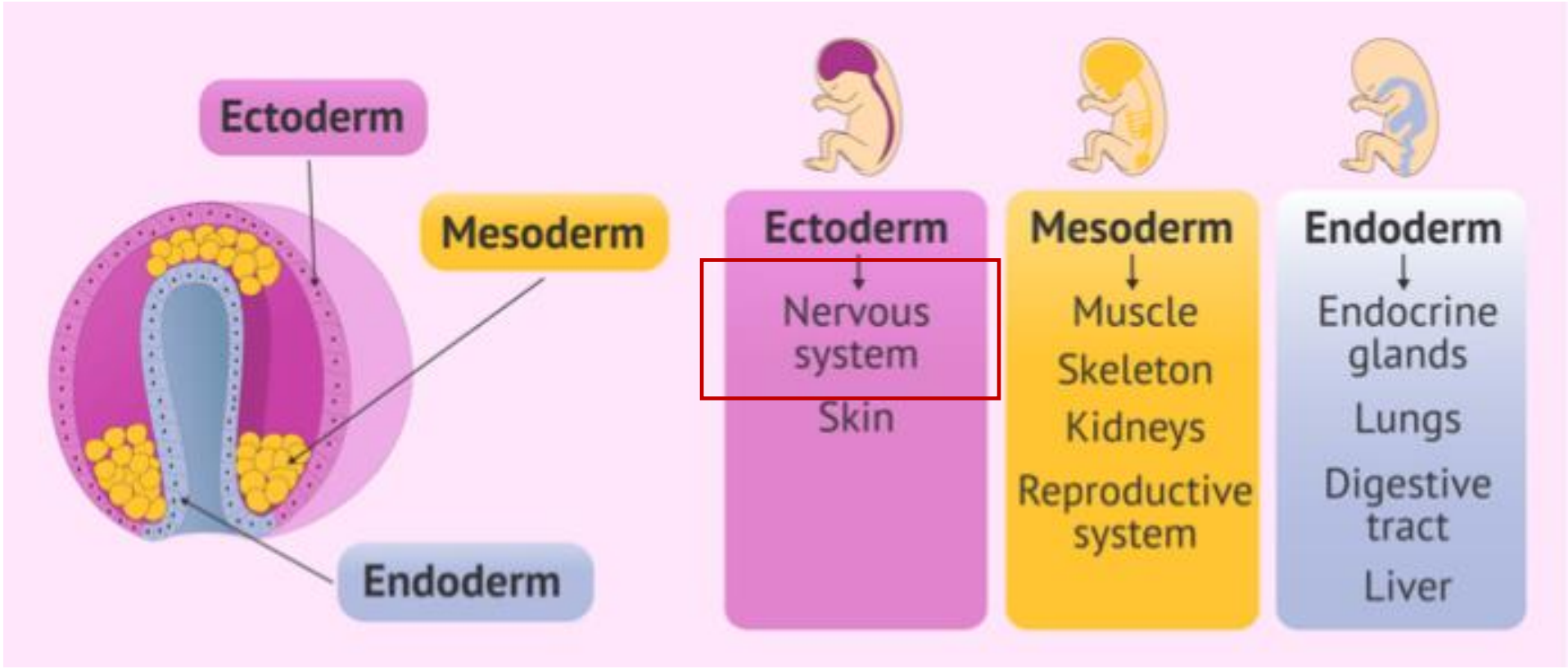




Development of Nervous System

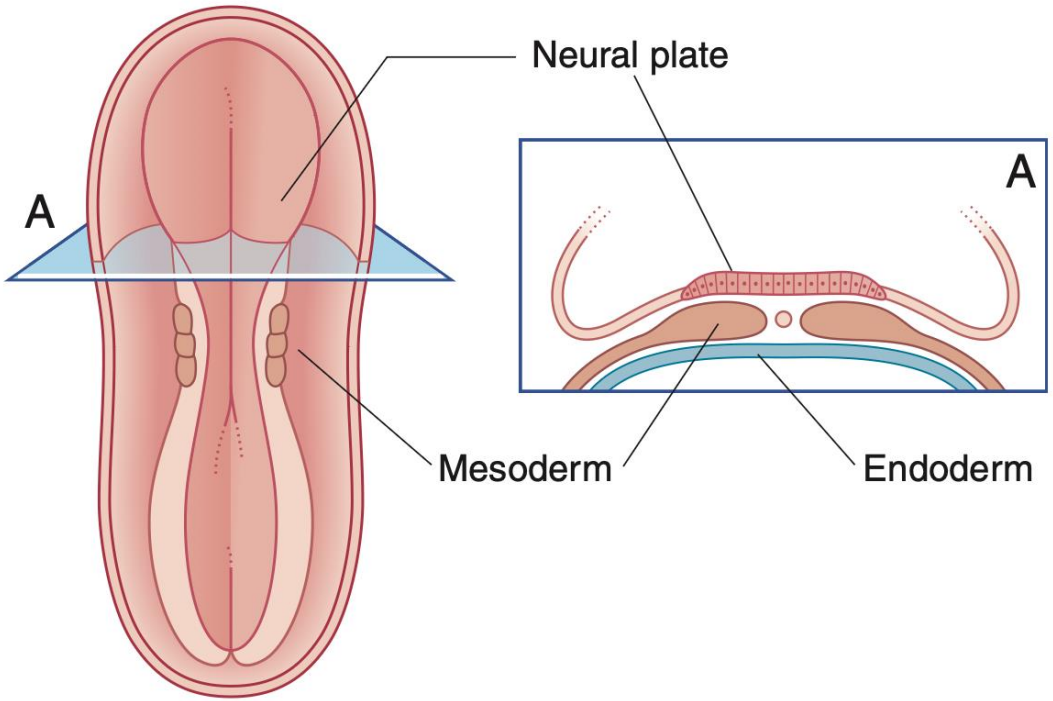
Gastrula stage





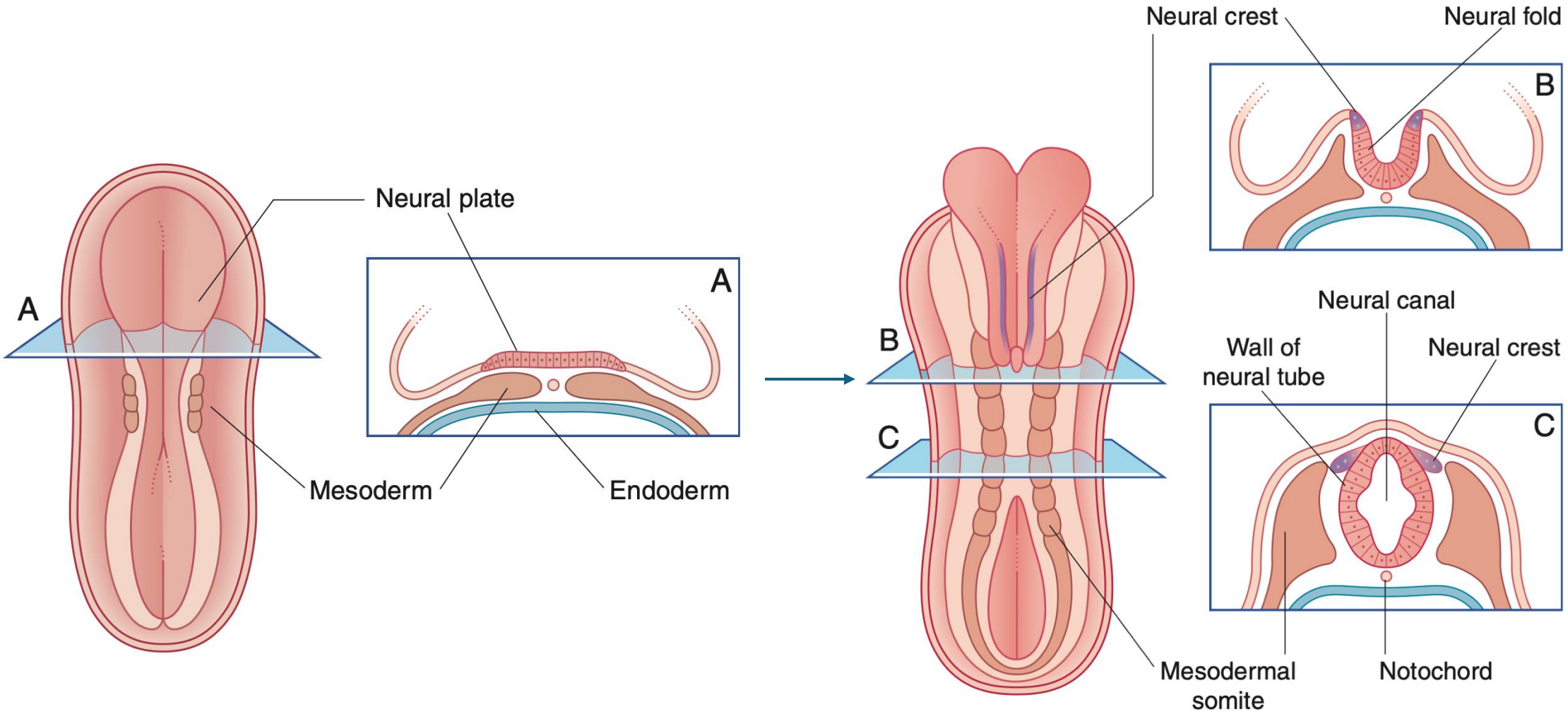
Development of Nervous System

Neurula stage



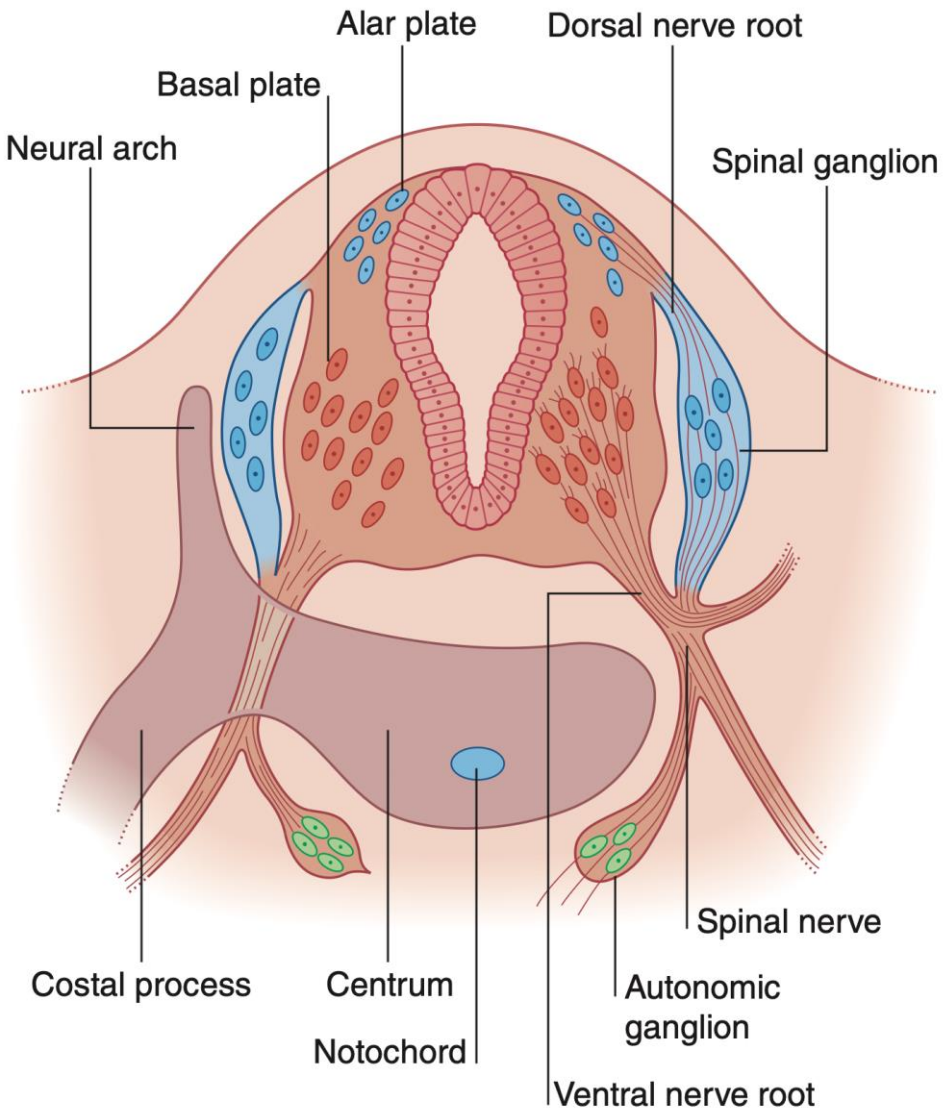
Development of Nervous System

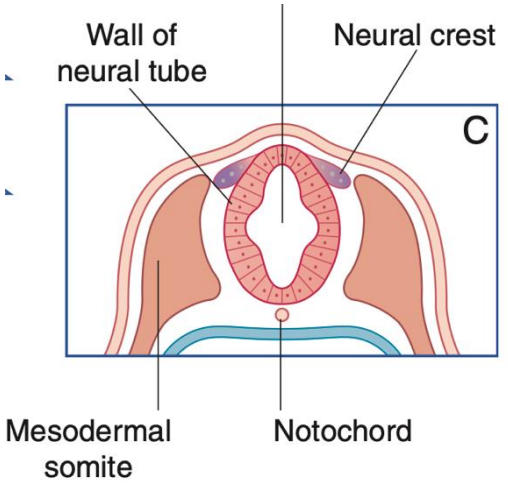
Neurula stage



Development of Nervous System

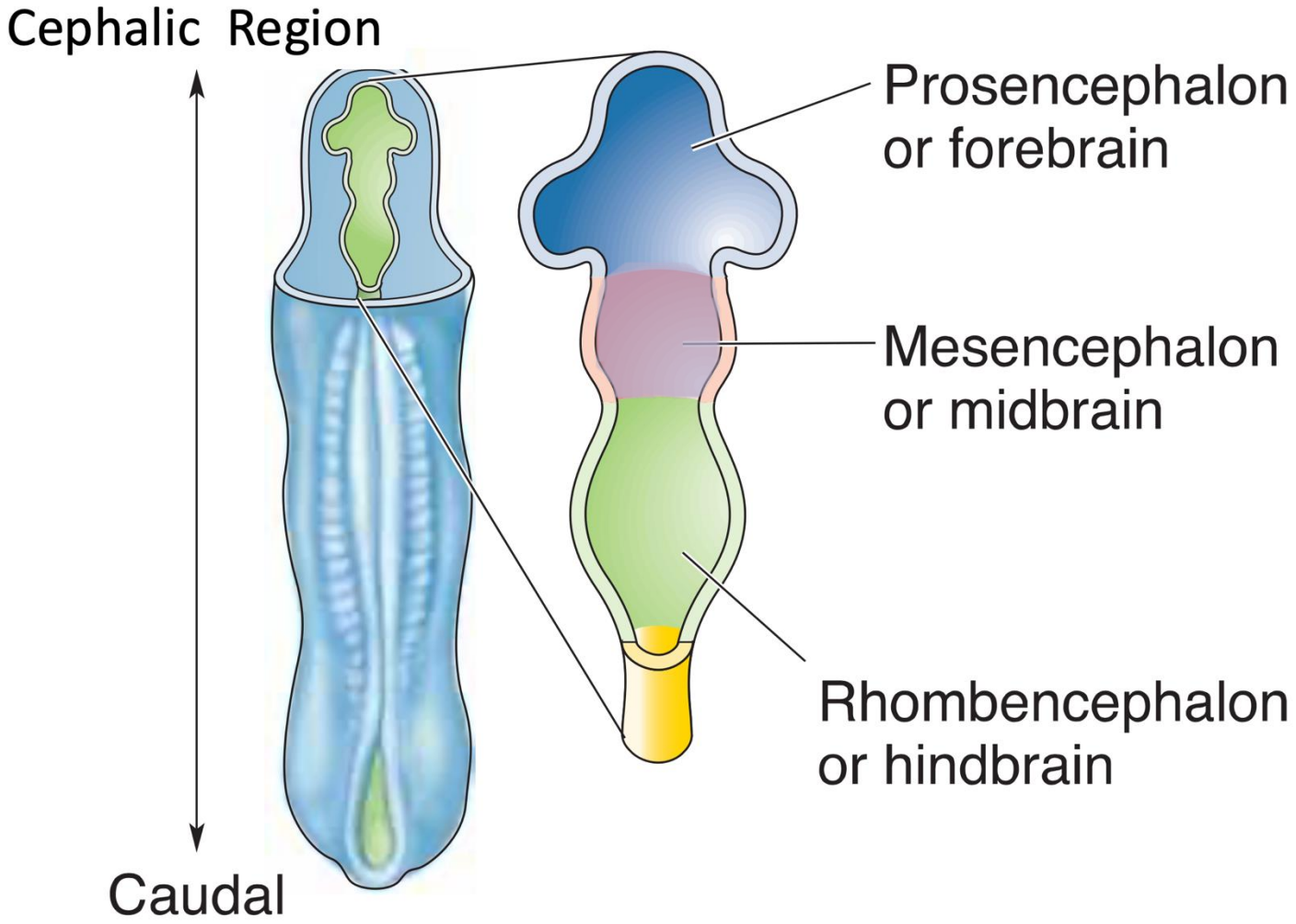
Spinal nerves formation





Development of Nervous System

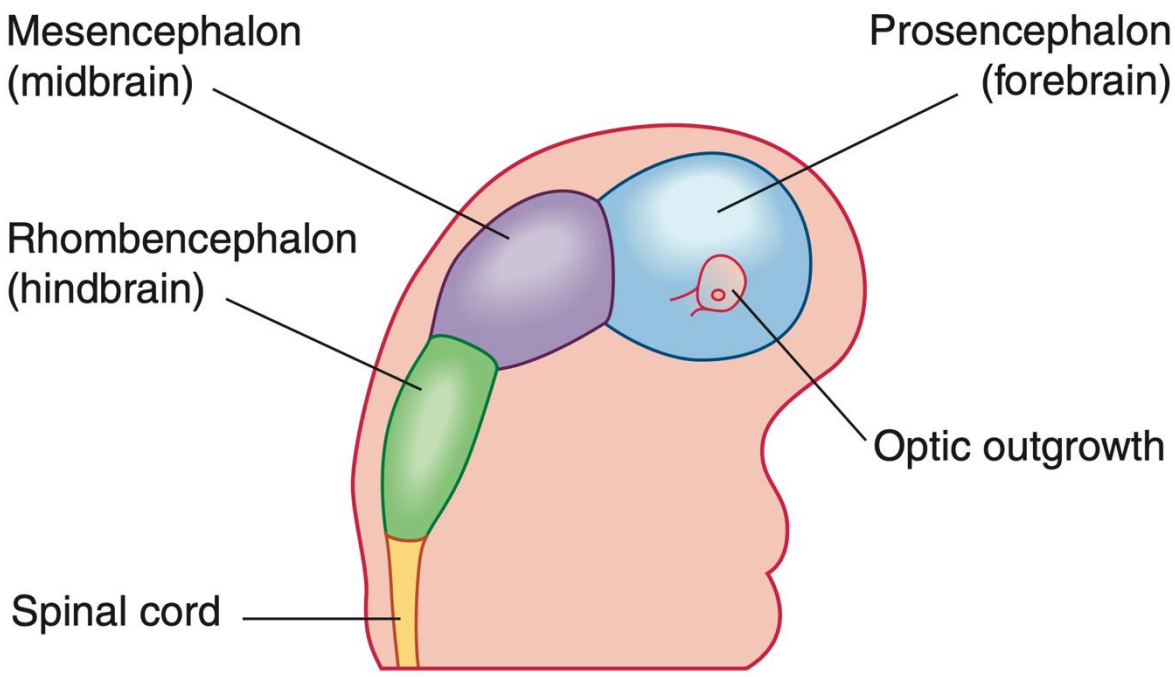
Brain formation - Primary Brain Vesicles



Development of Nervous System

Brain formation

Primary Brain Vesicles

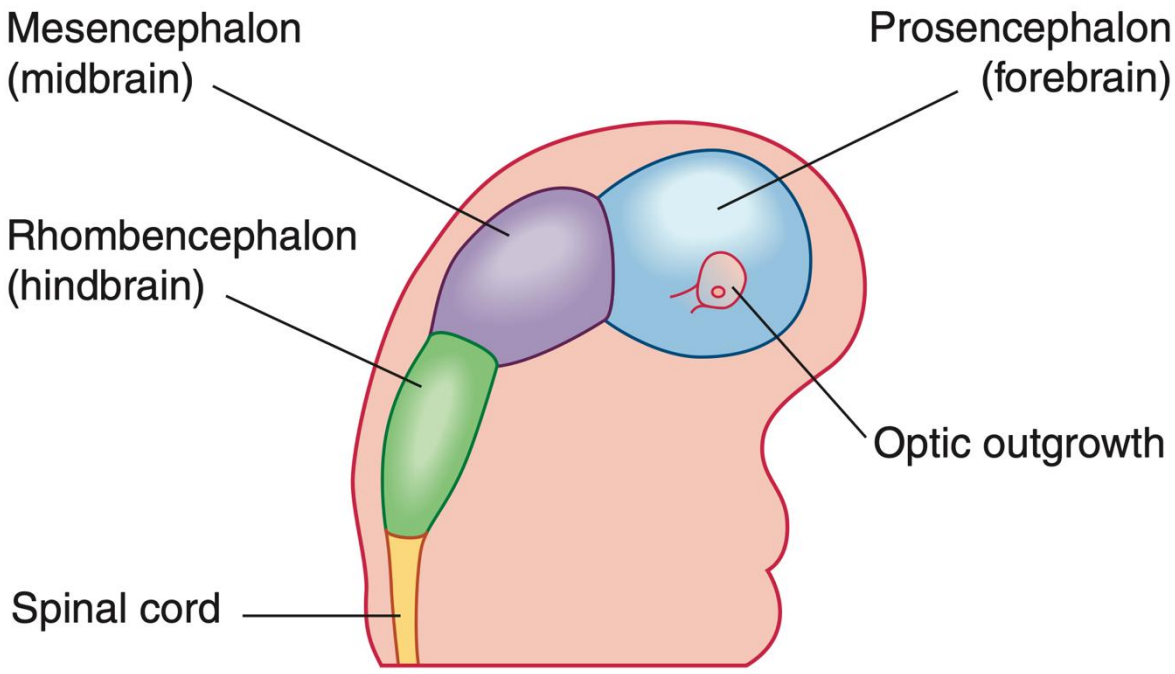


A 4 weeks

Development of Nervous System

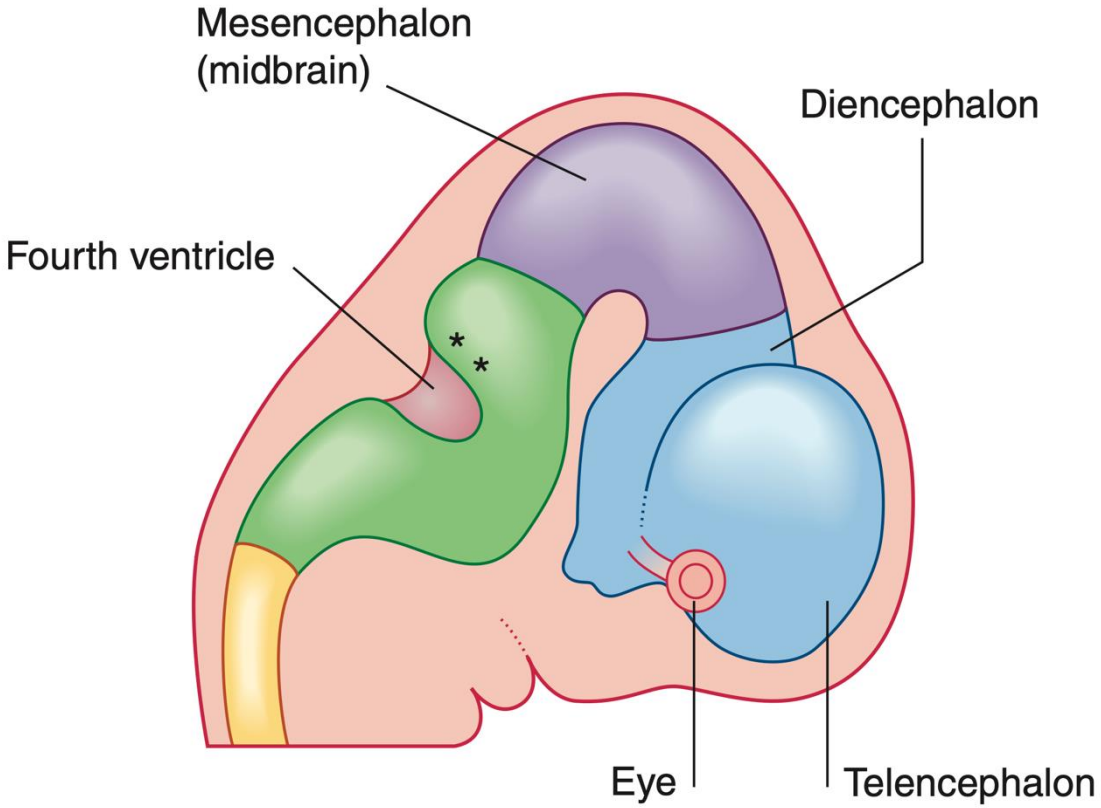
Brain formation

Primary Brain Vesicles



A 4 weeks

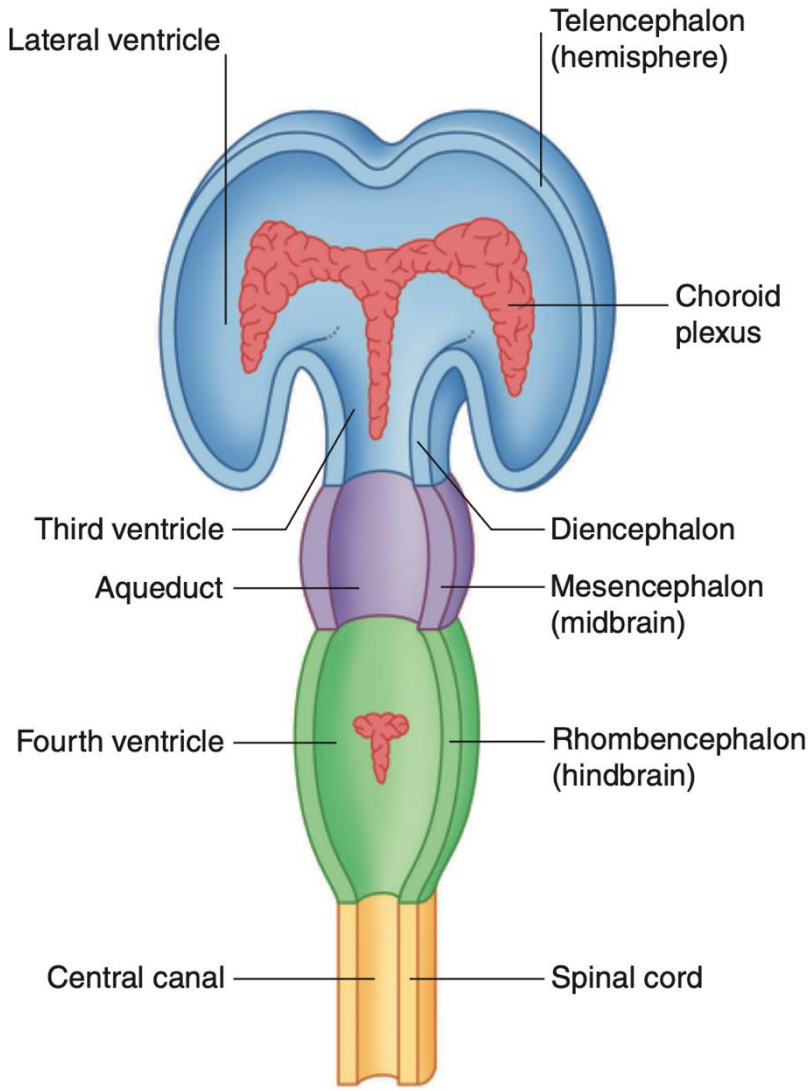
Secondary Brain Vesicles



B 6 weeks

Development of Nervous System

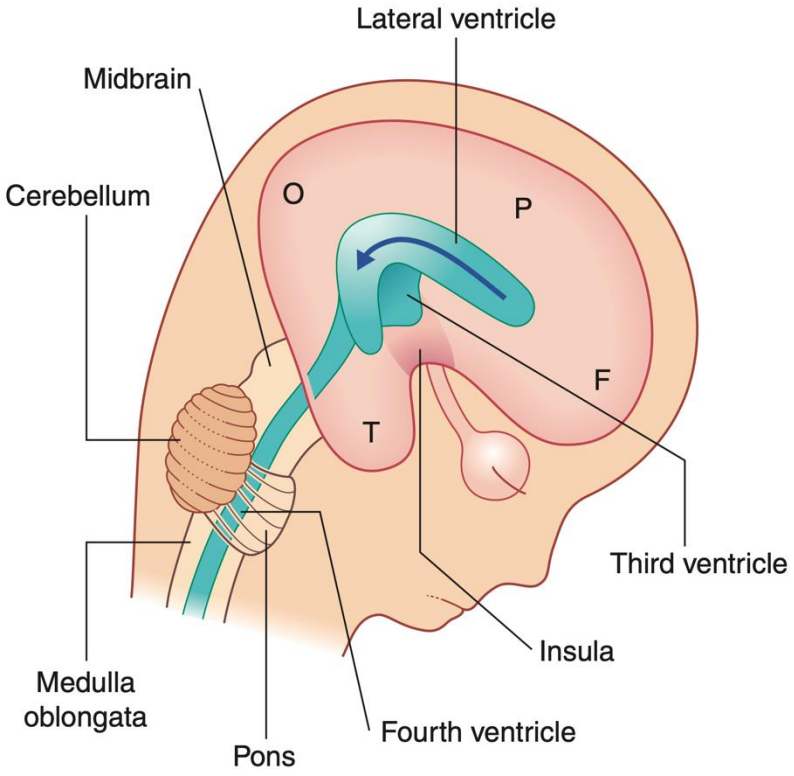
Ventricular system and choroid plexuses



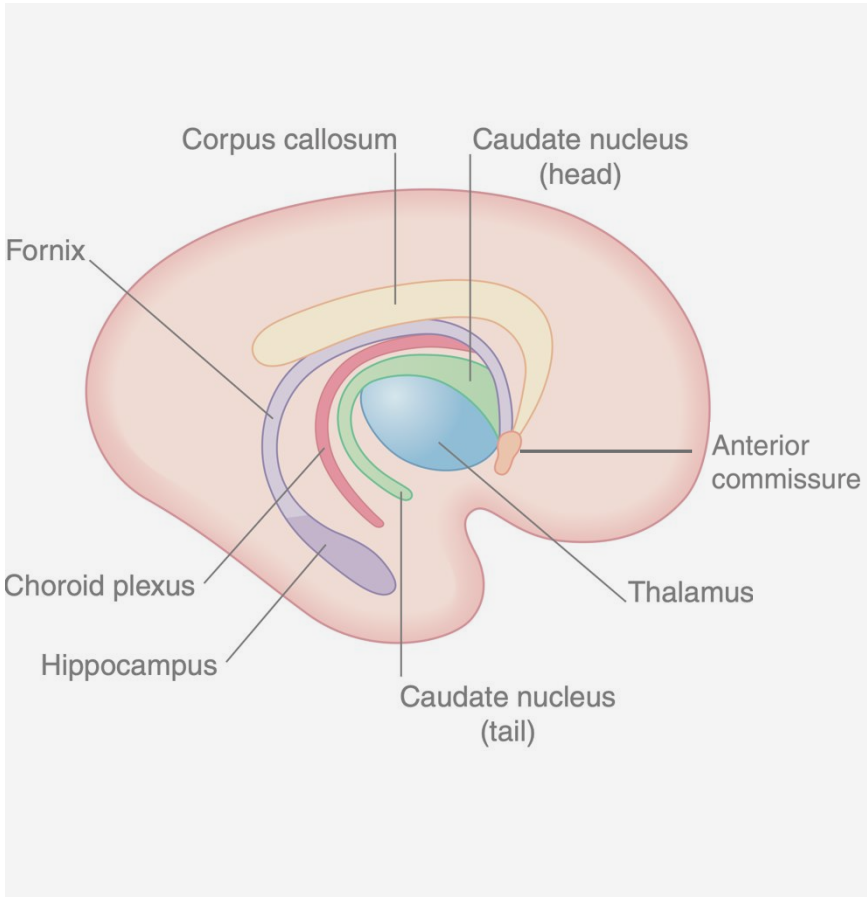
Development of Nervous System

Cerebral hemispheres

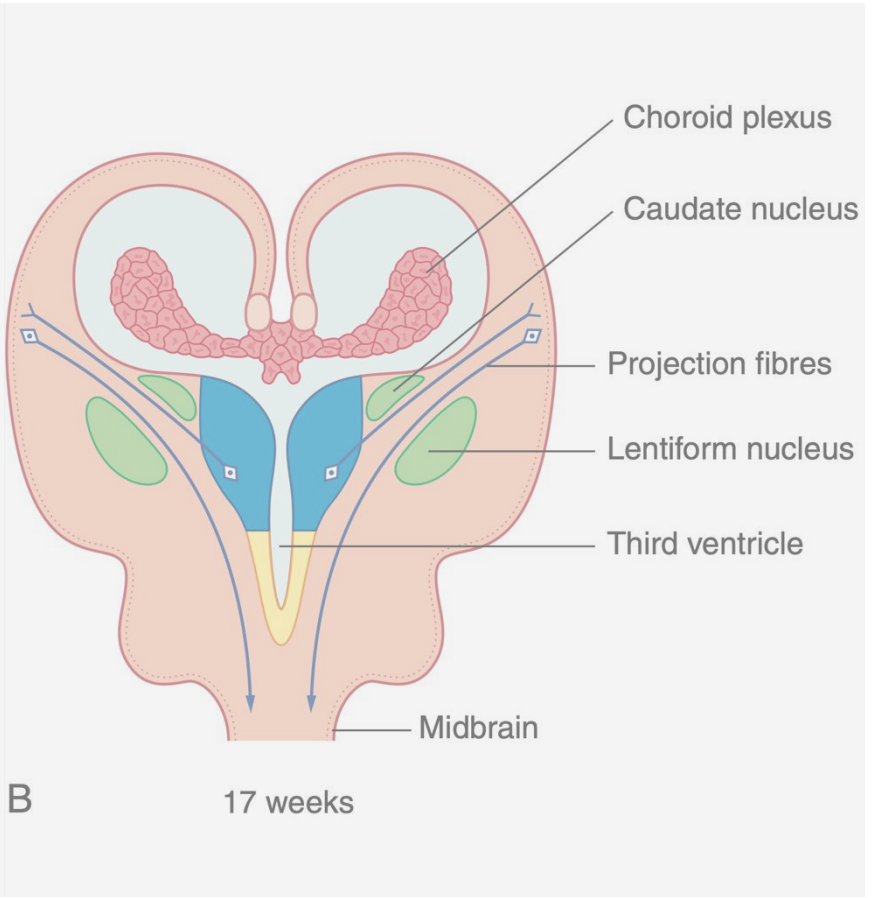
Lateral view



Medial view



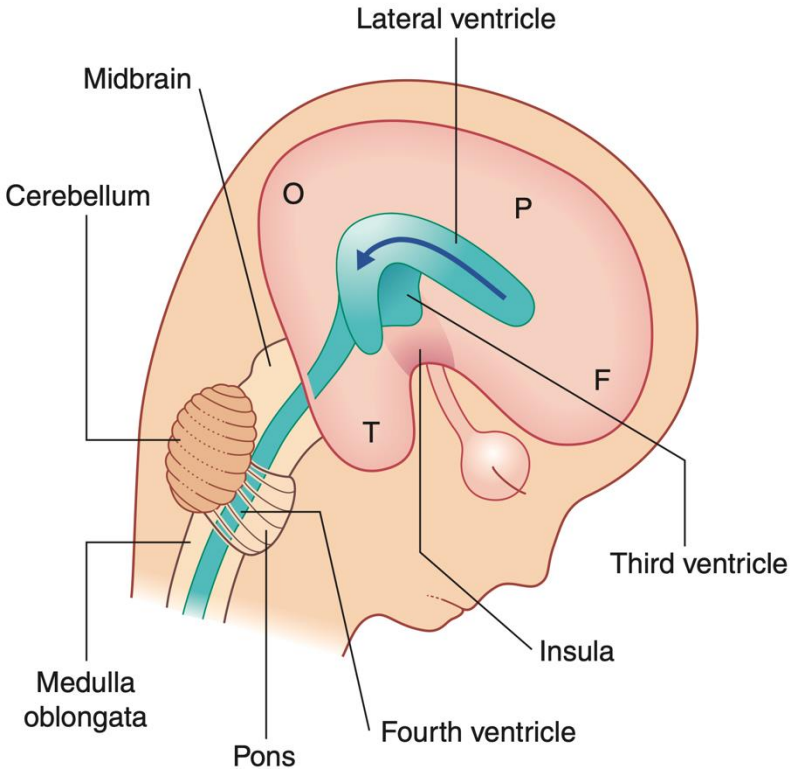
Coronal view



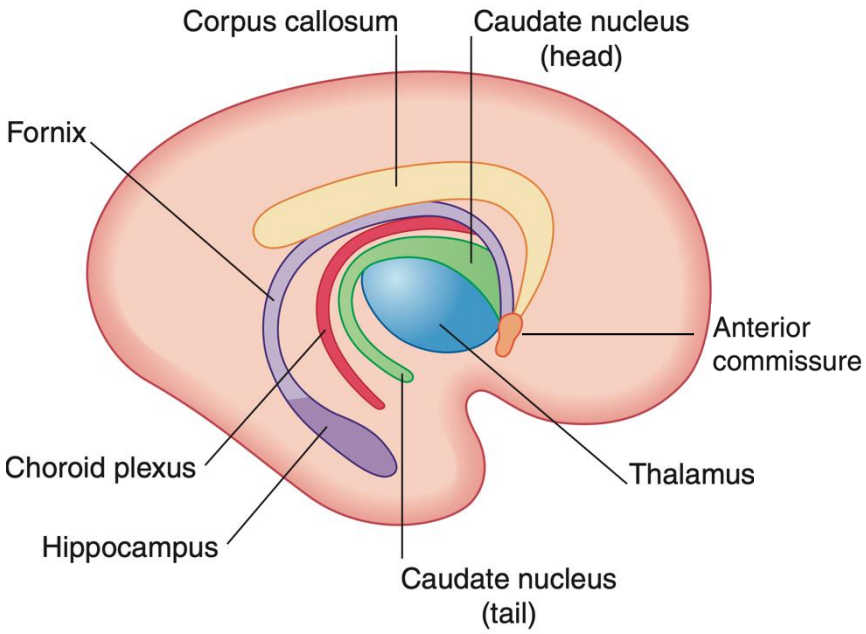
Development of Nervous System

Cerebral hemispheres

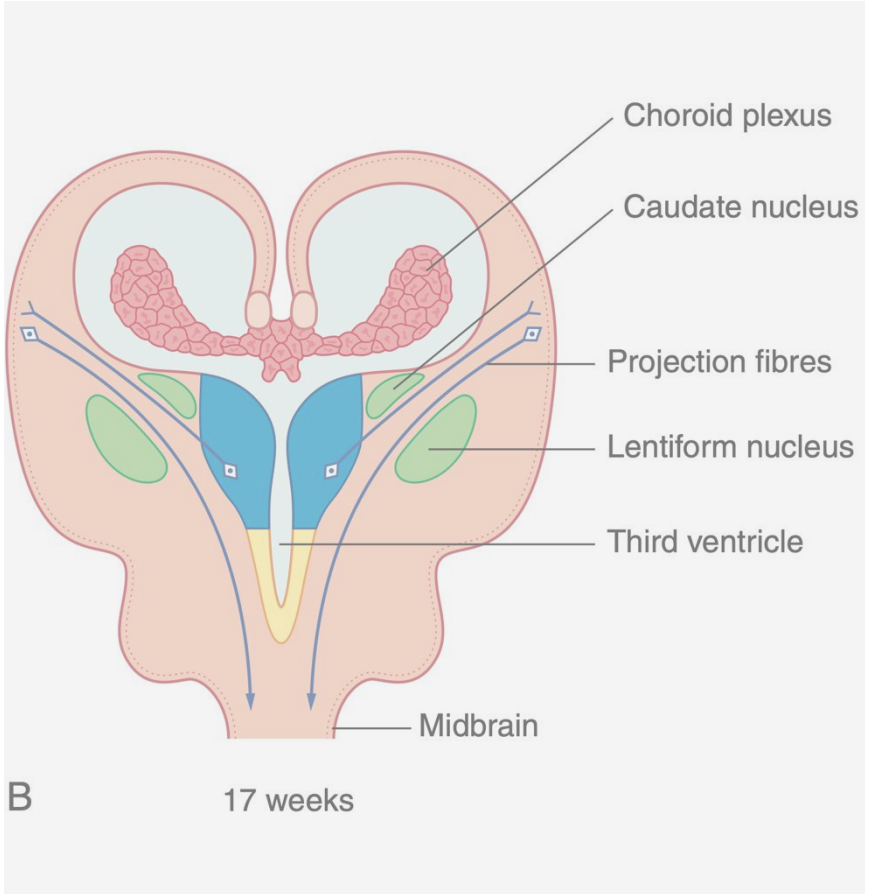
Lateral view



Medial view



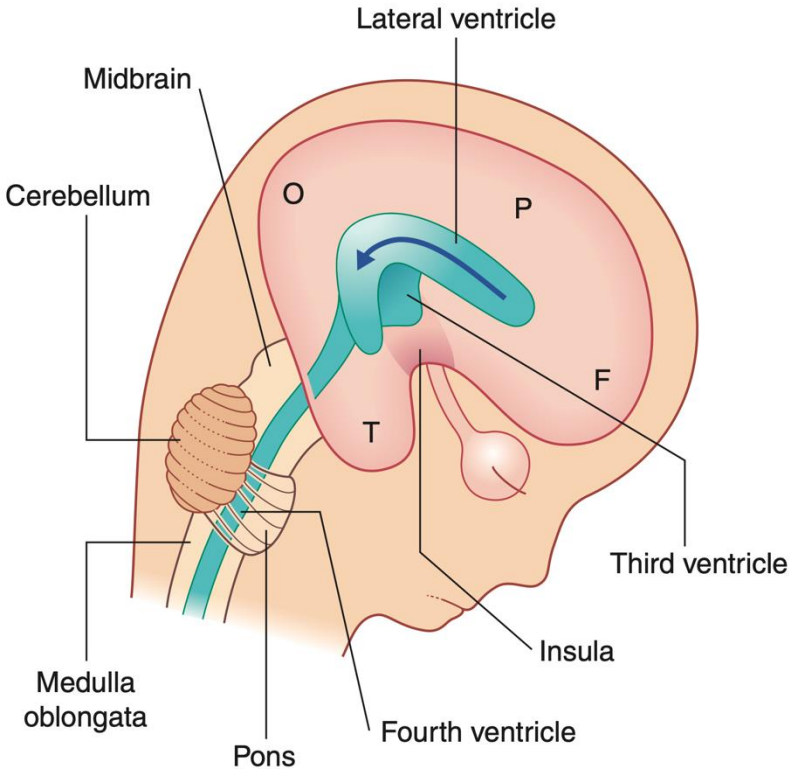
Coronal view



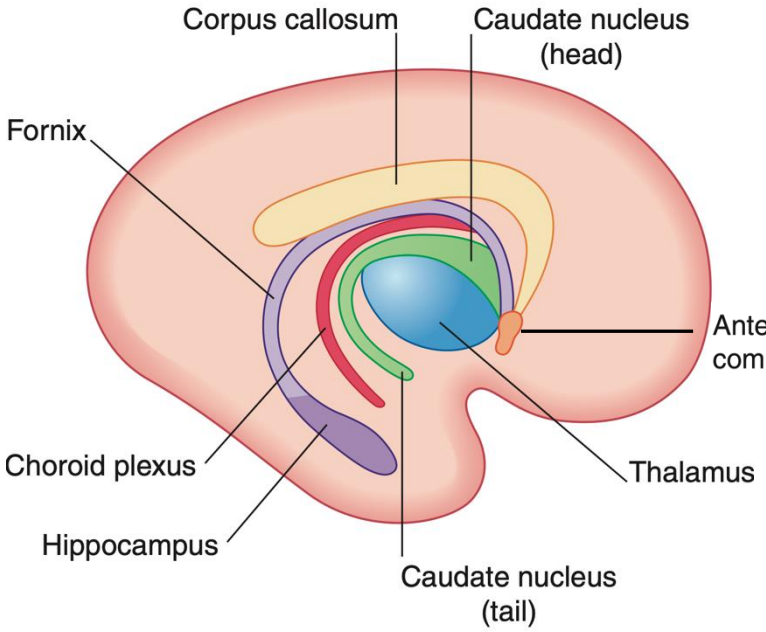
Development of Nervous System

Cerebral hemispheres

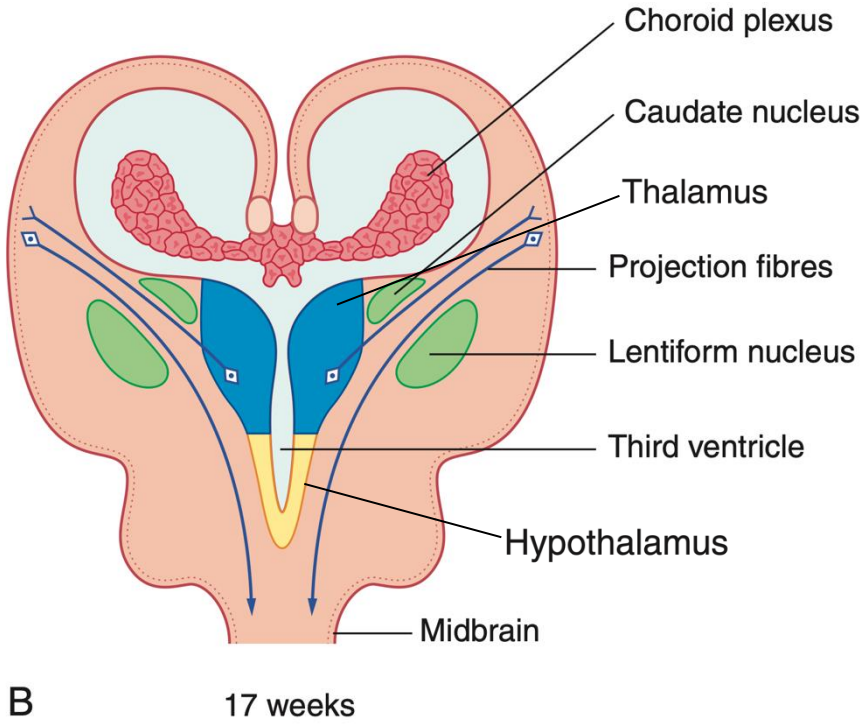
Lateral view



Medial view

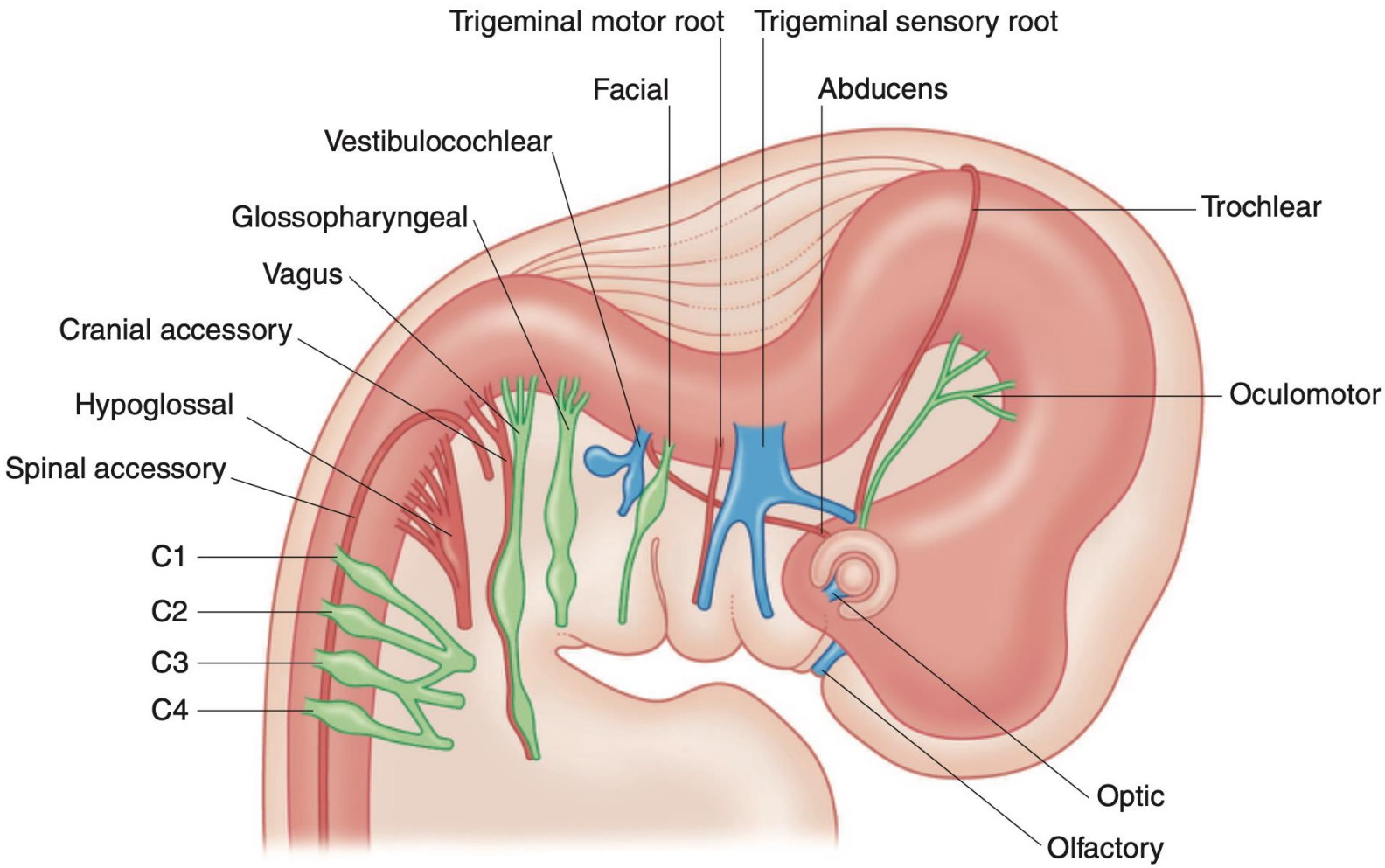


Coronal view



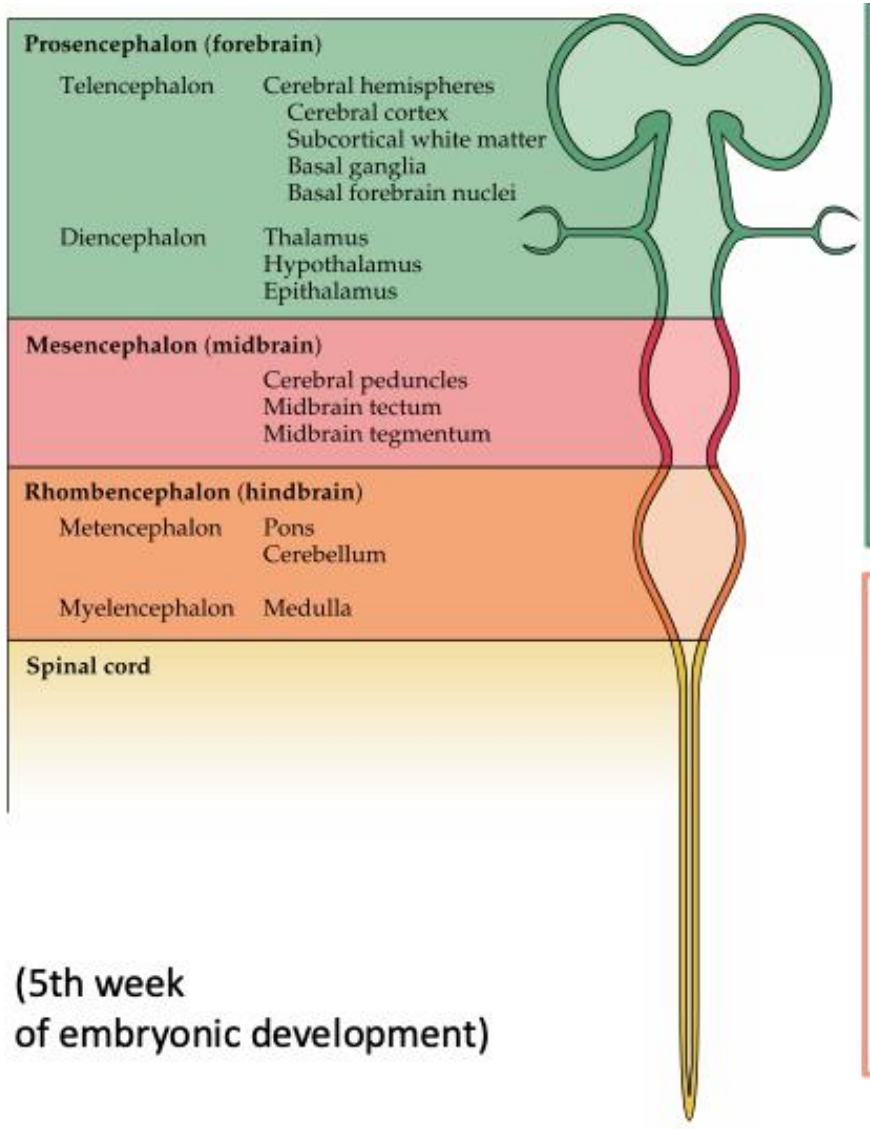
Development of Nervous System

The cranial nerves

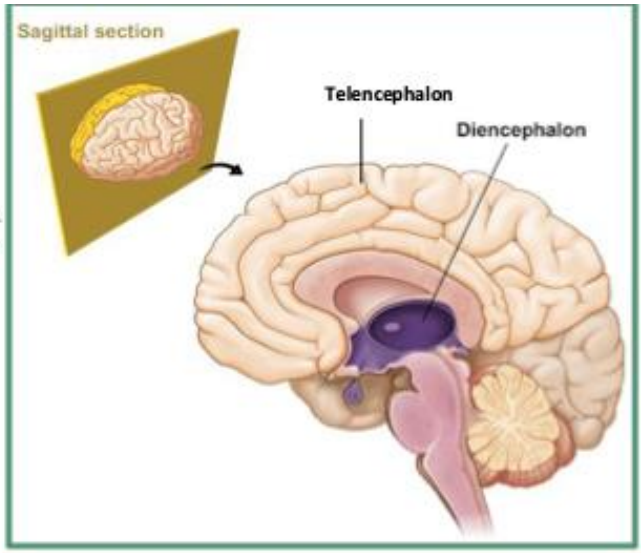


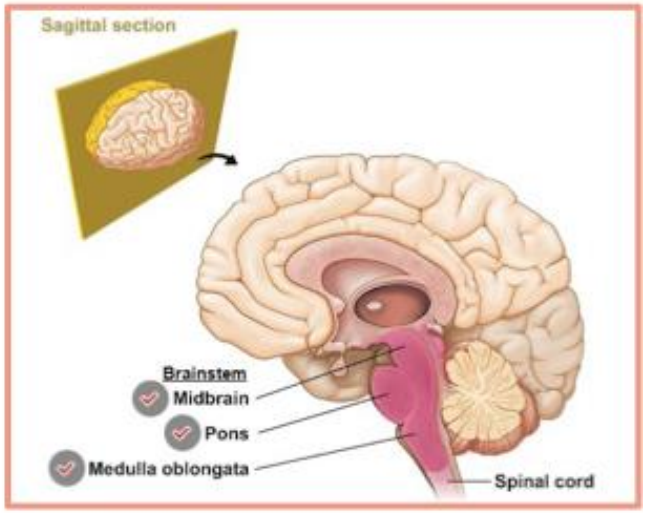
Development of Nervous System

From embryogenesis to adulthood



(5th week
of embryonic development)

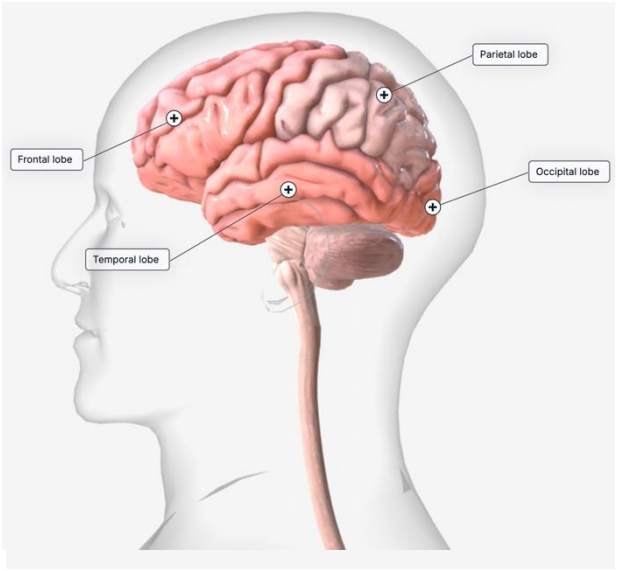




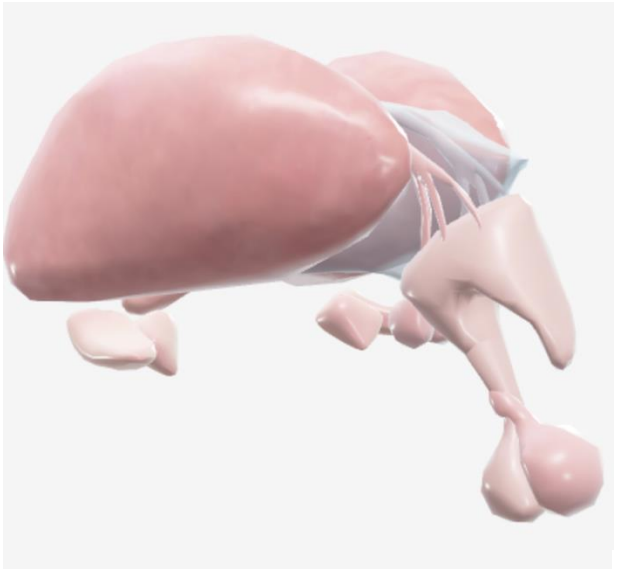
The macroscopic organization of CNS

Macroscopic organization of CNS

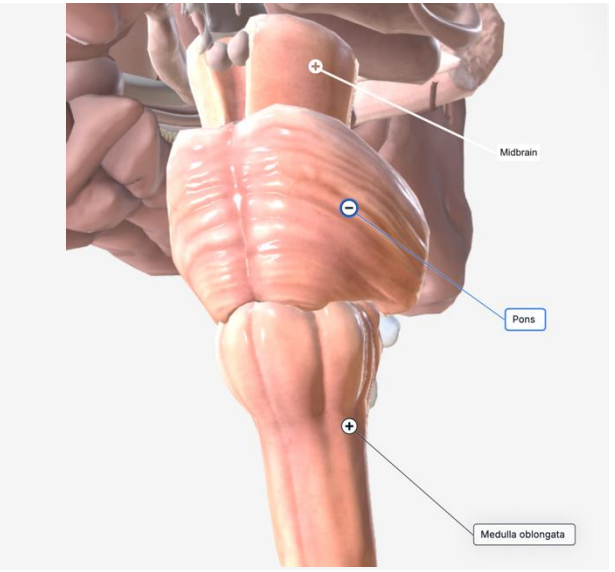
Cerebral hemispheres



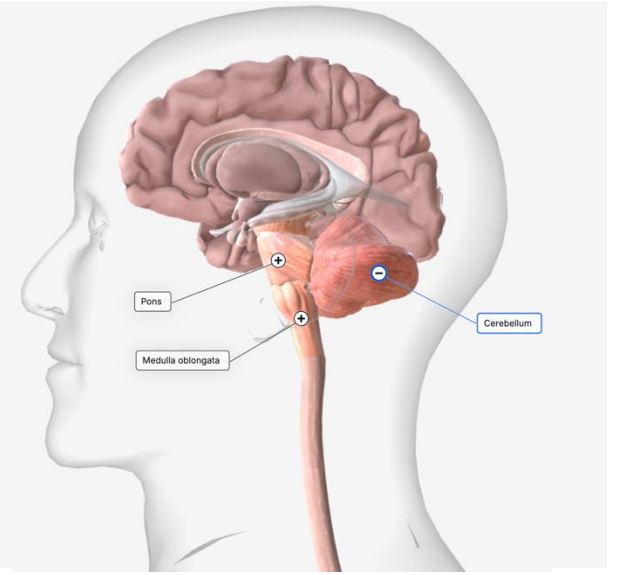
Diencephalon



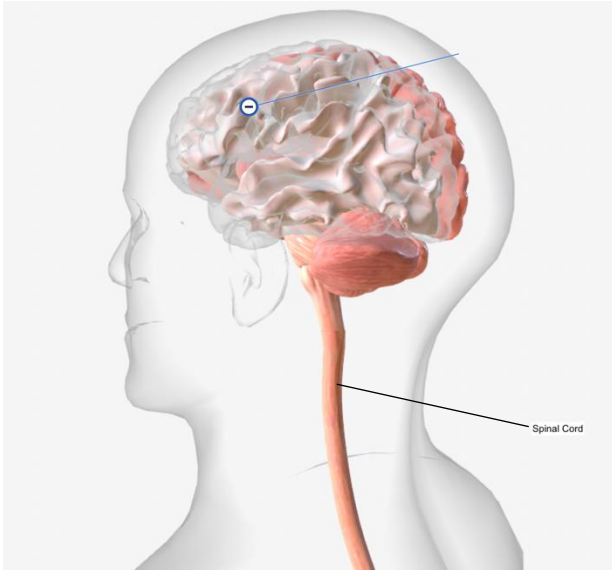
Brainstem



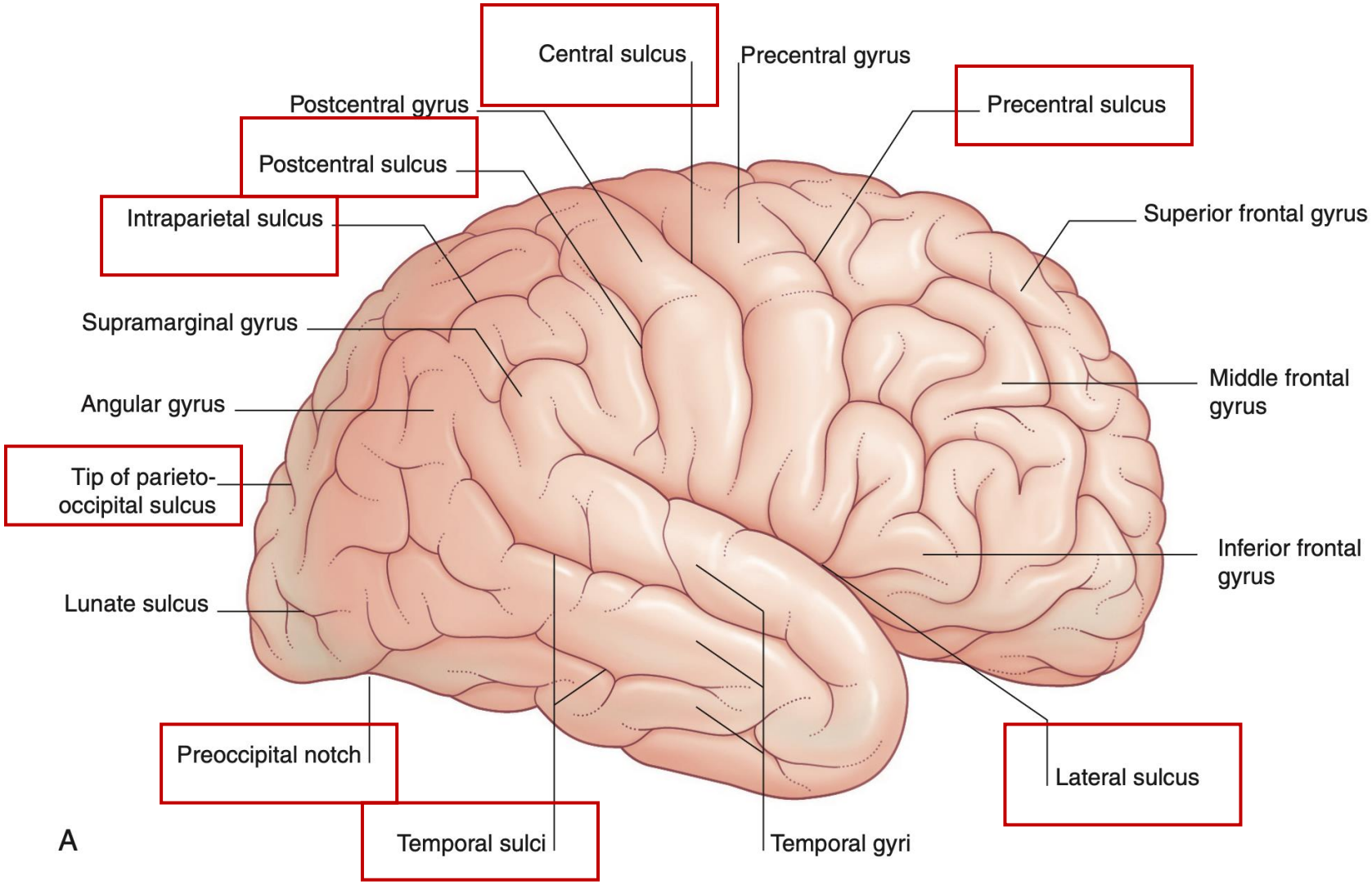
Cerebellum



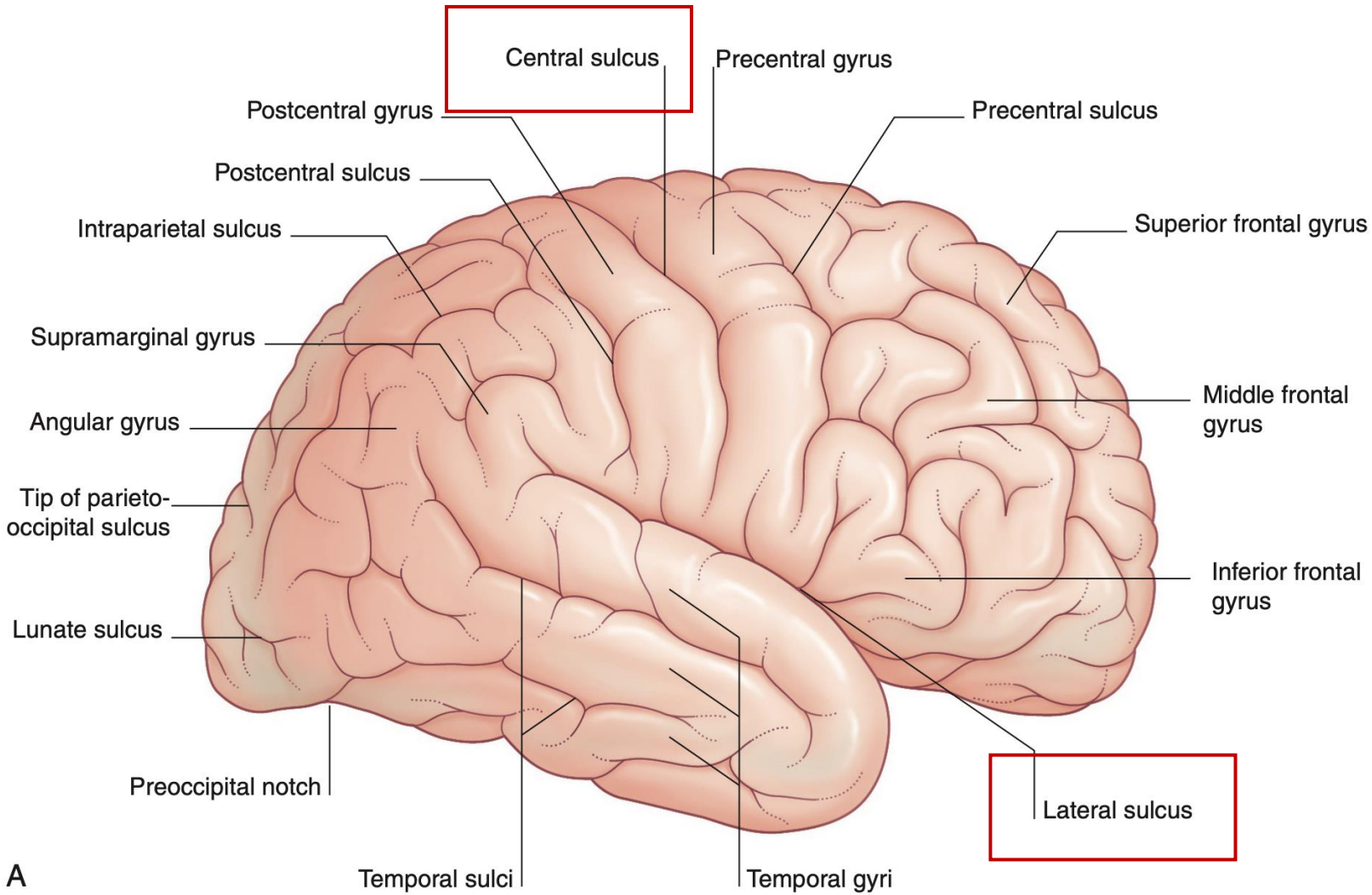
Spinal cord



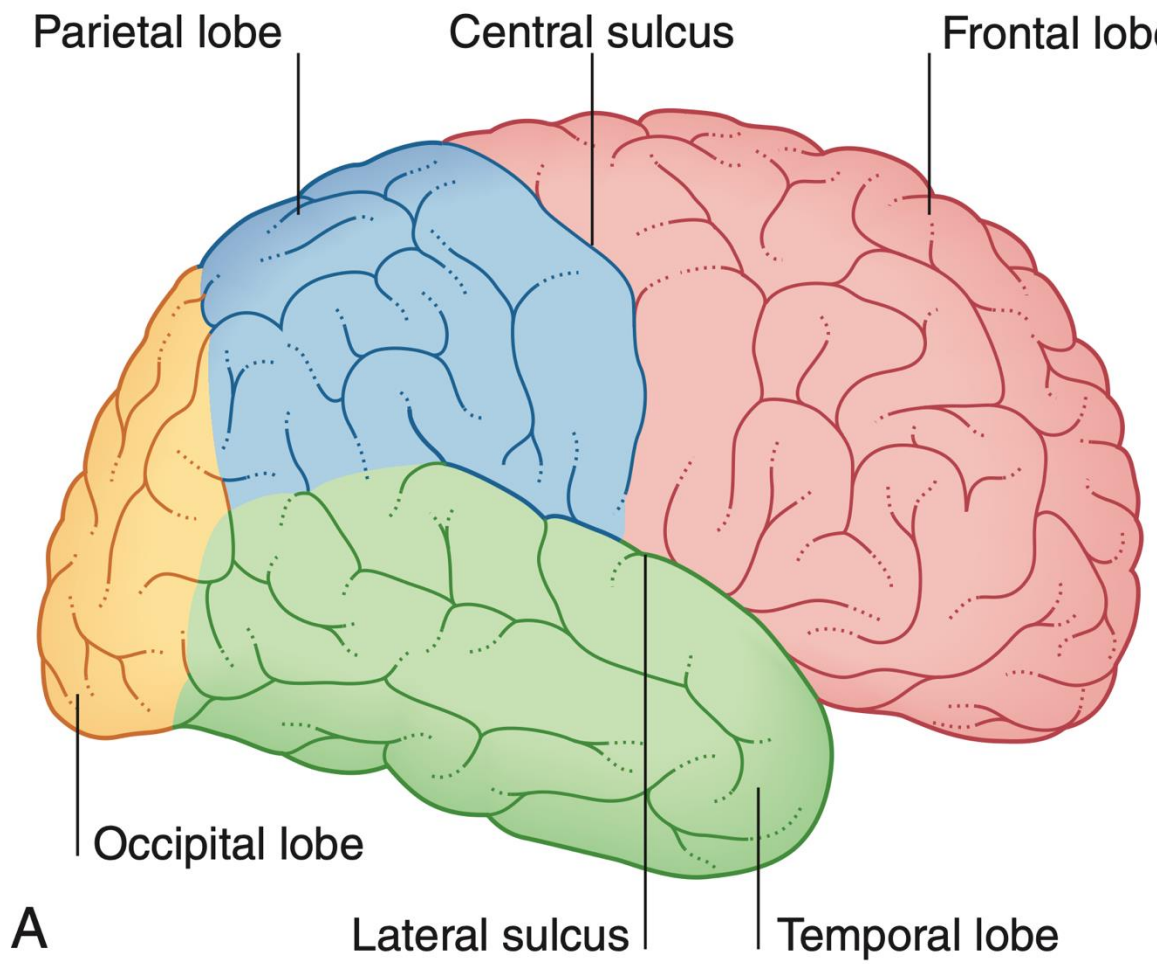
Surface Organization of the Cerebral Hemispheres



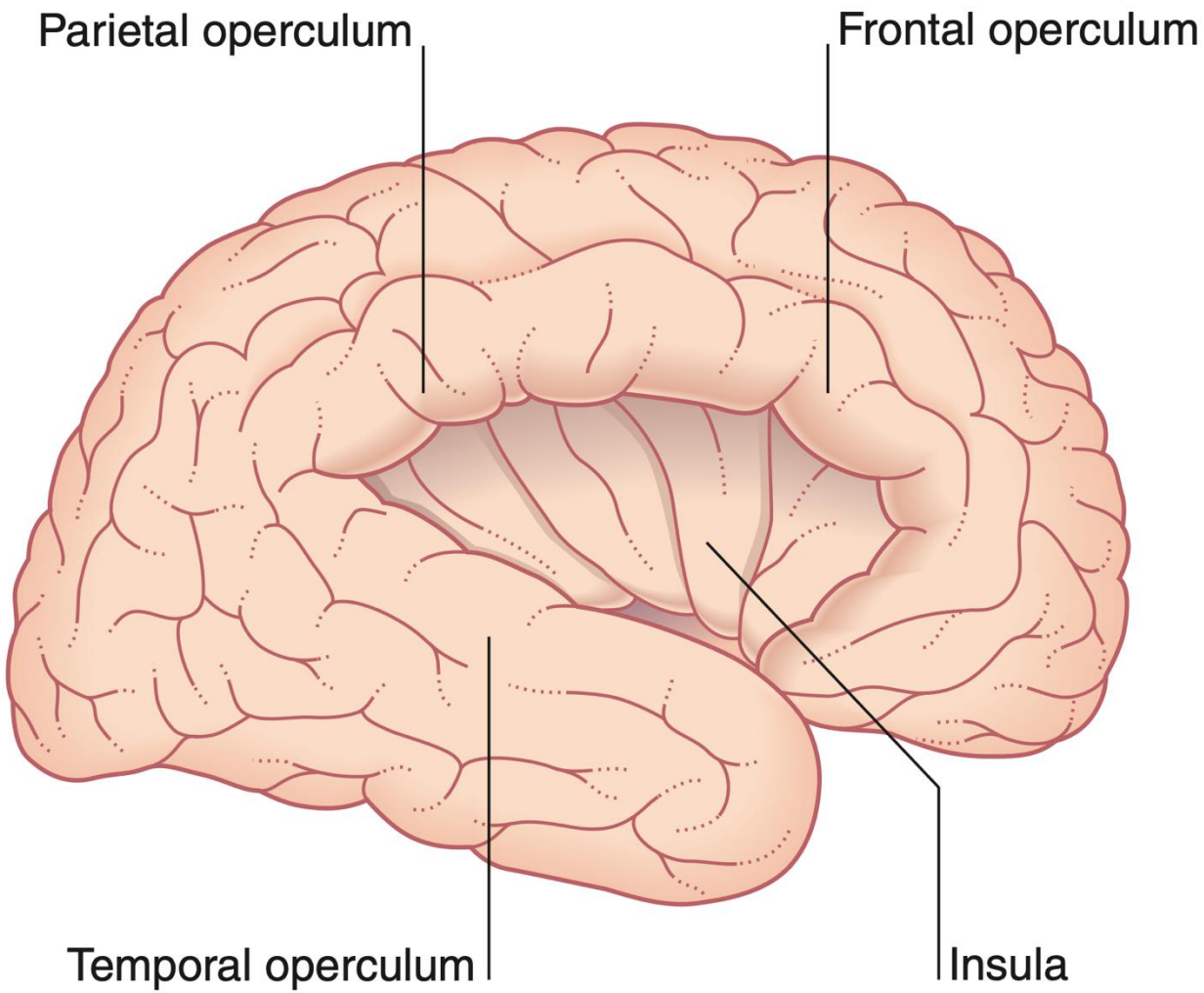
Surface Organization of the Cerebral Hemispheres



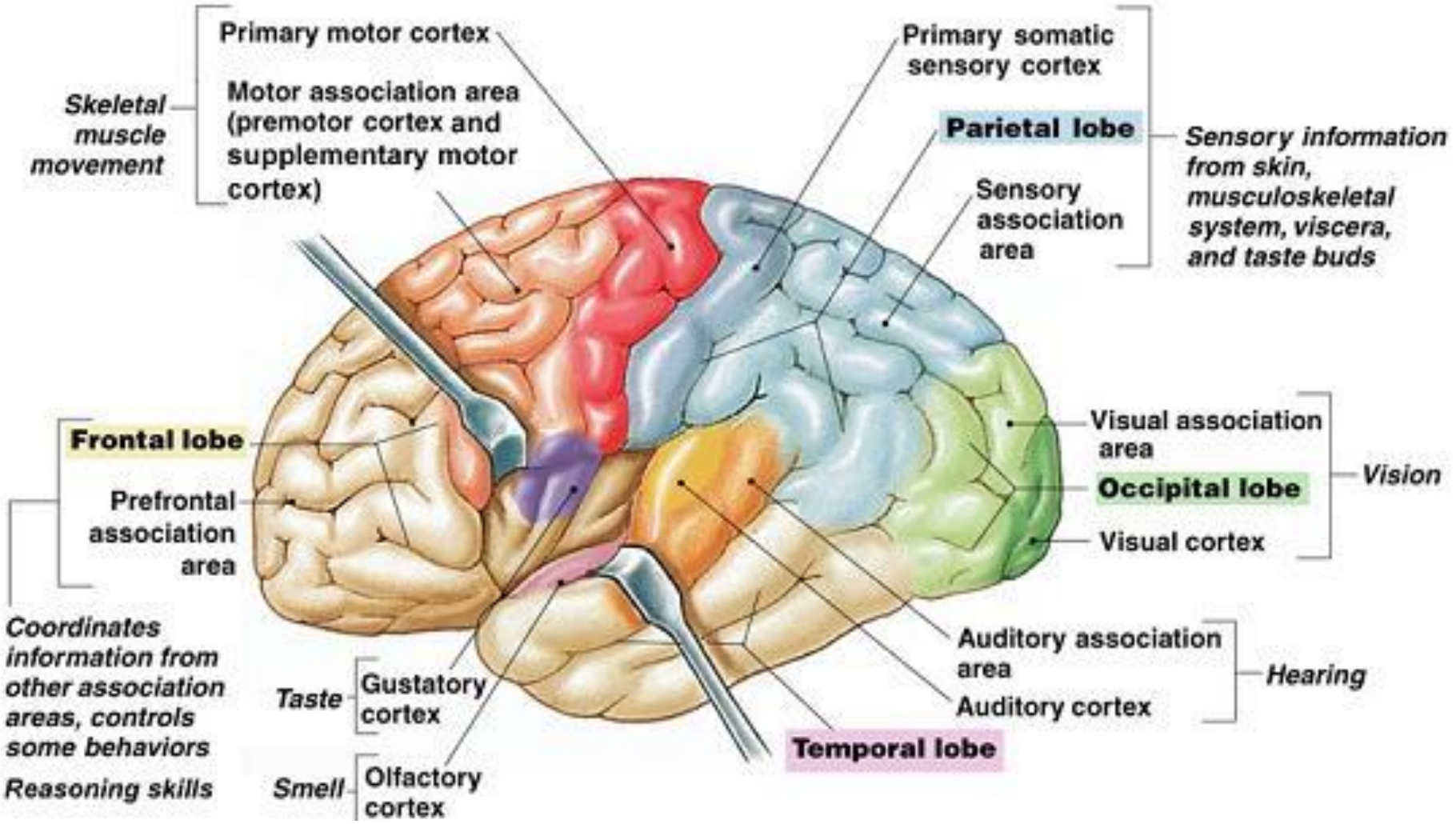
Surface Organization of the Cerebral Hemispheres



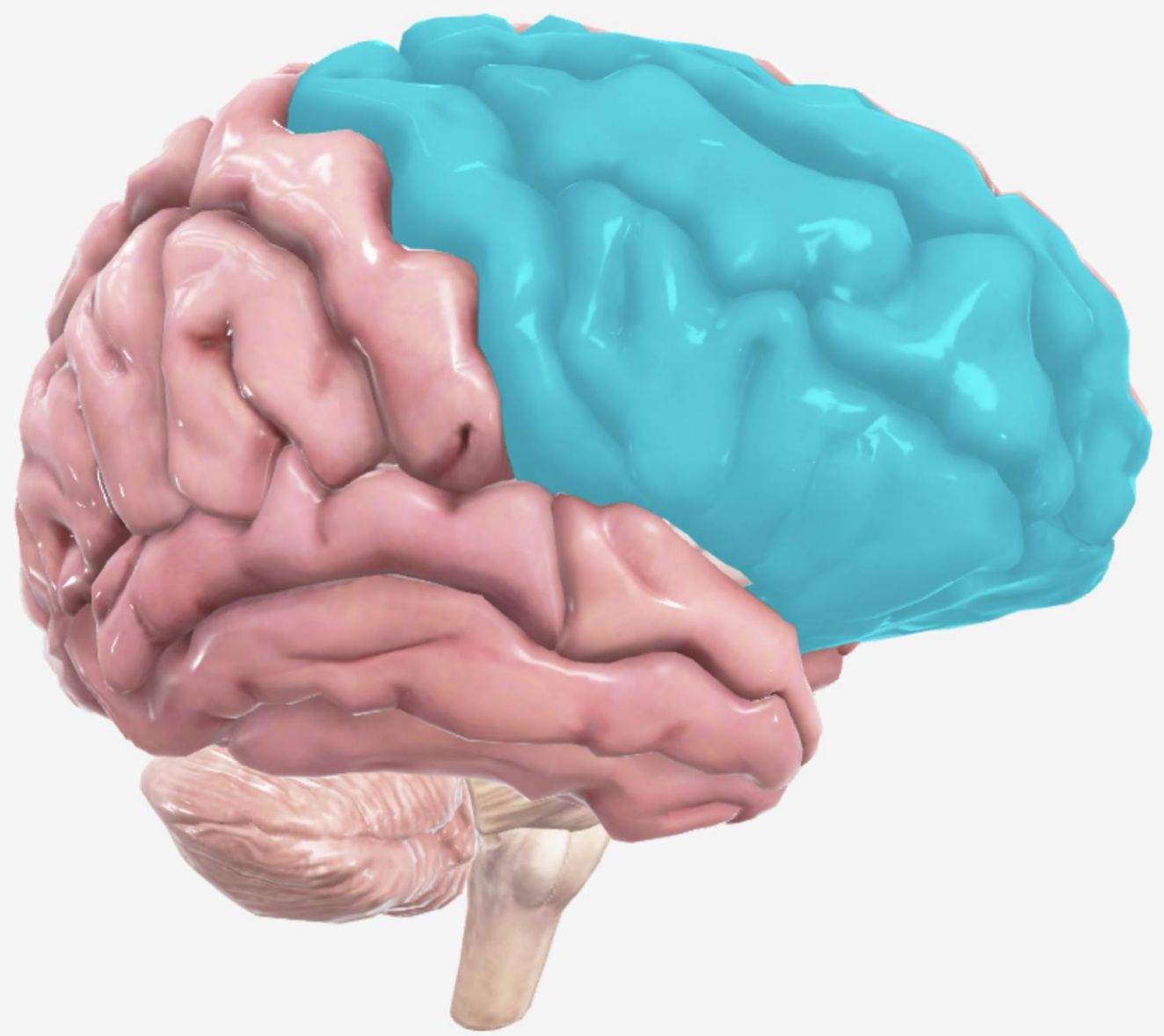
Surface Organization of the Cerebral Hemispheres



Functions of the cerebral lobes



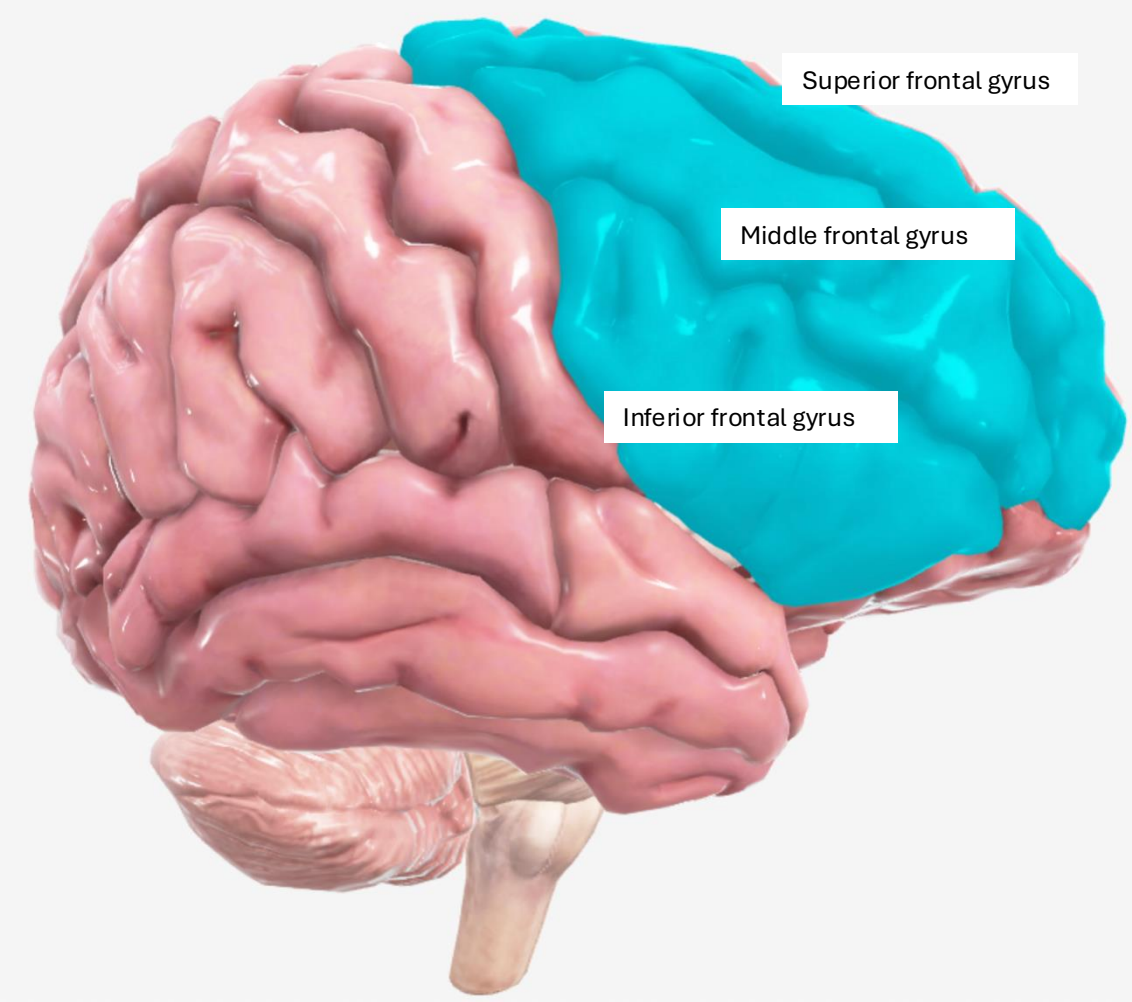
The Frontal Lobe



The frontal lobe includes:

- The prefrontal cortex
- The precentral gyrus
- The orbitofrontal gyrus.

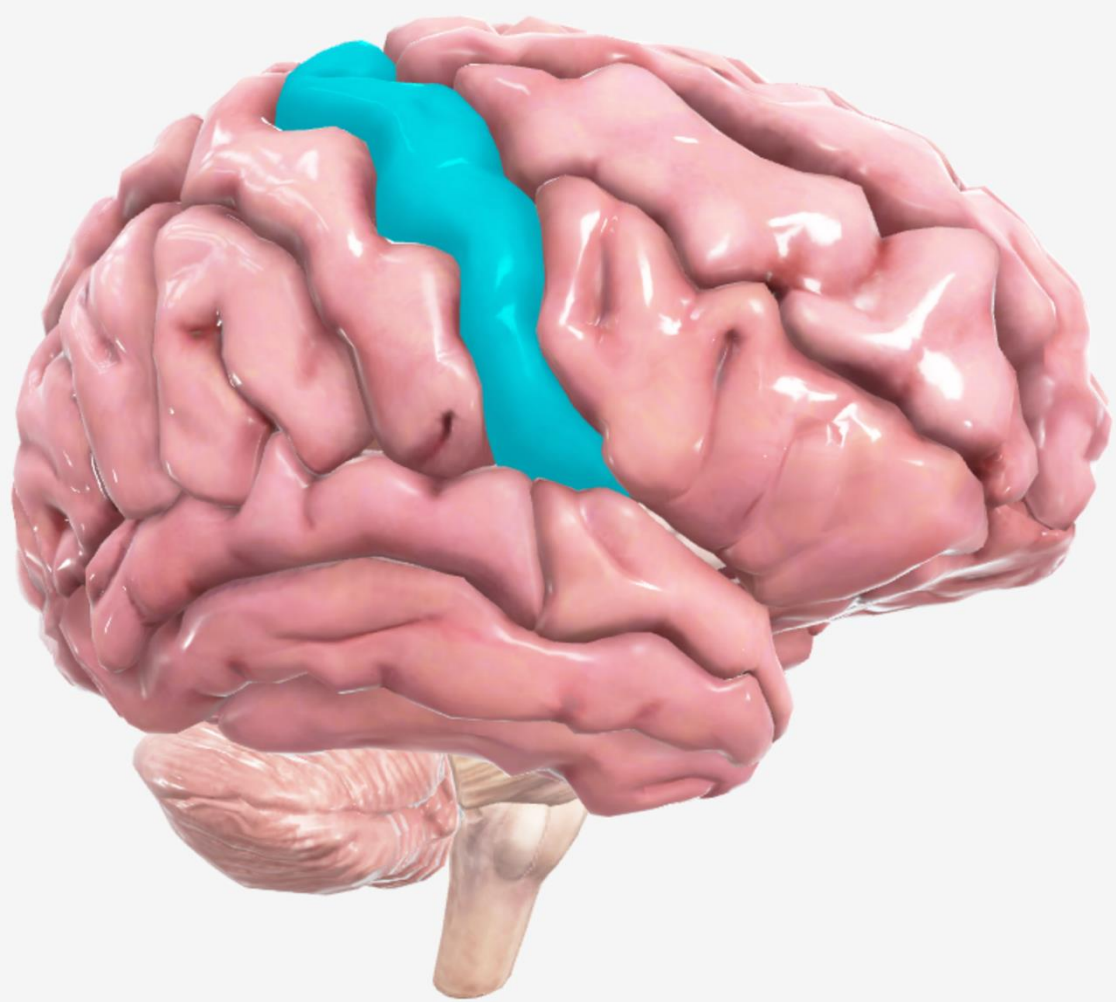
The Frontal Lobe



The prefrontal cortex subserves higher cognitive functions, such as executive functioning and emotional regulation.
It includes:

- The superior frontal gyrus
- The middle frontal gyrus
- The inferior frontal gyrus

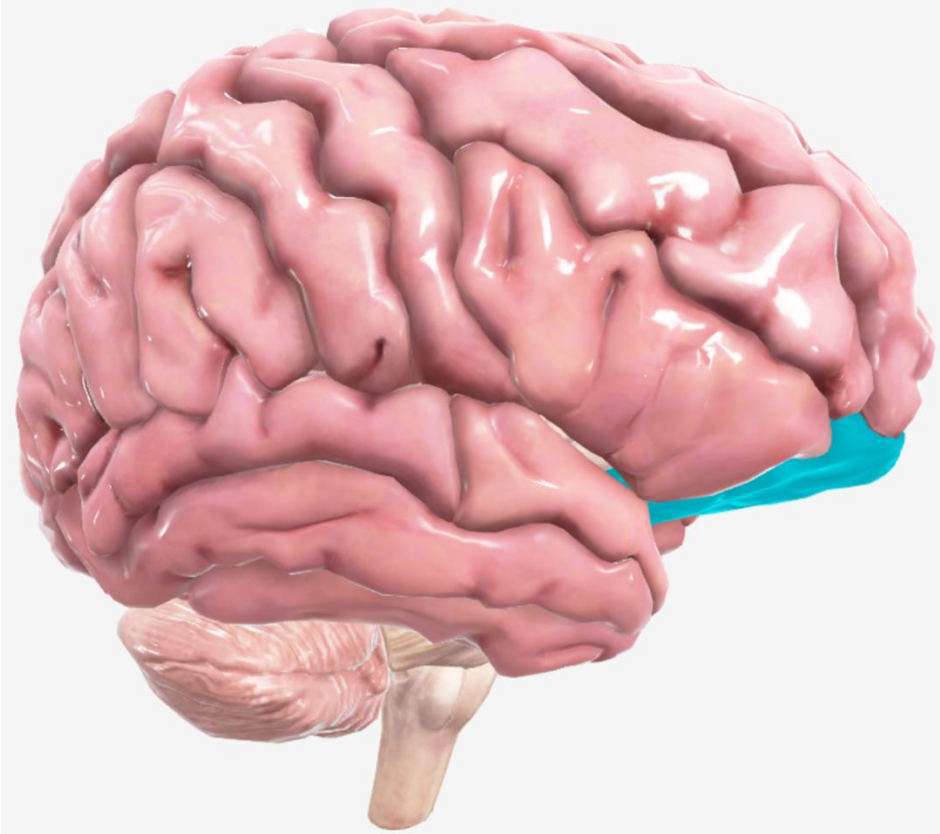
The Frontal Lobe

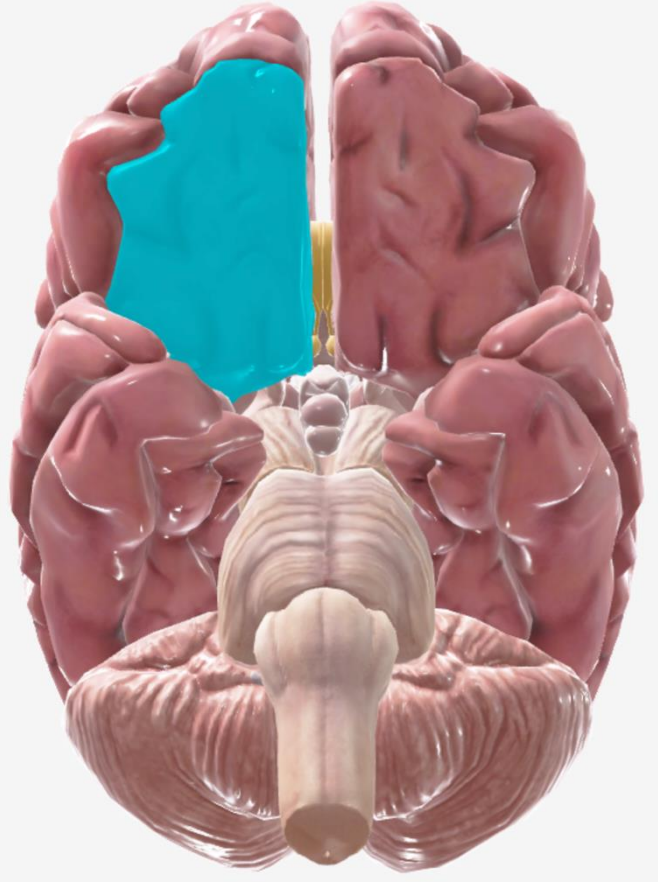


The precentral gyrus is located in the posterior region of the frontal lobe.

The precentral gyrus togheter with the anterior part of the paracentral lobule (in the medial surface), forms the primary motor cortex, that initiates volitional movements of the controlateral side of the body and contains the representation of the body (humunculus motorius).

The Frontal Lobe





The orbital gyrus is involved with intellectual and emotional expression.

It is located on the concave inferior surface of the frontal lobe.

It is located medially to the olfactory sulcus and laterally to the straight gyrus (gyrus rectus).

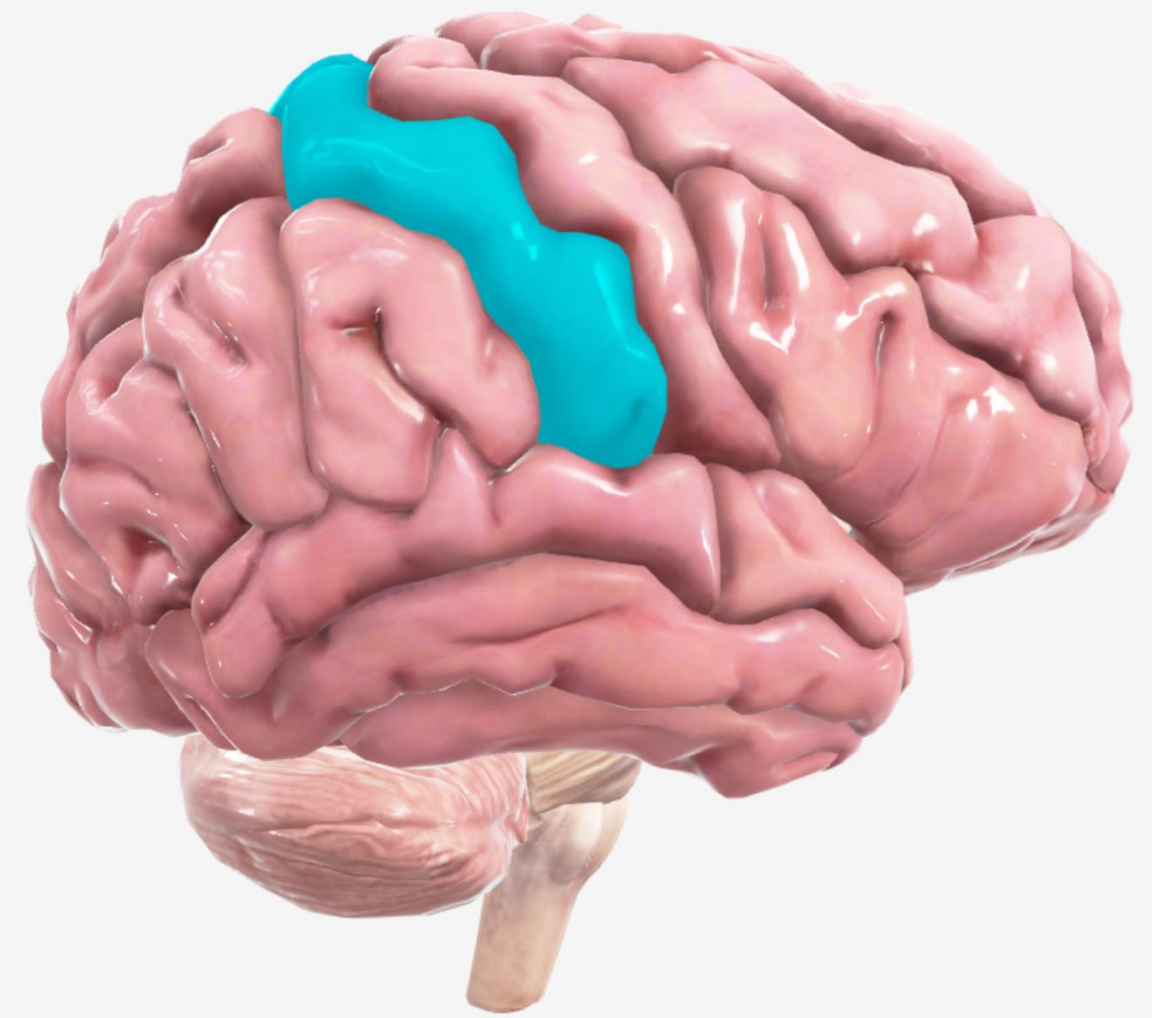
The Parietal Lobe



The parietal lobe includes:

- The postcentral gyrus
- The parietal lobule
- The supramarginal gyrus
- The angular gyrus

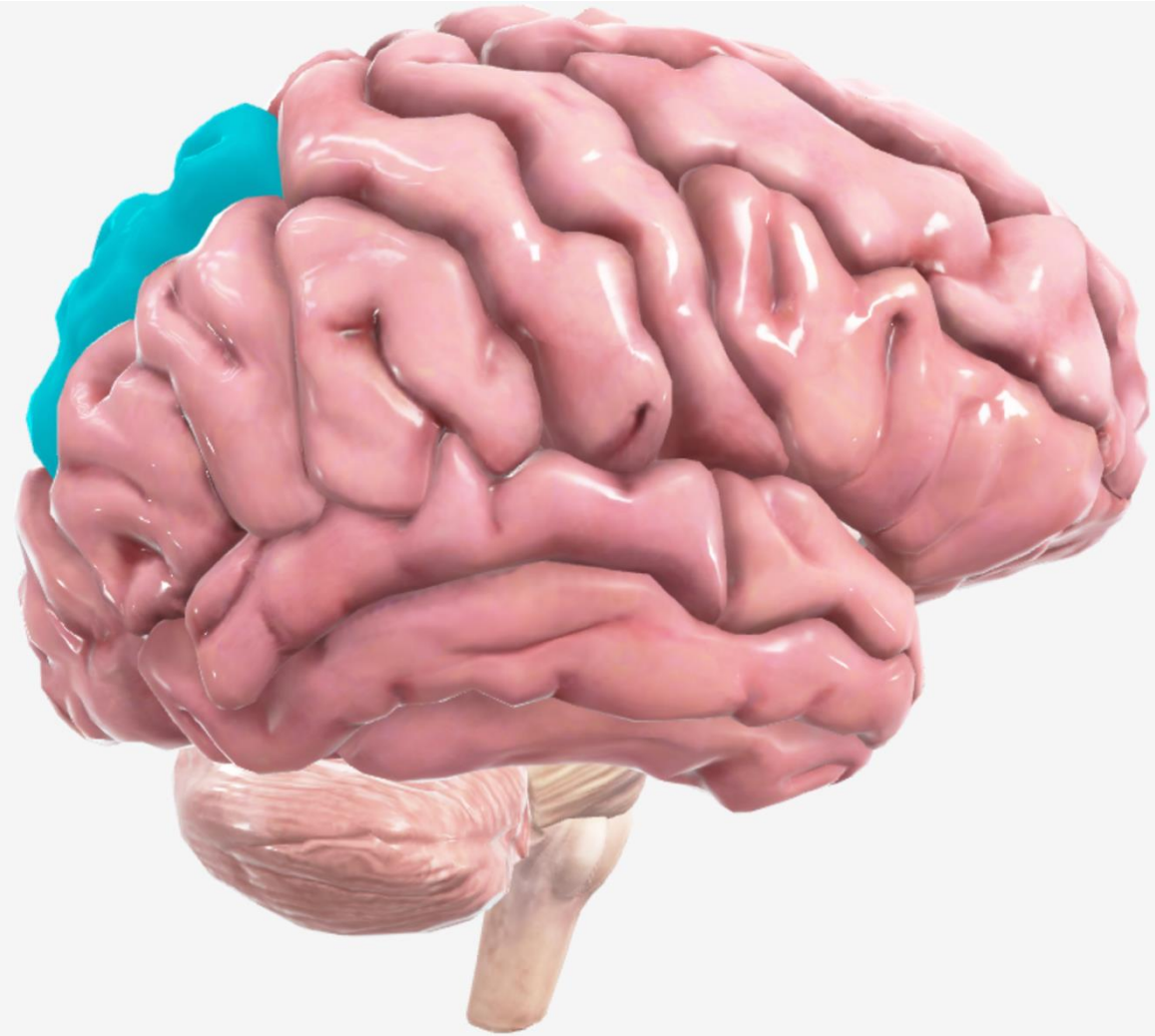
The Parietal Lobe



The postcentral gyrus contains the primary somatosensory cortex which is responsible for somatosensory perception, including touch, pressure, temperature, and pain.
It contains the representation of the body (sensory homunculus).

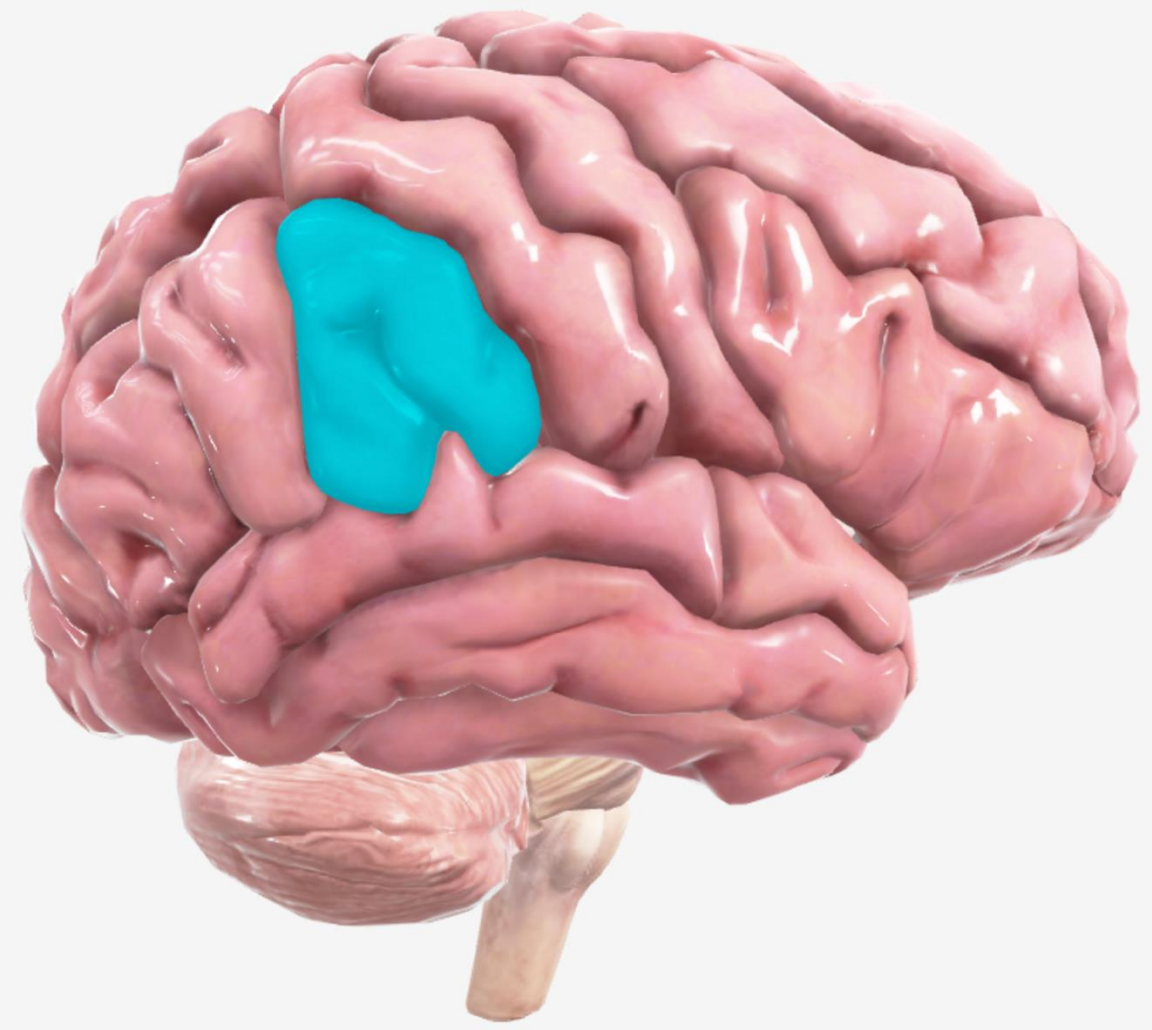
It is a long and narrow gyrus posterior to the central sulcus, which separates it from the precentral gyrus.
The postcentral gyrus is separated from the rest of the parietal lobe by the postcentral sulcus.

The Parietal Lobe



The parietal lobule is involved in visual and spatial perception and attention.
It is rectangular shaped and bounded by the postcentral sulcus superiorly; the intraparietal sulcus, which separates it from the inferior parietal lobule; and the parieto-occipital sulcus, which separates the parietal lobe from the occipital lobe.

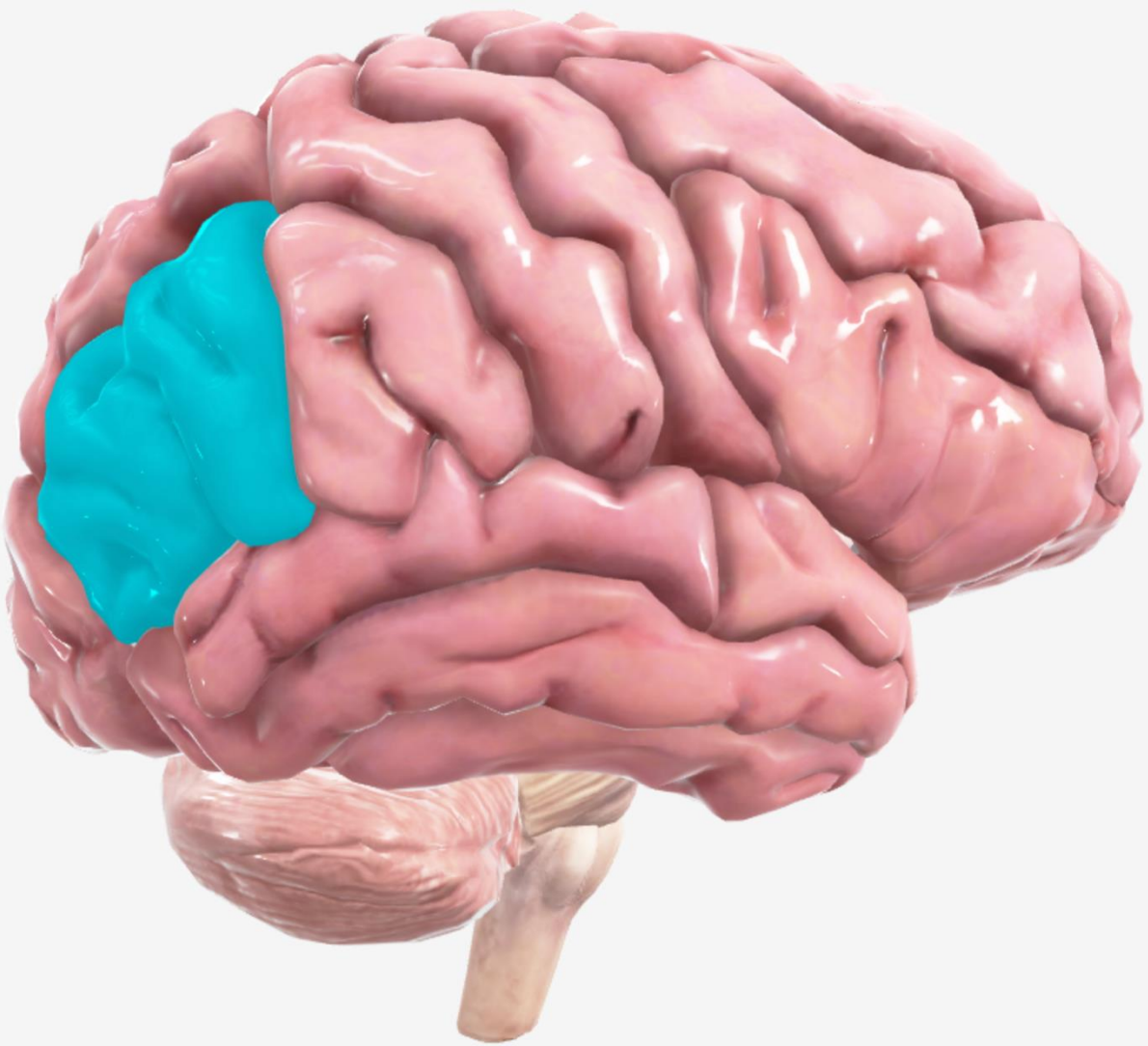
The Parietal Lobe



The supramarginal gyrus is part of the somatosensory complex and involved in spatial awareness.

It is a small region, bordered by the postcentral gyrus, the angular gyrus, the superior parietal lobule, and the superior temporal gyrus.

The Parietal Lobe

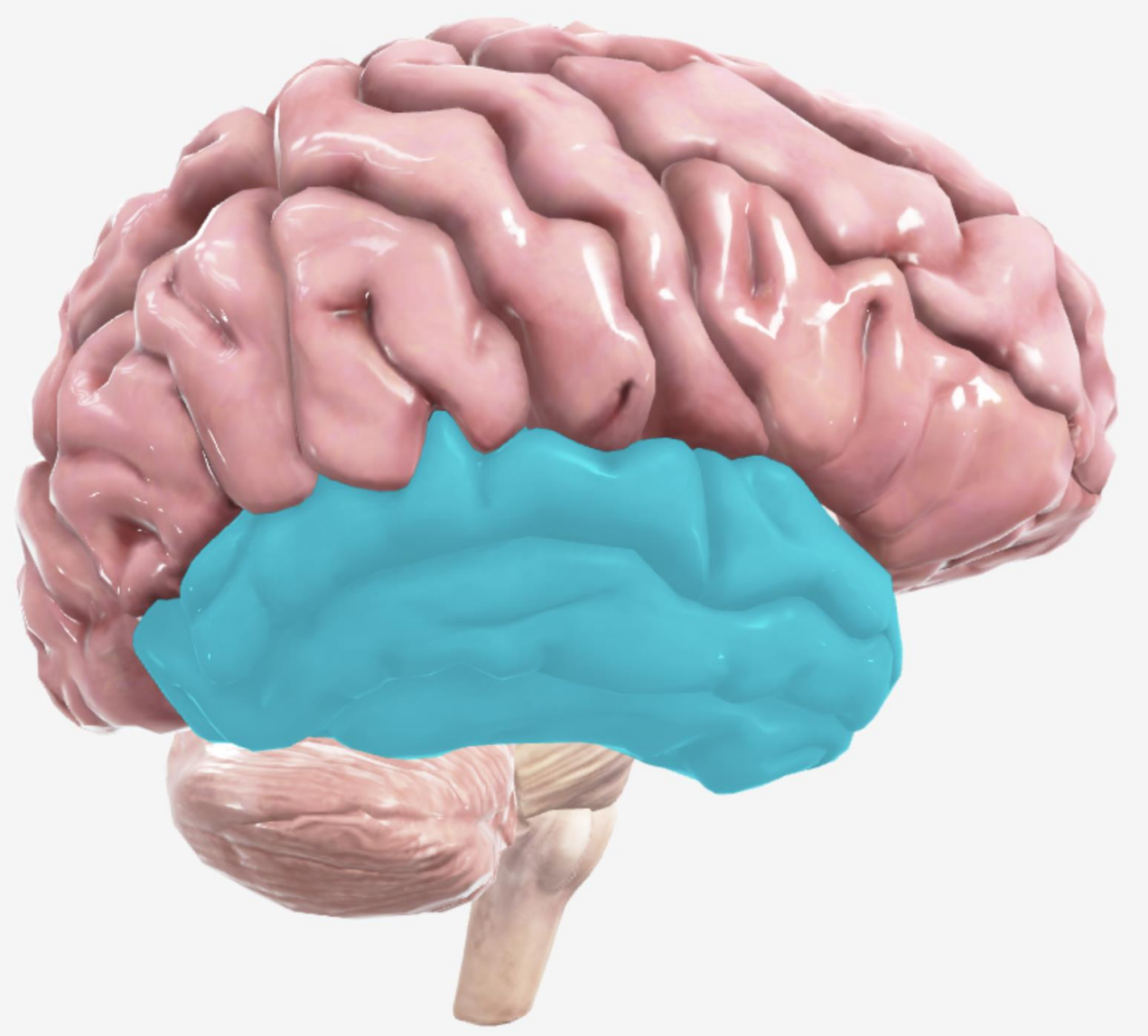


The angular gyrus is associated with various tasks, including memory, attention, emotional regulation, reasoning, and number processing an L-shaped convolution formed by the union of the posterior ends of the superior and middle temporal gyri.

The superior boundary is the intraparietal sulcus, the anterior boundary by the intermediate sulcus of Jensen and the posterior boundary is the anterior occipital sulcus.

Together with the supramarginal gyrus, the angular gyrus forms the inferior parietal lobule.

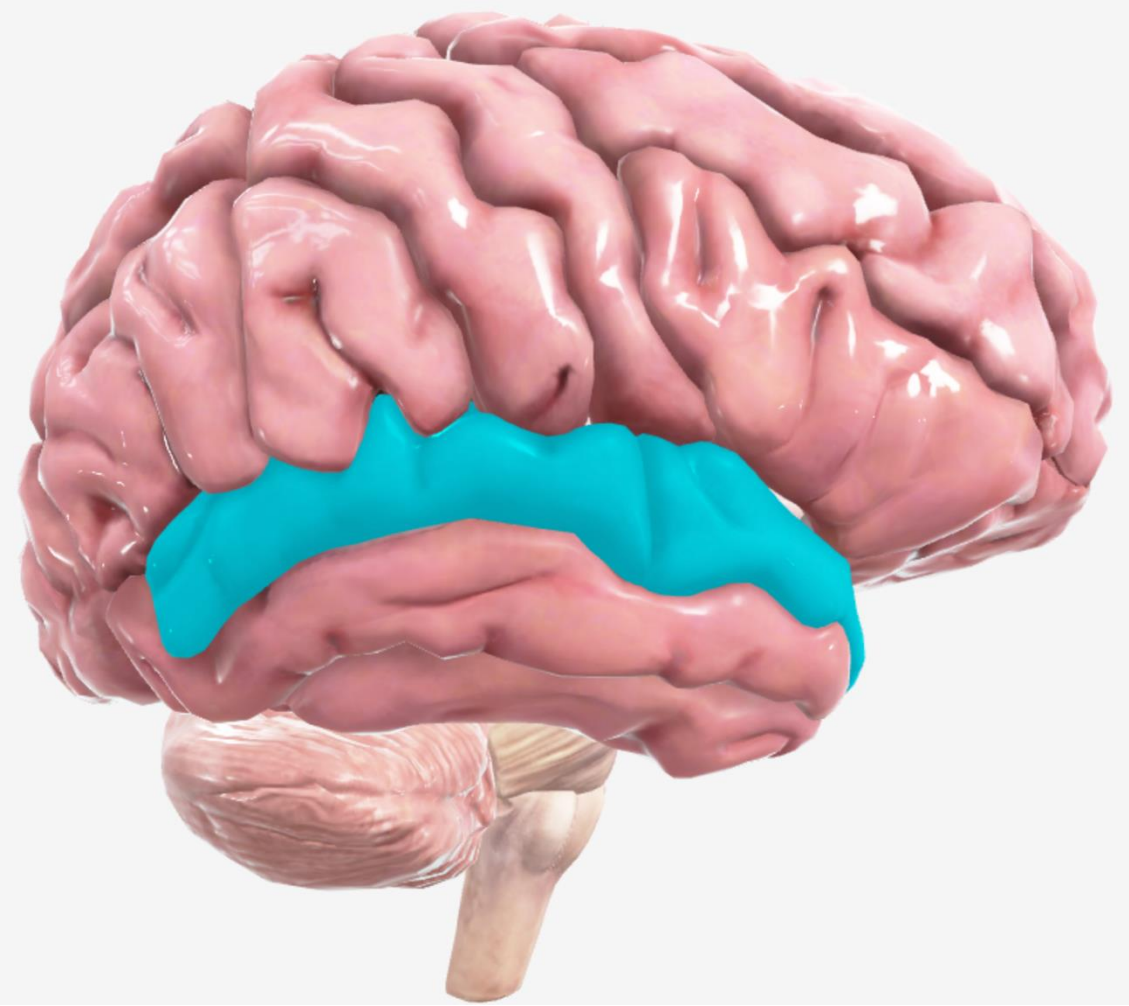
The Temporal Lobe



The Temporal lobe includes:

- The superior temporal gyrus
- The middle temporal gyrus
- The inferior temporal gyrus
- Part of the fusifor gyrus
- The paraippocampal gyrus

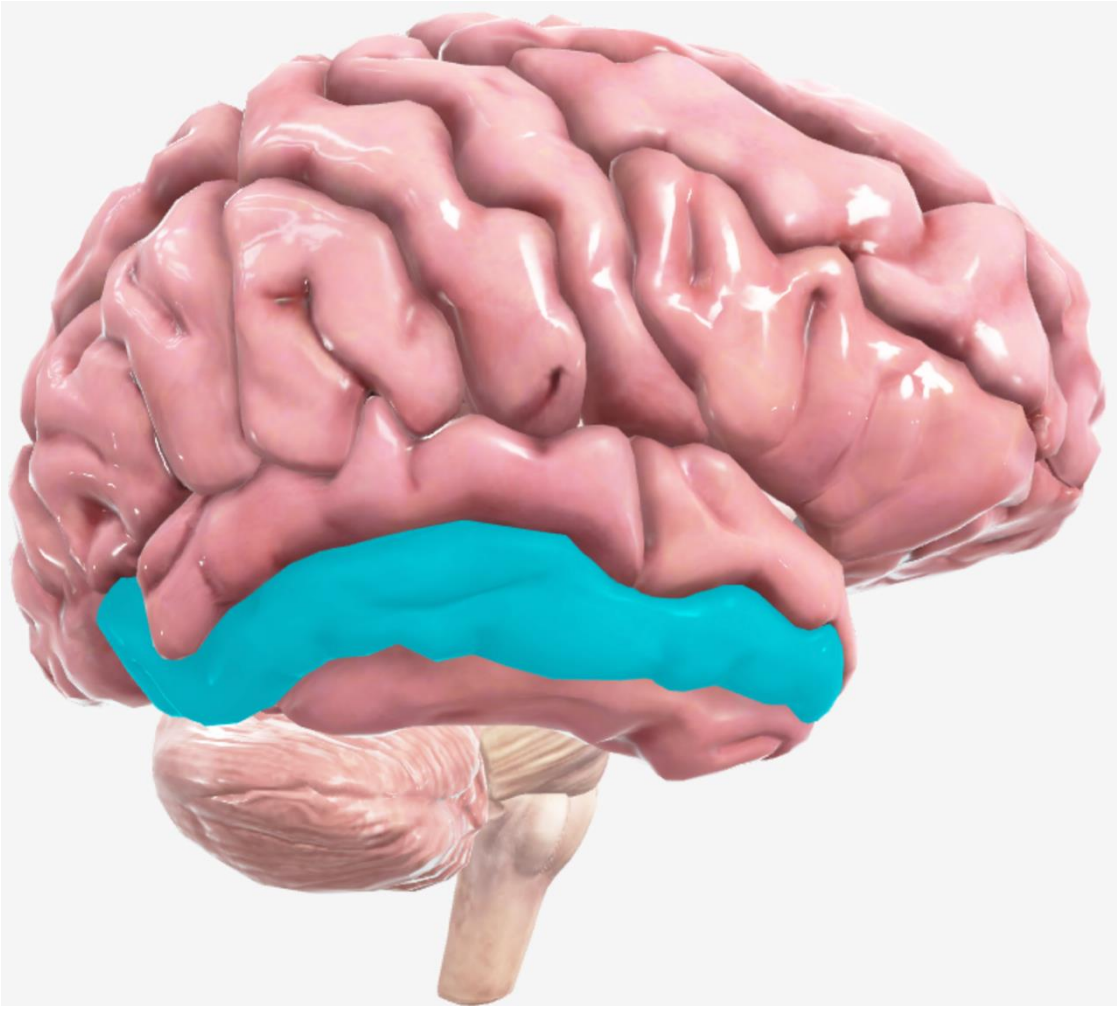
The Temporal Lobe



The superior temporal gyrus is the uppermost of the three temporal gyri in the temporal lobe and is formed by Brodmann's areas 22 and 42, that are responsible for processesing word meaning and speech generation.

It is positioned between the frontal and parietal lobes superiorly, and middle temporal gyrus.

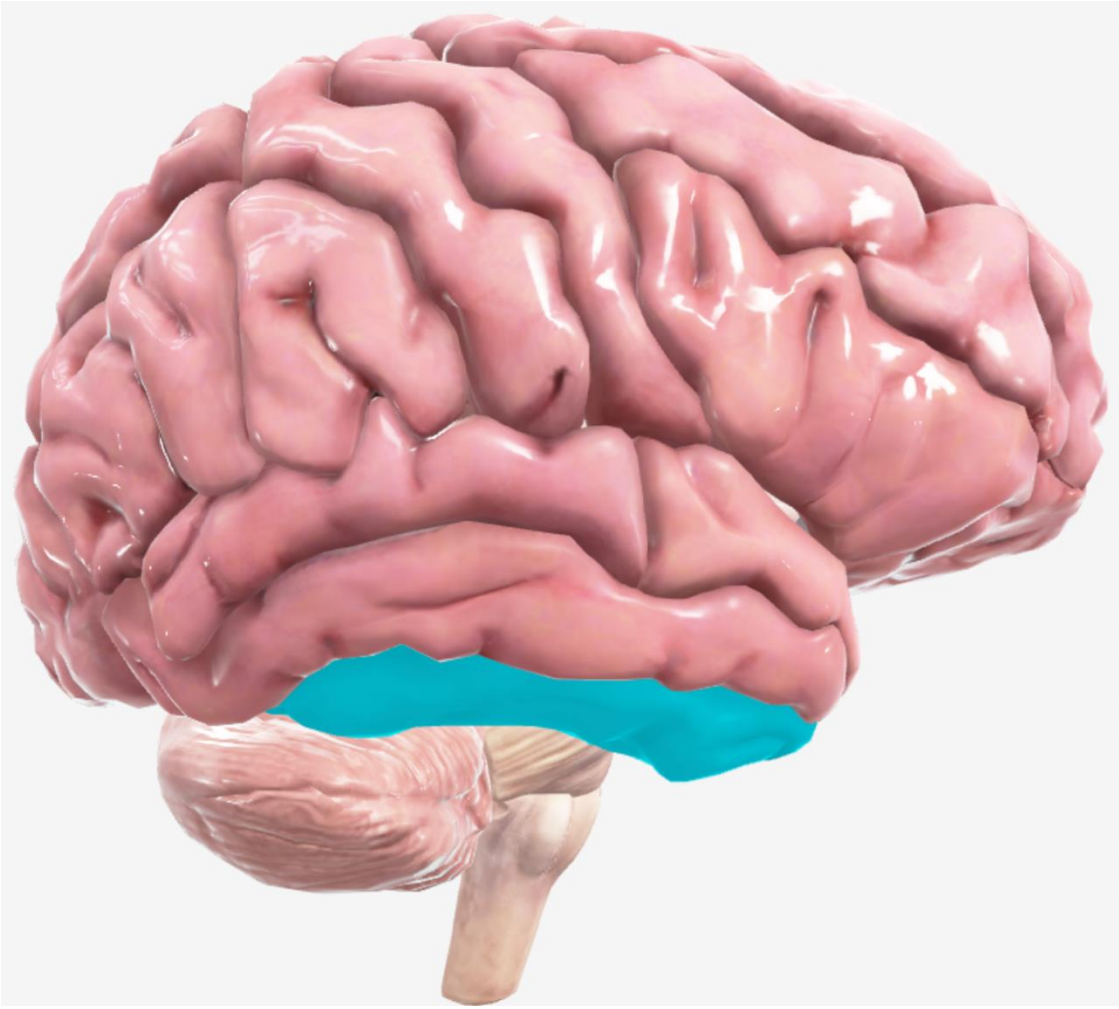
The Temporal Lobe



The middle temporal gyrus is involved with language and memory processing.

It is positioned between the superior and inferior temporal gyri, separated by the superior temporal sulcus superiorly and the inferior temporal gyrus inferiorly.

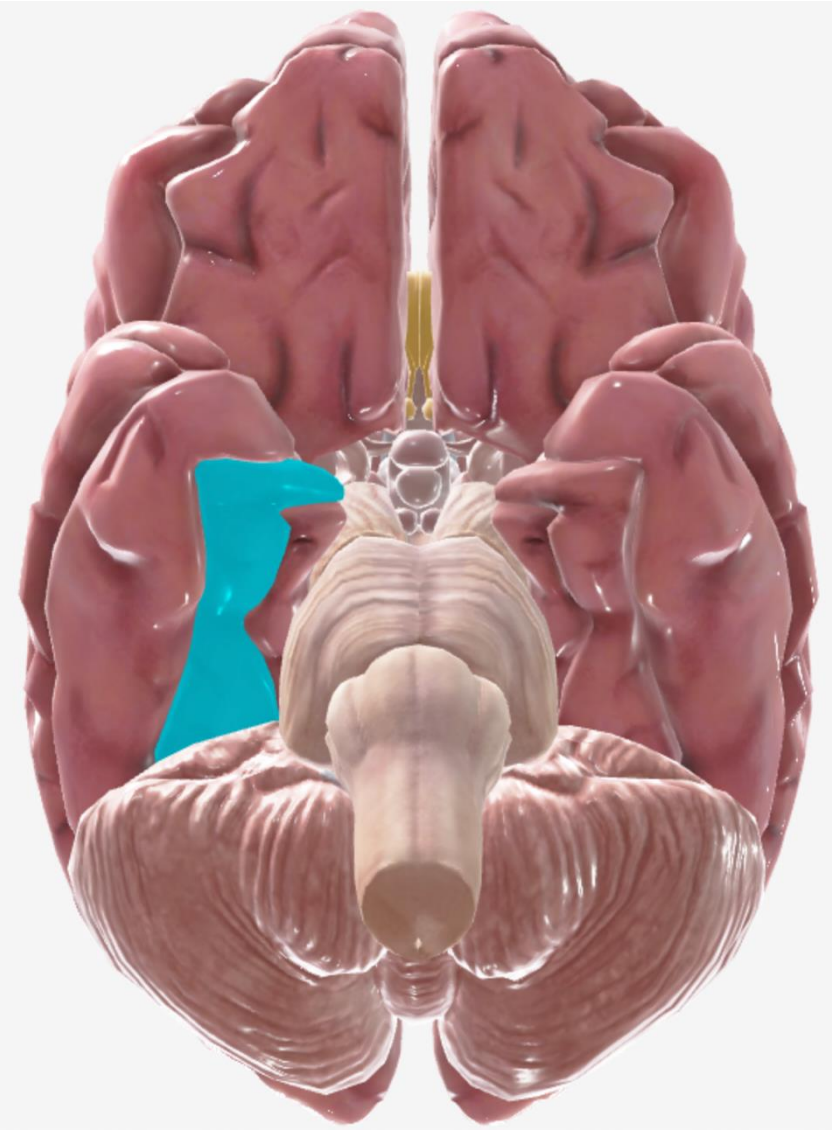
The Temporal Lobe



The inferior temporal gyrus extends from the temporal pole to an imaginary line called the lateral parietotemporal line, which separates the temporal lobe from the occipital lobe.
The inferior temporal gyrus is associated with higher-level visual processing, including facial recognition and visual memory.

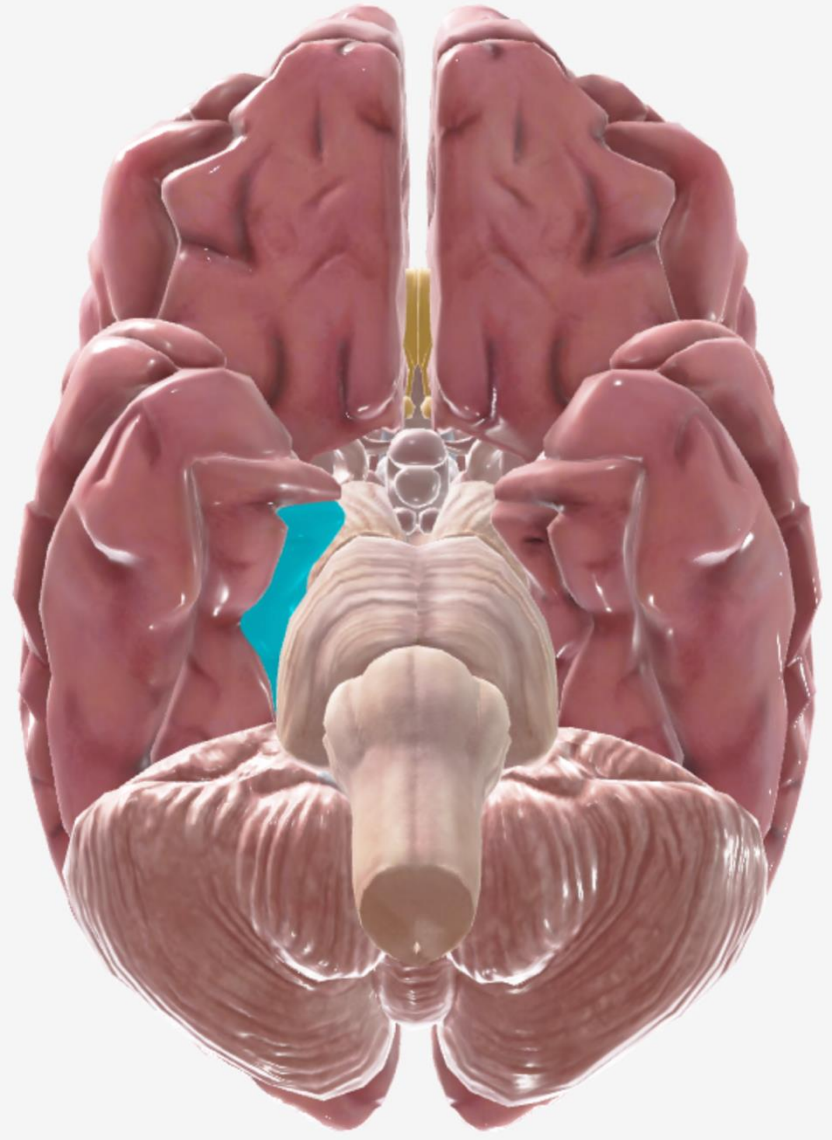
It is located inferior to the middle temporal gyrus, separated from the middle temporal gyrus on the superior side by the inferior temporal sulcus and from the right fusiform gyrus on the inferior side by the lateral occipitotemporal sulcus.

The Temporal Lobe



The fusiform gyrus or lateral occipitotemporal gyrus, is involved in facial and object recognition.
It is a spindle shaped structure that runs along the basal surface of the occipital and temporal lobes.
It includes a temporal, or anterior, portion, and an occipital, or posterior, portion.
The fusiform gyrus is laterally to the parahippocampal gyrus and lingual gyrus, and medially to the inferior temporal gyrus.

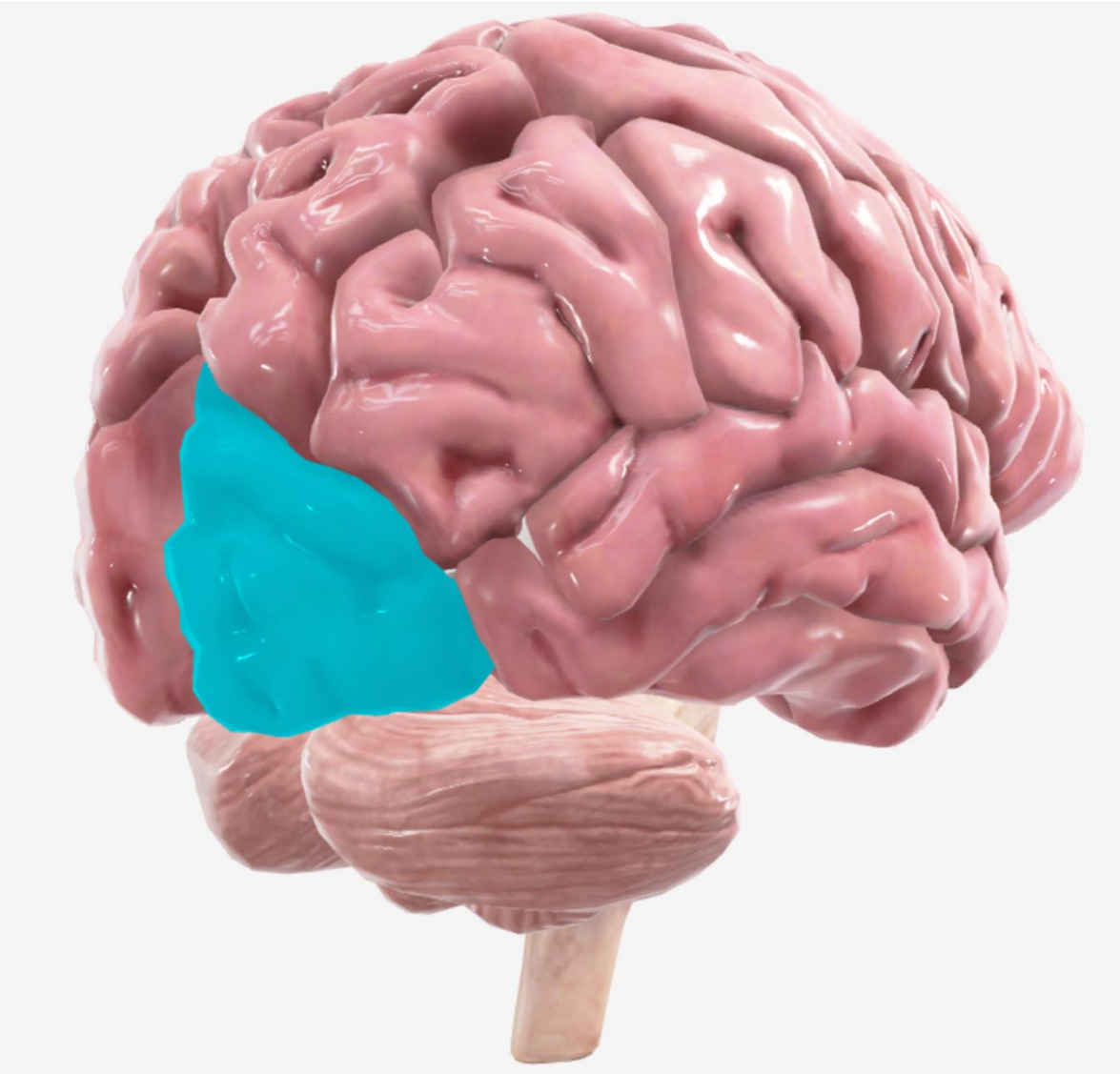
The Temporal Lobe



The parahippocampal gyrus plays an important role in memory encoding and retrieval.

It is located in the medial temporal lobe and surrounds the hippocampus.
It represents an integrated region of the limbic lobe, separated from the fusiform gyrus by the collateral sulcus.
The anterior portion of the parahippocampal gyrus is called uncus and is located near the amygdala.

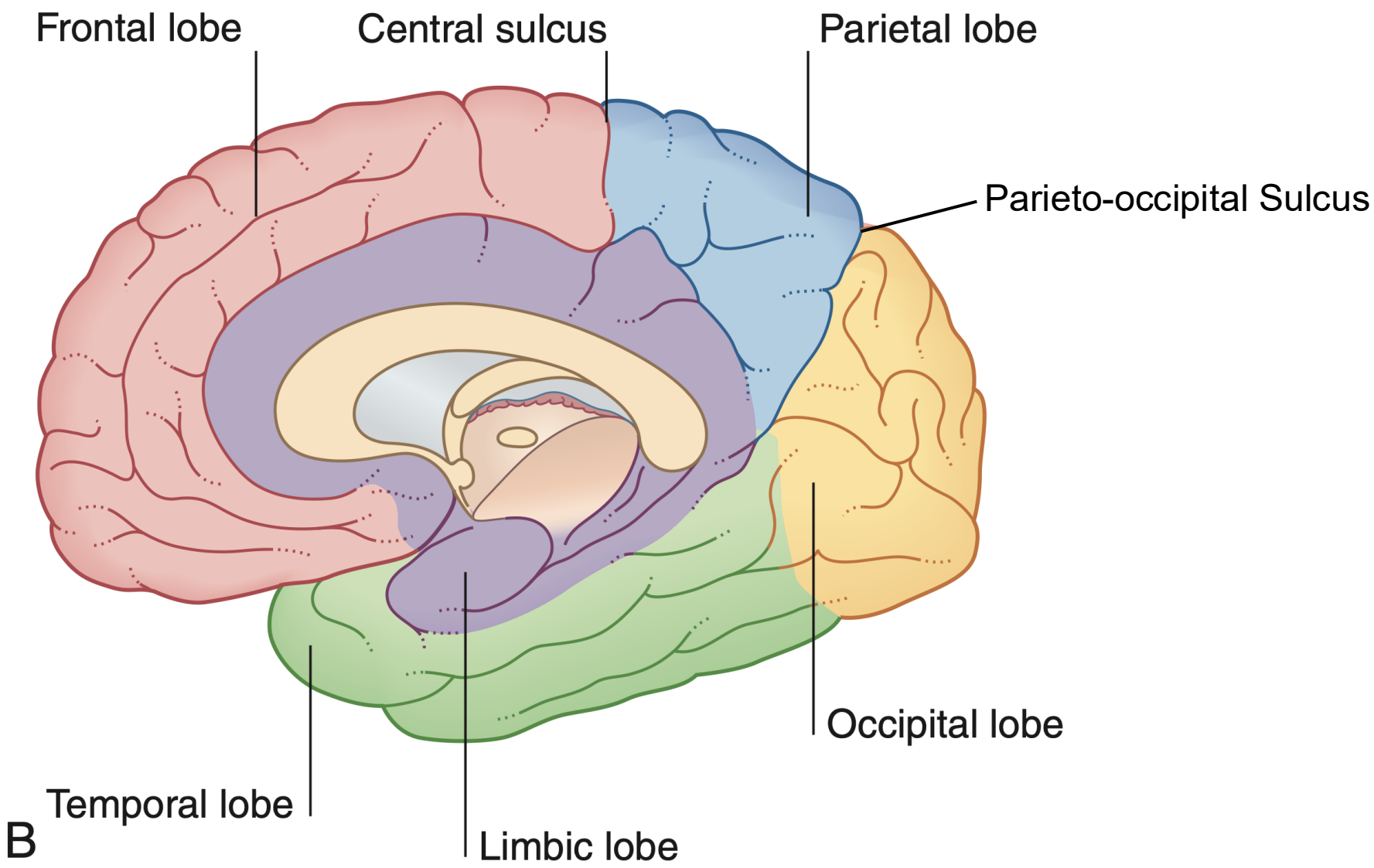
The Occipital Lobe



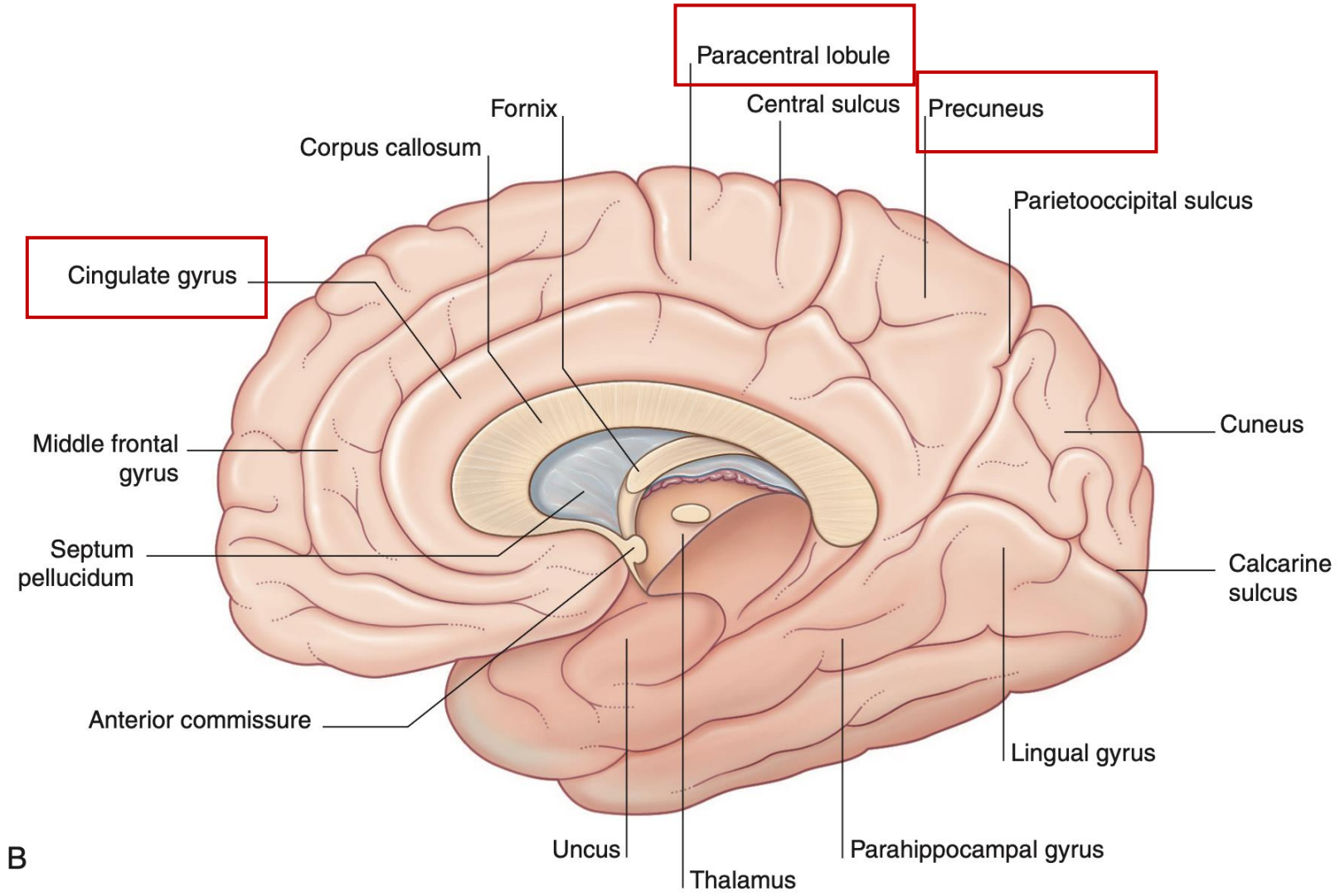
The occipital lobe is the most posteriorly located of the brain lobes.
It contains the primary visual cortex, the main brain region for processing vision.

On the lateral surface, it is separated from the parietal and temporal lobes by an imaginary line drawn from the preoccipital notch to the posterior lateral sulcus.
On the medial surface, it is separated from the parietal lobe by the parieto-occipital sulcus and from the temporal lobe by an imaginary line ascending superiorly from the preoccipital notch to the parieto-occipital sulcus.

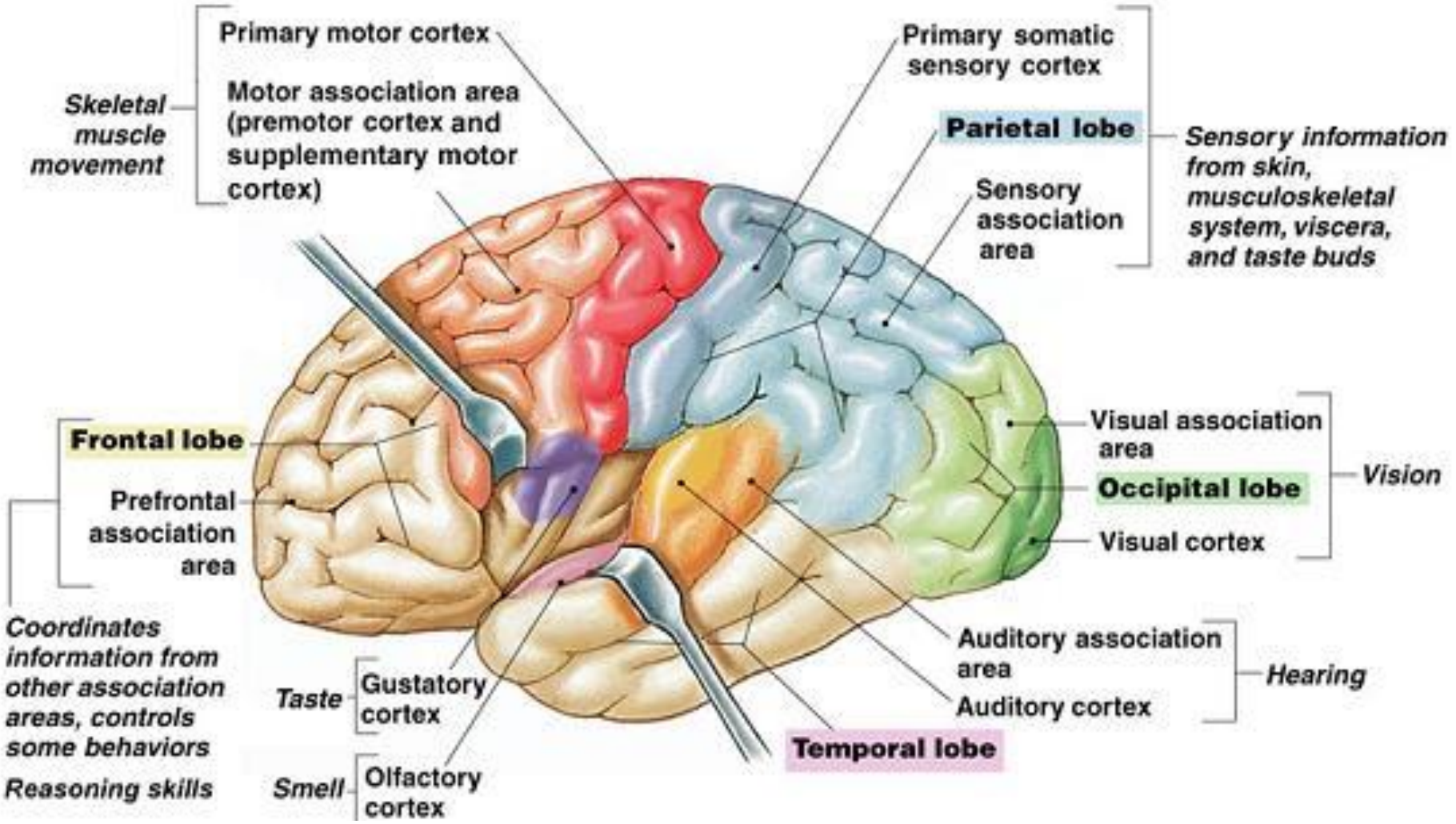
Surface Organization of the Cerebral Hemispheres



Surface Organization of the Cerebral Hemispheres

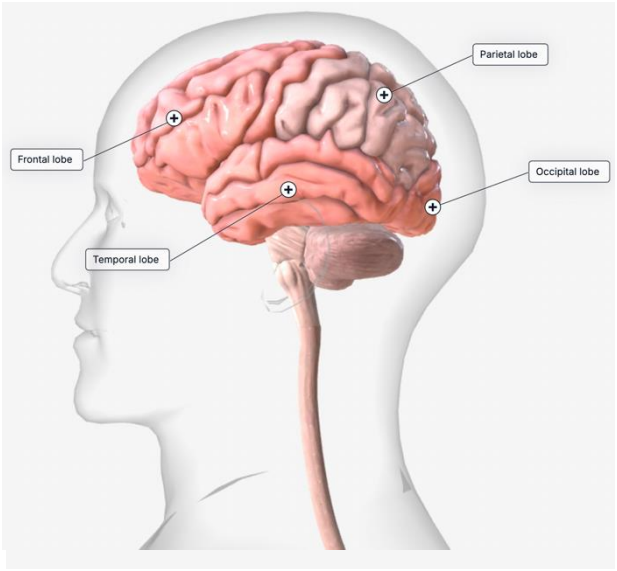


Functions of the cerebral lobes

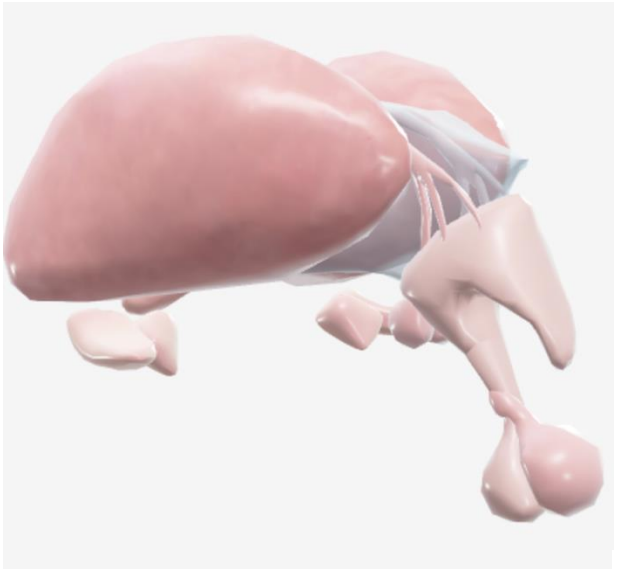


Macroscopic organization of CNS

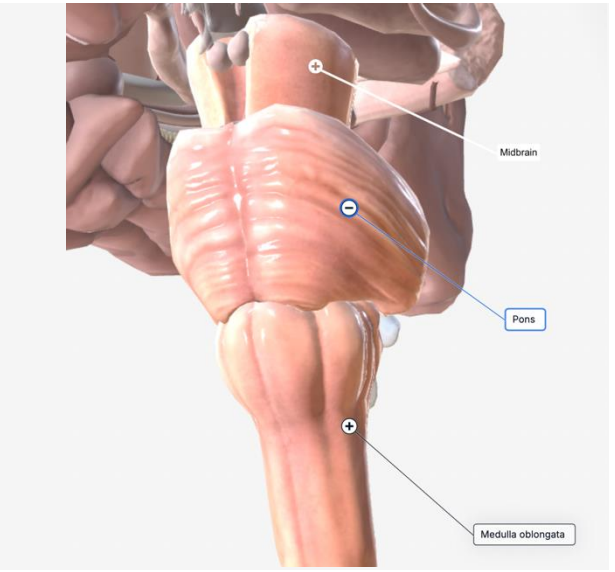
Cerebral hemispheres



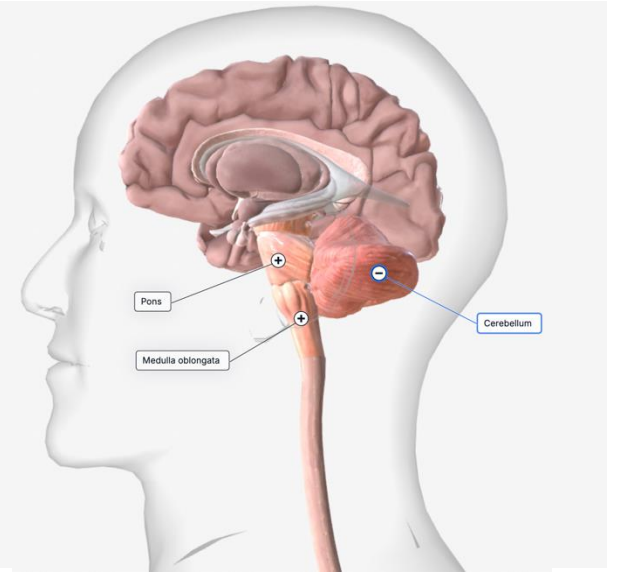
Diencephalon



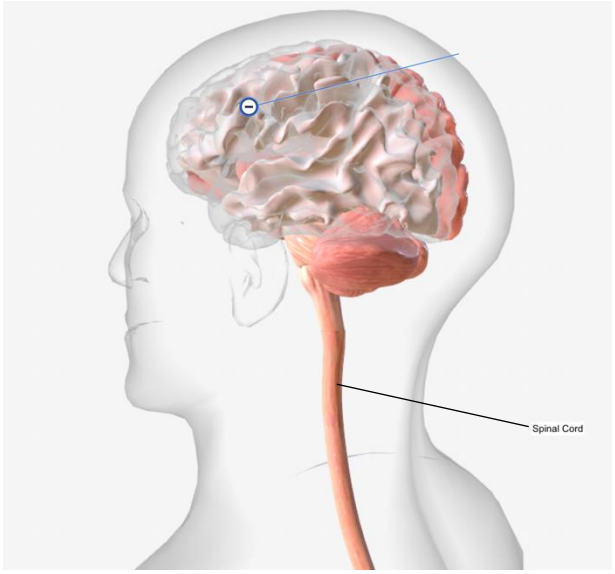
Brainstem



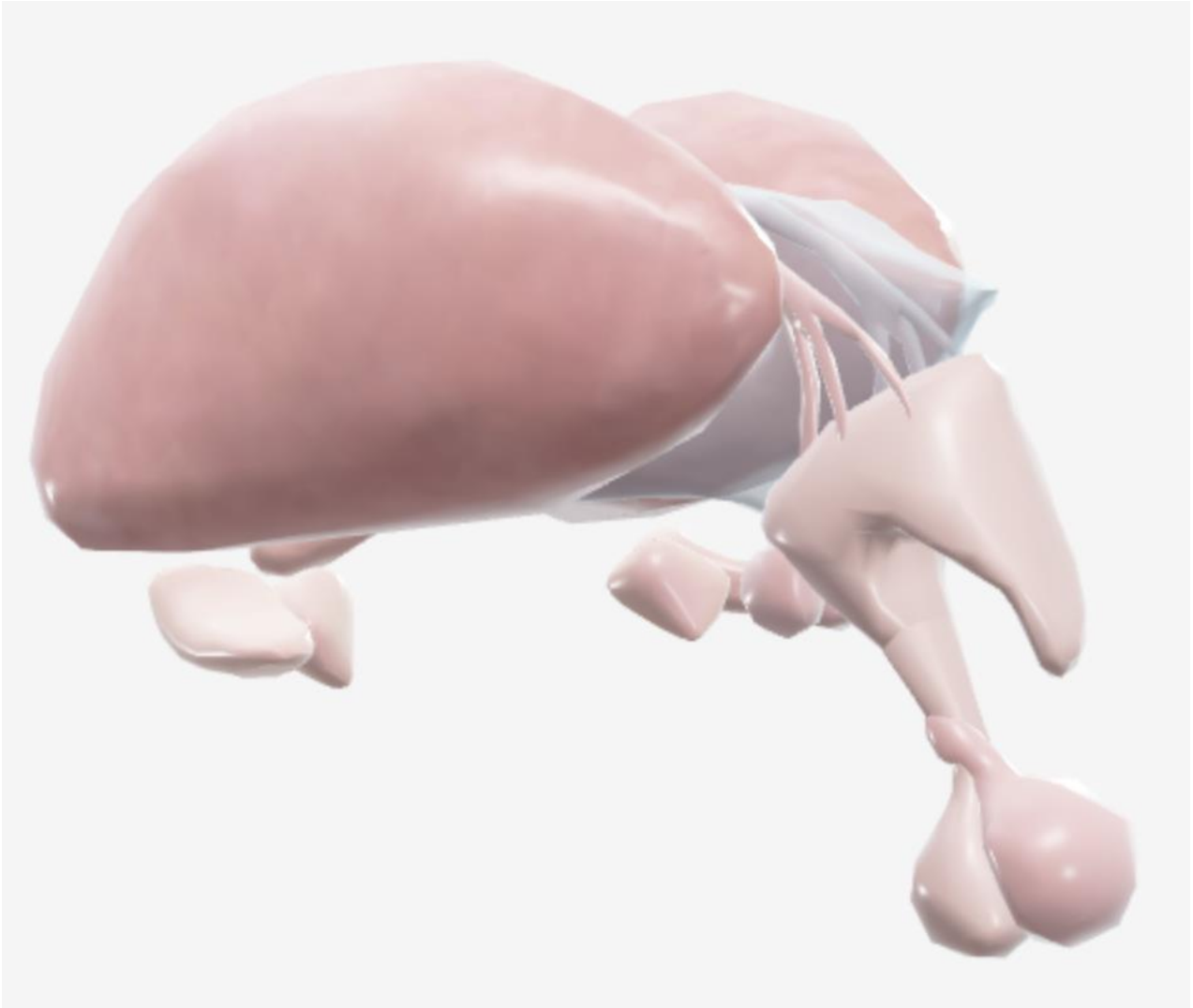
Cerebellum



Spinal cord



Diencephalon



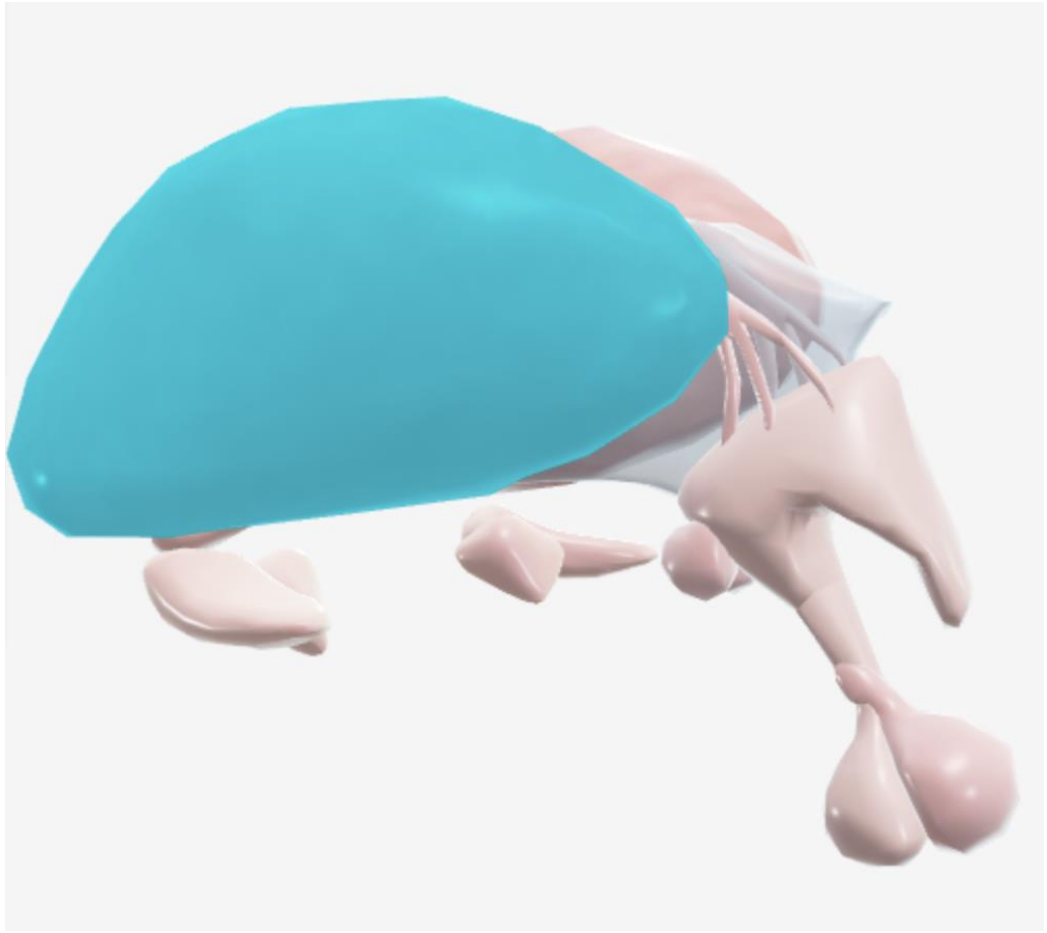
The diencephalon surrounds the third ventricle. Its major components:

- Thalamus
- Hypothalamus
- Subthalamus
- Epithalamus

Developmentally, this region arises from the forebrain vesicle.

Its central location reflects its integrative role.

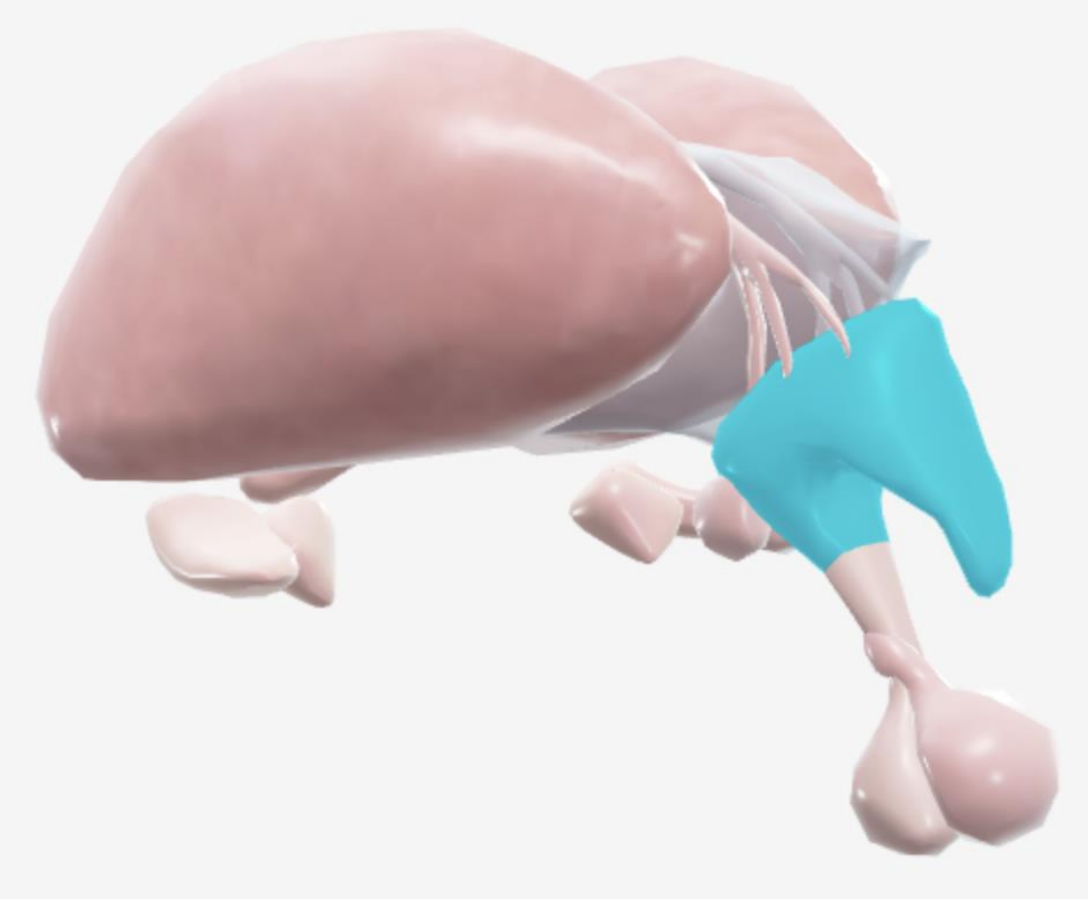
Diencephalon



The thalamus is a paired structure. The left and right structures in the thalamus are connected by the intrathalamic adhesion and are positioned on either side of the lateral ventricle.

The right and left thalamus are divided into distinct nuclei that receive and integrate signals from sensory systems throughout the body and relay those signals into regions of the cortex.

Diencephalon

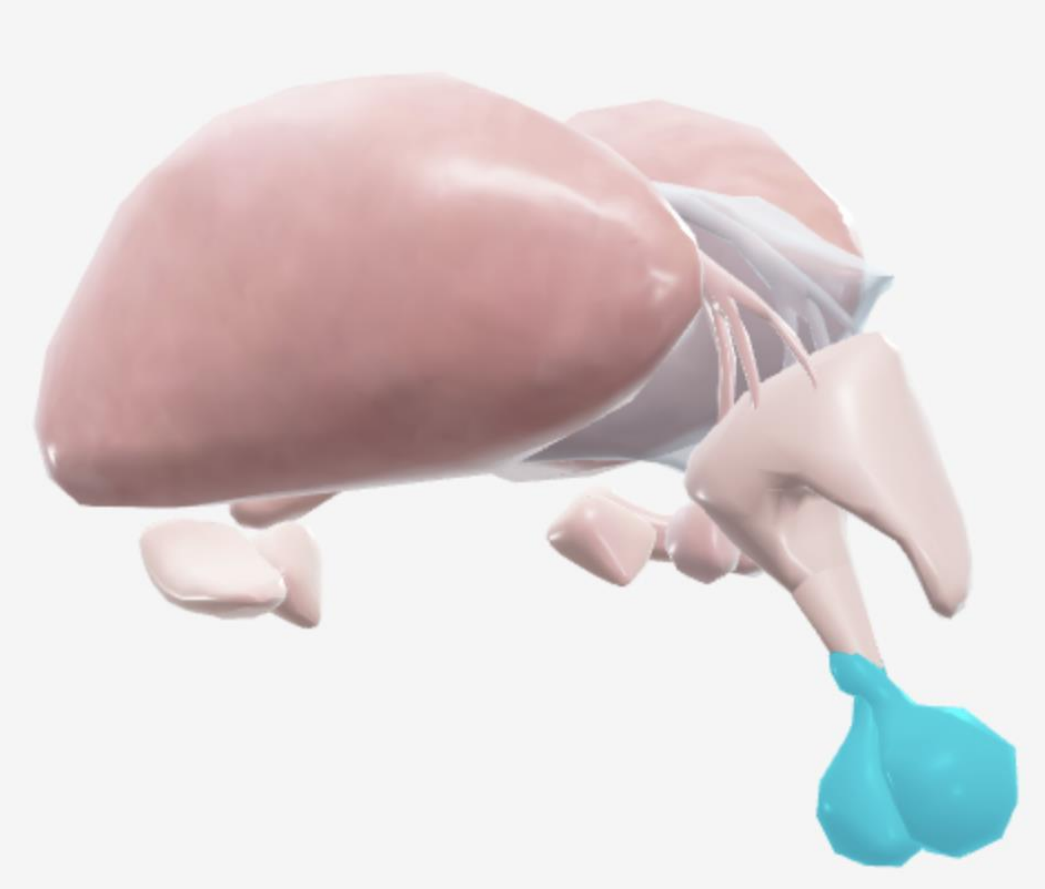


The hypothalamus is positioned directly below the thalamus, from which it is separated by the hypothalamic sulcus of Monro, and above the pituitary gland, to which it is connected by the infundibular stalk.
It contains both grey matter nuclei and white matter myelinated nerve fibers.

The hypothalamus regulates:
- Autonomic output
- Endocrine function
- Homeostasis

It links nervous and endocrine systems.
Despite its small size, it controls survival functions.

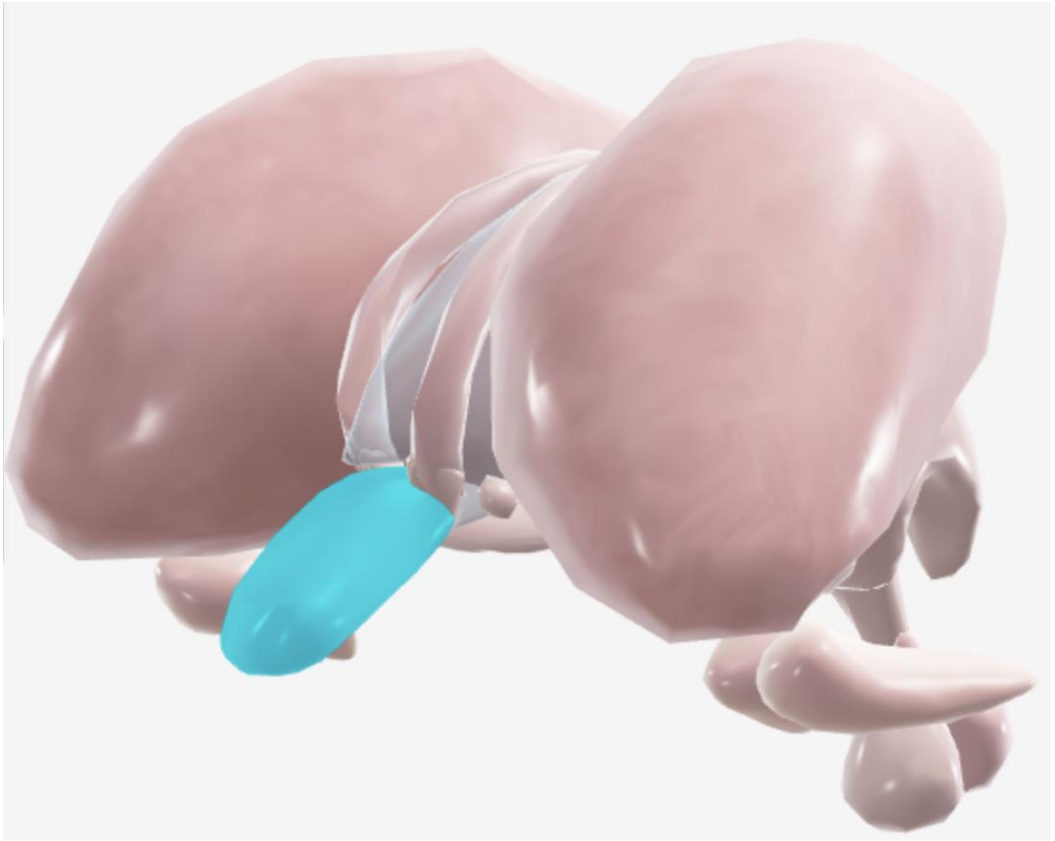
Diencephalon



The pituitary gland includes,

- the pituitary gland posterior lobe: neural or post-neural lobe, which stores and releases vasopressin, oxytocin, and neurophysins.
- the pituitary gland anterior lobe: the glandular or anterior lobe of the pituitary gland which secretes several hormones.

Diencephalon



The glandula pinealis is connected by a stalk to the posterior wall of the third ventricle and positioned superior to a groove in the thalamus.
The majority of cells in the pineal gland are pinealocytes, followed by scattered subtypes of glial cells throughout the structure.

The pineal gland's primary role is regulating the production of melatonin in response to light and dark cycles, thus regulating sleep and the circadian rhythm. The nuclei of habenula are contained in small bulges on the stalk of the pineal gland.

Internal anatomy of the cerebrum

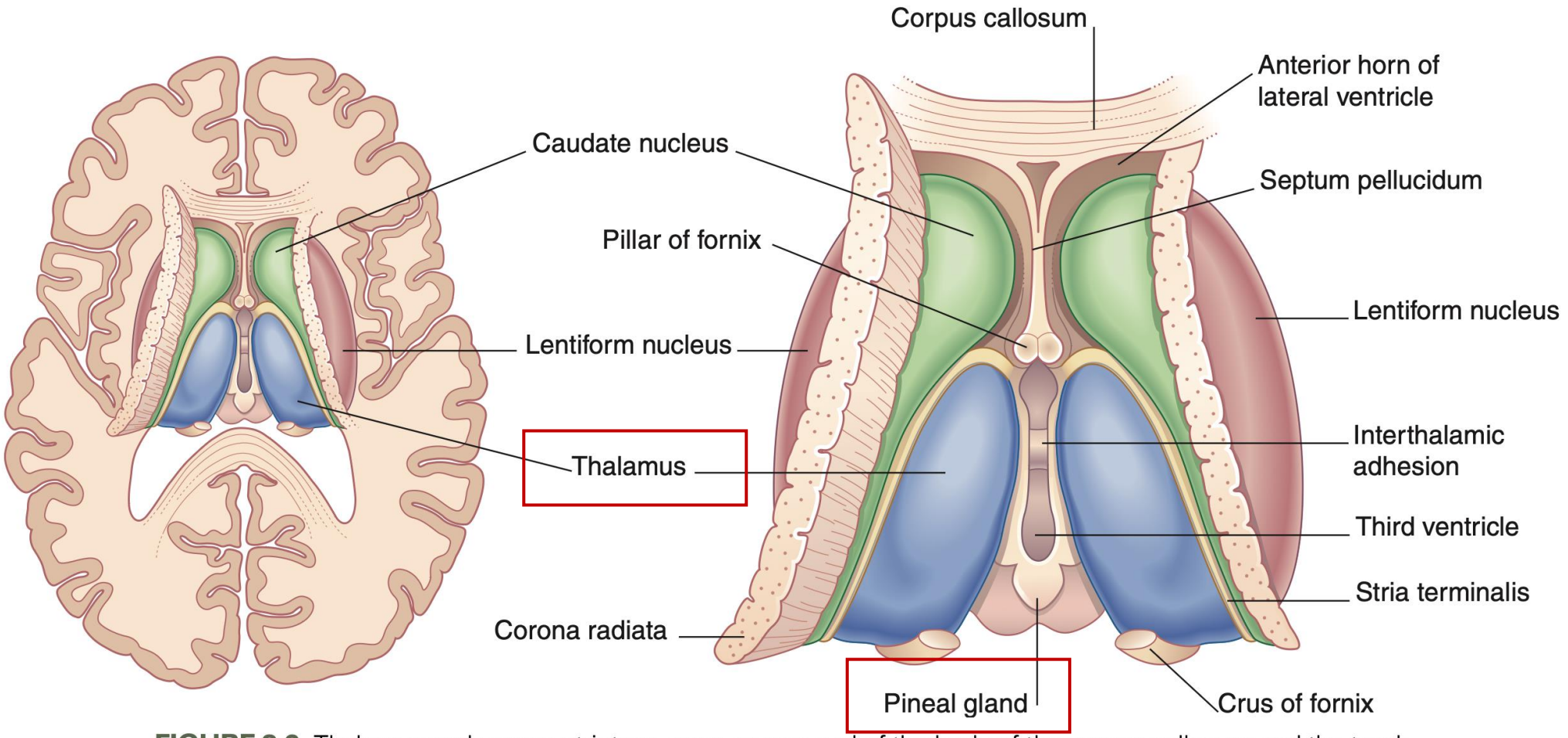
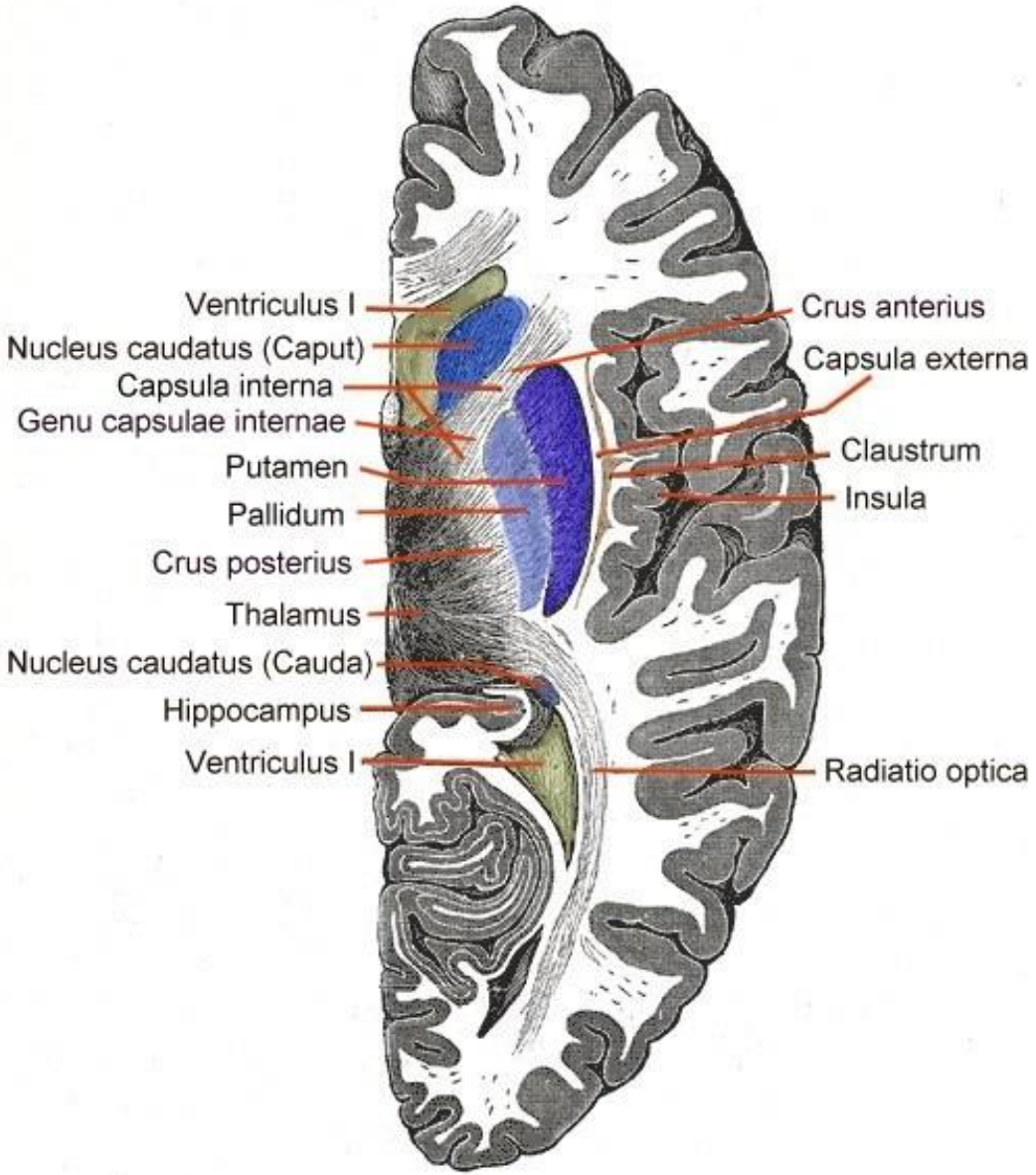
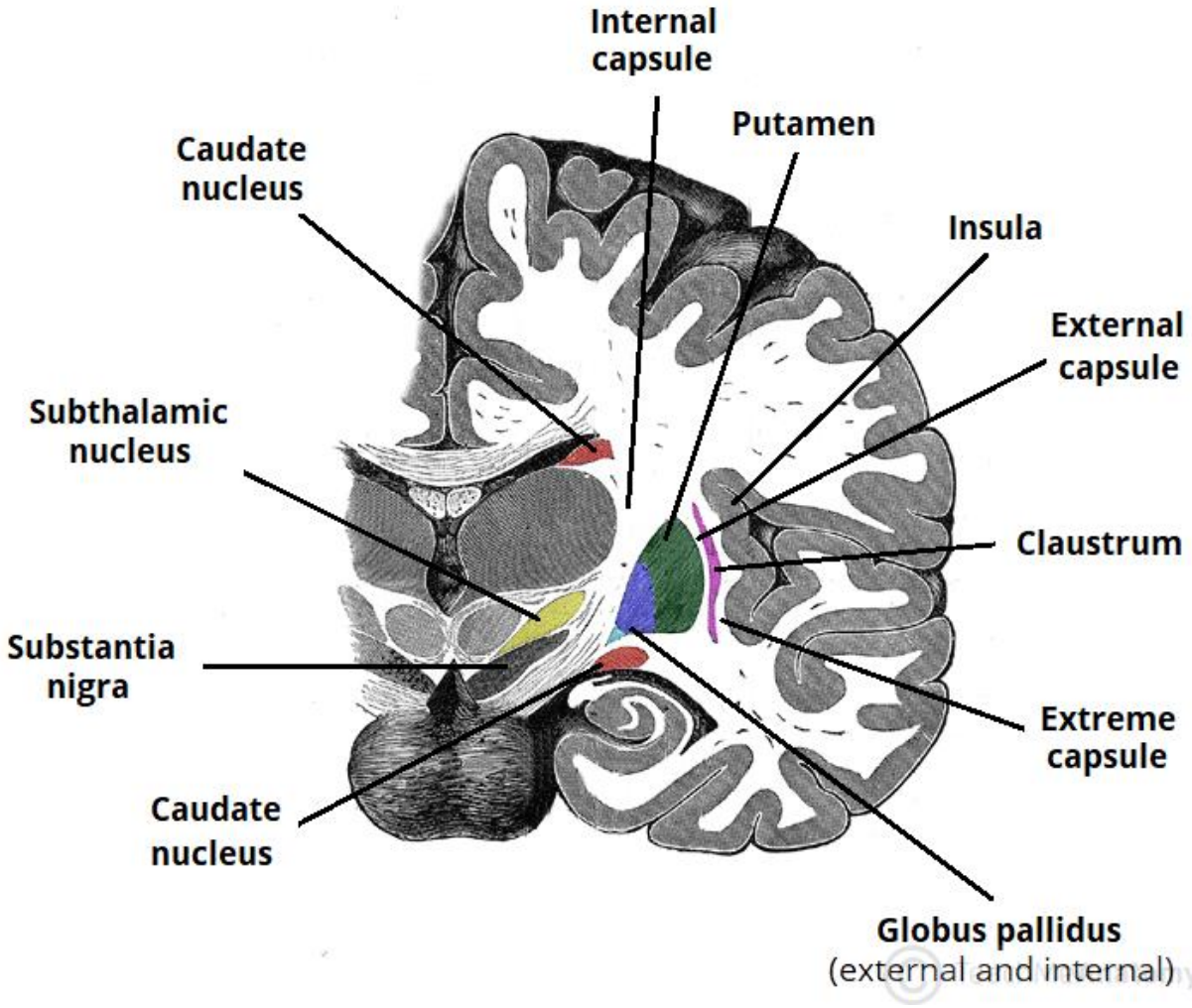


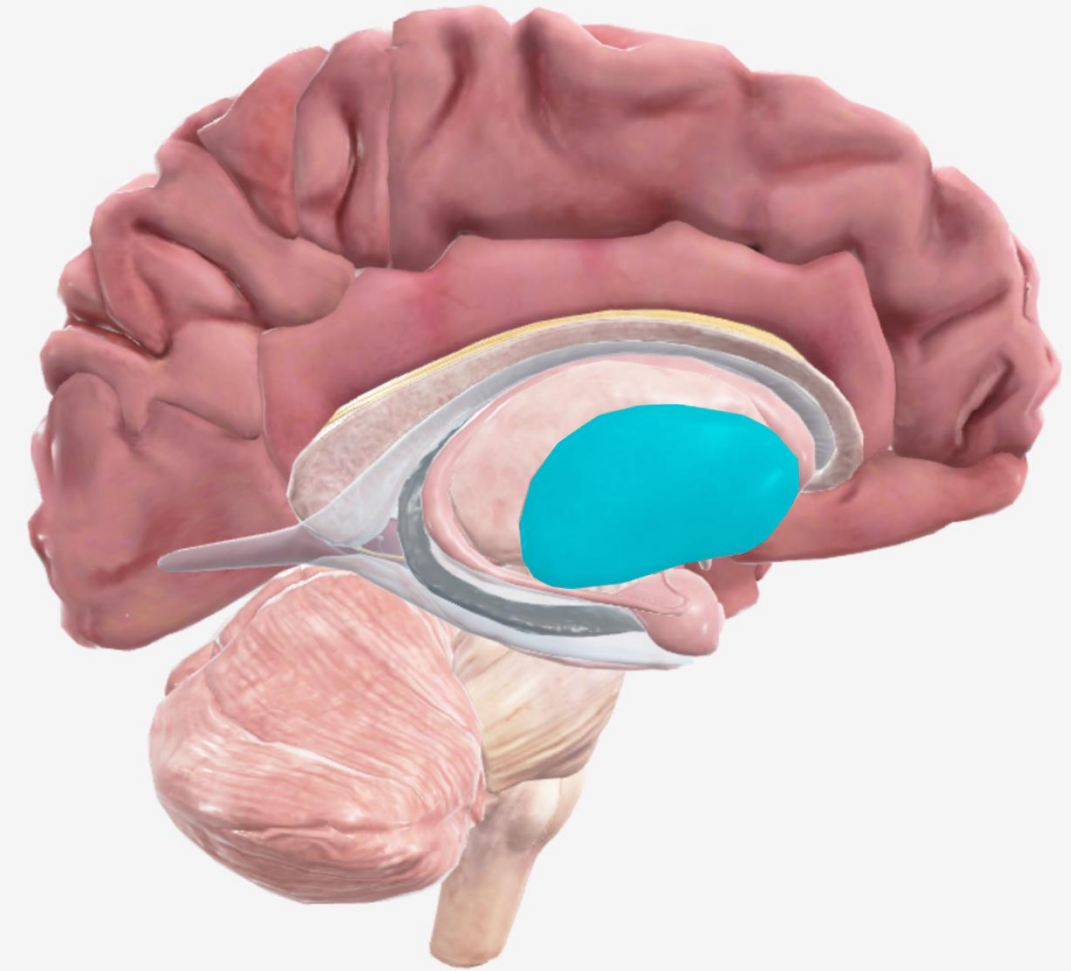
FIGURE 2.9 Thalamus and corpus striatum, seen on removal of the body of the corpus callosum and the trunk of the fornix.

Internal anatomy of the cerebrum



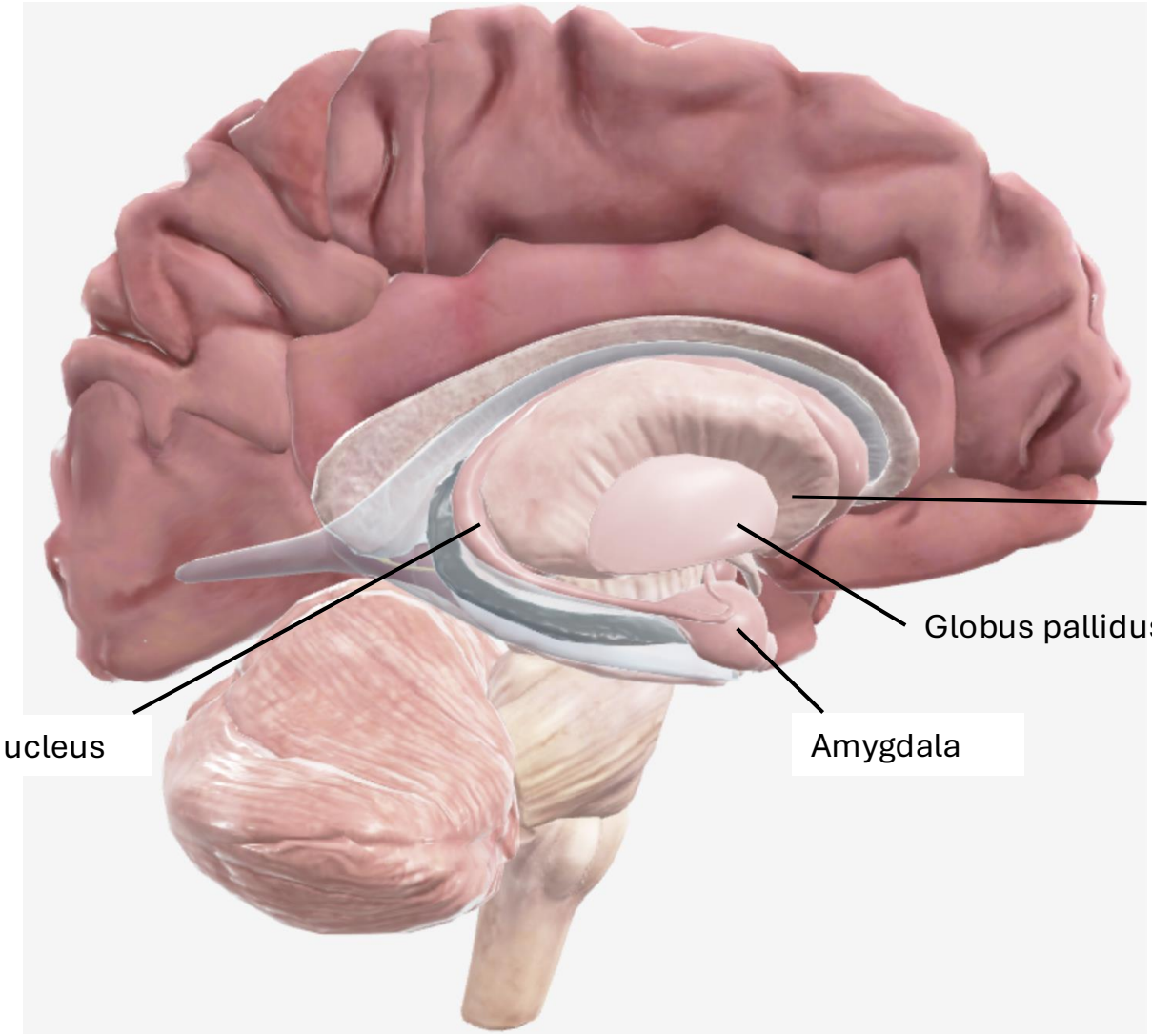


Putamen

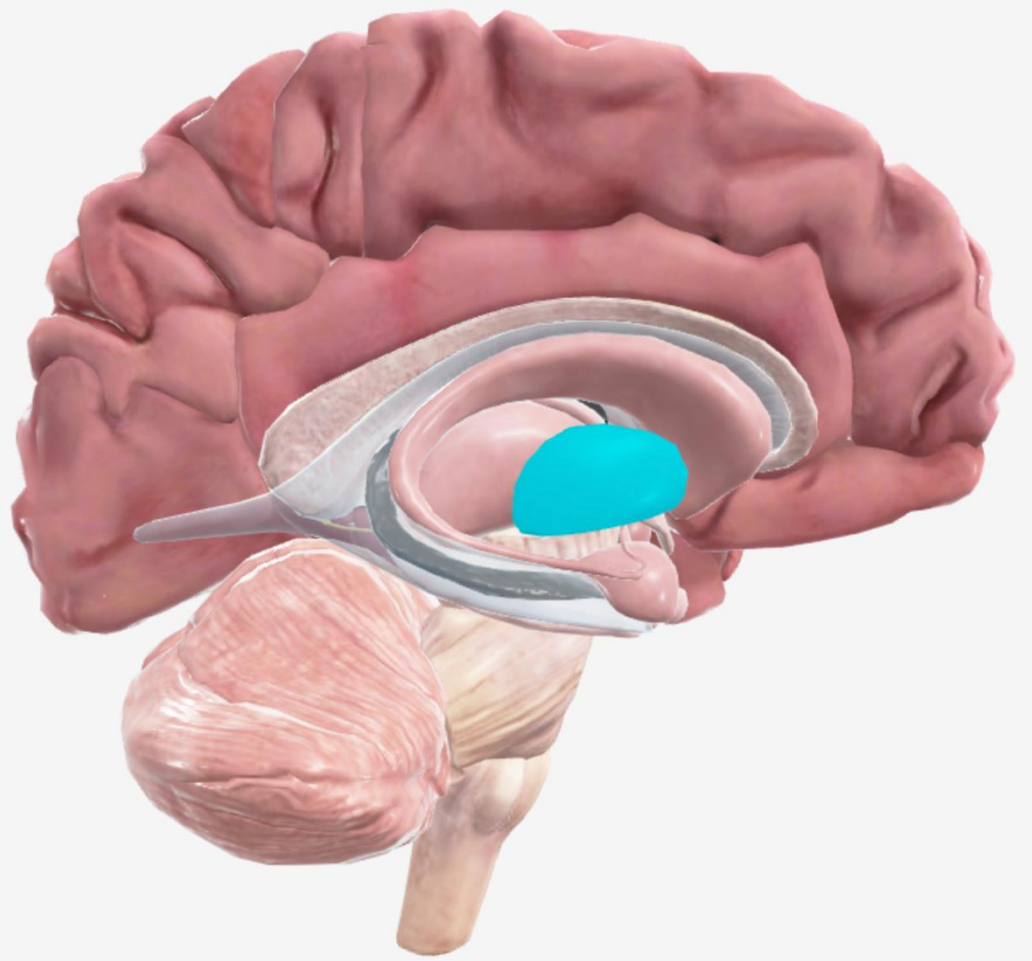


Putamen is the structure located in the middle of the brain. The putamen is part of the basal ganglia and together with the caudate forms the striatum that influences motor activity.

Internal anatomy of the cerebrum

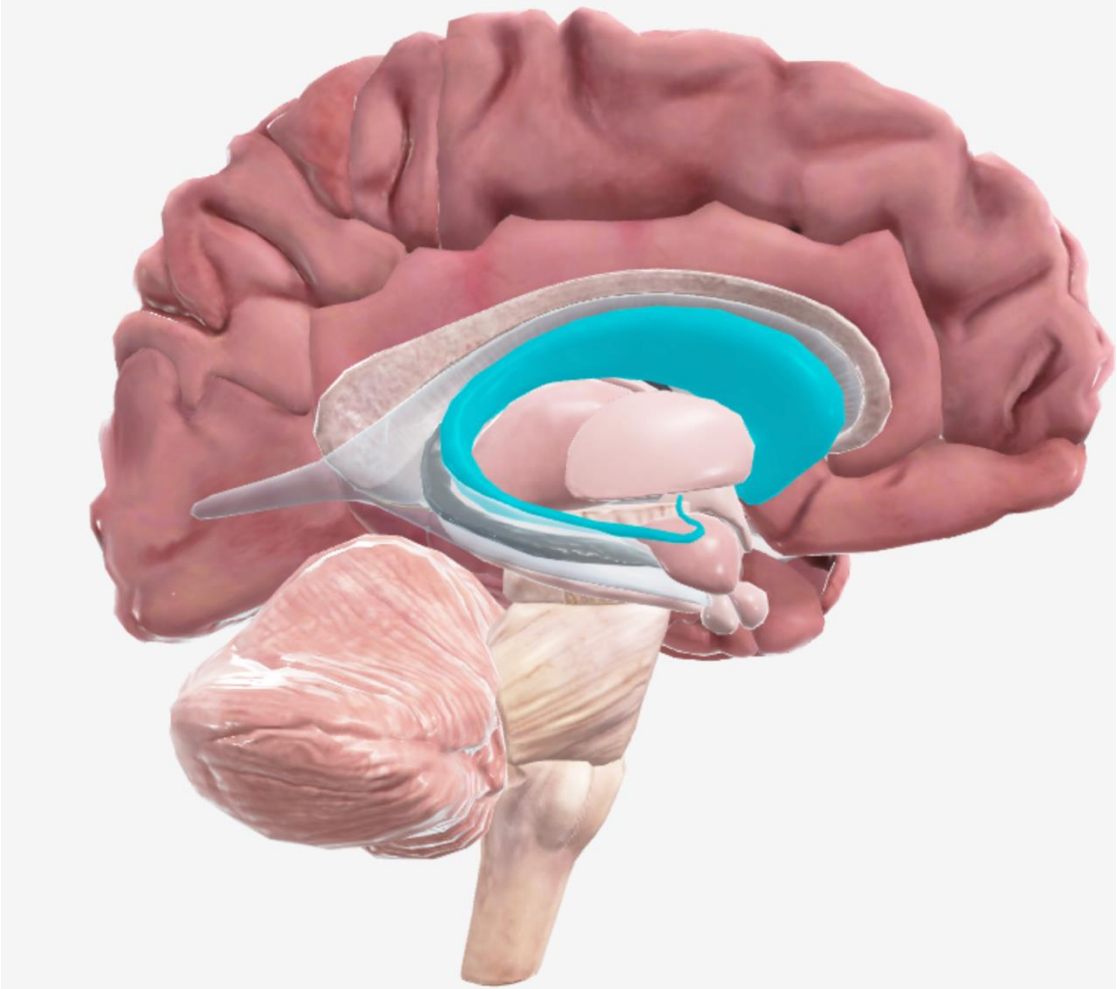


Globus pallidus



Globus pallidus a paired structures in the brain that helps control conscious and planned movement, memory building, and reinforcement.
Both the right and left globus pallidus are part of the basal ganglia and join the right and left putamen to form the lentiform (lenticular) nuclei.
The right globus pallidus is generally smaller in volume than the left globus pallidus.
Each globus pallidus is divided into two sections by the medial medullary lamina, forming the globus pallidus internus on the medial aspect and the globus pallidus externus on the lateral aspect adjacent to the putamen.

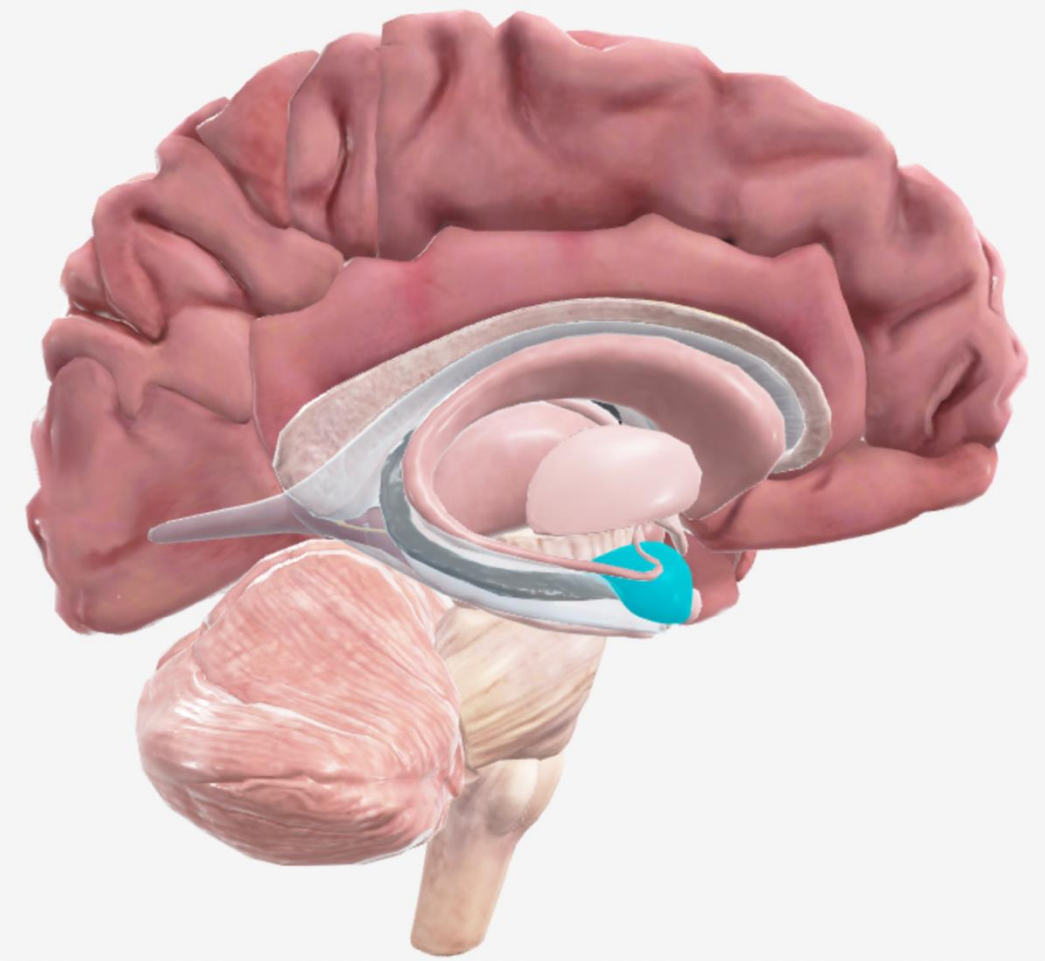
The caudate nucleus



The caudate nucleus is one of two paired structures located within the corpus striatum.
The caudate nucleus is a C-shaped subcortical structure, located near the thalamus.
Each caudate nucleus consists of a more prominent "head" that tapers into a thinner body and a tail.

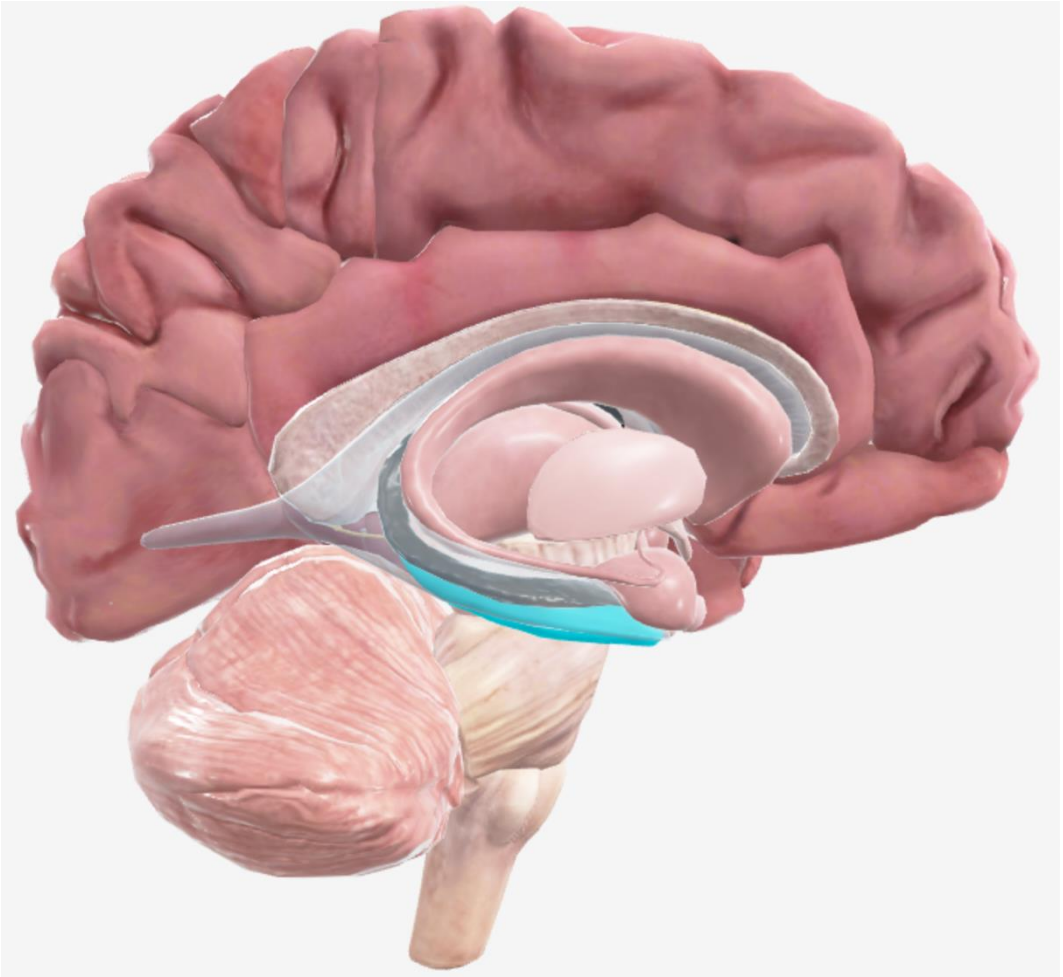
The caudate nucleus plays vital roles in executing movement, maintaining posture, executive functions, associative learning, reward, motivation, memory, and emotions.

The amigdala



The amygdala is an almond-shaped organ, part of the limbic system, involved in the processing of emotions, emotional memories, and fear responses.

The hippocampus

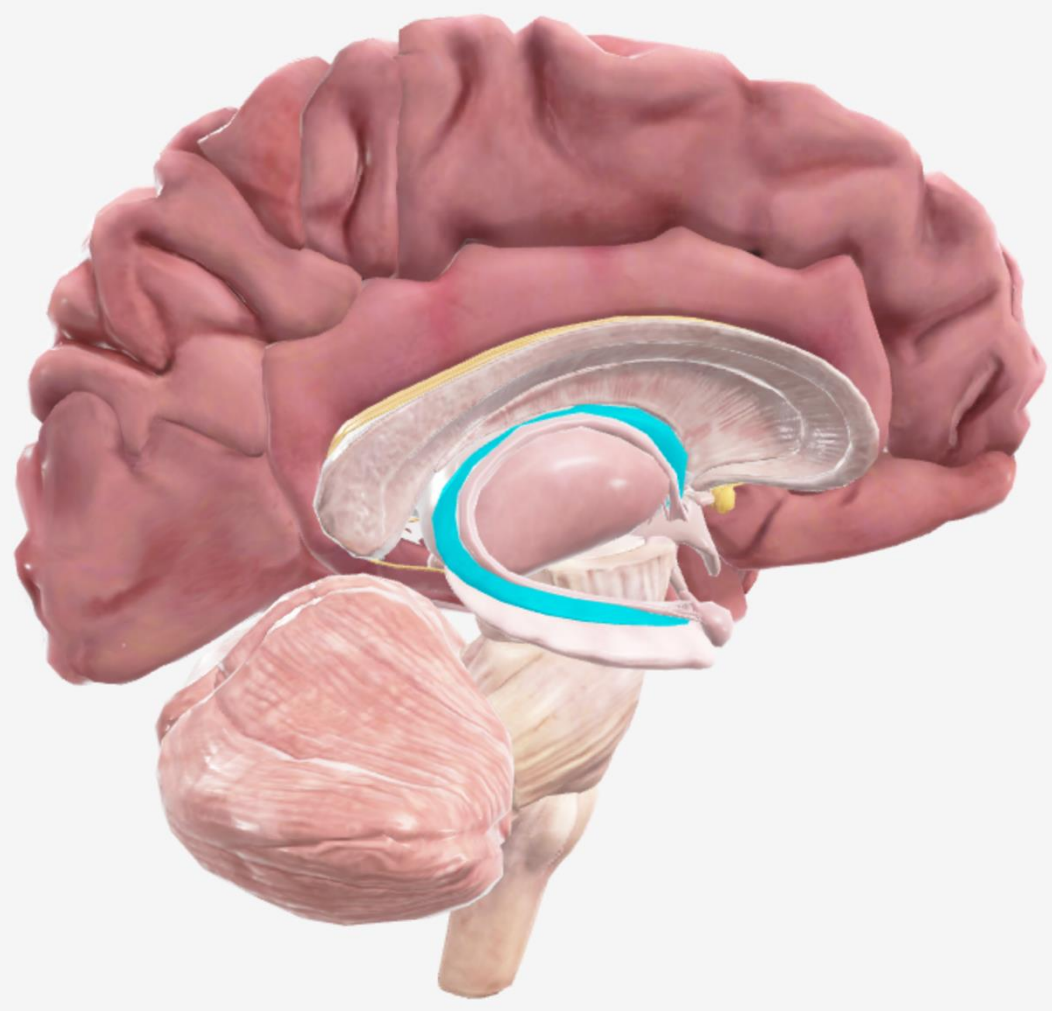


The hippocampus rises from the floor of the inferior temporal horn of the lateral ventricle and is composed of two gyri (Ammon horn and the dentate gyrus) and their corresponding white matter.

The hippocampus is part of the limbic system and receives afferent fibers from the entorhinal area of the parahippocampal gyrus and transparent septum.

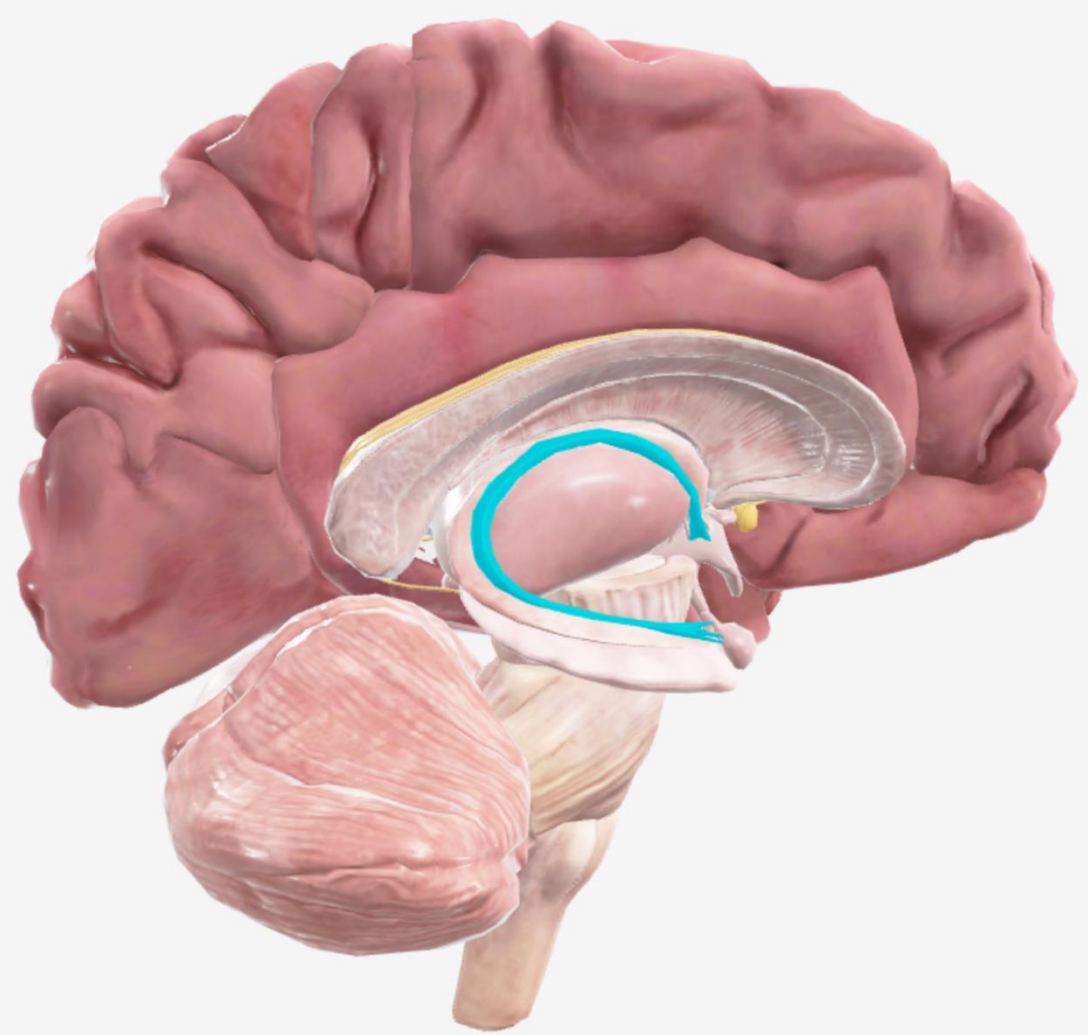
The hippocampus plays a critical role in spatial memory and navigation.

Fornix



The fornix originates in the hippocampus.
It is a white-fiber bundle that projects to the hippocampus and to the septal nuclei of the basal forebrain, the anterior thalamic nucleus, and mammillary nuclei to relay sensory information involved in memory and cognition between the different structures of the limbic system.

Stria terminalis



The stria terminalis is white matter band of fibers situated in the depression between the caudate nucleus and the thalamus.

As one of the major efferent pathways of the amygdala, the stria terminalis connects the amygdala to the hypothalamus and modulates hypothalamic functions.