Ventricles of brain

- Ventricles are cavities or expansions within the brain that are derived from the lumen of the embryonic neural tube.
- They are continuous with one another as well as with the central canal of the spinal cord
- Ventricles are filled with CSF
- There are four ventricles in the brain:
  - Two lateral ventricles
  - The third ventricle
  - The fourth ventricle

Two lateral ventricles

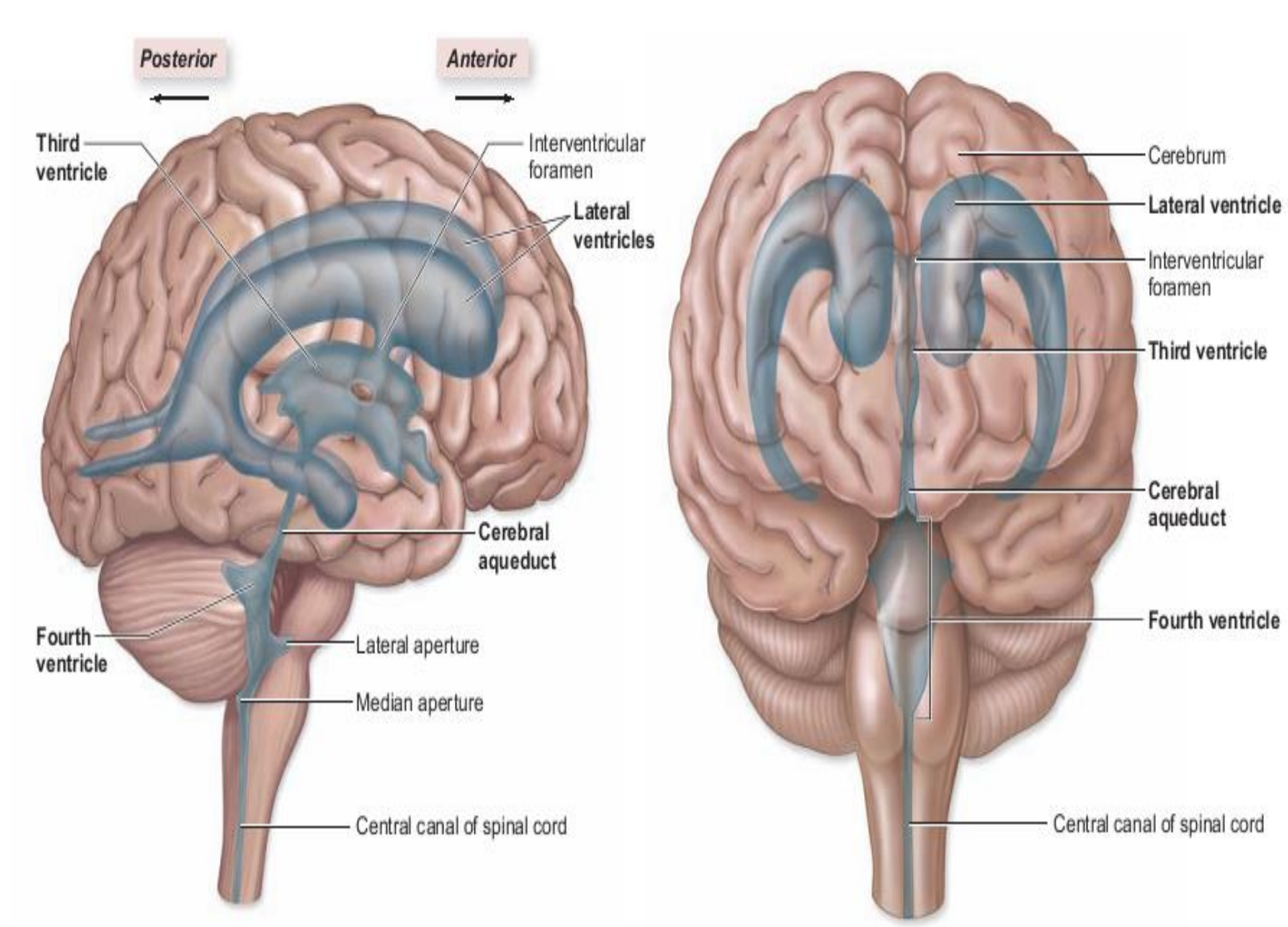
- are large fluid filled cavities contained in the two lobes of cerebral hemispheres.
- There is one lateral ventricle in each hemisphere of the cerebrum.
- The lateral ventricles meet at the midline just inferior to the corpus callosum where they are separated by a thin membrane, the septum pellucidum

The third ventricle

- is a smaller slit-like cavity located in the midline in center of the diencephalon between the two halves of the thalamus.
- Each lateral ventricle communicates with the third ventricle through an opening called the interventricular foramen

The fourth ventricle

- lies between the brain stem and the cerebellum.
- The third ventricle connects with the fourth ventricle through a narrow canal, the cerebral aqueduct, which passes through the midbrain.
- The fourth ventricle is continuous with the central canal of the spinal cord, which extends nearly the full length of the cord.
- The fourth ventricle connects with the subarachnoid space through three openings—a median aperture in the roof of the fourth ventricle and two lateral apertures, one in each lateral wall of the fourth ventricle.

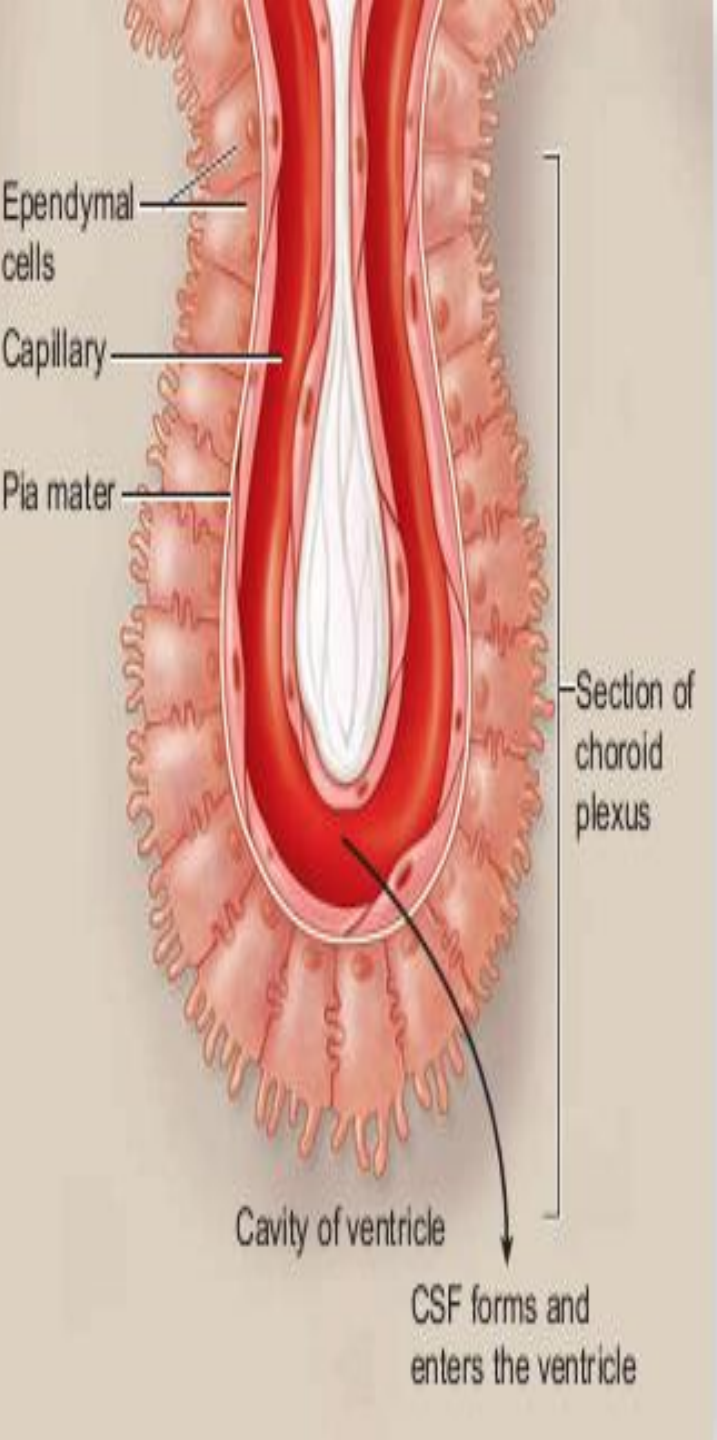

Posterior
Anterior
Third ventricle
Interventricular foramen
Lateral ventricles
Cerebral aqueduct
Fourth ventricle
Lateral aperture
Median aperture
Central canal of spinal cord
(a) Lateral view
Cerebrum
Lateral ventricle
Interventricular foramen
Third ventricle
Cerebral aqueduct
Fourth ventricle
Central canal of spinal cord
(b) Anterior view

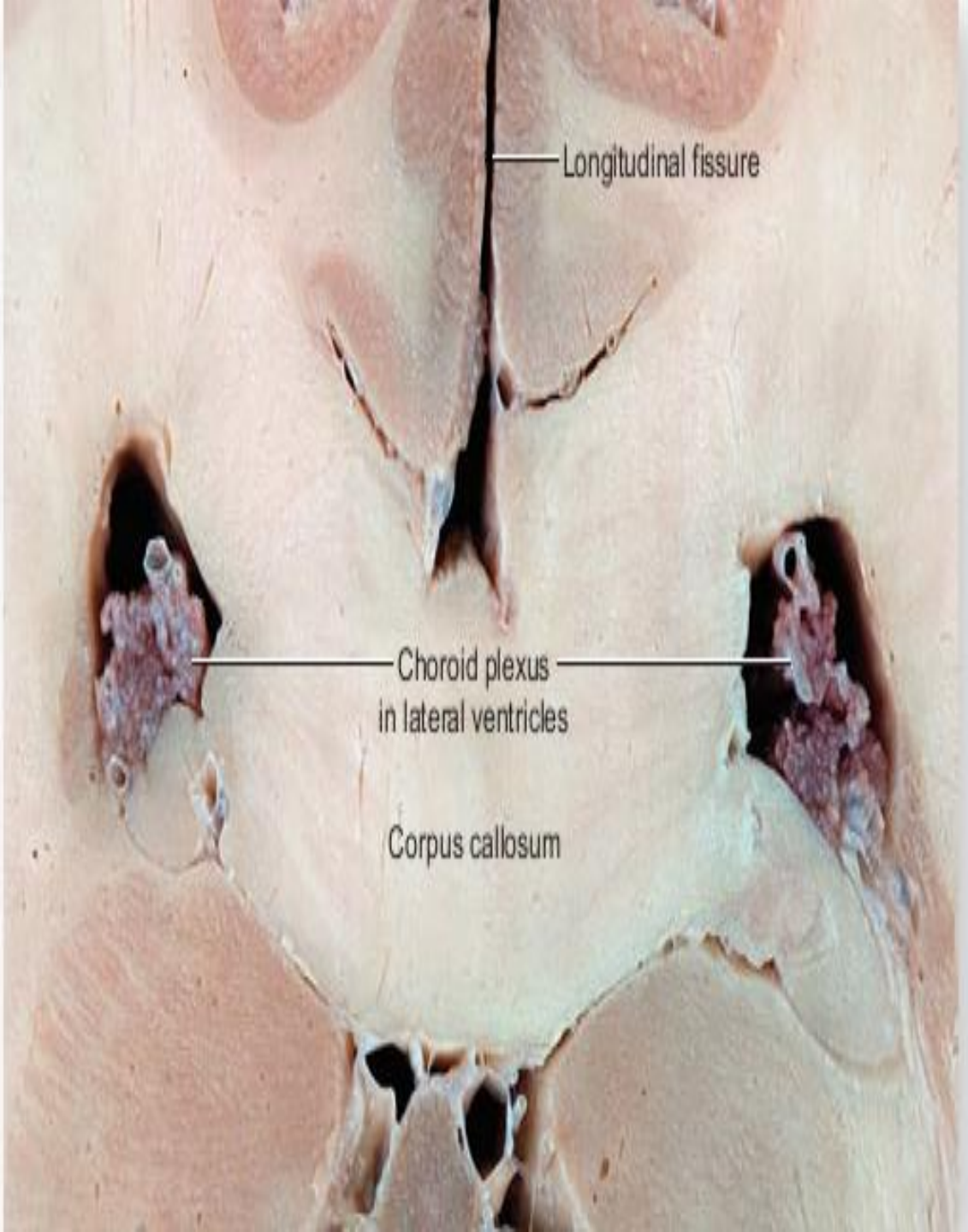
Cerebrospinal fluid

- Cerebrospinal fluid (CSF)is a clear, colorless liquid composed primarily of water that protects the brain and spinal cord from chemical and physical injuries.
- CSF continuously circulates through cavities in the brain and spinal cord and around them in the subarachnoid space
- The total volume of CSF is 80 to 150 mL. The brain produces about 500 mL of CSF per day, but the fluid is constantly reabsorbed at the same rate

Formation of CSF

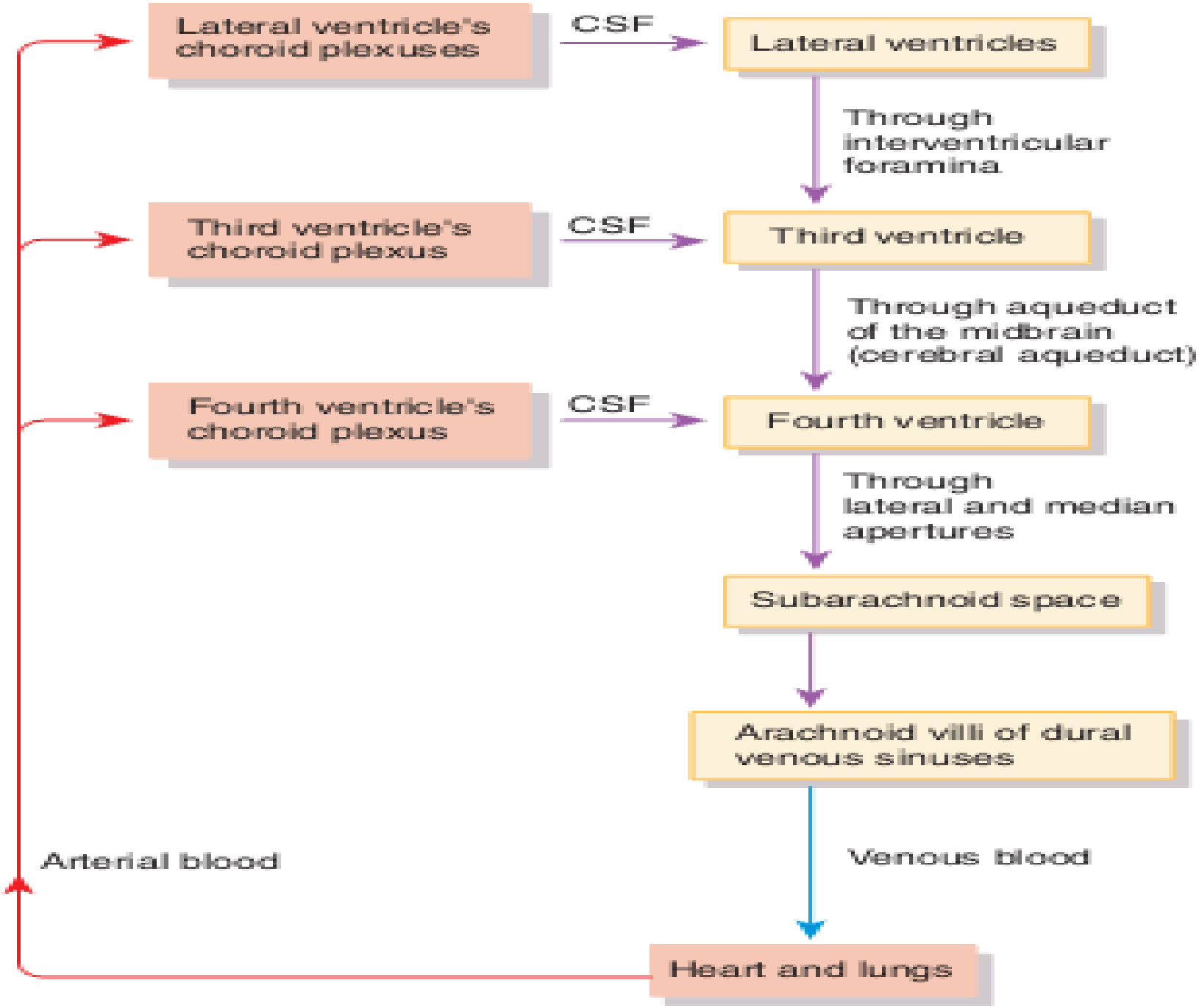
- The majority of CSF production is from the choroid plexuses
- Choroid plexus is tuft of capillaries in the ventricles
- Ependymal cells cover the capillaries of the choroid plexuses such that contents that diffuse from capillaries must first pass through ependymal cells before entering the ventricles to become CSF
- CSF forms partly by the filtration of blood plasma through the choroid plexuses and then modification of this filtrate by ependymal cells so that CSF has more sodium and chloride than the blood plasma, but less potassium, calcium, and glucose and very little protein

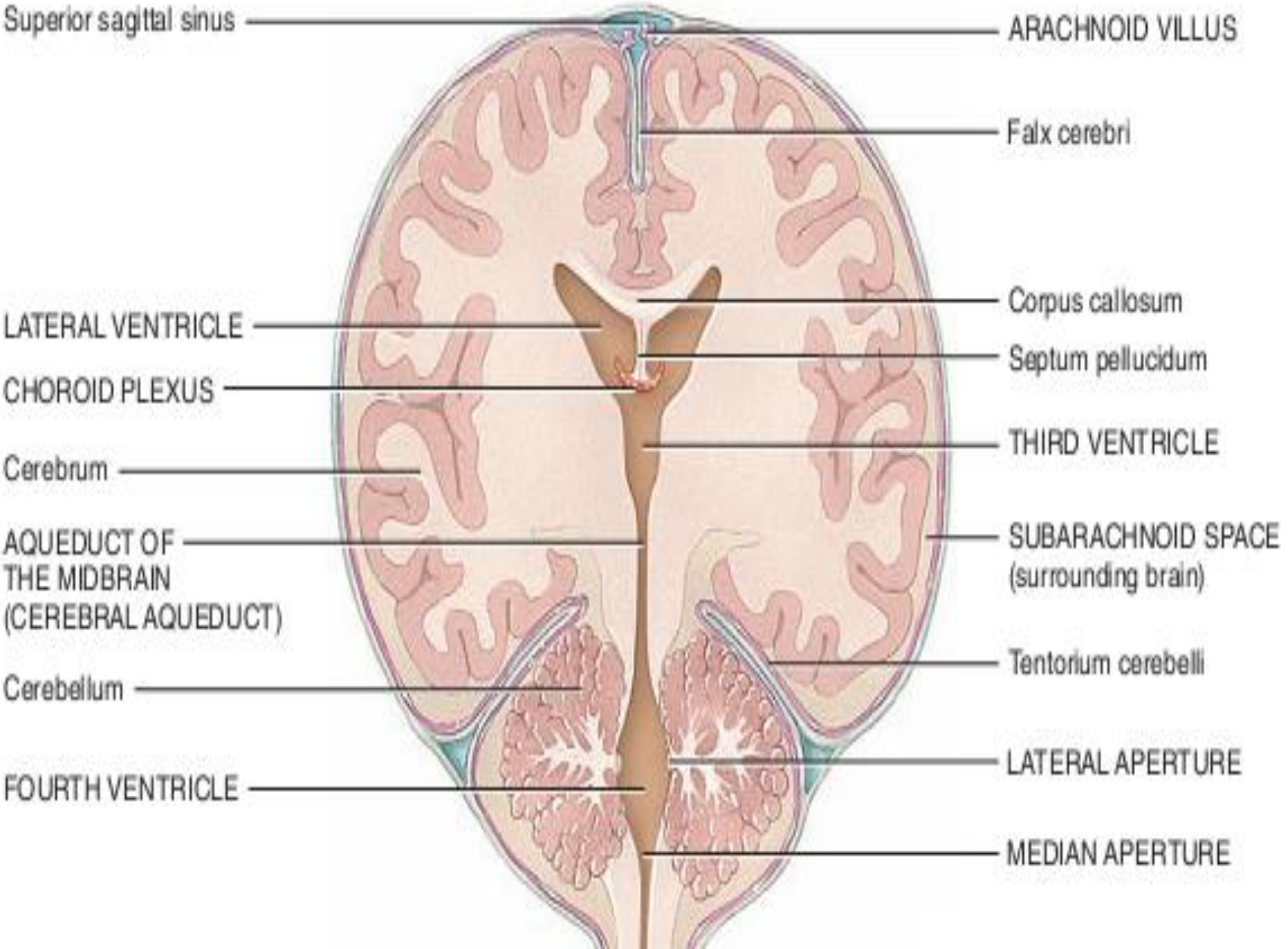

Ependymal cells
Capillary
Pia mater
Section of choroid plexus
Cavity of ventricle
CSF forms and enters the ventricle

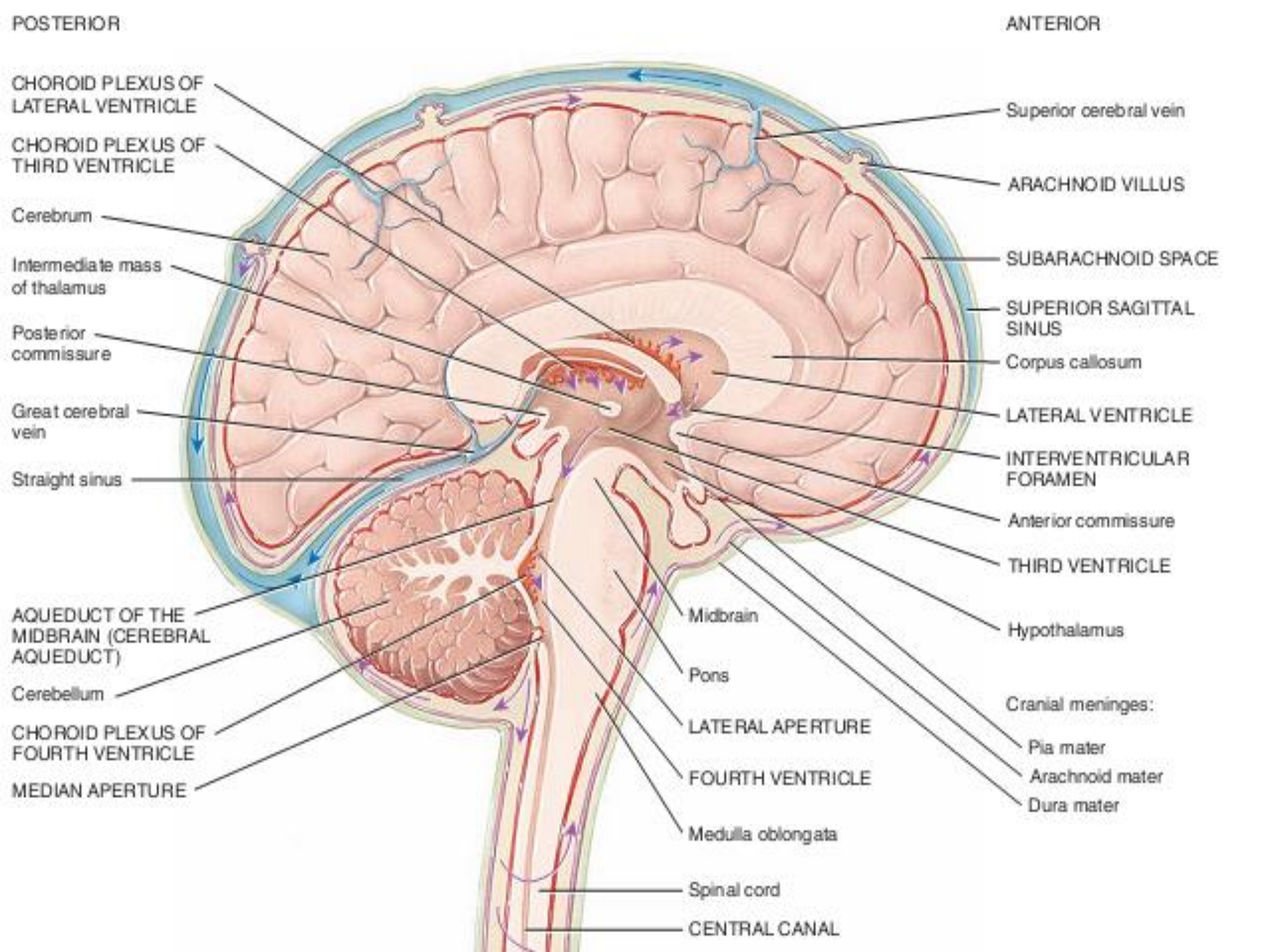

Longitudinal fissure
Choroid plexus in lateral ventricles
Corpus callosum

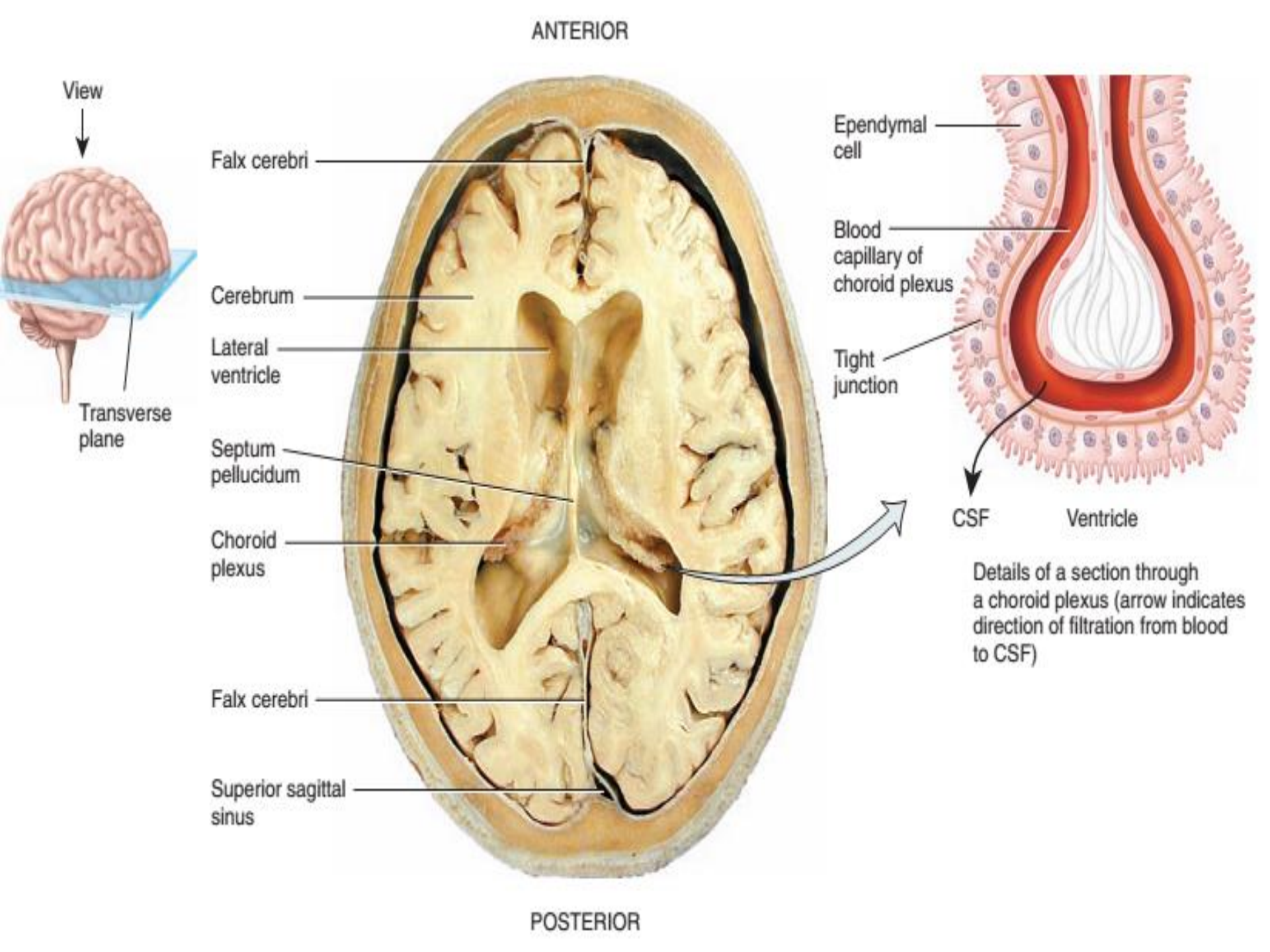
Circulation of CSF

- The CSF is not a stationary fluid but continually flows through and around the CNS, driven partly by its own pressure and partly by rhythmic pulsations of the brain produced by each heartbeat
- The CSF secreted in the lateral ventricles flows through the interventricular foramina into the third ventricle and then down the cerebral aqueduct to the fourth ventricle.
- The third and fourth ventricles and their choroid plexuses add more CSF along the way.
- A small amount of CSF fills the central canal of the spinal cord, but ultimately, all of it escapes through three pores in the walls of the fourth ventricle—a *median aperture and two lateral apertures.*
- *These lead into the subarachnoid* space on the brain surface. From this space, the CSF is absorbed by **arachnoid villi.**
- CSF penetrates the walls of the arachnoid villi and mixes with the blood in the dural venous sinus.


Lateral ventricle's choroid plexuses
CSF
Lateral ventricles
Through interventricular foramina
Third ventricle's choroid plexus
CSF
Third ventricle
Through aqueduct of the midbrain (cerebral aqueduct)
Fourth ventricle's choroid plexus
CSF
Fourth ventricle
Through lateral and median apertures
Subarachnoid space
Arachnoid villi of dural venous sinuses
Venous blood
Arterial blood
Heart and lungs


Superior sagittal sinus
ARACHNOID VILLUS
Falx cerebri
Corpus callosum
LATERAL VENTRICLE
Septum pellucidum
CHOROID PLEXUS
THIRD VENTRICLE
Cerebrum
SUBARACHNOID SPACE
(surrounding brain)
AQUEDUCT OF
THE MIDBRAIN
(CEREBRAL AQUEDUCT)
Tentorium cerebelli
Cerebellum
LATERAL APERTURE
FOURTH VENTRICLE
MEDIAN APERTURE


POSTERIOR
ANTERIOR
CHOROID PLEXUS OF LATERAL VENTRICLE
CHOROID PLEXUS OF THIRD VENTRICLE
Cerebrum
Intermediate mass of thalamus
Posterior commissure
Great cerebral vein
Straight sinus
AQUEDUCT OF THE MIDBRAIN (CEREBRAL AQUEDUCT)
Cerebellum
CHOROID PLEXUS OF FOURTH VENTRICLE
MEDIAN APERTURE
Superior cerebral vein
ARACHNOID VILLUS
SUBARACHNOID SPACE
SUPERIOR SAGITTAL SINUS
Corpus callosum
LATERAL VENTRICLE
INTERVENTRICULAR FORAMEN
Anterior commissure
THIRD VENTRICLE
Hypothalamus
Midbrain
Pons
LATERAL APERTURE
FOURTH VENTRICLE
Medulla oblongata
Spinal cord
CENTRAL CANAL
Cranial meninges:
Pia mater
Arachnoid mater
Dura mater


ANTERIOR
View
Transverse plane
Falx cerebri
Cerebrum
Lateral ventricle
Septum pellucidum
Choroid plexus
Falx cerebri
Superior sagittal sinus
POSTERIOR
Ependymal cell
Blood capillary of choroid plexus
Tight junction
CSF
Ventricle
Details of a section through a choroid plexus (arrow indicates direction of filtration from blood to CSF)

Cerebrum

- The cerebrum is formed from the telencephalon
- Superior part of the brain, make up 80% of the brain mass
- Seat of intelligence
- Made up of three layers
  - **Cortex** - gray matter on the outer surface of the cerebrum
  - **Cerebrum medulla** – white matter present next to cortex
  - **Cerebral nuclei/ basal nuclei** – aggregates of gray matter inside the medulla
- The surface of the cerebrum folds into elevated ridges, called **gyri**, which allow a greater amount of cortex to fit into the cranial cavity.
- Adjacent gyri are separated by shallow **sulci** or deeper grooves called **fissures**

- The most prominent fissure in the cerebrum in **longitudinal fissure** which extend along midsagittal plane and divides the cerebrum into **right and left hemisphere**

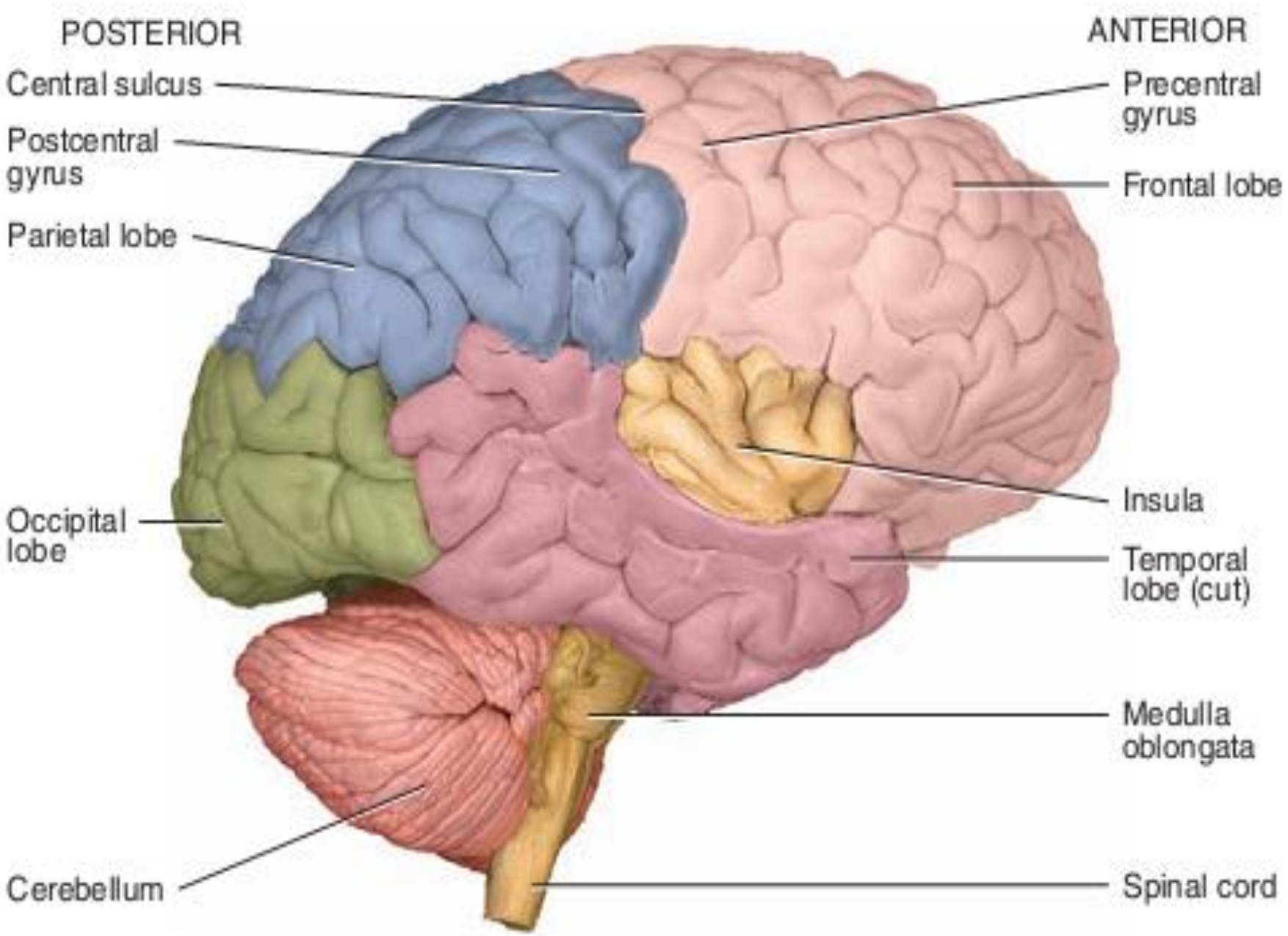
- The falx cerebri extend along the longitudinal fissure

- The separation between cerebral hemispheres is not complete instead a broad band of white matter containing axons that extend between the hemispheres allow for communication between them. That tract of white matter is called **corpus callosum**

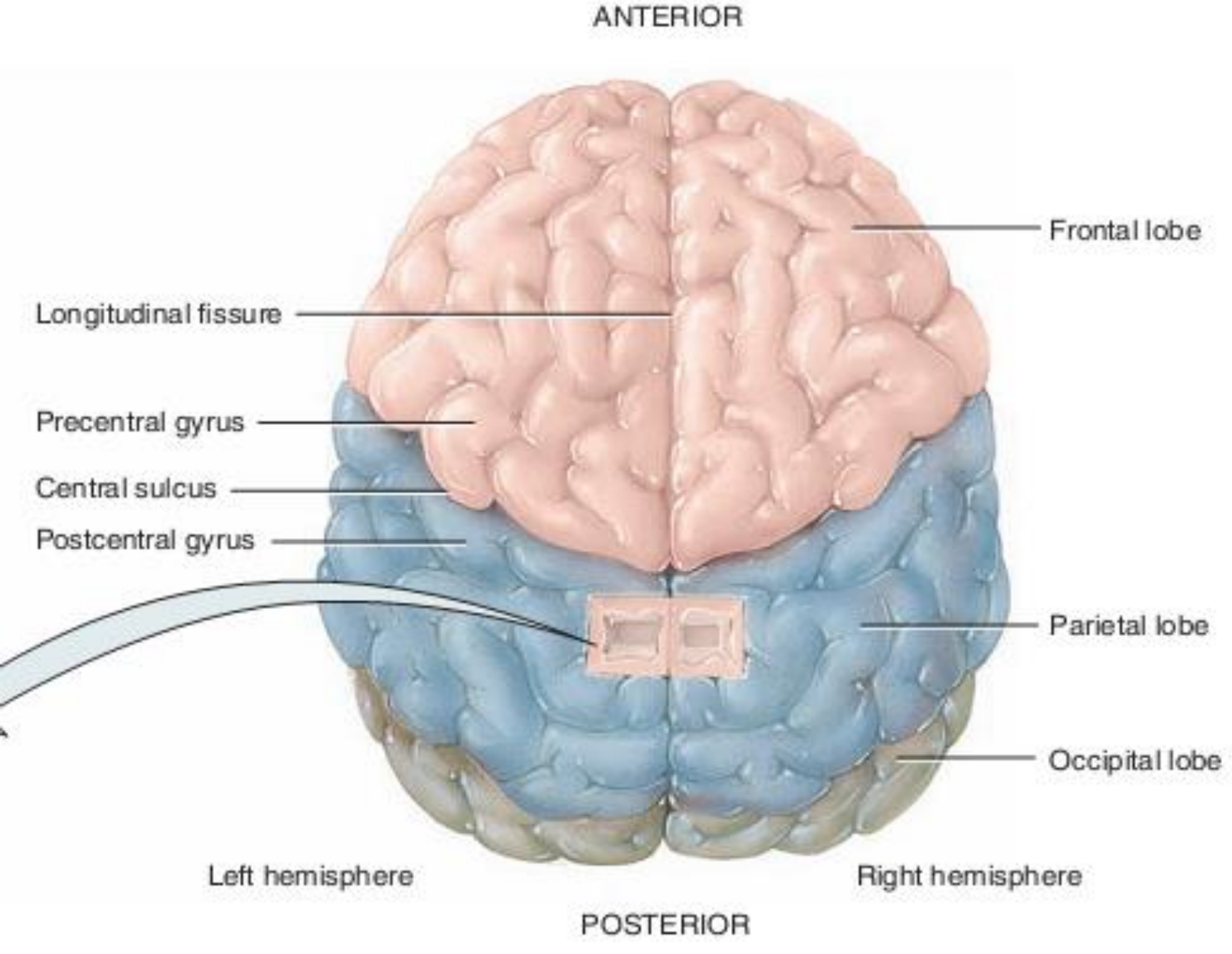
- Each cerebral hemisphere is divided into five anatomically and functionally distinct **lobes** by sulci or fissures. The lobes are named for the skull bones overlying each one:
  - Frontal,
  - Parietal,
  - Temporal, and
  - Occipital lobes
  - Insula - the fifth lobe is not visible at the surface of the hemispheres.

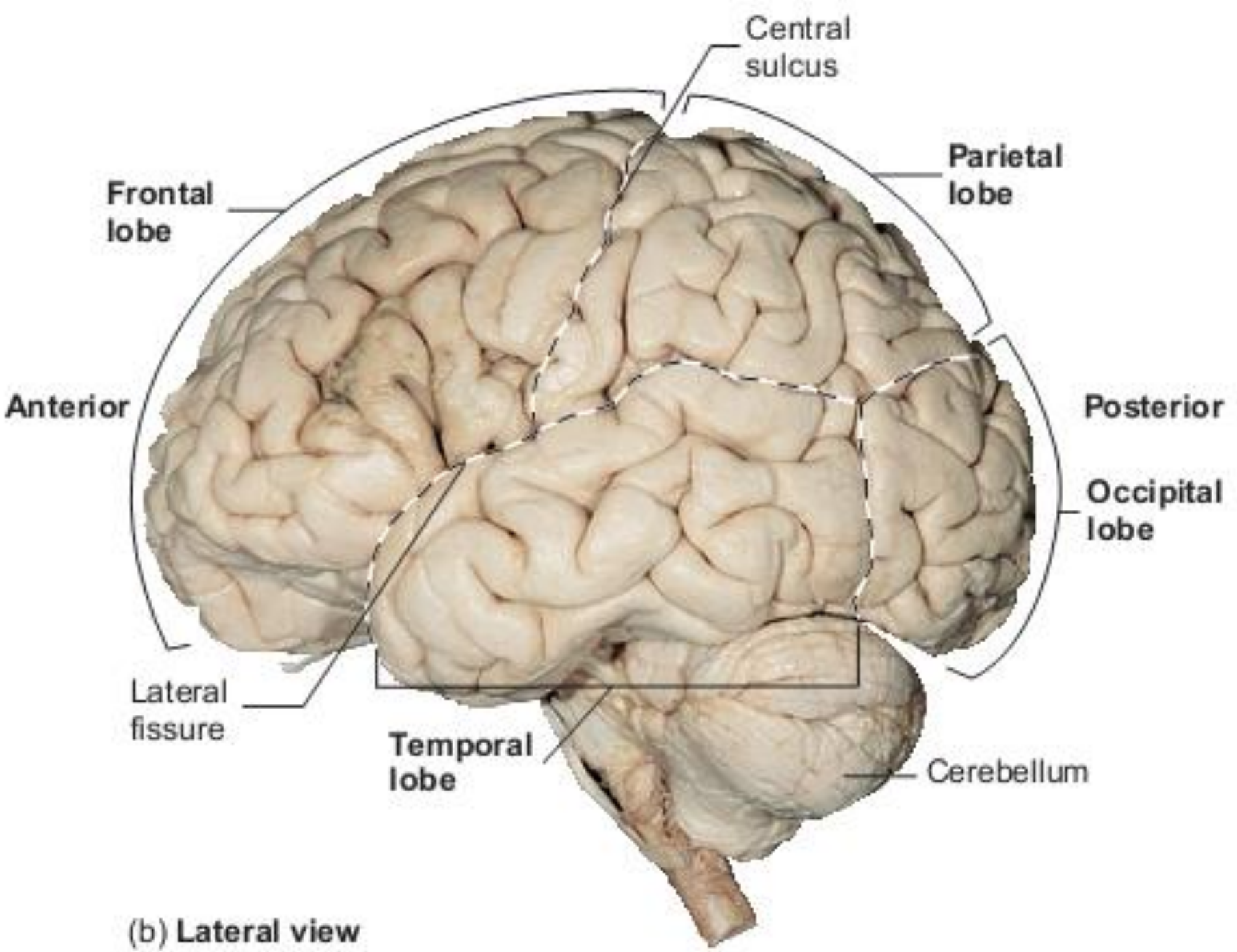
The frontal lobe

- Lies deep to the frontal bone and forms the anterior part of the cerebral hemisphere.
- The frontal lobe ends posteriorly at a deep groove called the central sulcus. The central sulcus extends across the lateral surface of the cerebrum from superior to inferior and is located about midway along the length of the brain
- Central sulcus separates frontal lobe from parietal lobe
- A major gyrus, the precentral gyrus—located immediately anterior to the central sulcus—contains the primary motor area of the cerebral cortex
- The inferior border of the frontal lobe is marked by the lateral sulcus, a deep groove that separates the frontal and parietal lobes from the temporal lobe
- The frontal lobe is primarily concerned with voluntary motor functions, concentration, verbal communication, decision making, planning, personality, motivation, aggression, the sense of smell, and mood



(c) Right lateral view with temporal lobe cut away


ANTERIOR
Frontal lobe
Longitudinal fissure
Precentral gyrus
Central sulcus
Postcentral gyrus
Parietal lobe
Occipital lobe
Left hemisphere
Right hemisphere
POSTERIOR



(b) **Lateral view**

The Parietal lobe

- lies internal to the parietal bone and forms the superoposterior part of each cerebral hemisphere.
- It terminates anteriorly at the central sulcus, posteriorly at a relatively indistinct parieto-occipital sulcus, and laterally at the lateral sulcus.
- A major gyrus, the post-central gyrus, which is located immediately posterior to the central sulcus, contains the primary somatosensory area of the cerebral cortex
- The parietal lobe is involved with general sensory functions, such as evaluating the shape and texture of objects being touched . It is a major center for the reception and evaluation of most sensory information, such as touch, pain, temperature, balance, and taste.

The temporal lobe

- underlies the temporal bone.
- The temporal lobe is located below the parietal lobe and the posterior portion of the frontal lobe. It is separated from both by the lateral sulcus.
- The temporal lobe contains auditory centers that receive sensory fibers from the cochlea of the ear. This lobe also interprets some sensory experiences and stores memories of both auditory and visual experiences.
- Its anterior and inferior portions are referred to as the "psychic cortex," and they are associated with such brain functions as abstract thought and judgment

The occipital lobe

- forms the posterior region of each hemisphere and immediately underlies the occipital bone.
- It is not distinctly separated from the temporal and parietal lobes
- It lies superior to the cerebellum and is separated from it by an infolding of the meningeal layer called the tentorium cerebelli
- The principal functions of the occipital lobe concern vision. It integrates eye movements by directing and focusing the eye. It is also responsible for visual association—correlating visual images with previous visual experiences and other sensory stimuli

The insula

- The insula is a deep lobe of the cerebrum that cannot be viewed on the surface .
- It lies deep to the lateral sulcus and is covered by portions of the frontal, parietal, and temporal lobes
- It is apparently involved in memory and the interpretation of taste.

The central white matter

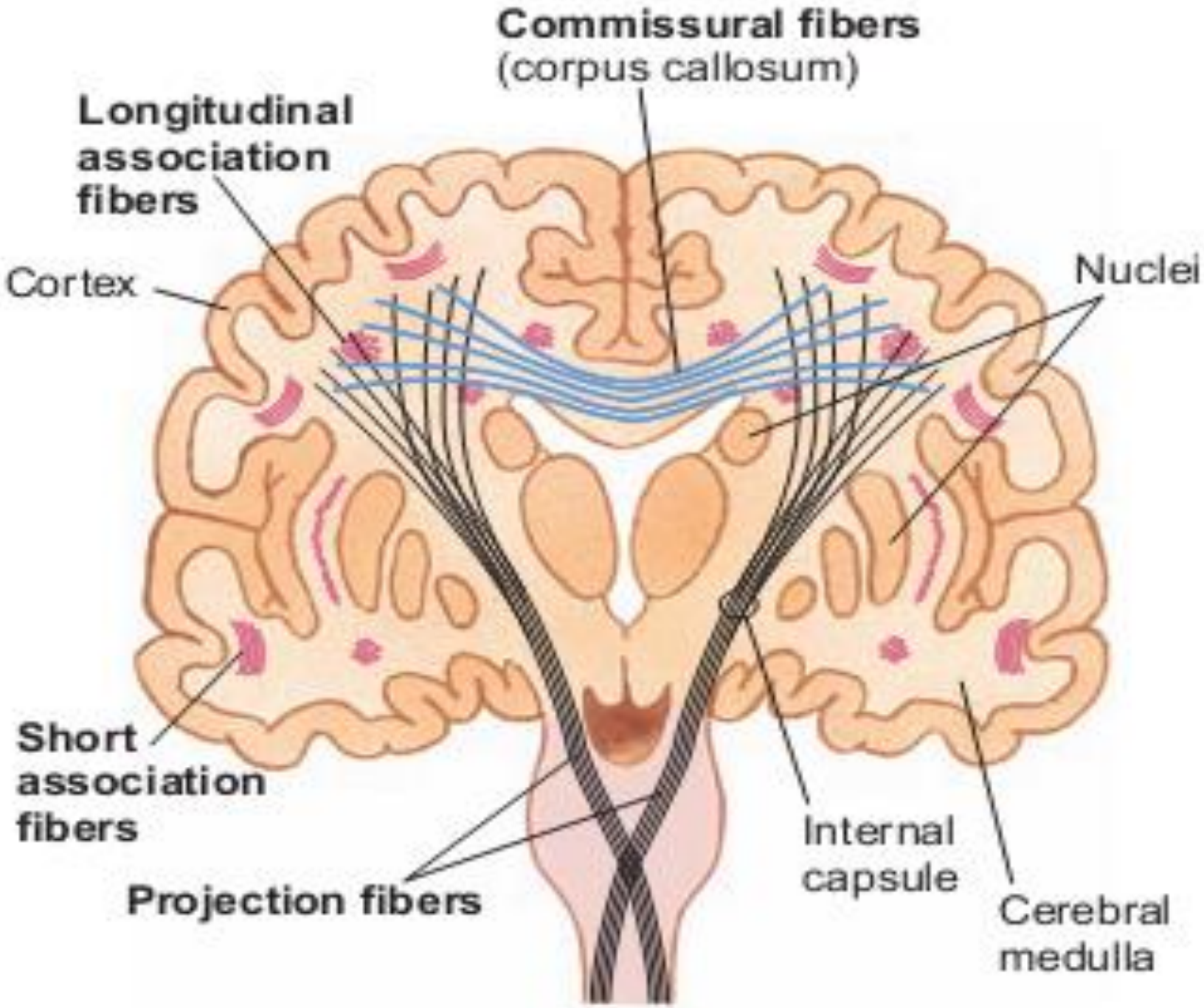
- lies deep to the gray matter of the cerebral cortex and is composed primarily of myelinated axons.

- Most of these axons are grouped into bundles called tracts. There are three type of tracts:

  - **Association tracts –** has axons that connect different regions of the cerebral cortex within the same hemisphere.

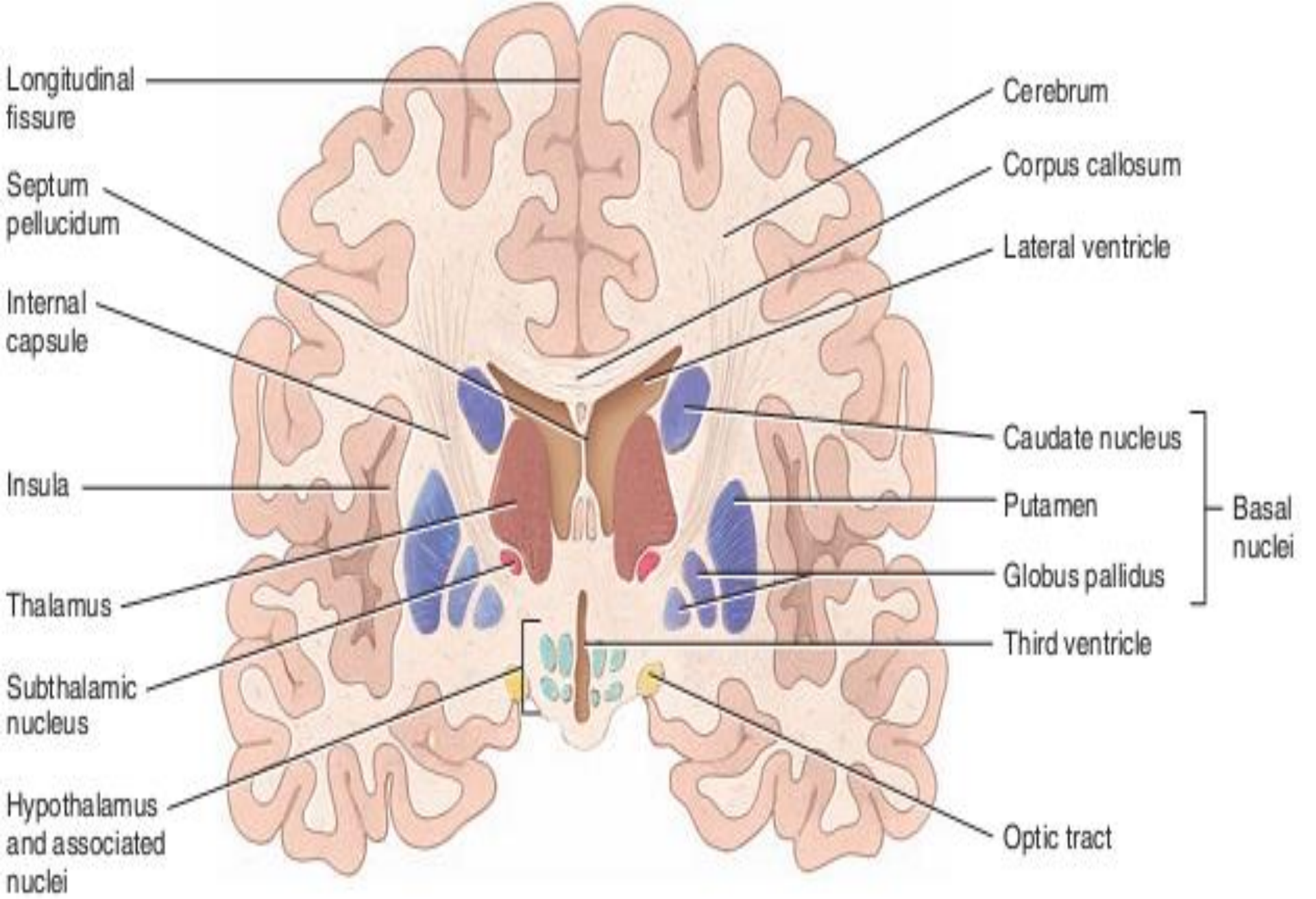
  - **Commissural tracts -** has axons that connect the cerebral hemispheres. The prominent commissural tracts that link the left and right cerebral hemispheres include the large, C -shaped corpus callosum anterior commissure, and posterior commissure.

  - **Projection tracts-** link the cerebral cortex to the inferior brain regions and the spinal cord. Examples of projection tracts are the corticospinal tracts that carry motor signals from the cerebrum to the brainstem and spinal cord.

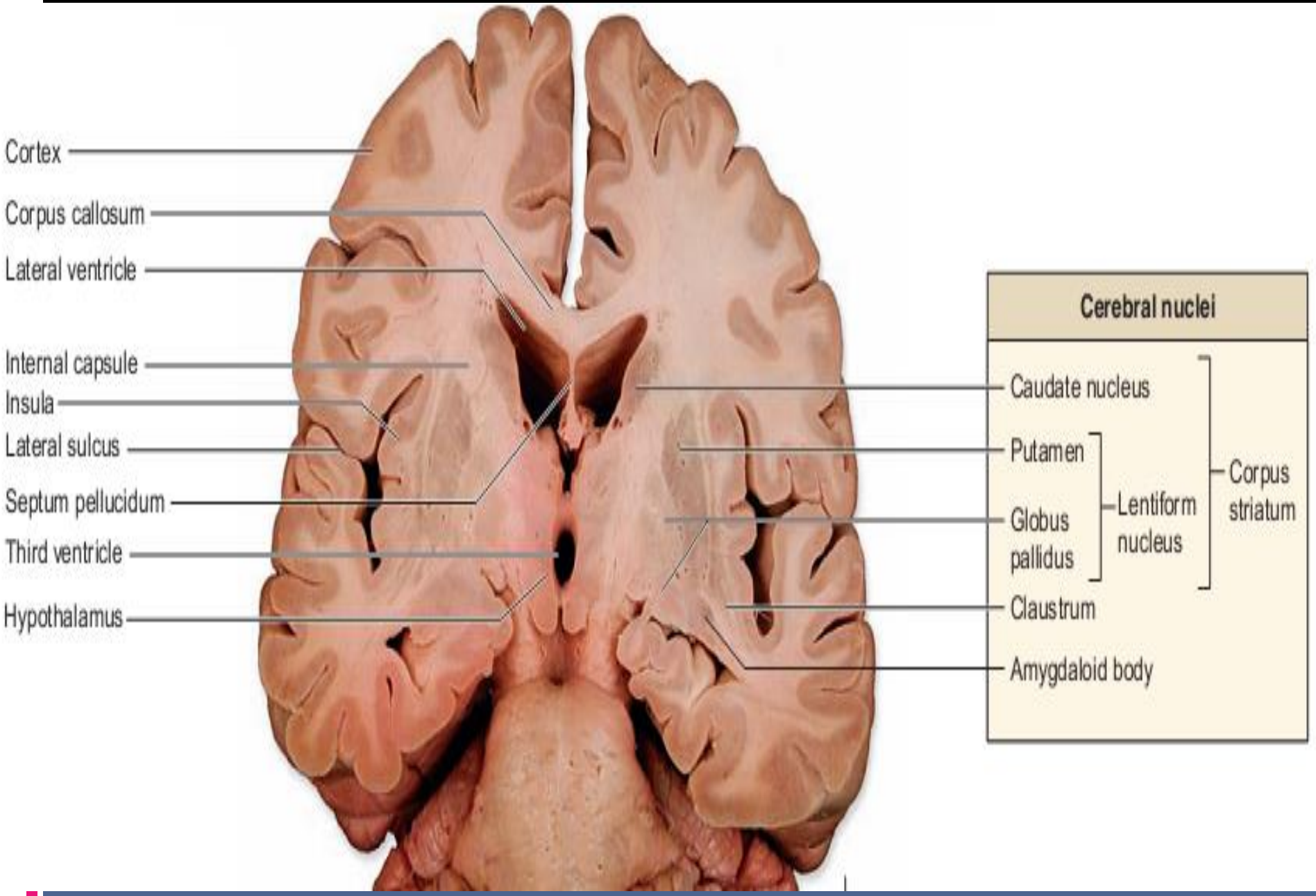

Commissural fibers
(corpus callosum)
Longitudinal association fibers
Cortex
Nuclei
Short association fibers
Projection fibers
Internal capsule
Cerebral medulla

Basal nuclei

- The basal nuclei are a group of functionally related nuclei located bilaterally in the inferior cerebrum, diencephalon, and midbrain
- The nuclei in the cerebrum are collectively called the corpus striatum
- These include caudate nucleus and lentiform nucleus
- The caudate nucleus is upper mass and separated from lentiform nucleus by a thick band of white matter (internal capsule)
- The lentiform nucleus has a lateral portion, called the putamen, and a medial portion, called the globus pallidus.
- The claustrum is a thin sheet of gray matter situated lateral to the putamen. It is considered by some to be a subdivision of the basal nuclei.



(b) Anterior view of frontal section


Cortex
Corpus callosum
Lateral ventricle
Internal capsule
Insula
Lateral sulcus
Septum pellucidum
Third ventricle
Hypothalamus
Cerebral nuclei
Caudate nucleus
Putamen
Globus pallidus
Lentiform nucleus
Corpus striatum
Claustrum
Amygdaloid body

Functional Areas of the Cerebrum

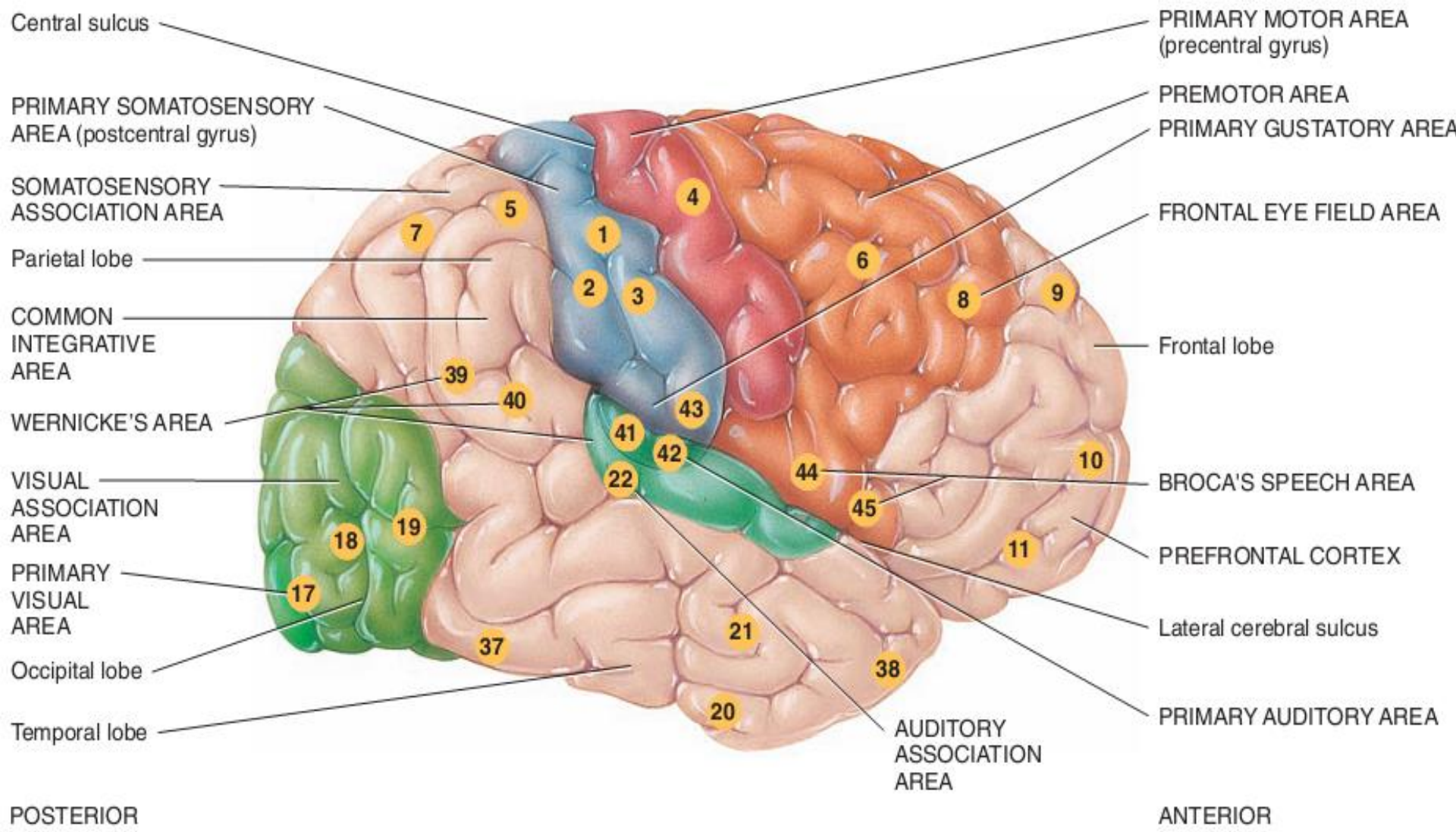
- Specific structural areas of the cerebral cortex have distinct motor and sensory functions

- Three categories of functional areas are present:

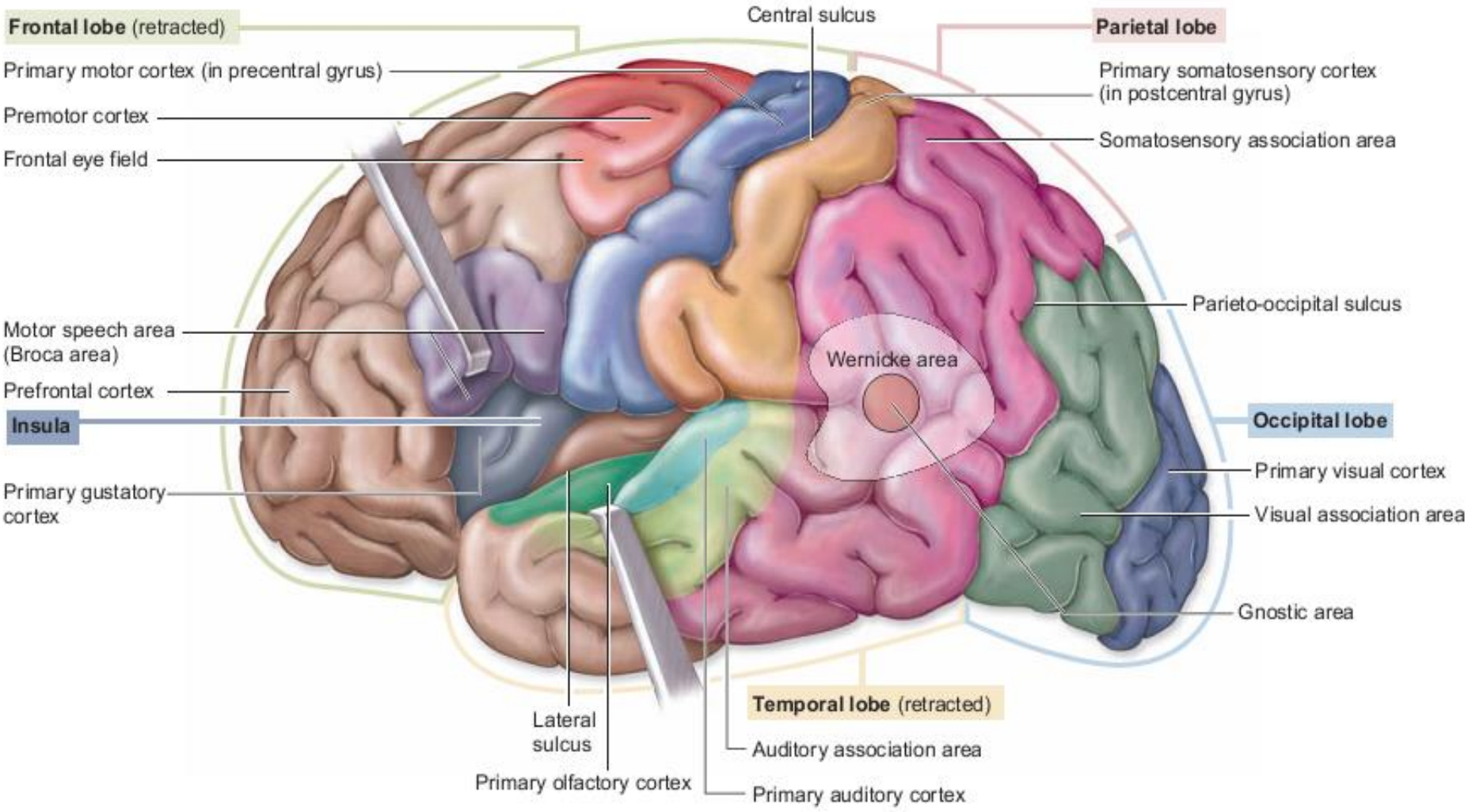
  - motor areas that control voluntary motor functions;

  - sensory areas that provide conscious awareness of sensation (perception)

  - association areas deal with more complex integrative functions such as memory, emotions, reasoning, will, judgment, personality traits, and intelligence



Lateral view of right cerebral hemisphere

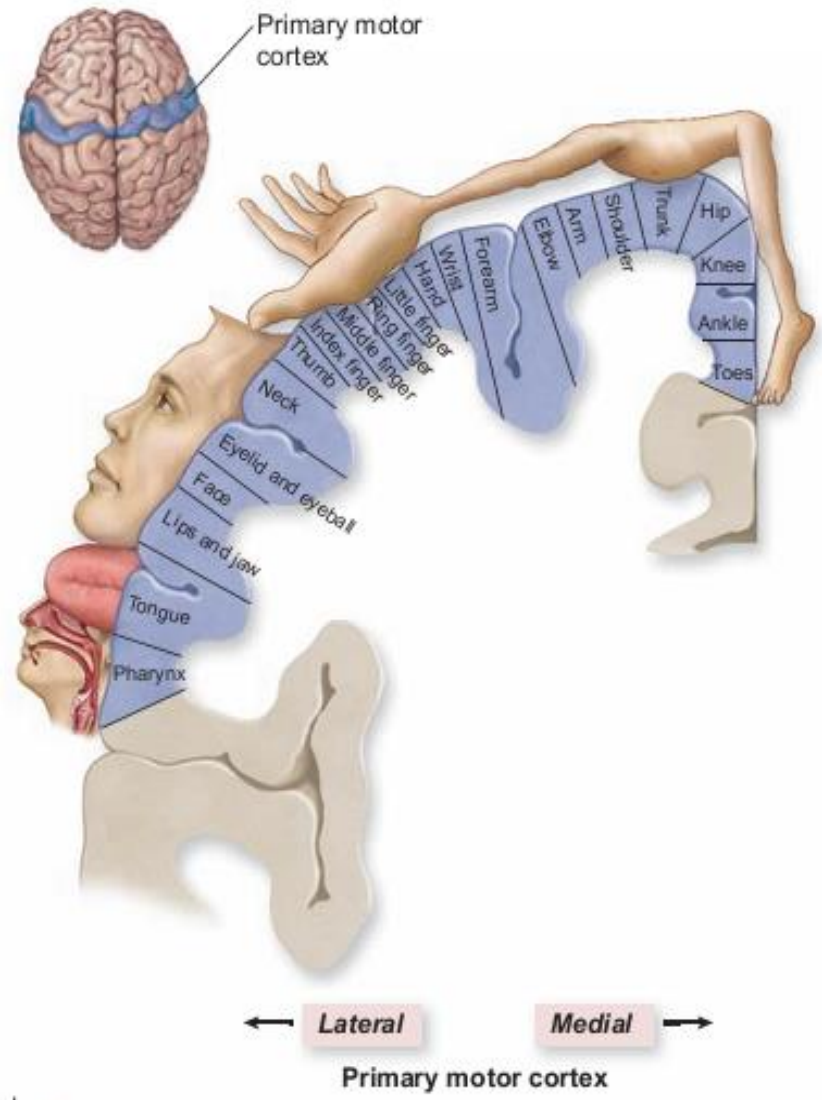

Frontal lobe (retracted)
Primary motor cortex (in precentral gyrus)
Premotor cortex
Frontal eye field
Motor speech area (Broca area)
Prefrontal cortex
Insula
Primary gustatory cortex
Central sulcus
Parietal lobe
Primary somatosensory cortex (in postcentral gyrus)
Somatosensory association area
Parieto-occipital sulcus
Wernicke area
Occipital lobe
Primary visual cortex
Visual association area
Gnostic area
Temporal lobe (retracted)
Lateral sulcus
Primary olfactory cortex
Auditory association area
Primary auditory cortex

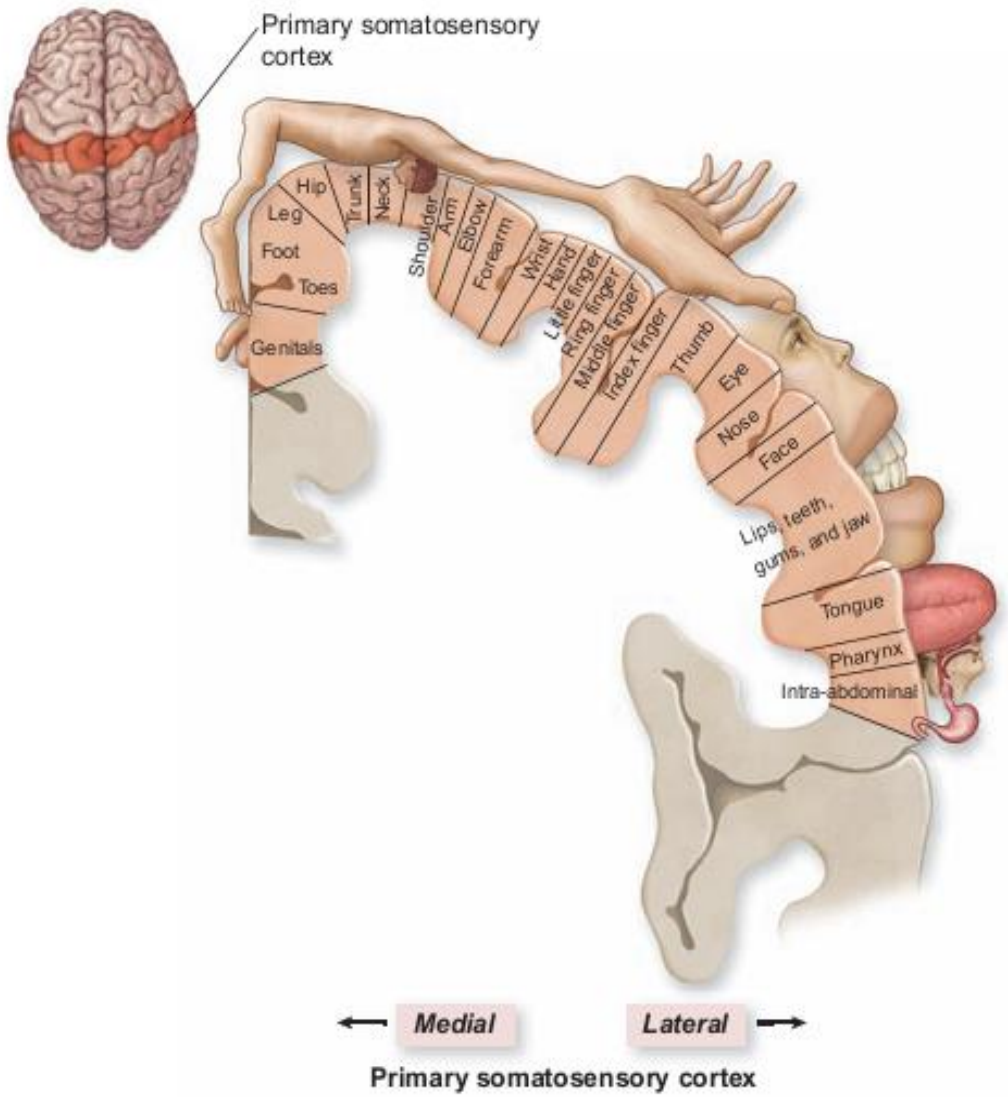
Motor areas

- The cortical areas that control motor functions are housed within the frontal lobes.

- The primary motor cortex, (area 4) also called the somatic motor area, is located within the precentral gyrus of the frontal lobe which control voluntary skeletal muscle activity.
- A "map" of the entire body is present in the primary motor area. Each region within the area controls voluntary contractions of specific muscles or groups of muscles.
- Different muscles are represented unequally in the primary motor area. More cortical area is devoted to those muscles involved in skilled, complex, or delicate movement
- The axons of these neurons project contralaterally (to the opposite side) to the brainstem and spinal cord. Thus, the left primary motor cortex controls the right-side voluntary muscles, and vice versa.

- The motor speech area/ the Broca area, (areas 44 and 45) is located in most individuals within the inferolateral portion of the left frontal lobe. This region is responsible for controlling the muscular movements necessary for vocalization.
- The frontal eye field control and regulate the eye movements needed for reading and coordinating binocular vision


Primary motor cortex
Trunk
Hip
Knee
Ankle
Toes
Shoulder
Arm
Elbow
Forearm
Wrist
Hand
Little finger
Ring finger
Middle finger
Index finger
Thumb
Neck
Eyelid and eyeball
Face
Lips and jaw
Tongue
Pharynx
Lateral
Medial
Primary motor cortex


Primary somatosensory cortex
Hip
Leg
Foot
Toes
Genitals
Trunk
Neck
Shoulder
Arm
Elbow
Forearm
Wrist
Hand
Little finger
Ring finger
Middle finger
Index finger
Thumb
Eye
Nose
Face
Lips, teeth, gums, and jaw
Tongue
Pharynx
Intra-abdominal
Medial
Lateral
Primary somatosensory cortex

Sensory areas

- The cortical areas involved conscious awareness of sensation are present in parietal, temporal, and occipital lobes

- The primary somatosensory cortex is housed within the postcentral gyrus of the parietal lobes.(area 1, 2 ,3) Neurons in this cortex receive general somatic sensory information from touch, pressure, pain, proprioception and temperature receptor. A "map" of the entire body is present in the primary somatosensory area. Each point within the area receives impulses from a specific part of the body. The size of the cortical area receiving impulses from a particular part of the body depends on the number of receptors present there rather than on the size of the body part

- The primary gustatory cortex (area 43), located in the parietal cortex, receives impulses for taste and is involved in gustatory perception and taste discrimination

- The primary visual cortex, (area 17) located in the occipital lobe, receives and processes incoming visual information.

- The primary auditory cortex, (area 41 and 42) located in the temporal lobe, receives and processes auditory information.

- Primary olfactory cortex,(area 28) located in the temporal lobe, provides conscious awareness of smells.

Association areas

- The association areas of the cerebrum consist of large areas of the occipital, parietal, and temporal lobes and of the frontal lobes anterior to the motor areas.
- Association areas are connected with one another by association tracts
- The primary motor and sensory cortical regions are connected to adjacent association areas that either process and interpret incoming data or coordinate a motor response.
- Association areas integrate new sensory inputs with memories of past experiences
- The premotor area (area 6)
  - is a motor association area that is immediately anterior to the primary motor area in frontal lobe.
  - Neurons in this area communicate with the primary motor cortex, the sensory association areas in the parietal lobe, the basal nuclei, and the thalamus.
  - The premotor area deals with learned motor activities of a complex and sequential nature. It generates nerve impulses that cause specific groups of muscles to contract in a specific sequence
  - The premotor area also serves as a memory bank for such various skilled movements.

- The somatosensory association area (area 5 and 7)
  - is located in the parietal lobe and lies immediately posterior to the primary somatosensory cortex. It receives input from the primary somatosensory area, as well as from the thalamus and other parts of the brain
  - It interprets sensory information and is responsible for integrating and interpreting sensations to determine the texture, temperature, pressure, and shape of objects.
  - Another role of this area is storage of memories of past somatic sensory experiences, enabling one to compare current sensations with previous experiences

- The visual association area (areas 18 and 19)
  - located in the occipital lobe, receives sensory impulses from the primary visual area and the thalamus.
  - relates present and past visual experiences and is essential for recognizing and evaluating what is seen

- The facial recognition area, (corresponding roughly to areas 20, 21, and 37)
  - in the inferior temporal lobe, receives nerve impulses from the visual association area.
  - This area stores information about faces, and it allows to recognize people by their faces.

- The auditory association area (area 22)
  - located within the temporal lobe posterior to primary auditory area. Help to recognize a particular sound as speech, music, or noise.

- Wernicke's (posterior language) area (area 22, 39,40)
  - a broad region in the left temporal and parietal lobes, interprets the meaning of speech by recognizing spoken words.
  - It is active in translating words into thoughts.
  - The regions in the right hemisphere that correspond to Broca's and Wernicke's areas in the left hemisphere also contribute to verbal communication by adding emotional content, such as anger or joy, to spoken words.

- The common integrative area (areas 5, 7, 39, and 40)
  - composed of regions of the parietal, occipital, and temporal lobes
  - This region integrates all sensory, visual, and auditory information being processed by the association areas within these lobes. Thus it provides comprehensive understanding of a current activity
  - It then transmits signals to other parts of the brain for the appropriate response to the sensory signals it has interpreted.

Brain and language

Test your facility for English word recognition

Aoccdrnig to rscheearch at Cmabrigde Uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be at the rghit pclae. The rset can be a total mses and you can sitll raed it wouthit a porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe.

- The prefrontal cortex (frontal association area) (areas 9, 10, 11, and 12)

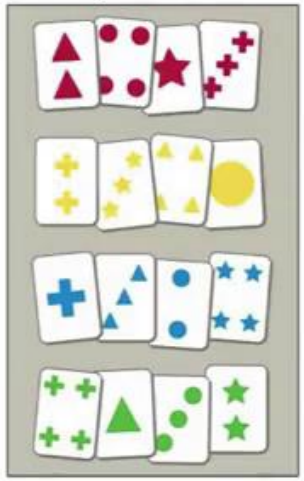
  - an extensive area in the anterior portion of the frontal lobe.

  - This area has numerous connections with other areas of the cerebral cortex, thalamus, hypothalamus, limbic system, and cerebellum.

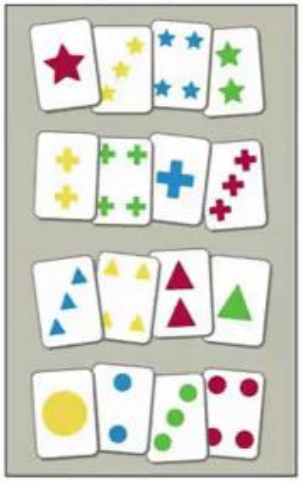
  - The prefrontal cortex is concerned with the makeup of a person's personality, intellect, complex learning abilities, recall of information, initiative, judgment, fore-sight, reasoning, conscience, intuition, mood, planning for the future, and development of abstract ideas

Testing frontal lobe function

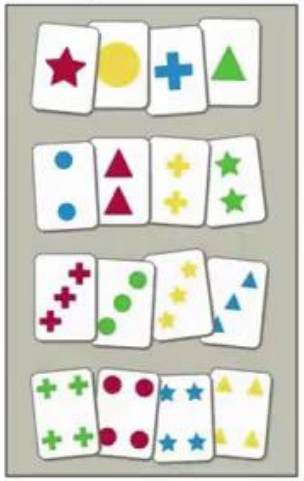
Sort by color



Sort by shape



Sort by number



***NEUROSCIENCE 5e*, Box 26B**

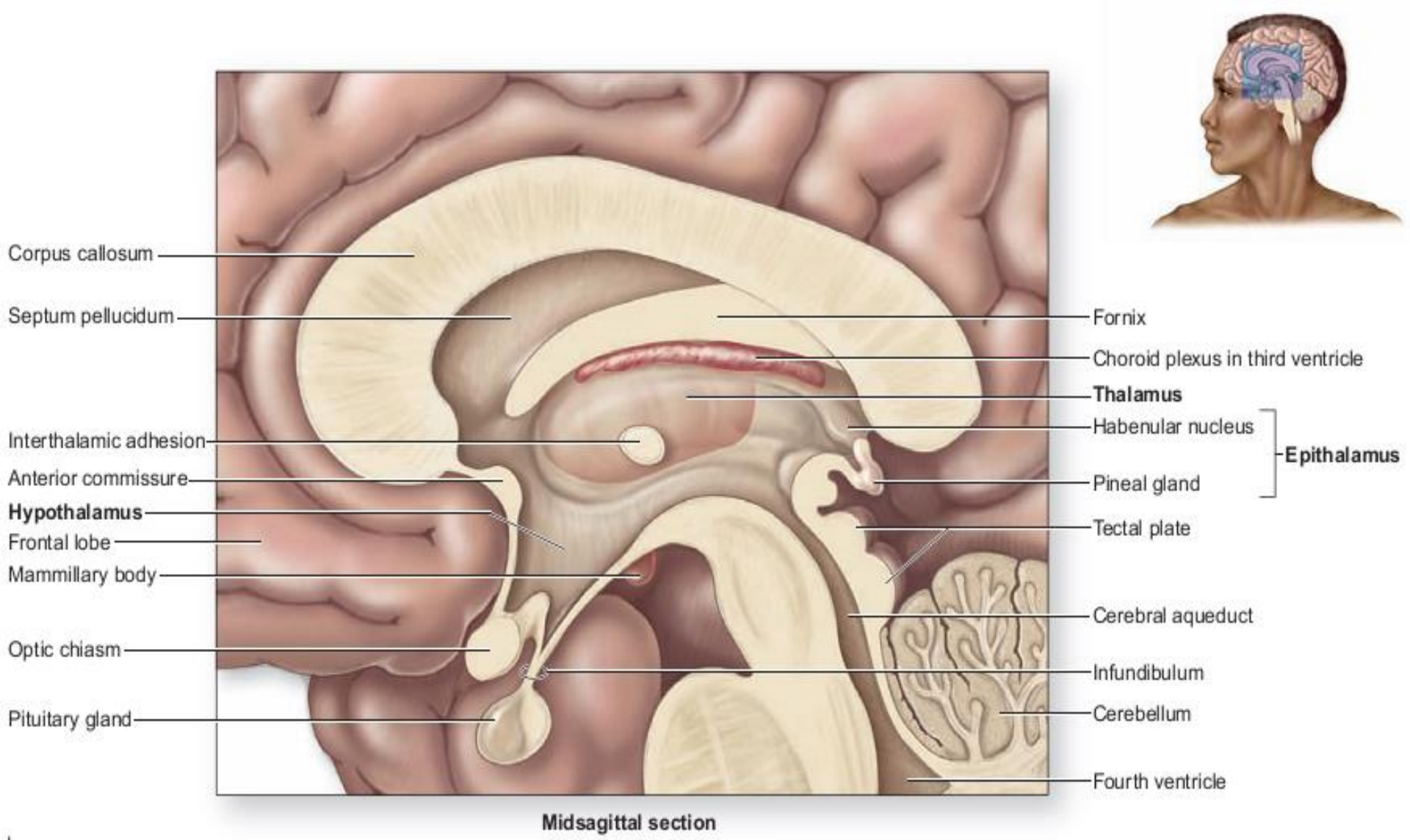
DIENCEPHALON

- The diencephalon forms a central core of brain tissue just superior to the midbrain. It is almost completely surrounded by the cerebral hemispheres and contains numerous nuclei

- The components of the diencephalon include:
  - Epithalamus
  - Thalamus
  - Hypothalamus

- The third ventricle is a narrow midline cavity within the diencephalon

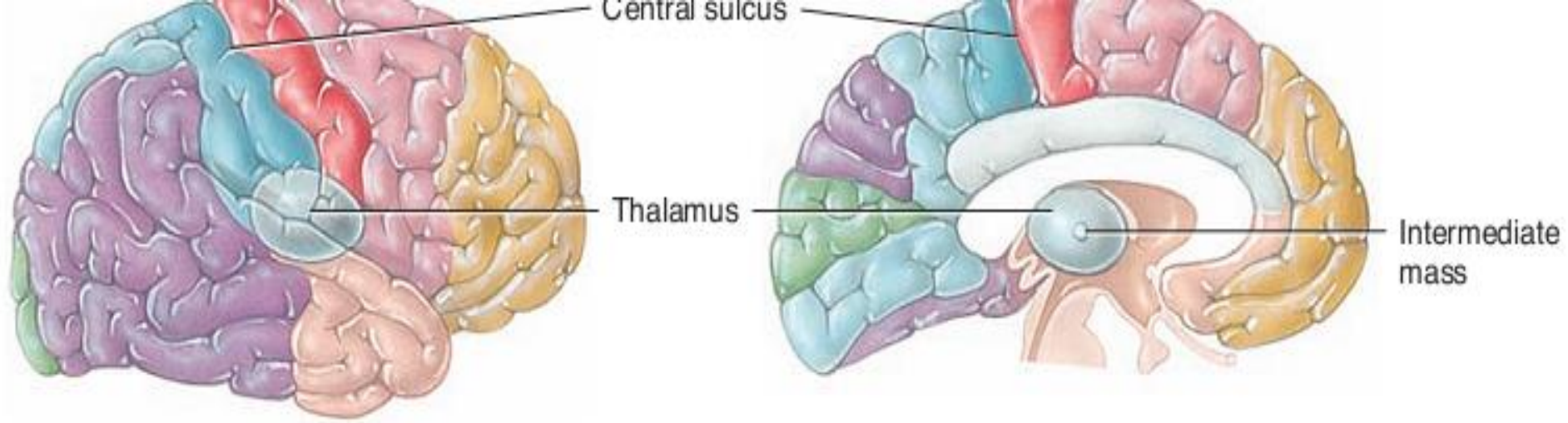
- The diencephalon provides the relay and switching center for some sensory and motor pathways



Midsagittal section

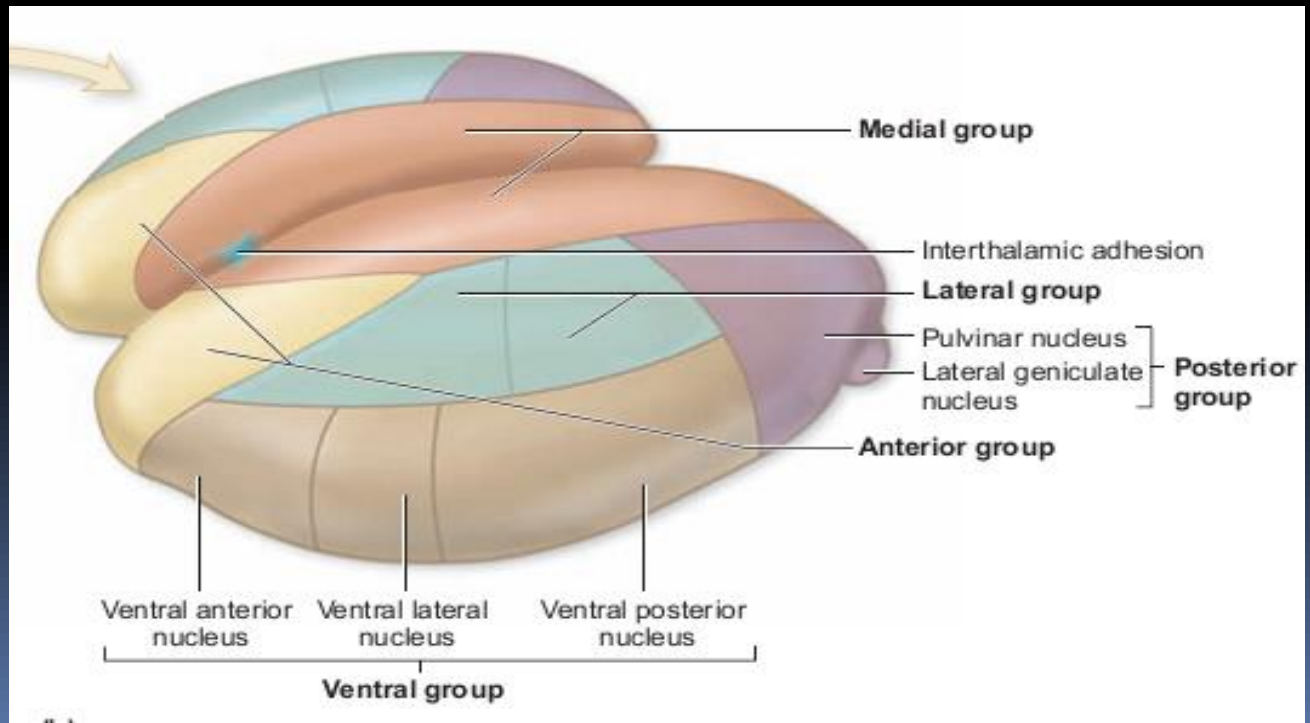
Thalamus

- The thalamus refers to paired oval masses of gray matter that lie on each side of the third ventricle. The lateral portions of thalamus are connected in the center by a small stalk called the interthalamic adhesion
- Anterior to thalamus is present anterior commissure, posterior to it is present pineal gland, superior to it is present lateral ventricles, inferior to it is present mid brain
- Each part of the thalamus is a gray matter mass composed of group of nuclei from which axons project to particular regions of the cerebral cortex.
- Sensory impulses from all the conscious senses except olfaction converge on the thalamus and synapse in at least one of its nuclei
- The thalamus is the principal and final relay point for sensory information that will be processed and projected to the primary somatosensory cortex. Thalamus acts as an information filter for those sensory stimuli
- Some of the thalamic nuclei are involved with controlling skeletal muscles. They connect to, and interact with, other parts of the brain that control skeletal muscle contraction, especially the motor areas of the cerebral cortex, the cerebellum, and the basal nuclei
- Some of the thalamic nuclei are involved with the limbic system and emotions. They connect different parts of the limbic system and influence mood and actions associated with strong emotions, such as fear and rage



(a) Lateral view of right cerebral hemisphere

(b) Medial view of left cerebral hemisphere

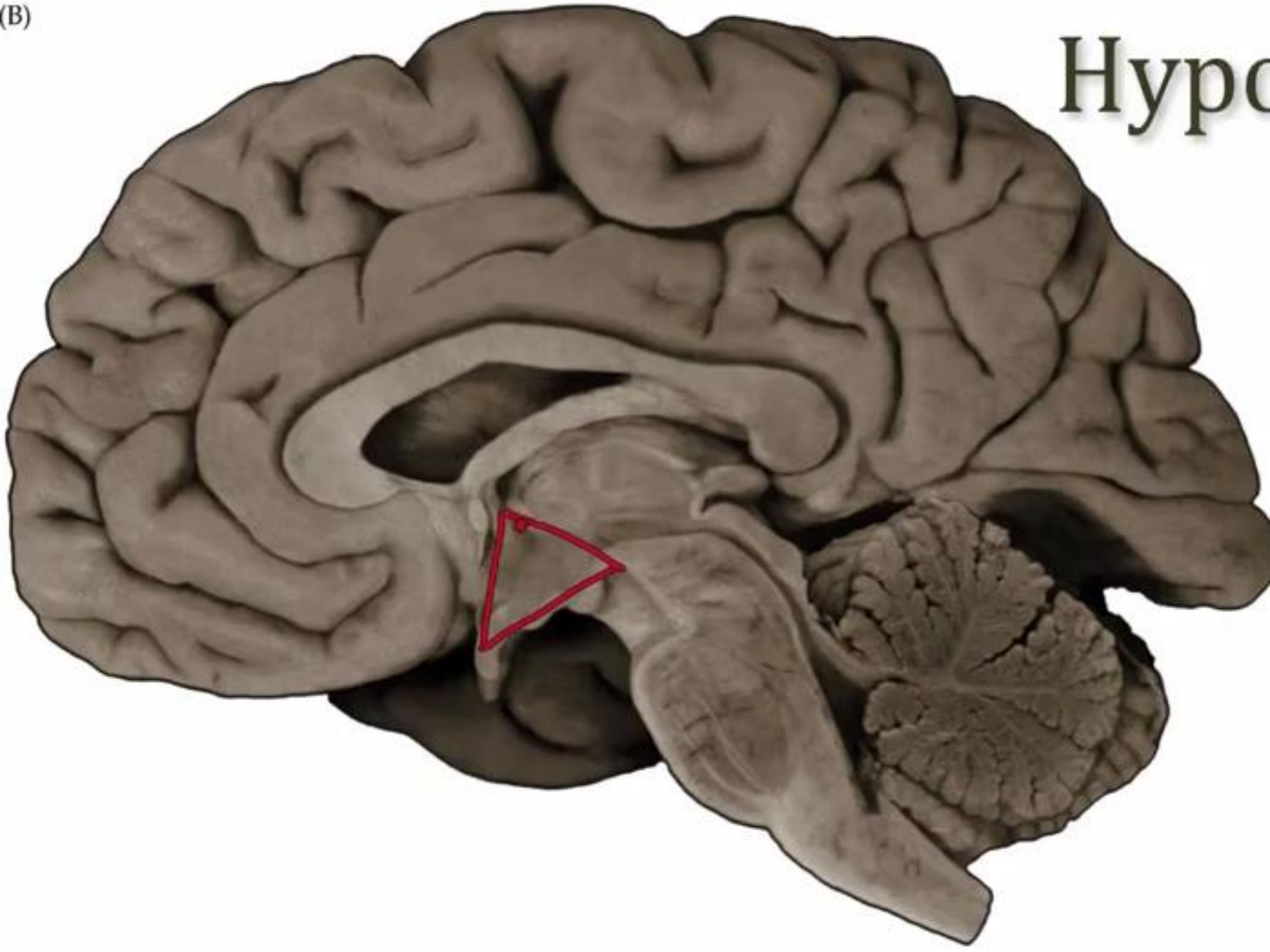


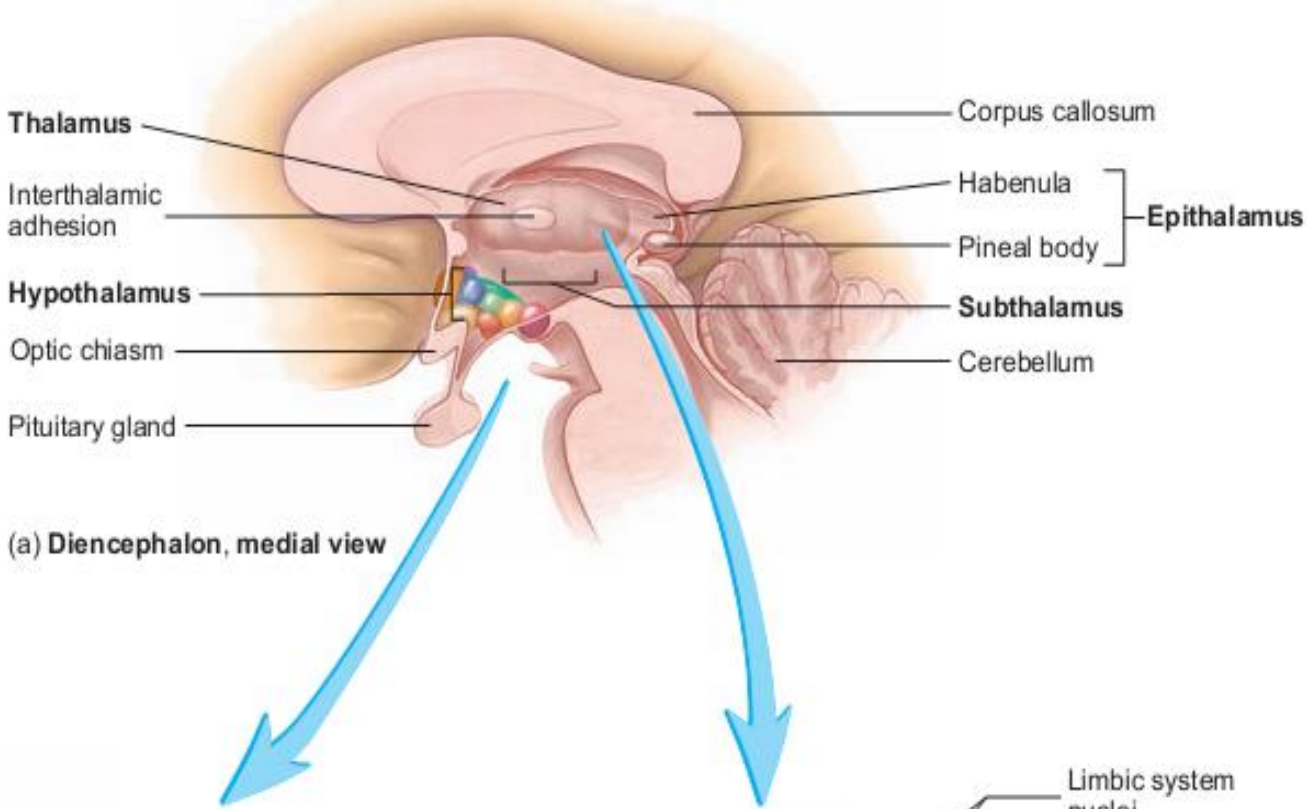
Epithalamus

- The epithalamus is a small area superior and posterior to the thalamus consists of the pineal gland and habenular nuclei
- The pineal gland is a small pea sized, pine shaped gland that protrudes from the posterior midline of the third ventricle. The pineal gland is part of the endocrine system because it secretes the hormone melatonin which has role in maintaining circadian rhythm
- The posterio-superior portion of the epithalamus houses the habenular nuclei. The habenular nuclei, are involved in olfaction, especially emotional responses to odors

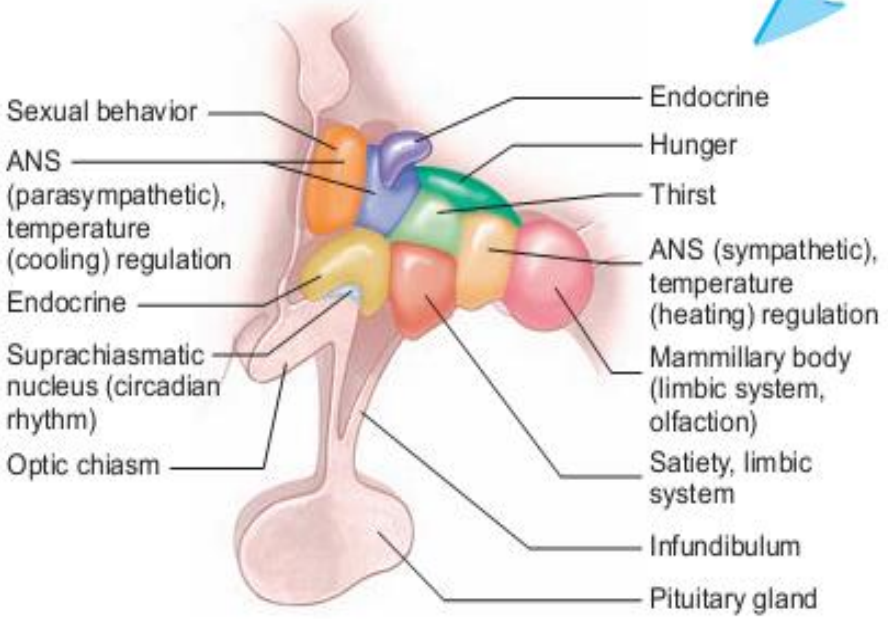
Hypothalamus

- The hypothalamus is a collection of nuclei that is present in the anteroinferior region of the diencephalon.
- It is connected to other parts of brain and spinal cord and control autonomic, emotional and basic body functions
- A thin, stalklike infundibulum extends inferiorly from the hypothalamus to attach to the pituitary gland
- Hypothalamus performs following functions
  - **Body-temperature regulation.**
  - **Regulation of water and electrolyte balance.(ADH)**
  - **Regulation of hunger and control of gastrointestinal activity.**
  - **Emotions.** (including anger, fear, pain, and pleasure).
  - **Control of endocrine functions. The hypothalamus produces** neurosecretory chemicals that stimulate the anterior and posterior pituitary to release various hormones.

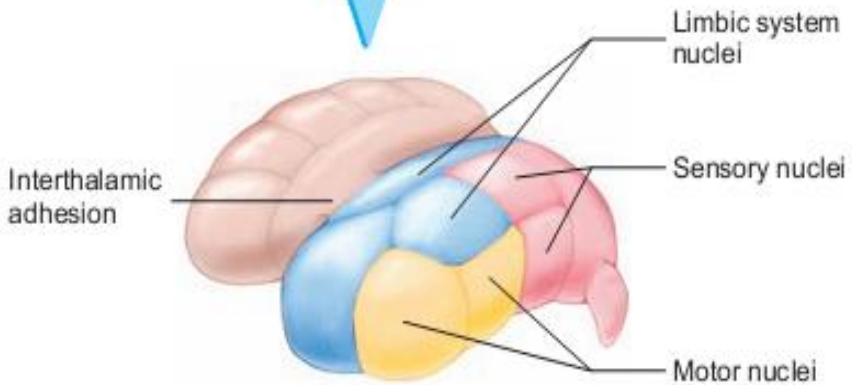

(B)
Hypo



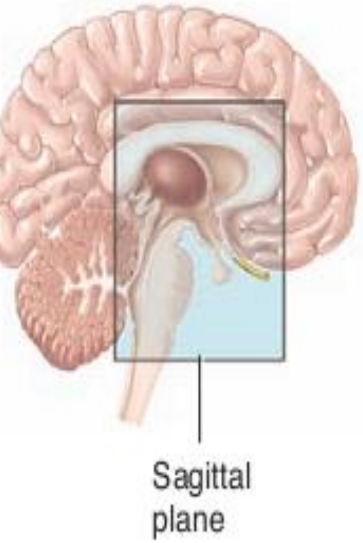
(a) **Diencephalon, medial view**

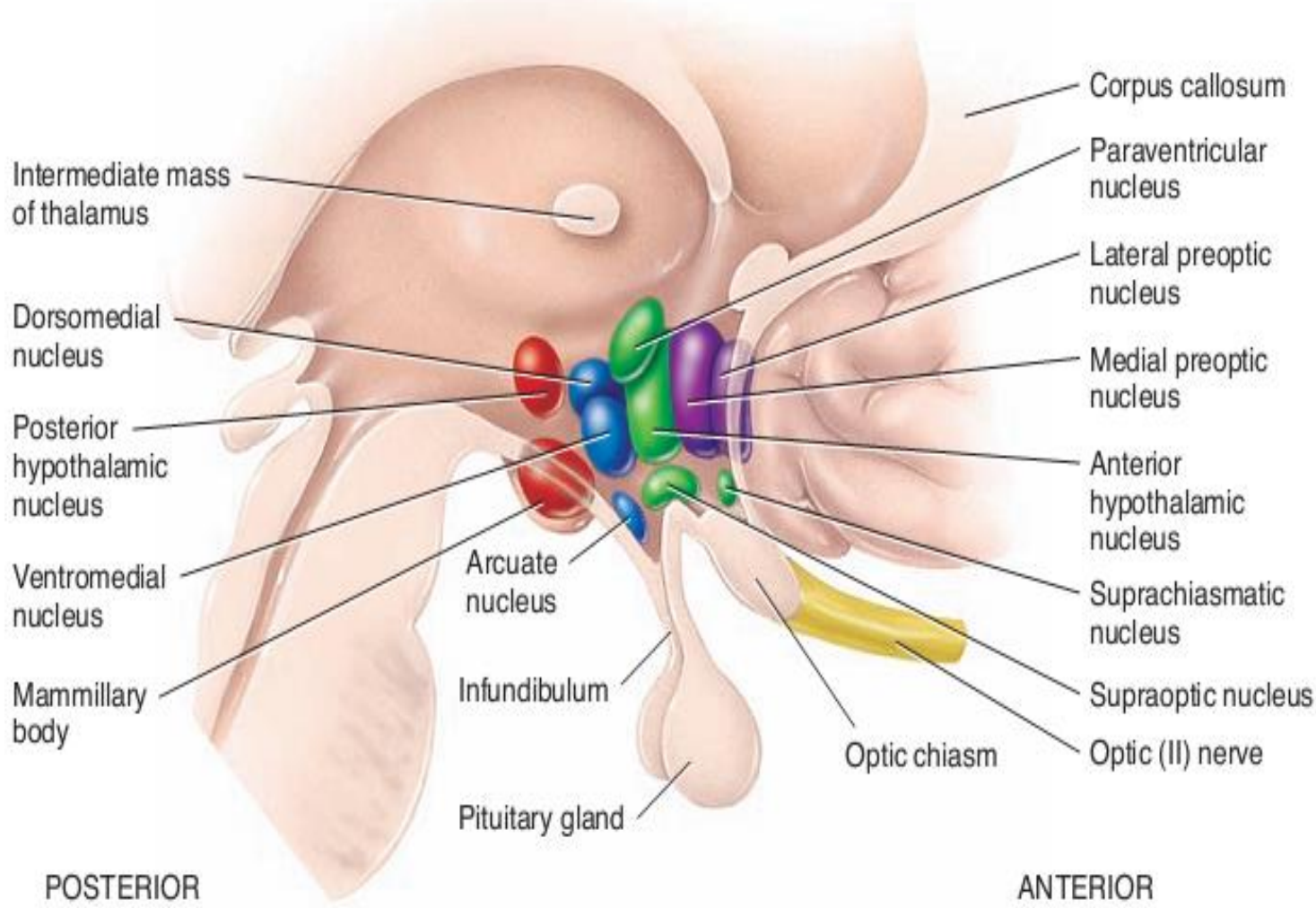


(c) **Hypothalamus, medial view**



(b) **Thalamus, anterolateral view**





Key:

- Mammillary region
- Tuberal region
- Supraoptic region
- Preoptic region

Sagittal section of brain showing hypothalamic nuclei

Mesencephalon / Midbrain

- The mesencephalon (or midbrain) is the superior portion of the brainstem
- It extends from diencephalon to pons and is about 2.5 cm long.
- Cerebral aqueduct passes through the midbrain, connecting the third ventricle above with the fourth ventricle below
- The midbrain contain both nuclei and tracts.

- Anterior of midbrain contain bundles of axon called cerebral peduncles, posterior of mid brain contain four (two pairs) of elevation which are sensory nuclei collectively called tectum, in middle is present cerebral aqueduct around which are present masses of gray matter named Periaqueductal gray, substantia nigra, red bodies and reticular formation

- **Cerebral peduncles** are motor tracts located on the anterolateral surfaces of the mesencephalon conduct nerve impulses from motor areas in the cerebral cortex to the spinal cord, medulla, and pons.

- **Tectum**

- is present is the posterior region of the mesencephalon dorsal to the cerebral aqueduct made up of two pairs of sensory nuclei, the superior and inferior colliculi, which are collectively called the tectal plate or corpora quadrigemina.
- These nuclei are relay stations in the processing pathway of visual and auditory sensations.
- The superior colliculi (superior nuclei) act as "visual reflex centers" because they help visually track moving objects and control reflexes such as turning the eyes and head in response to a visual stimulus.
- The paired inferior colliculi are the "auditory reflex centers," meaning that they control reflexive turning of the head and eyes in the direction of a sound.

Substantia nigra

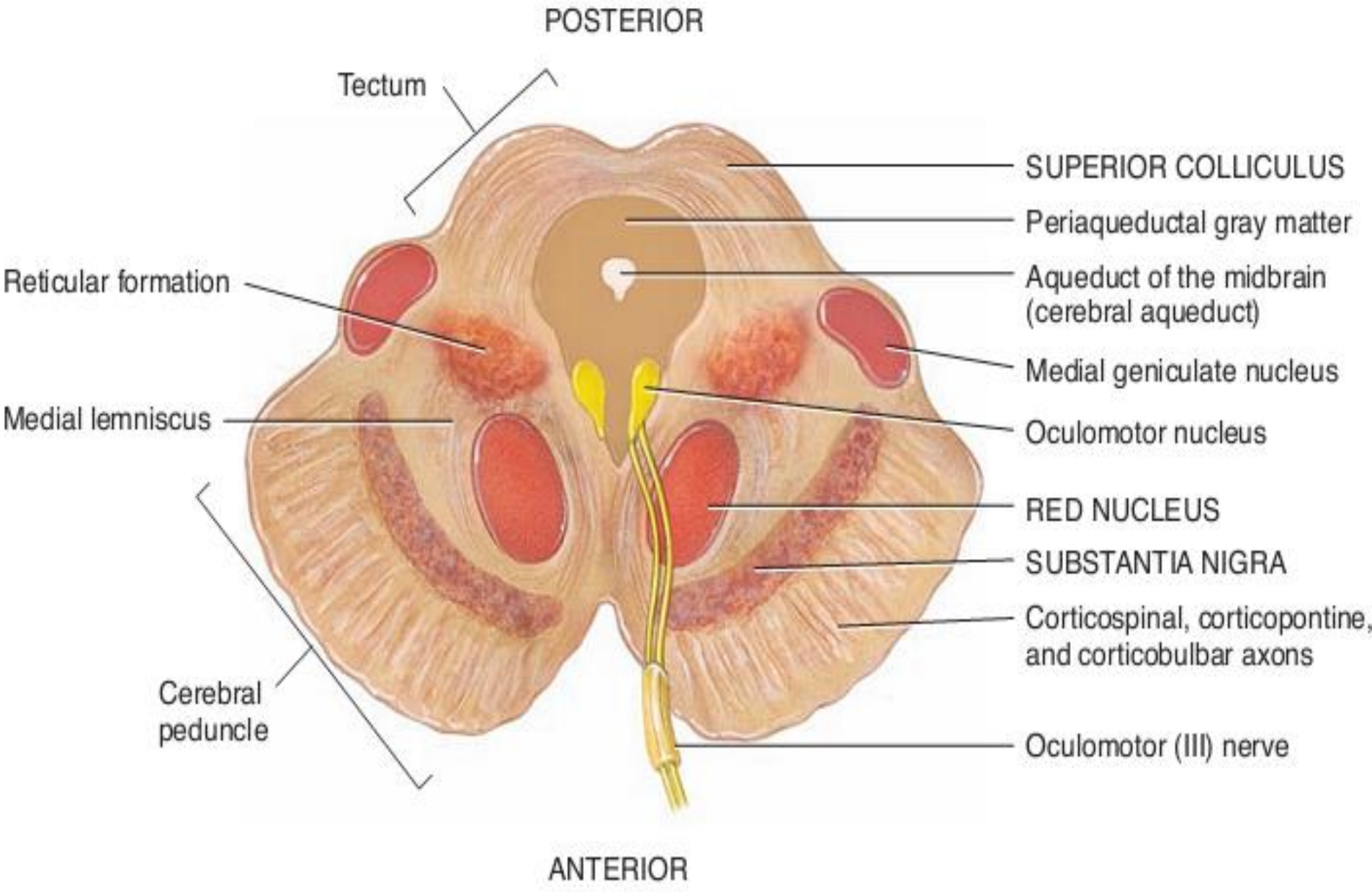
- consists of bilaterally symmetrical nuclei within the mesencephalon.
- Its name derives from its black appearance, which is due to melanin pigmentation.
- Neurons in substantia nigra, release dopamine, extend from the substantia nigra to the basal nuclei, help control subconscious muscle activities emotional response, and ability to experience pleasure and pain

Red nuclei

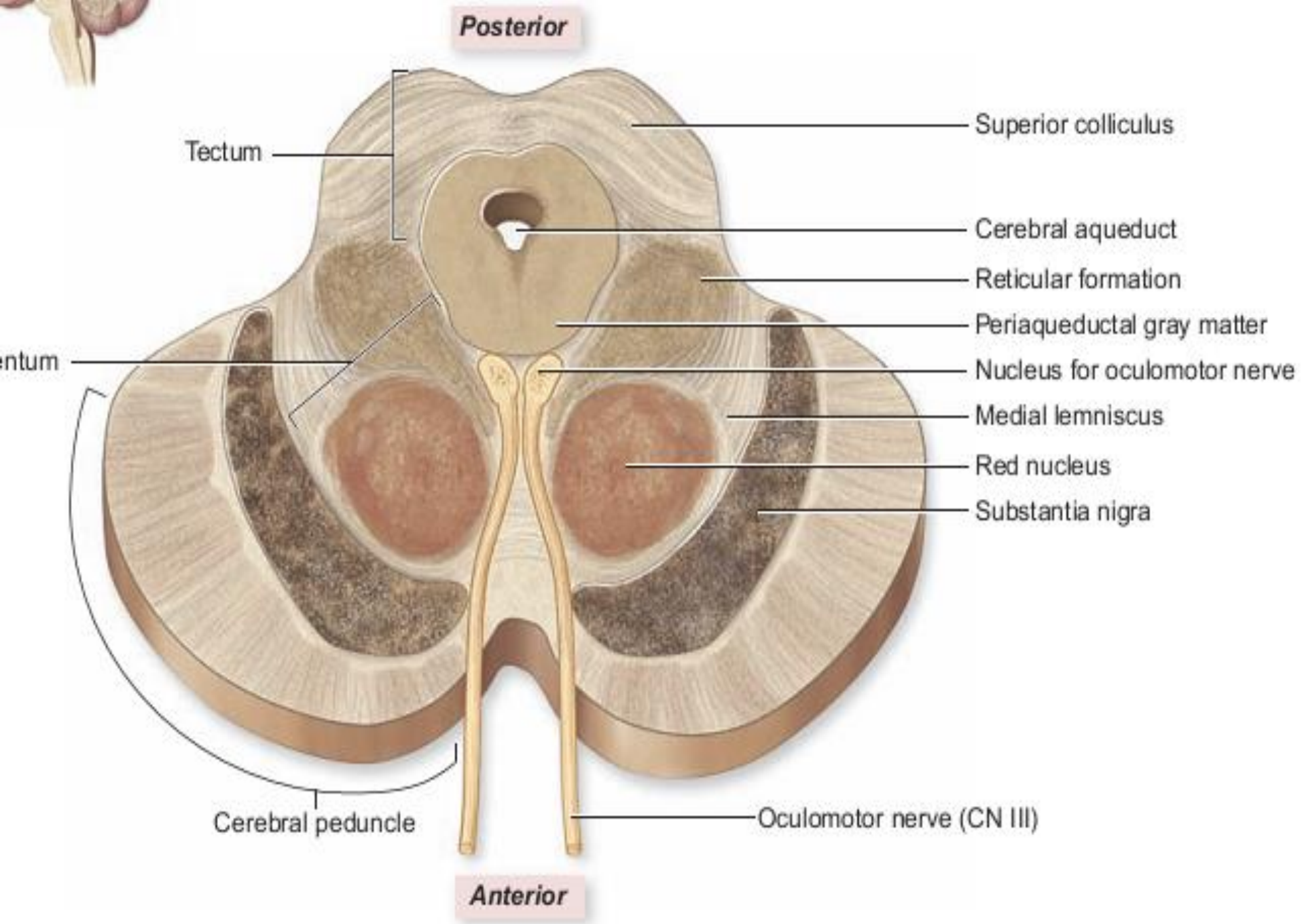
- The mid brain contain left and right red nuclei, which look reddish due to their rich blood supply and an iron-containing pigment in their neuronal cell bodies.
- Axons from the cerebellum and cerebral cortex form synapses in the red nuclei, which help control muscular movements

Rerticular formation

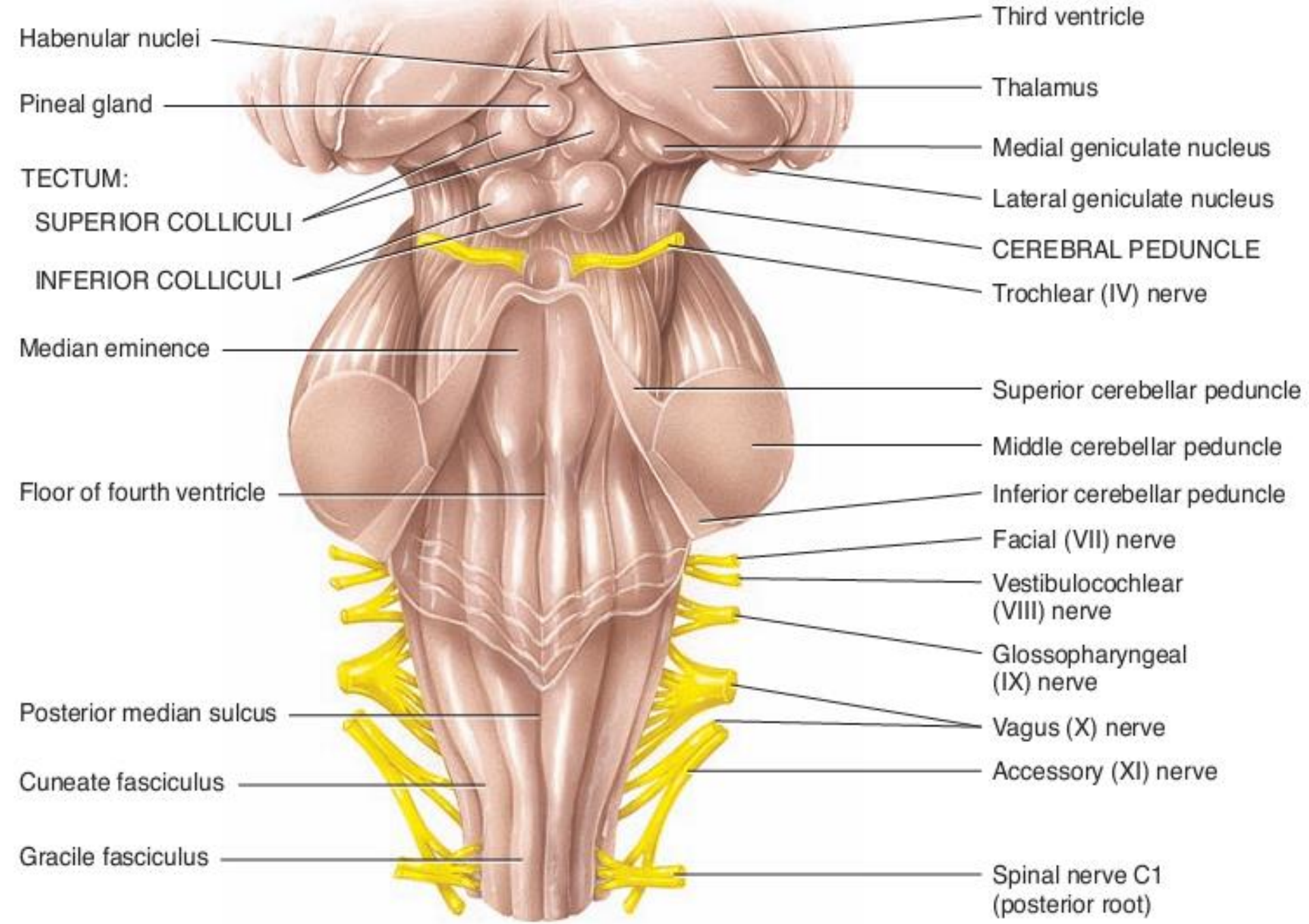
- the brain stem consists of small clusters of neuronal cell bodies (gray matter) interspersed among small bundles of myelinated axons (white matter). The broad region where white matter and gray matter exhibit a netlike arrangement is known as the reticular formation.
- It extends from the superior part of the spinal cord, throughout the brain stem, and into the inferior part of the diencephalon.
- Neurons within the reticular formation have both ascending (sensory) and descending (motor) functions.
- The ascending portion of the reticular formation is called the reticular activating system (RAS), which consists of sensory axons that project to the cerebral cortex, both directly and through the thalamus. They have role in arousal and consciousness



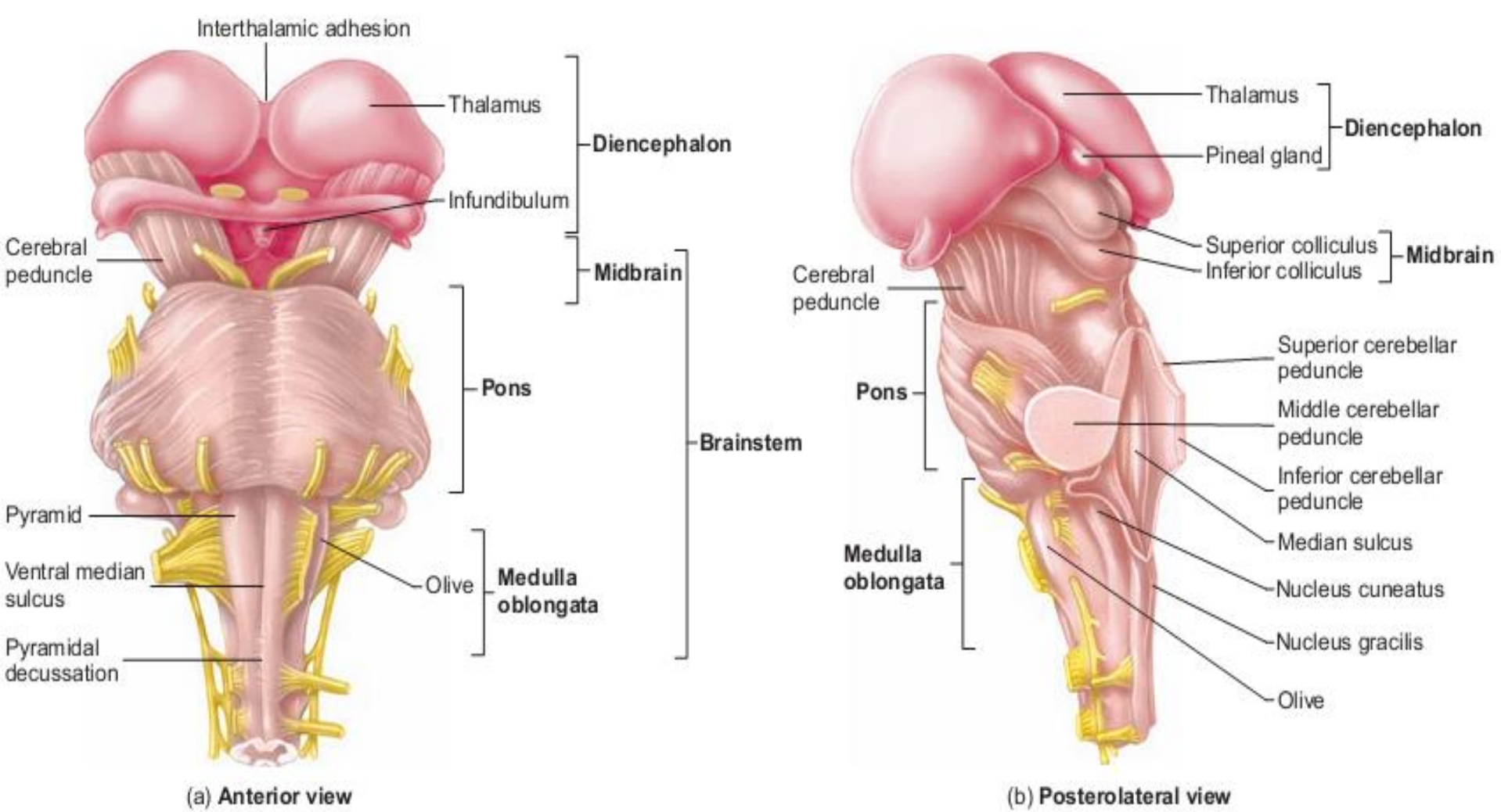
(b) Transverse section of midbrain

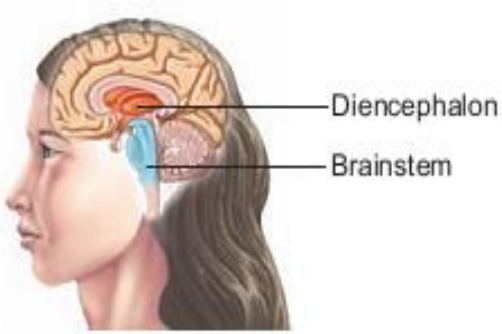


Mesencephalon, cross-sectional view



(a) Posterior view of midbrain in relation to brain stem


Interthalamic adhesion
Thalamus
Diencephalon
Infundibulum
Cerebral peduncle
Midbrain
Pons
Brainstem
Pyramid
Ventral median sulcus
Olive
Medulla oblongata
Pyramidal decussation
(a) Anterior view
Thalamus
Diencephalon
Pineal gland
Superior colliculus
Midbrain
Inferior colliculus
Cerebral peduncle
Superior cerebellar peduncle
Pons
Middle cerebellar peduncle
Inferior cerebellar peduncle
Median sulcus
Medulla oblongata
Nucleus cuneatus
Nucleus gracilis
Olive
(b) Posterolateral view


Diencephalon
Brainstem

Medulla oblangata

- The medulla oblongata or medulla forms the inferior part of the brain stem, It is continuous with the superior part of the spinal cord.
- Medulla is 3 cm long and extends between pons and foramen magnum
- The medulla oblongata is composed of vital nuclei and white matter that form all the descending and ascending tracts communicating between the spinal cord and various parts of the brain.
- The anteromedial surface of the medulla has two surface projections called pyramids. Pyramids houses corticospinal tracts which are motor tracts descending from cortex to spinal cord
- Inferiorly the axons in the pyramids cross over to the opposite side making decussation of pyramids
- The antero lateral surface of medulla has two swellings, one on each side, called olive which contain mass of gray matter called inferior olivary nucleus which relay ascending sensory impulses, especially proprioceptive information, to the cerebellum.

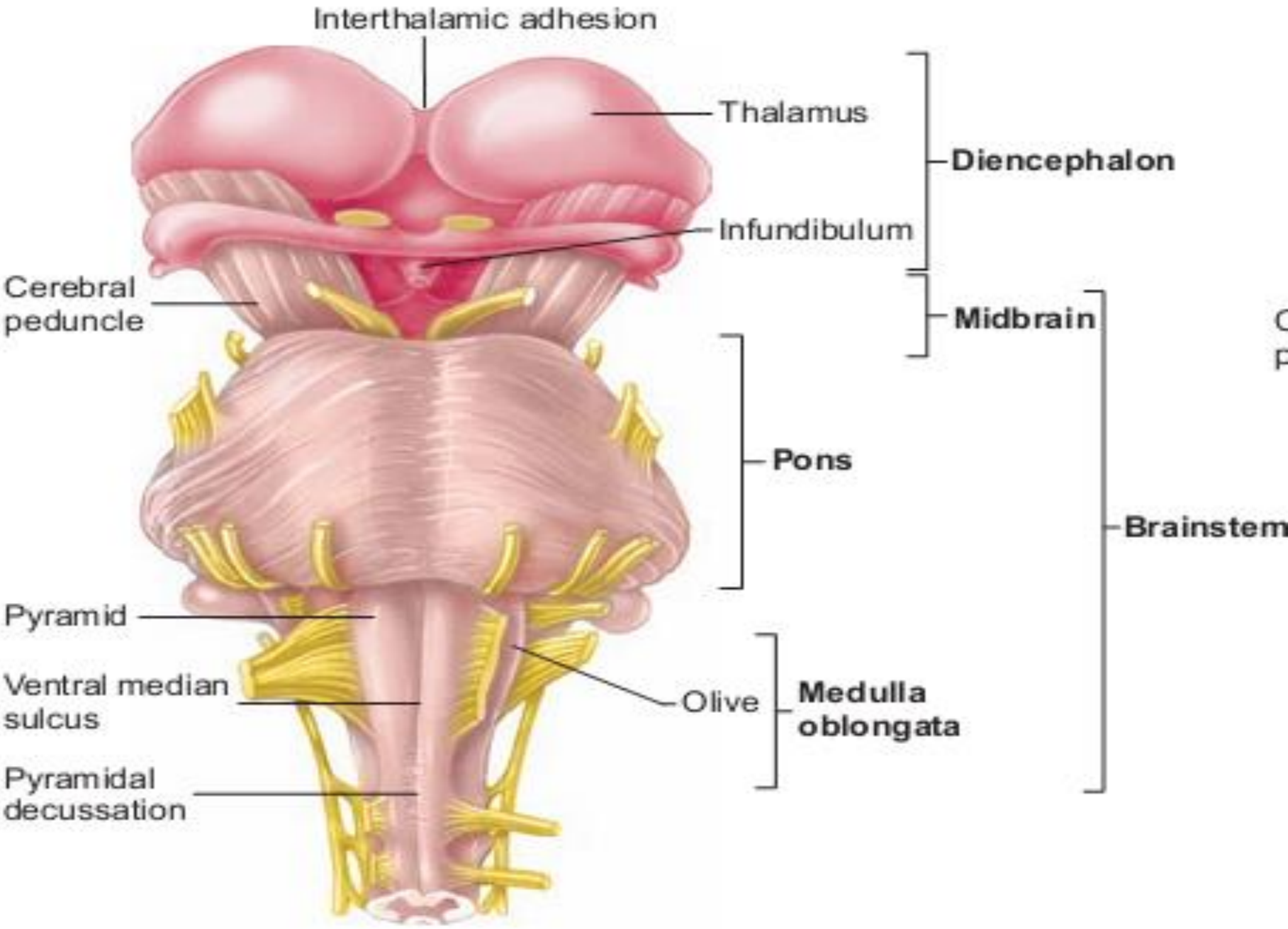
- Other than these medulla oblongata have additional nuclei that have various functions:

  - The cranial nerve nuclei are associated with the vestibulocochlear (CN VIII), glossopharyngeal (CN IX), vagus (CN X), accessory (CN XI), and hypoglossal (CN XII) cranial nerves.

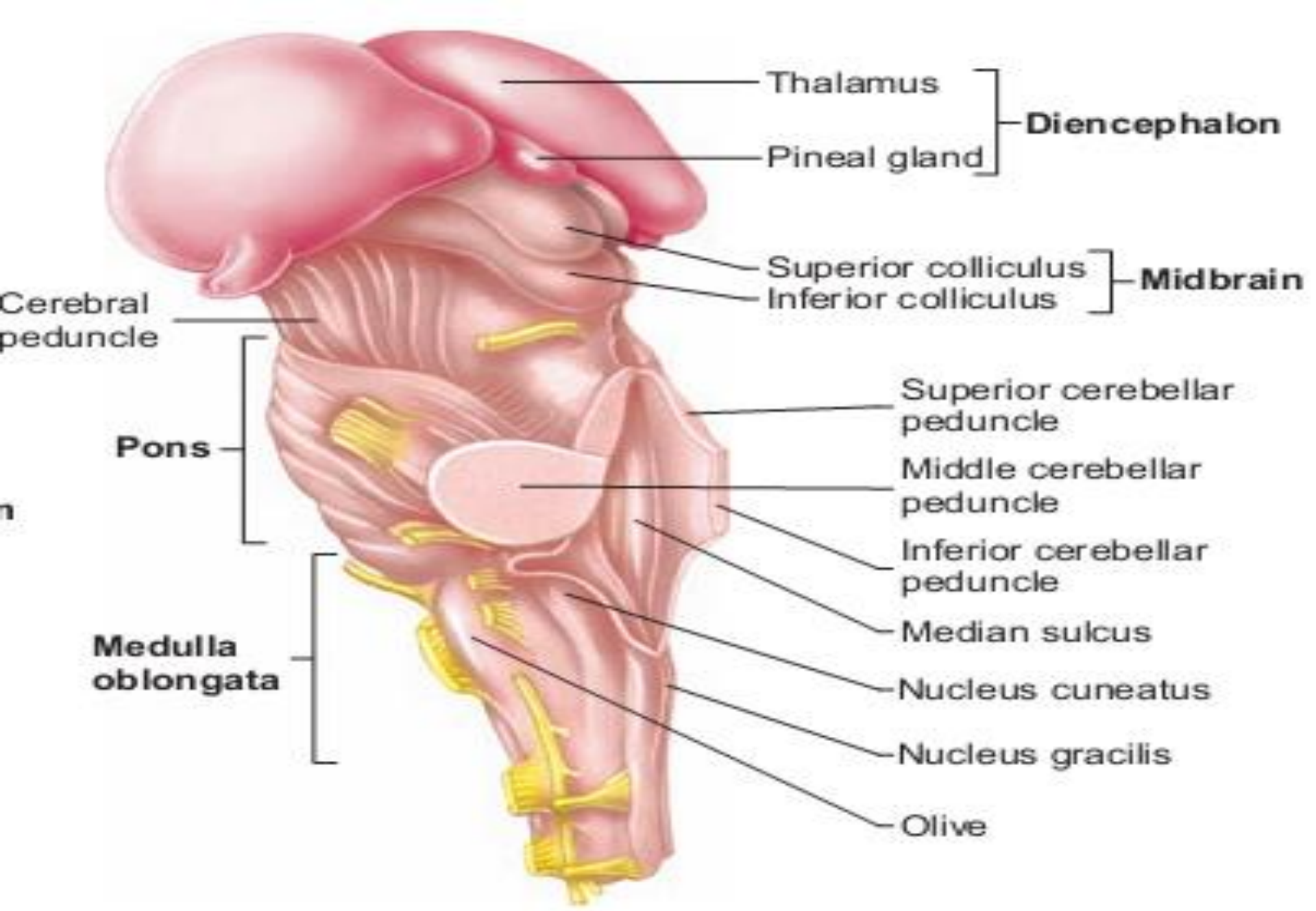
  - In addition there are paired nucleus cuneatus and the nucleus gracilis , which relay somatic sensory information to the thalamus. The nucleus cuneatus receives sensory innervation from the arm and hand of the same side. The nucleus gracilis receives sensory information from the leg and lower limbs of the same side

  - Medulla contains several autonomic nuclei, which regulate vital functions. Autonomic nuclei group together to form centers in the medulla oblongata. The important autonomic centers in medulla are cardiac center (regulate heart rate and contraction), vasomotor center (control blood pressure) and respiratory center (regulate rate of respiration)

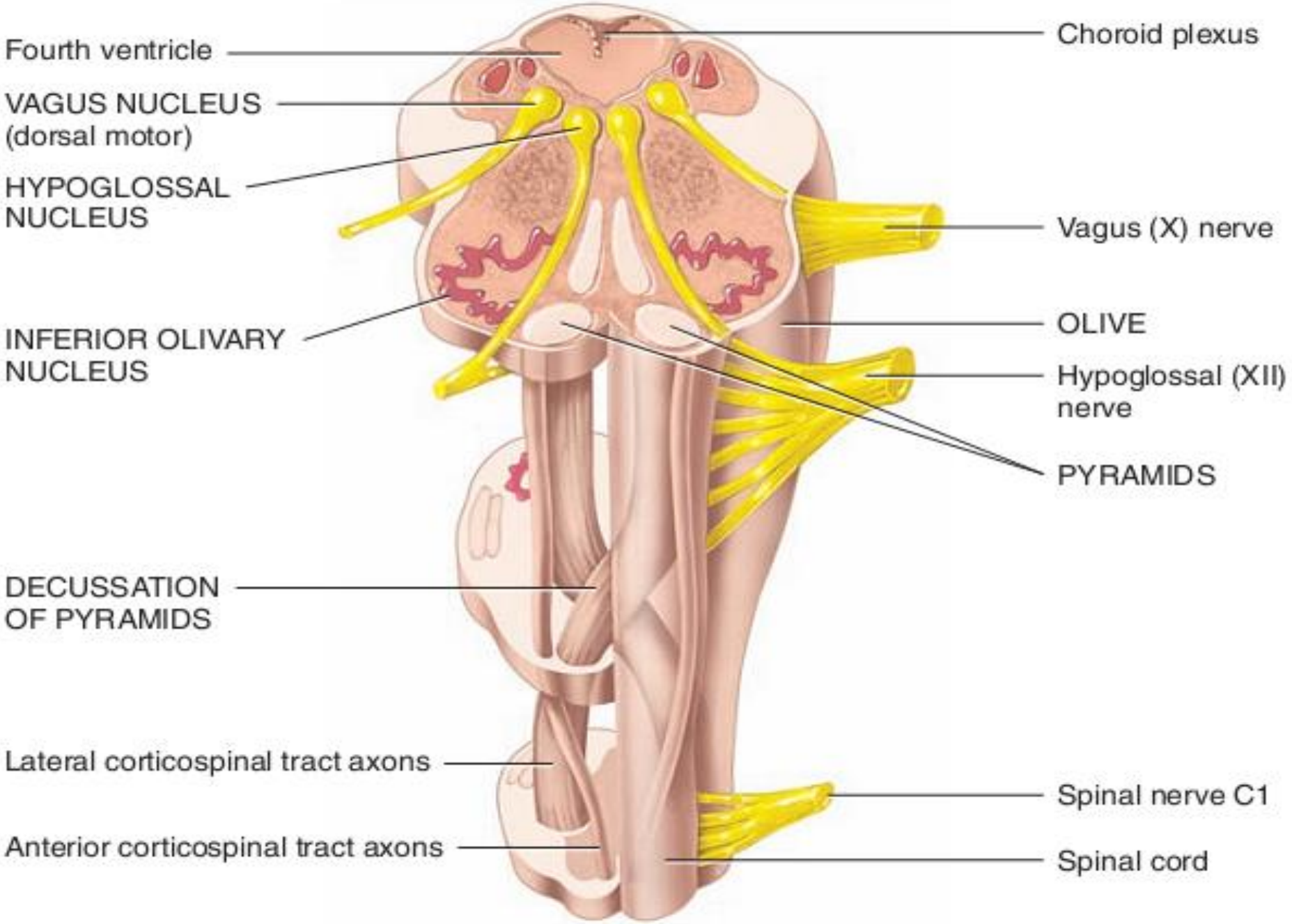
  - Medulla also house nuclei for various reflexes like coughing, sneezing, salivating, swallowing, gagging, and vomiting



(a) **Anterior view**



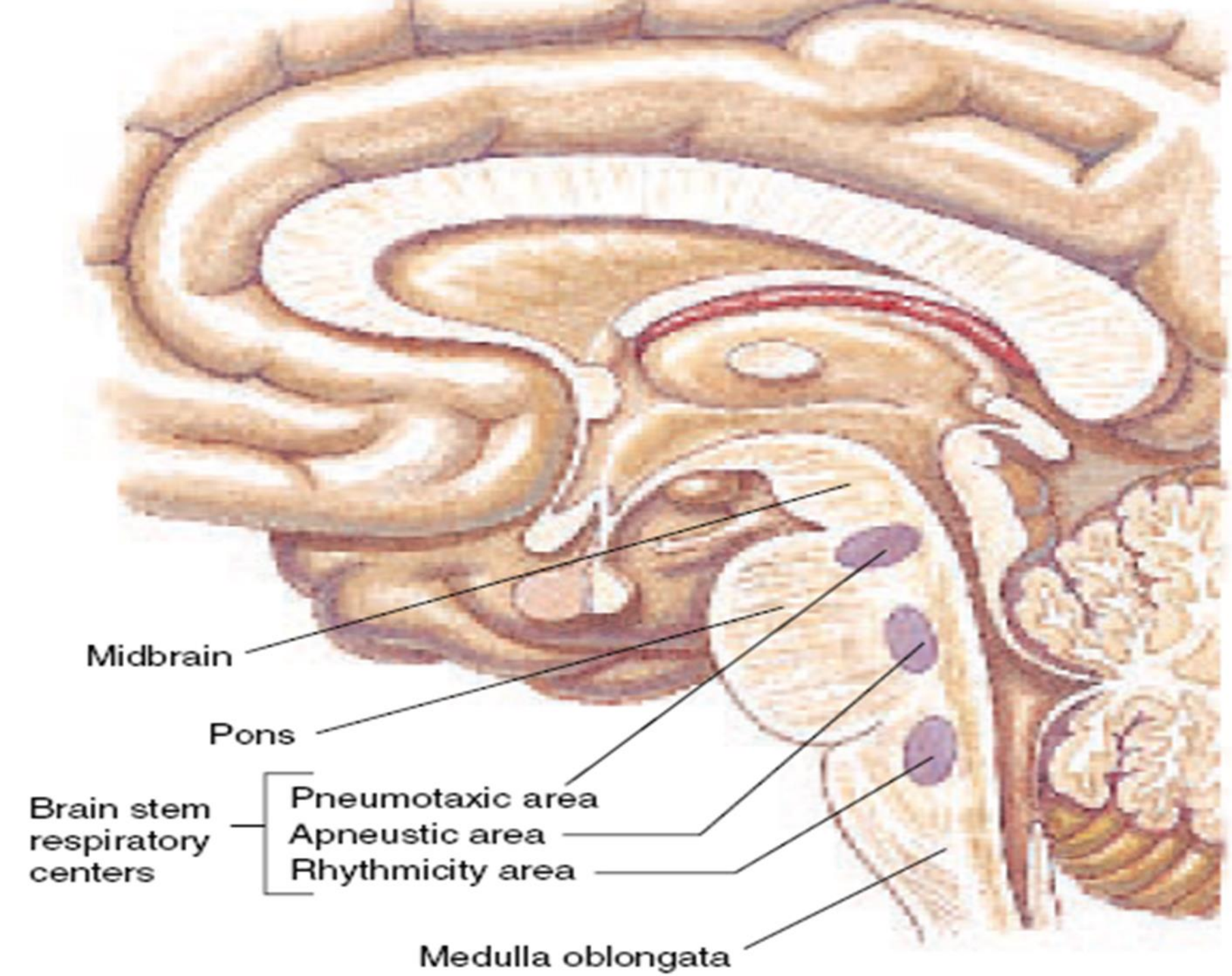
(b) **Posterolateral view**



Transverse section and anterior surface of medulla oblongata

Pons

- The pons is a bulging region on the anterior part of the brainstem that forms from part of the metencephalon.
- It contains ascending and descending nerve tracts, as well as several nuclei
- Within the pons are sensory and motor tracts that connect to the brain and spinal cord
- In addition, the middle cerebellar peduncles are transverse groups of fibers that connect the pons to the cerebellum
- The pons also houses two autonomic respiratory centers: the pneumotaxic center and the apneustic center
- The pons houses sensory and motor cranial nerve nuclei for the trigeminal (CN V), abducens (CN VI), and facial (CN VII) cranial nerves.
- It also houses superior olivary complex which receives auditory input and is involved in the pathway for sound localization

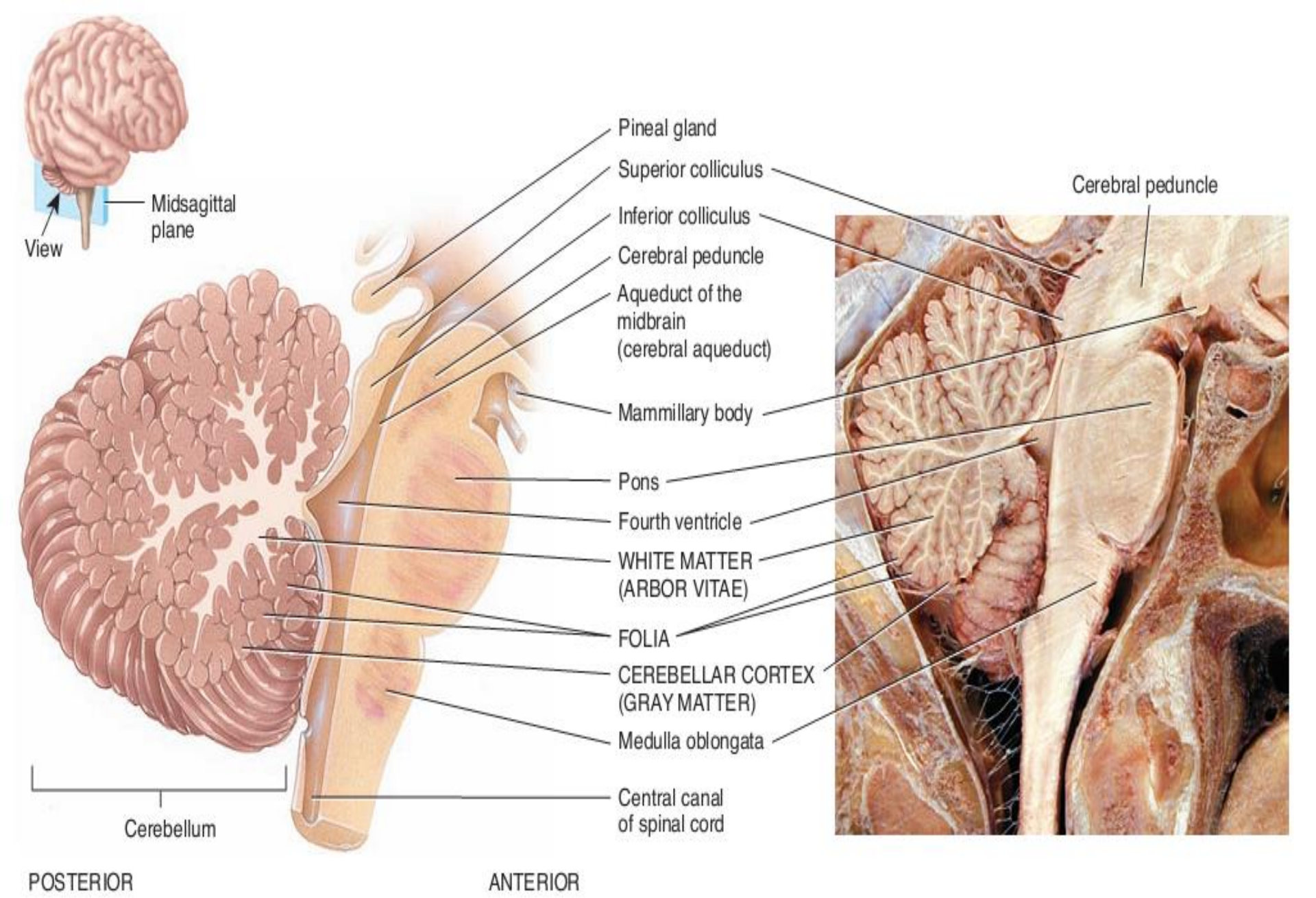

Midbrain
Pons
Brain stem respiratory centers
Pneumotaxic area
Apneustic area
Rhythmicity area
Medulla oblongata

Cerebellum

- The **cerebellum is the second largest structure of** the brain. It is located in the metencephalon and occupies the inferior and posterior aspect of the cranial cavity.
- The cerebellum is separated from the overlying cerebrum by a **transverse fissure.**
- A portion of the meninges called the **tentorium cerebelli** extends into the transverse fissure.
- The cerebellum consists of two **hemispheres and a central constricted area called the vermis**
- The **falx cerebelli is the portion of the meninges** that partially extends between the hemispheres

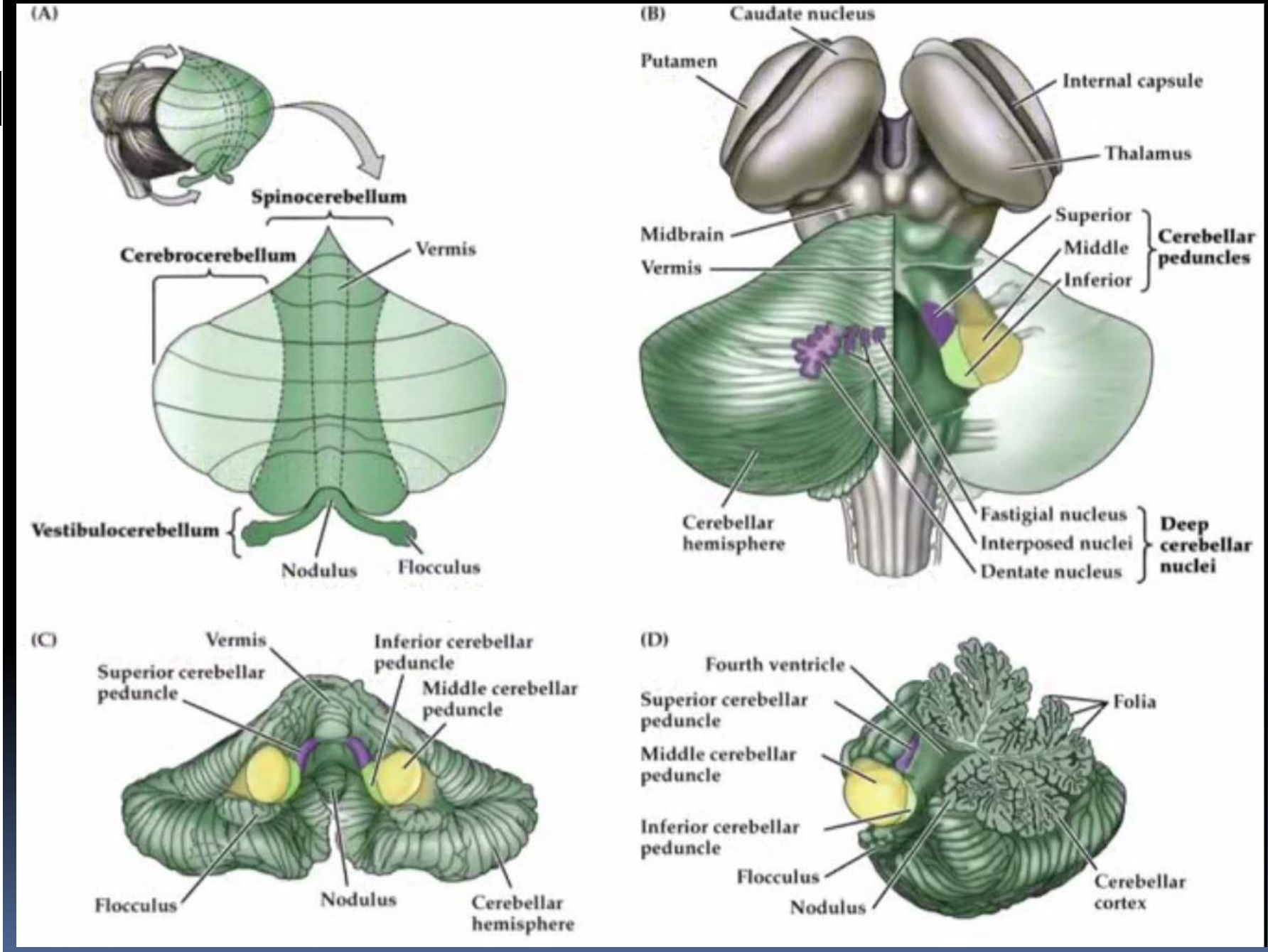
- Cerebellum is made up of three layers:
  - The outer layer of gray matter called cerebellar cortex
  - The middle layer of tracts of white matter arranged in a branching pattern like tree called arbor vitae
  - Innermost regions of gray matter which are cerebellar nuclei from where axons arise and connect various regions of brain
- Three paired cerebellar peduncles which are bundles of axons attach the cerebellum to the brain stem. These are:
  - The superior cerebellar peduncles contain axons that extend from the cerebellum to the red nuclei of the midbrain and to several nuclei of the thalamus
  - The middle cerebellar peduncles axons carry impulses for voluntary movements from the pontine nuclei (which receive input from motor areas of the cerebral cortex) into the cerebellum
  - The inferior cerebellar peduncles have diverse connectivity that includes connectivity with spinal cord for proprioception from limbs, connectivity with vestibular apparatus and nulcei, connectivity with olivary nuclei of medulla and connectivity with reticular formation

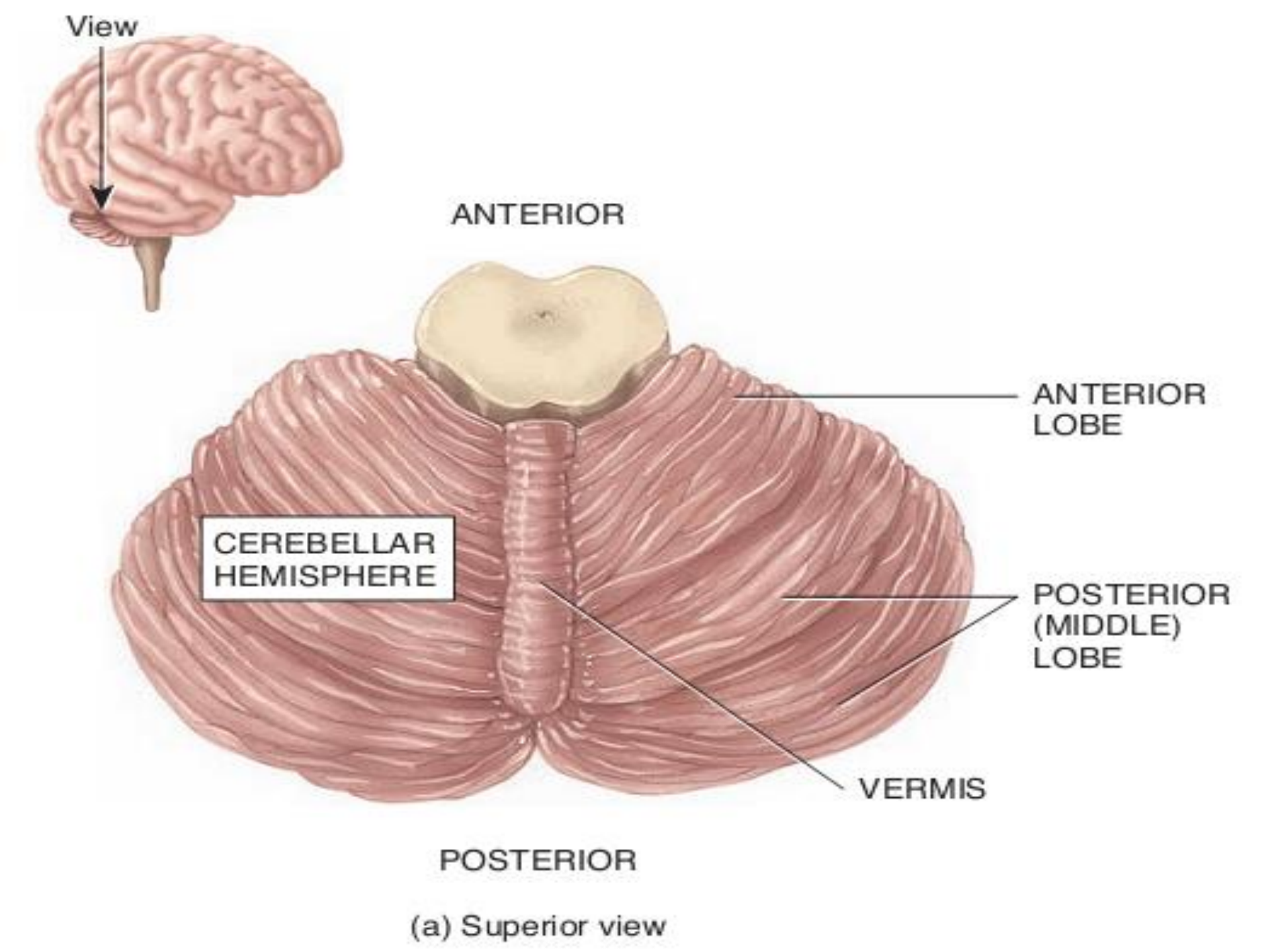
- The primary function of the cerebellum is to evaluate how well movements initiated by motor areas in the cerebrum are actually being carried out.
- Cerebellum detects the discrepancies in the complex movements of muscles and send feedback to the motor cortex for correction.
- It is also involved in maintaining posture and balance while performing motor activities



(c) Midsagittal section of cerebellum and brain stem

(d) Midsagittal section


(A)
Spinocerebellum
Cerebrocerebellum
Vermis
Vestibulocerebellum
Nodulus
Flocculus
(B)
Caudate nucleus
Putamen
Internal capsule
Thalamus
Midbrain
Vermis
Superior
Middle
Inferior
Cerebellar peduncles
Cerebellar hemisphere
Fastigial nucleus
Interposed nuclei
Dentate nucleus
Deep cerebellar nuclei
(C)
Vermis
Inferior cerebellar peduncle
Superior cerebellar peduncle
Middle cerebellar peduncle
Flocculus
Nodulus
Cerebellar hemisphere
(D)
Fourth ventricle
Folia
Superior cerebellar peduncle
Middle cerebellar peduncle
Inferior cerebellar peduncle
Flocculus
Nodulus
Cerebellar cortex



(a) Superior view

CRANIAL NERVES

- Cranial nerves arise from the brain.
- They are called cranial nerves because they pass through various foramina in cranium
- Each cranial nerve has both a number, designated by a roman numeral, and a name. The numbers indicate the order, from anterior to posterior, in which the nerves arise from the brain. The names designate a nerve's distribution or function
- 12 pairs of cranial nerves.
- 2 pairs arise from the forebrain.
- 10 pairs arise from the midbrain and brain stem.
- Cranial nerves may be sensory , motor or mixed.
- Cranial nerves are part of the PNS

- Three cranial nerves (I, II, and VIII) carry axons of sensory neurons and thus are called special sensory nerves. They are associated with the special senses of smelling, seeing, and hearing. The cell bodies of most sensory neurons are located in ganglia outside the brain

- Five cranial nerves (III, IV, VI, XI, and XII) are classified as motor nerves because they contain only axons of motor neurons as they leave the brain stem. The cell bodies of motor neurons lie in nuclei within the brain

- The remaining four cranial nerves (V, VII, IX, and X) are mixed nerves—they contain axons of both sensory neurons entering the brain stem and motor neurons leaving the brain stem.

- Cranial nerve III (oculomotor), VII (facial), IX (glossopharyngeal) X (vagus) also carry fibers of parasympathetic division of ANS

- Oh, Oh, Oh, To Take A Family Vacation! Go Vegas After Hours
- On Occasion Our Trusty Truck Acts Funny, Very Good Vehicle Any How
- EACH 1ST WORD OF THIS SENTENSE REPRESENT THE THE 1ST LETTER OF THE CRANIAL NERVE .
  - Olfactory
  - Optic
  - Occulomotor,
  - Trochler,
  - Trigeminal,
  - Abducens,
  - Facial,
  - Vestibulcocholear,
  - Glassopharyngeal,
  - Vagus,
  - Accessory,
  - Hypoglossal nerve

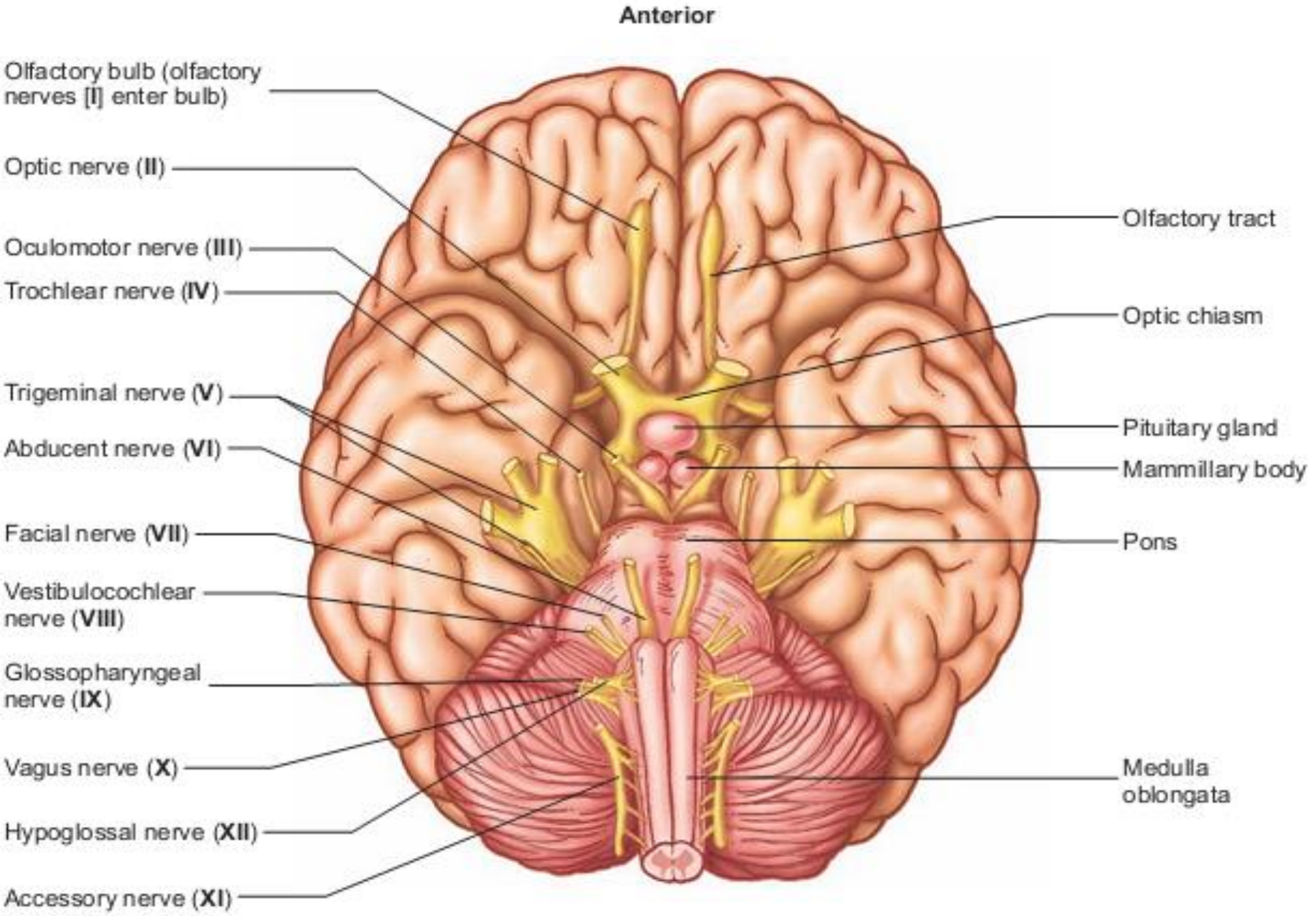

Anterior
Olfactory bulb (olfactory nerves [I] enter bulb)
Optic nerve (II)
Oculomotor nerve (III)
Trochlear nerve (IV)
Trigeminal nerve (V)
Abducent nerve (VI)
Facial nerve (VII)
Vestibulocochlear nerve (VIII)
Glossopharyngeal nerve (IX)
Vagus nerve (X)
Hypoglossal nerve (XII)
Accessory nerve (XI)
Olfactory tract
Optic chiasm
Pituitary gland
Mammillary body
Pons
Medulla oblongata
Posterior
Inferior view

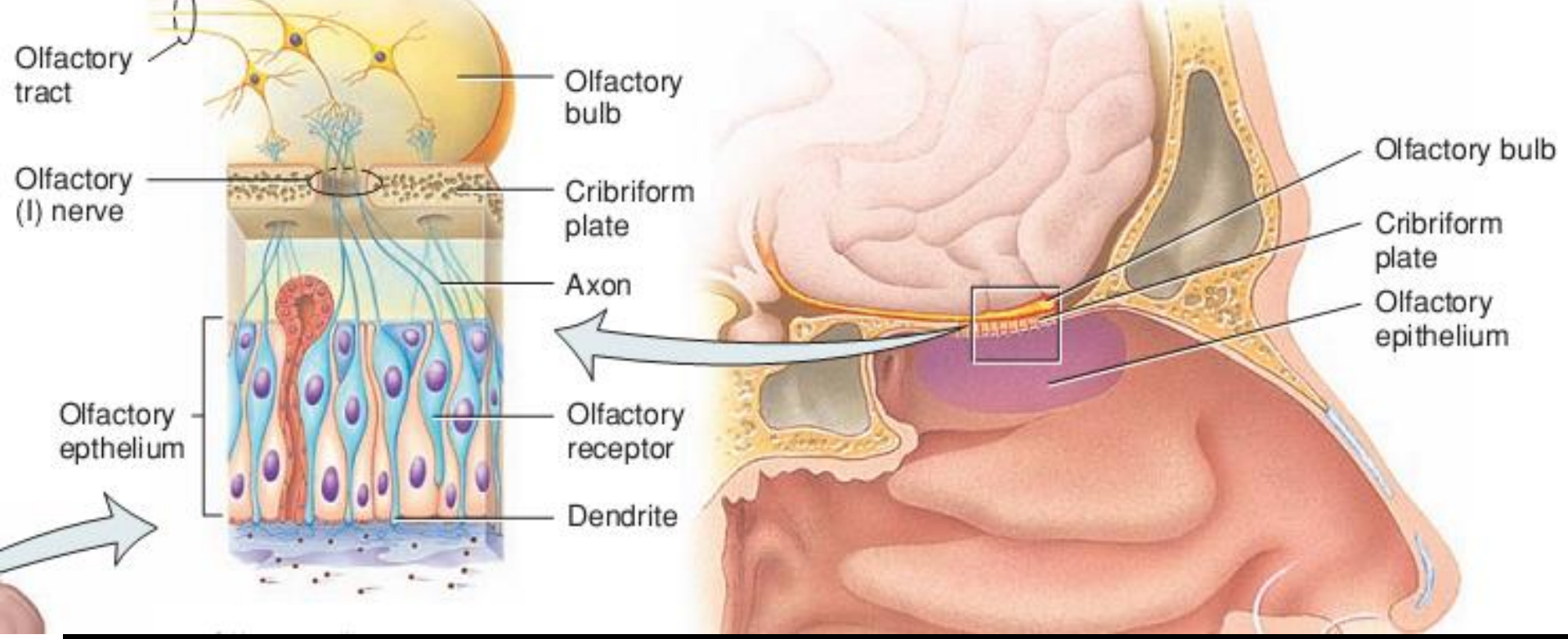
TABLE A2 The Cranial Nerves and Their Primary Functions

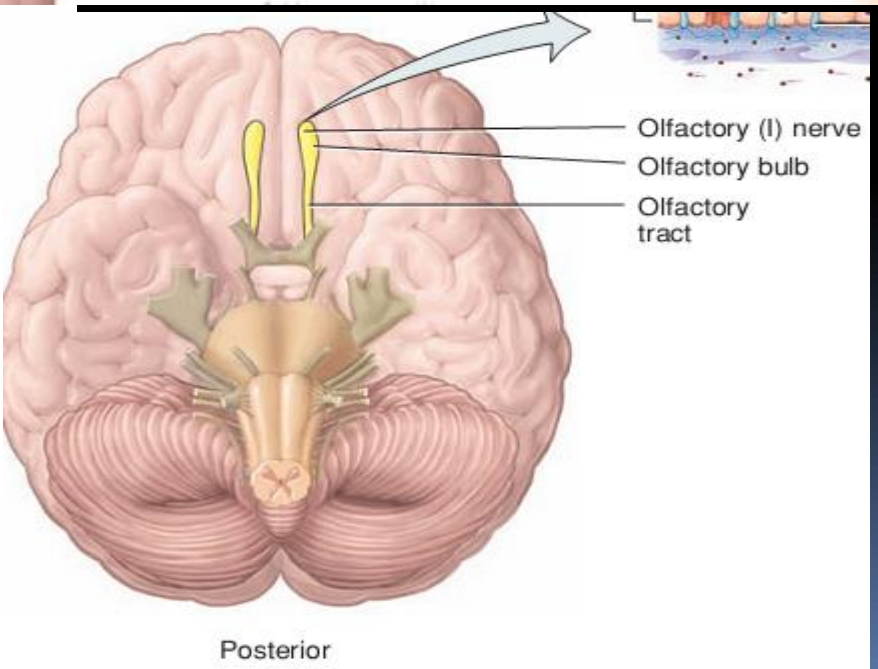
CRANIAL NERVE	NAME	SENSORY AND/OR MOTOR	MAJOR FUNCTION
I	Olfactory nerve	Sensory	Sense of smell
II	Optic nerve	Sensory	Vision
III	Oculomotor nerve	Motor	Eye movements; pupillary constriction and accommodation; muscles of eyelid
IV	Trochlear nerve	Motor	Eye movements (intorsion, downward gaze)
V	Trigeminal nerve	Sensory and motor	Somatic sensation from face, mouth, cornea; muscles of mastication
VI	Abducens nerve	Motor	Eye movements (abduction or lateral movements)
VII	Facial nerve	Sensory and motor	Controls the muscles of facial expression; taste from anterior tongue; lacrimal and salivary glands
VIII	Vestibulocochlear (auditory) nerve	Sensory	Hearing; sense of balance
IX	Glossopharyngeal nerve	Sensory and motor	Sensation from posterior tongue and pharynx; taste from posterior tongue; carotid baroreceptors and chemoreceptors
X	Vagus nerve	Sensory and motor	Autonomic functions of gut; sensation from larynx and pharynx; muscles of vocal cords; swallowing
XI	Spinal accessory nerve	Motor	Shoulder and neck muscles
XII	Hypoglossal nerve	Motor	Movements of tongue

***NEUROSCIENCE 5e*, Table A2 (Part 1)**

Olfactory nerve

- pure sensory nerve
- Very short nerve
- contains axons that conduct nerve impulses for olfaction, the sense of smell
- The olfactory epithelium occupies the superior part of the nasal cavity
- The olfactory receptors within the olfactory epithelium are bipolar neurons from where this nerve originate. Each has a single odor-sensitive dendrite projecting from one side of the cell body and an unmyelinated axon extending from the other side
- Bundles of axons extend through olfactory foramina of ethmoid bone on each side of nose making the right and left olfactory nerves
- Olfactory nerves end in the brain in paired masses of gray matter called the olfactory bulbs from which axons arise making the olfactory tracts which end in primary olfactory area in temporal lobe of cerebral cortex


Olfactory tract
Olfactory bulb
Olfactory (I) nerve
Cribriform plate
Axon
Olfactory epithelium
Olfactory receptor
Dendrite
Olfactory bulb
Cribriform plate
Olfactory epithelium

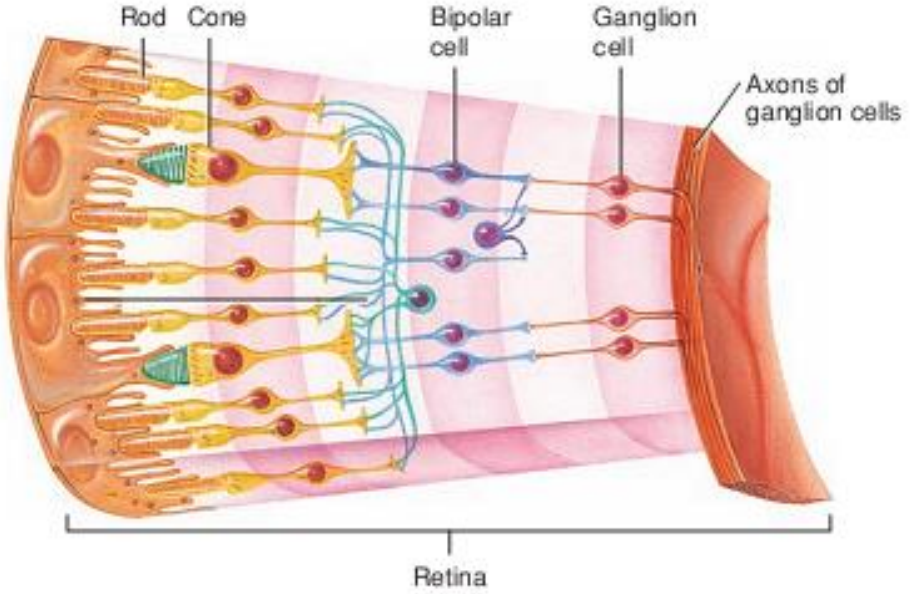

Olfactory (I) nerve
Olfactory bulb
Olfactory tract
Posterior

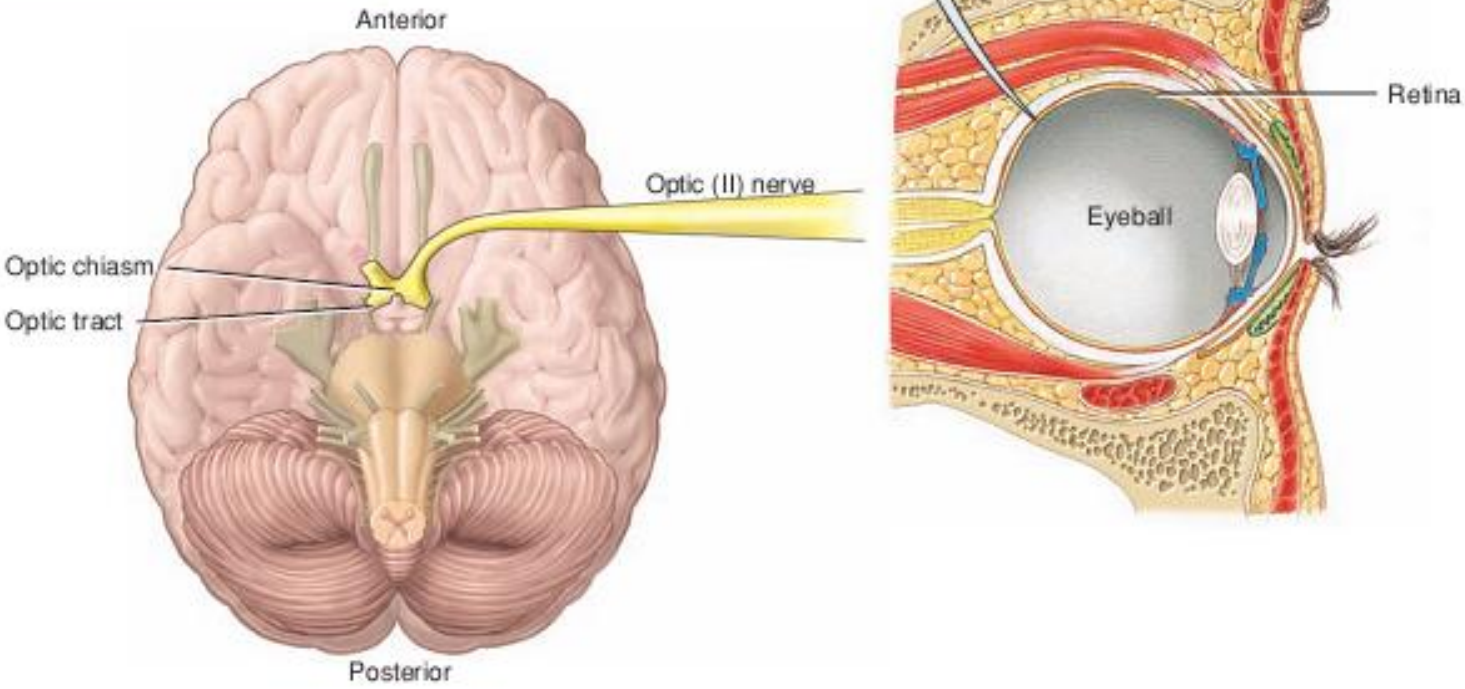
Optic nerve

- Pure sensory contains axons that conduct nerve impulses for vision
- The visual signal starts at rods and cons at retina which transmit it to bipolar cells. The bipolar cells then relay the signal to ganglion cells in the retina of each eye. Axon of the ganglion cells make optic nerve.
- Posterior to the eye ball at the floor of diencephalon the optic nerve cross over to form optic chiasm.
- Within the chiasm, axons from the medial half of each eye cross to the opposite side while axons from the lateral half remain on the same side
- Posterior to the chiasm, the regrouped axons form the optic tracts.
- Most axons in the optic tracts end in the lateral geniculate nucleus of the thalamus. There they synapse with neurons whose axons extend to the primary visual area in the occipital lobe of the cerebral cortex (area 17)
- As the optic tracts enter the brain, some of the fibers in the tracts terminate in the **superior colliculi (tectal system)** responsible for body movement eye coordination

CLINICAL CONNECTION | *Anopia*

Fractures in the orbit, brain lesions, damage along the visual pathway, diseases of the nervous system (such as multiple sclerosis), pituitary gland tumors, or cerebral aneurysms (enlargements of blood vessels due to weakening of their walls) may result in visual field defects and loss of visual acuity. Blindness due to a defect in or loss of one or both eyes is called **anopia** (an-Ō-pē-a). •





Occulomotor nerve

- Pure motor (both somatic and autonomic)
- Arise from midbrain.
- Nerve impulses through the oculomotor nerve produce certain extrinsic and intrinsic movements of the eyeball.
- Innervates upper eyelid muscle and four of the six extrinsic eye muscles

- ***Extrinsic Ocular Muscles***
- ***Four recti muscles (singular,rectus) maneuver the eyeball in the direction indicated by their names (superior, inferior, lateral, and medial),***
- ***And two oblique muscles (superior and inferior) rotate the eyeball.***

- ***Intrinsic Ocular Muscles***
- ***Cillary muscle.***
- ***Papillary constrictor muscle.***
- ***Papillary dilator muscle***

Somatic motor function

- It divides into superior and inferior branches as it passes through the superior orbital fissure in the orbit.
- The superior branch innervates the **superior rectus muscle,** which moves the eyeball superiorly, and the **levator palpebrae *superioris muscle, which raises the upper*** eyelid.
- The inferior branch innervates the **medial rectus, inferior rectus, and inferior oblique eye muscles for medial, inferior,** and superior lateral movement of the eyeball, respectively

Autonomic motor function

- In addition, fibers from the inferior branch of the oculomotor nerve enter the eyeball to supply parasympathetic autonomic motor innervation to the intrinsic smooth muscles of the iris for pupil constriction and to the muscles within the ciliary body for lens accommodation

Trochlear nerve

- Motor
- Arise from nuclei in midbrain
- Innervate the superior oblique muscle of the eyeball, another extrinsic eyeball muscle that controls movement of the eyeball
- Motor impulses to the superior oblique cause the eyeball to rotate downward and away from the midline.

Trigeminal

- Originate in pons
- Mixed cranial nerve (both sensory and motor)
- Sensory component is more strong and extensive than motor
- The larger **sensory root immediately enlarges into a** swelling called the **trigeminal ganglion.**
- Three large nerves arise from the trigeminal ganglion
  - The **ophthalmic nerve** conducts sensory impulses from cornea, nose, forehead, anterior scalp
  - The **maxillary nerve** conducts sensory impulses from nasal mucosa, palate, gums, cheek
  - And the **mandibular nerve** conducts sensory impulses from anterior two-thirds of tongue, skin of chin, lower jaw, lower teeth; one-third from sensory axons of auricle of ear
- The motor neurons are part of mandibular nerve and supply muscles of mastication

Abducens

- Motor
- originate from a nucleus in the pons
- Somatic motor axons extend from the nucleus to the lateral rectus muscle of the eyeball, move the eyeball away from the midline laterally

Facial nerve

- Mixed nerve
- Has autonomic fibers as well
- Arise from pons

- The motor neurons arise from a nucleus in the pons and innervate middle ear, facial, scalp, and neck muscles. Nerve impulses propagating along these axons cause contraction of the muscles of facial expression and other movements of muscles in face and neck

- Its sensory axons extend from the taste buds of the anterior two-thirds of the tongue. The taste buds act as chemo receptors. From here the sensory axons pass to the geniculate ganglion which ***is the enlargement*** of the facial nerve just before the entrance of the sensory portion into the pons. From the pons, axons extend to the thalamus, and then to the gustatory areas of the cerebral cortex
- The sensory portion of the facial nerve also contains axons from skin in the ear canal that relay touch, pain, and thermal sensations.
- Additionally, proprioceptors from muscles of the face and scalp relay information through their cell bodies in a nucleus in the midbrain

- Autonomic component Increases secretions of the lacrimal gland of the eye as well as the submandibular and sublingual salivary glands through parasympathetic fibers

Vestibulocochlear

- Sensory nerve
- Two branches – vestibular branch which carries impulses for equilibrium and cochlear branch which carries impulses for hearing
- Sensory axons in the vestibular branch extend from the semicircular canals, the saccule, and the utricle of the inner ear to the vestibular ganglion, where the cell bodies of the neurons are located and end in vestibular nuclei in the pons and cerebellum

- Sensory axons in the cochlear branch arise in the spiral organ (organ of Corti) in the cochlea of the internal ear. The cell bodies of cochlear branch sensory neurons are located in the spiral ganglion of the cochlea. From there, axons extend to nuclei in the medulla oblongata and end in the thalamus.

Glossopharyngeal nerve

- Mixed nerve
- Has autonomic fibers as well
- nuclei present in medulla
- Sensory axons of the glossopharyngeal nerve arise from
  - taste buds on the posterior one-third of the tongue reaching the thalamus, where they synapse with fibers that convey the impulses to the gustatory area of the cerebral cortex.
  - proprioceptors from some swallowing muscles supplied by the motor portion
  - baroreceptors (pressure-monitoring receptors) in the carotid sinus that monitor blood pressure,
  - chemoreceptors (receptors that monitor blood levels of oxygen and carbon dioxide) in the carotid bodies near the carotid arteries
- The motor fibers innervates the stylopharyngeus (pharynx muscle)
- The parasympathetic fibers of ANS are responsible for increase in secretion of parotid salivary gland

Vagus nerve

- Mixed nerve
- Also has autonomic function
- Nuclei in medulla
- Somatic motor supply muscles of the pharynx, larynx, and soft palate that are used in swallowing, vocalization, and coughing
- Autonomic motor has parasympathetic fibers that Innervates visceral smooth muscle, cardiac muscle, lungs, pharynx, larynx, trachea, and most abdominal organs
- Sensory portion collect visceral sensory information from pharynx, larynx, heart, lungs, and most abdominal organs.
- Sensory fibers helps in the sensation of hunger pangs, distension, intestinal discomfort, or laryngeal movements. Sensory fibers also arise from proprioceptors in the muscles innervated by the motor fibers of this nerve.
- Damage to Vagus nerve results in death

Accessary nerve

- Motor nerve
- Has two parts: one is cranial accessory nerve other is spinal accessory nerve

- The cranial accessory nerve arise from medulla innervates the skeletal muscles of the soft palate, pharynx, and larynx, which contract reflexively during swallowing.

- The spinal accessory nerve arise in the anterior gray horn of the first five segments of the cervical portion of the spinal cord. The axons from the segments exit the spinal cord laterally and come together, ascend through the foramen magnum and then exit through the jugular foramen along with the vagus and glossopharyngeal nerves.
- The accessory nerve conveys motor impulses to the sternocleidomastoid and trapezius muscles to coordinate head movements.

Hypoglossal Nerve

- Motor nerve
- The motor fibers arise from the hypoglossal nucleus within the medulla oblongata and pass through the hypoglossal canal of the skull to innervate both the extrinsic and intrinsic muscles of the tongue.
- Motor impulses along these fibers account for the coordinated contraction of the tongue muscles that is needed for such activities as food manipulation, swallowing, and speech