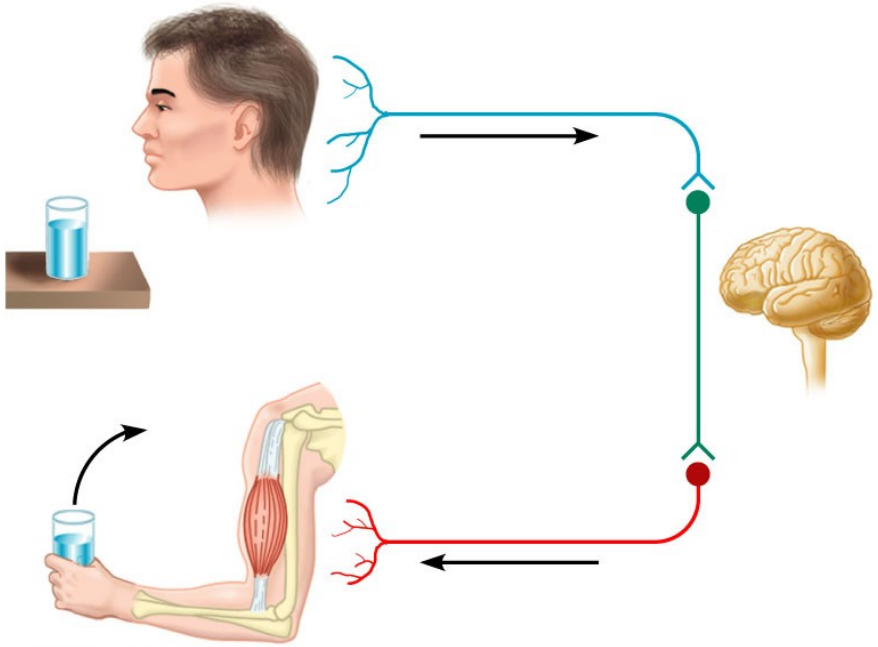
NERVOUS SYSTEM

By Chernet M.

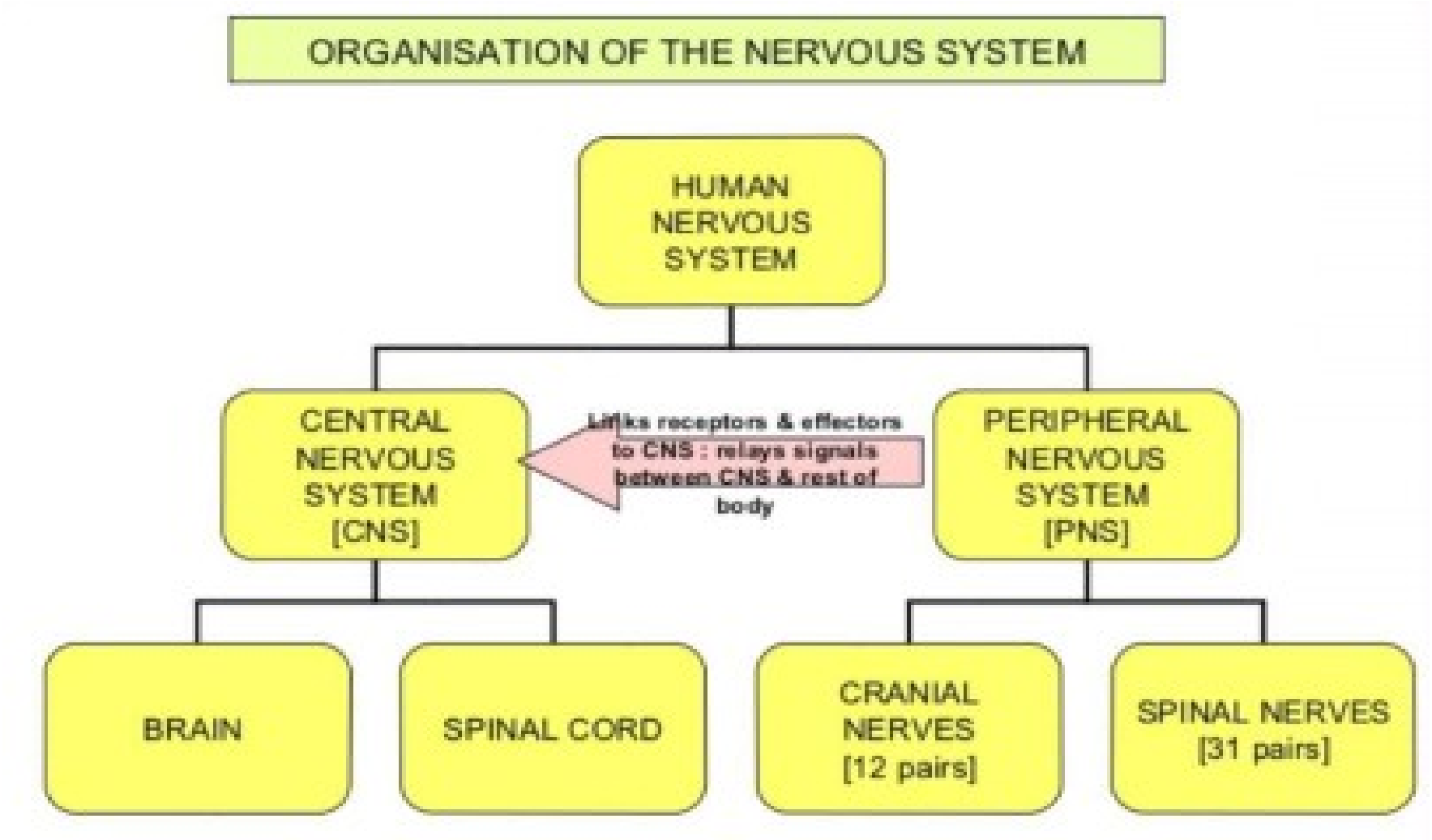
Nervous tissue

- **Controls** and **integrates** all body activities within limits that maintain life.

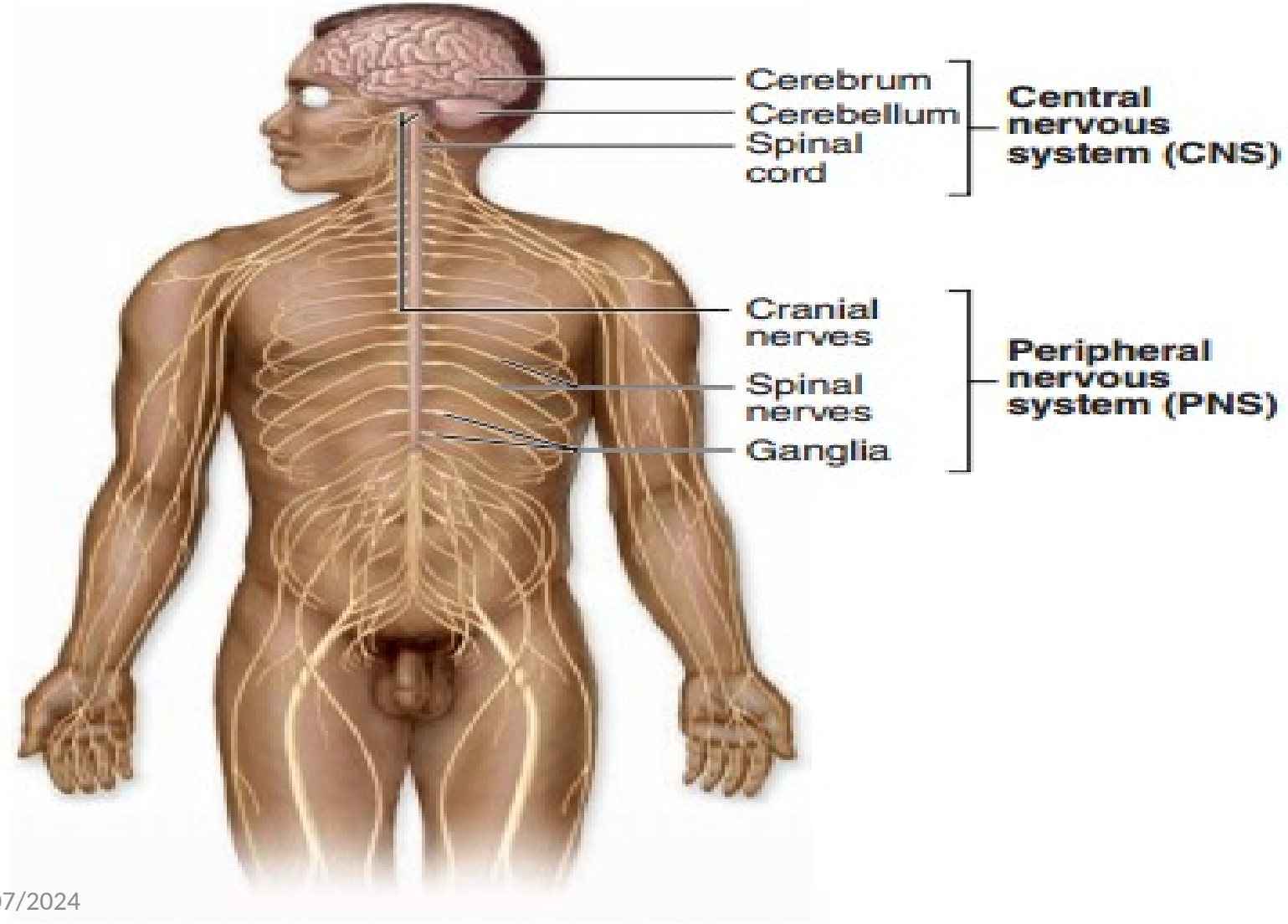
- Three basic functions of NS:
  1. Sensing changes with **sensory receptors**
  2. **Interpreting** and remembering those changes
  3. **Reacting** to those changes with effectors



Major Structures of the Nervous



Nervous tissue



Nervous Tissue

❖**General Characteristics and functions:**

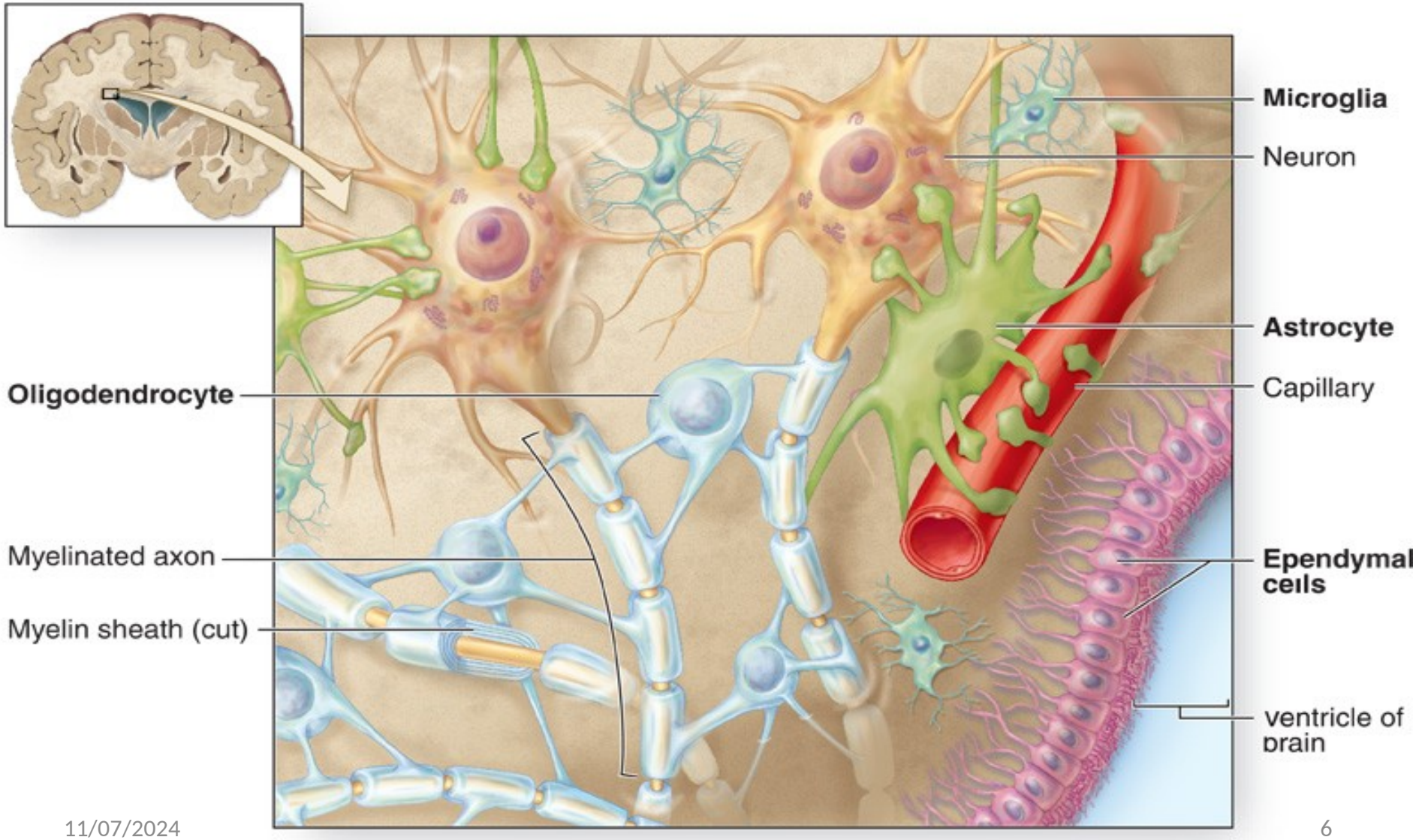
- Composed of **neurons** and associated supportive cells called **neuroglia.**

✓**Neurons** (excitable cells)

- functional units of the nervous system.
- are highly specialized cells that **generate and transmit electrical impulses** permitting rapid communication between distant areas of the body.
- **gather and process information** from receptors in contact with the external environment, and generate appropriate response signals.
- **Neurons are permanent cells that do not regenerate when injured.**

Nervous Tissue

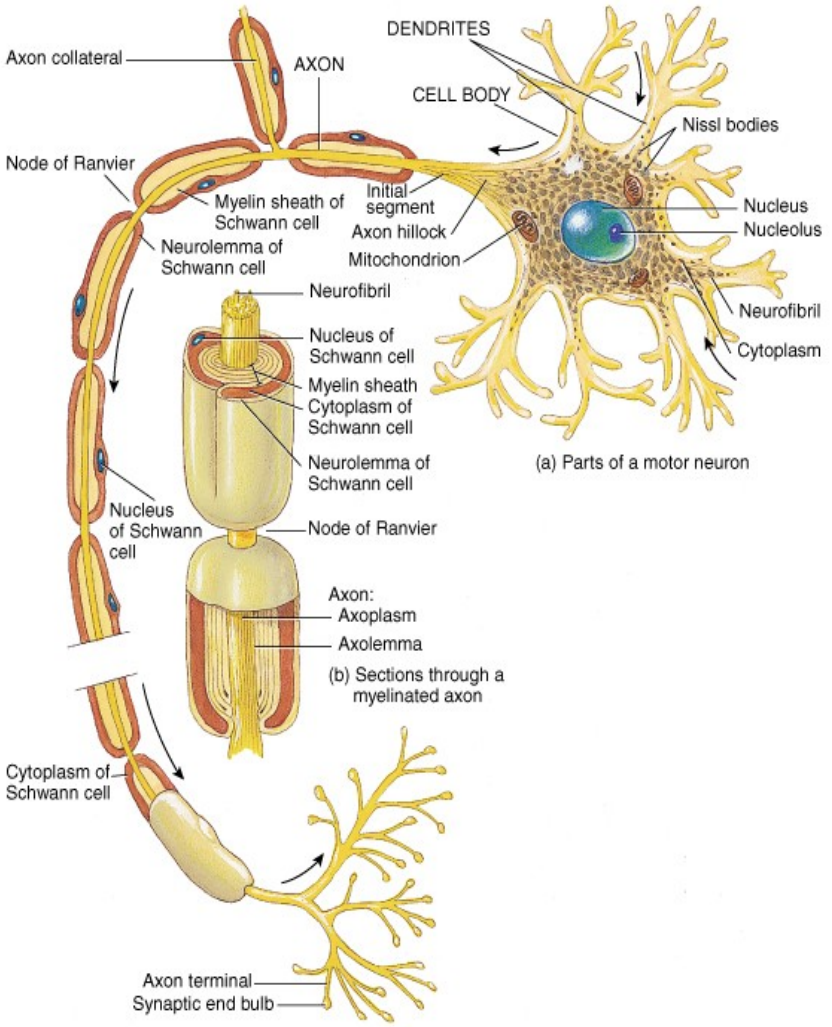
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Histology of Neural tissue

- Two types of neural cells in the nervous system:

1. ***Neurons*** - For processing, transfer, and storage of information
2. ***Neuroglia*** – For support, regulation & protection of neurons



Neurons

- Neurons are specialized for **conduction.**
- Neurons have a **high metabolic rate**
- They are **unable to survive long without oxygen** & glucose
- They have an **extremely long longevity, lasting a lifetime.**
- Neurons **do not divide.** (Amitotic)

➢ Have two parts:

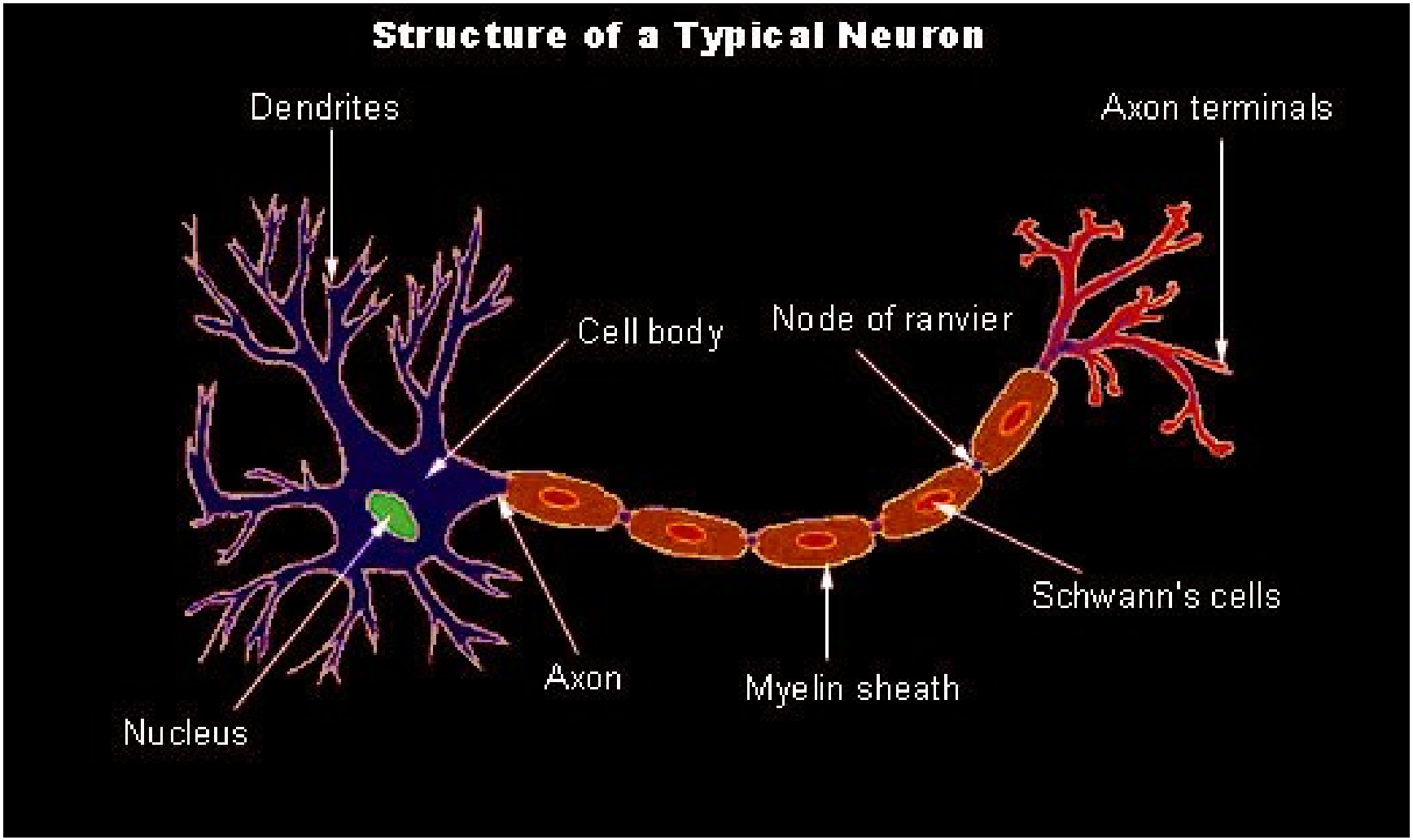
1. Cell body

- Is serves as the synthetic or **trophic** center for the entire neuron (location for most protein synthesis)
  - neurotransmitters & repair proteins

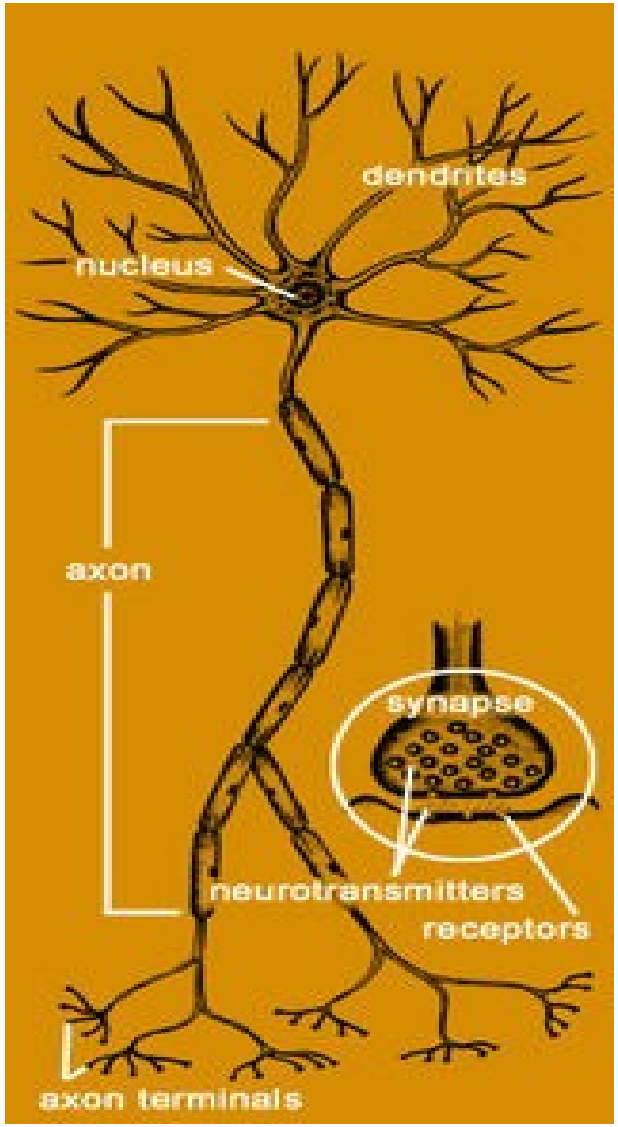
2. **Cell processes**

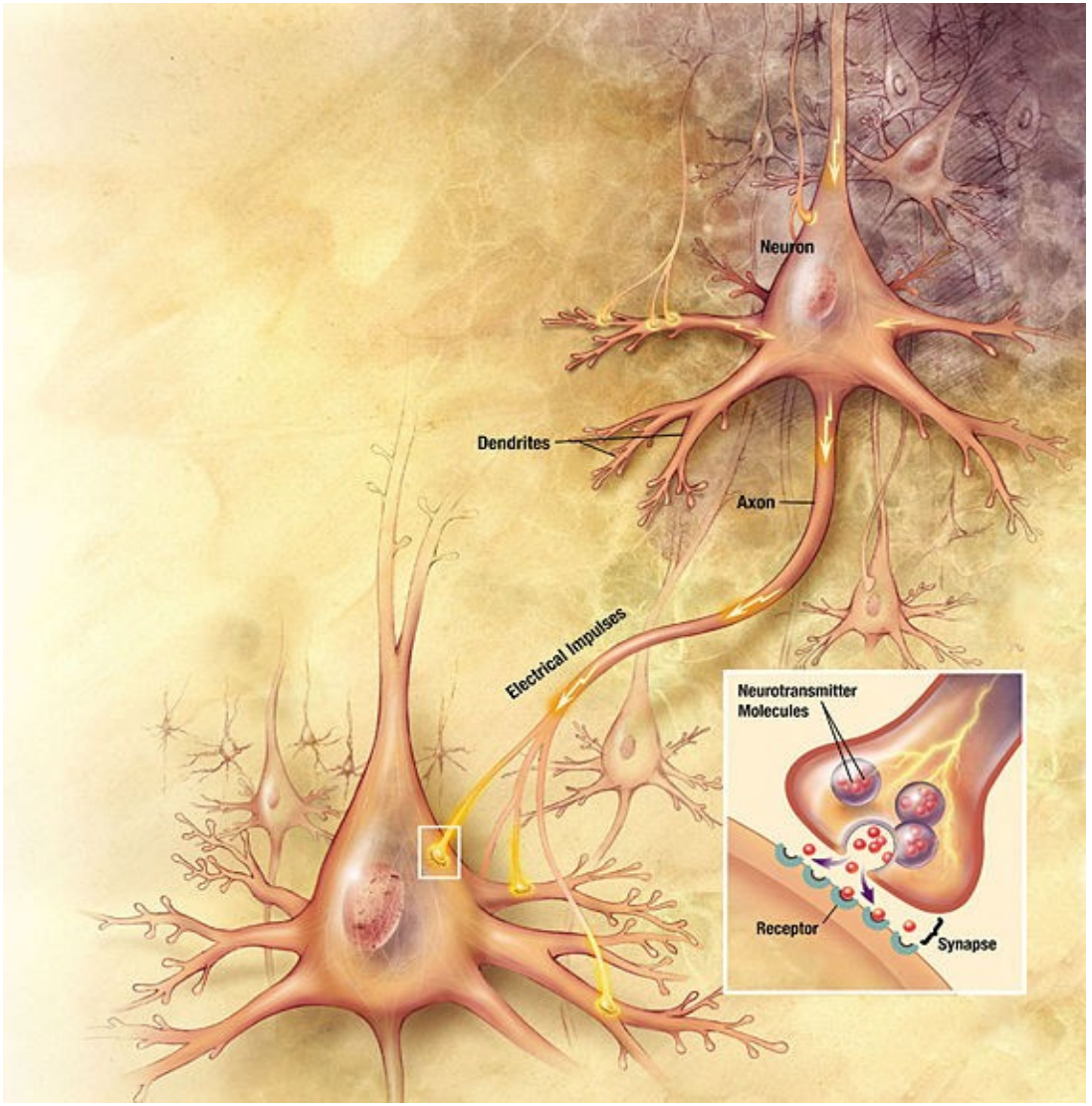
a) Dendrites
b) Axons

Neurons


Structure of a Typical Neuron
Dendrites
Axon terminals
Cell body
Node of ranvier
Schwann's cells
Axon
Myelin sheath
Nucleus

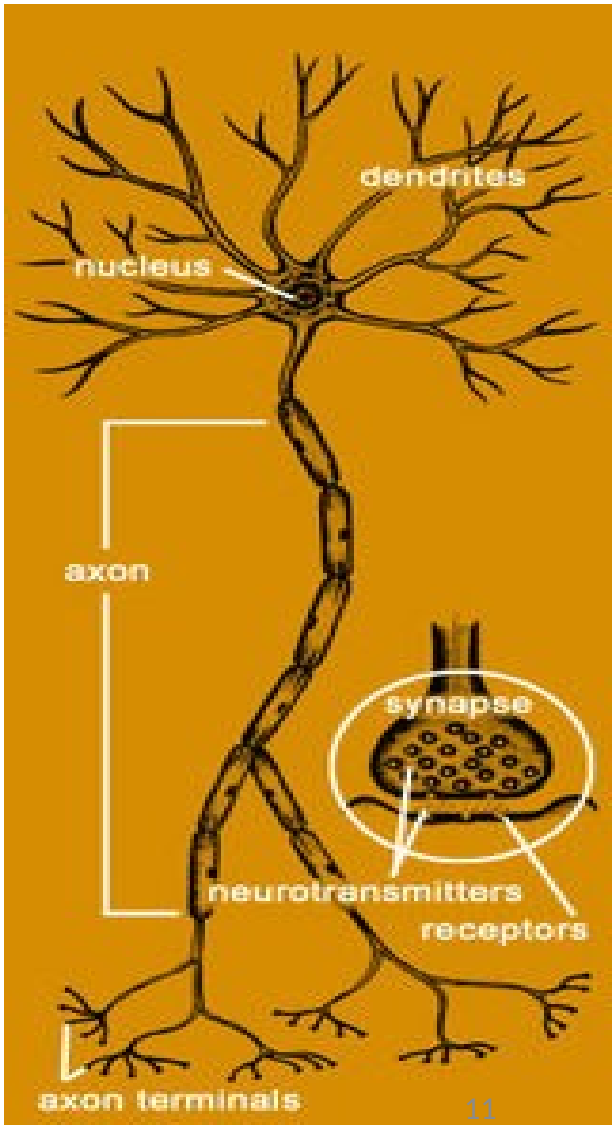
Neurons


dendrites
nucleus
axon
synapse
neurotransmitters
receptors
axon terminals


Neuron
Dendrites
Axon
Electrical Impulses
Neurotransmitter Molecules
Receptor
Synapse

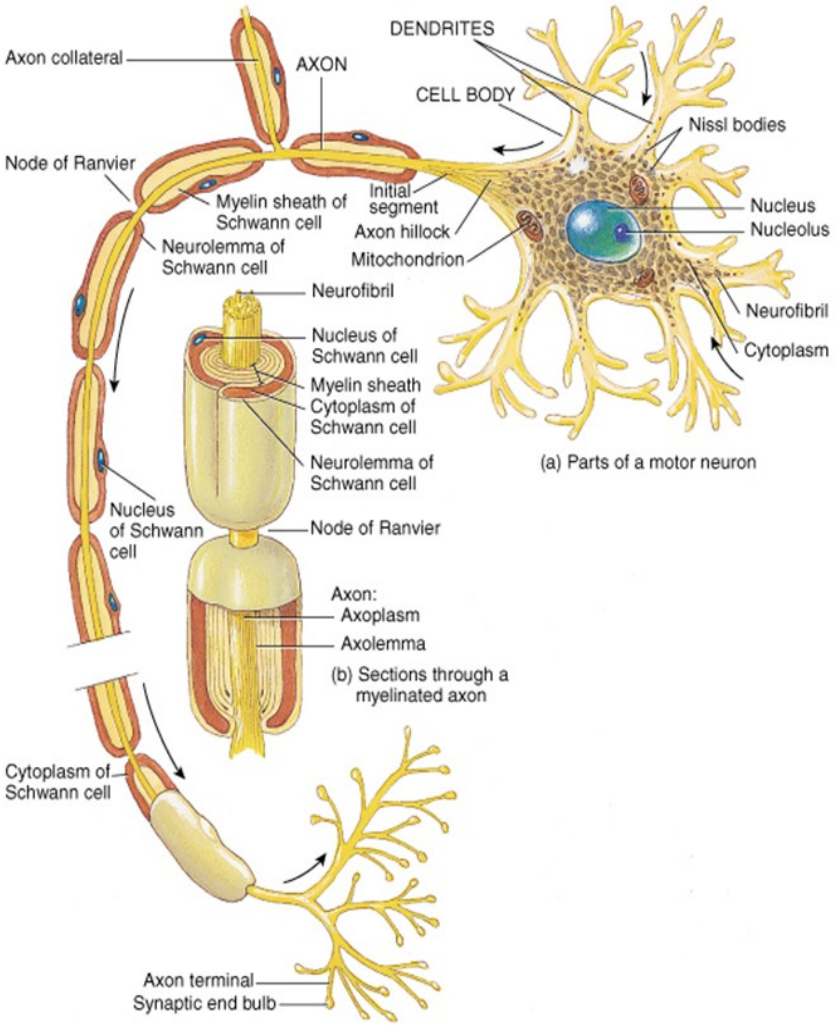
Dendrites

- Are the elongated processes specialized to conduct impulses towards the cell body
- Typically short, highly branched & unmyelinated
- Surfaces specialized for contact with other neurons

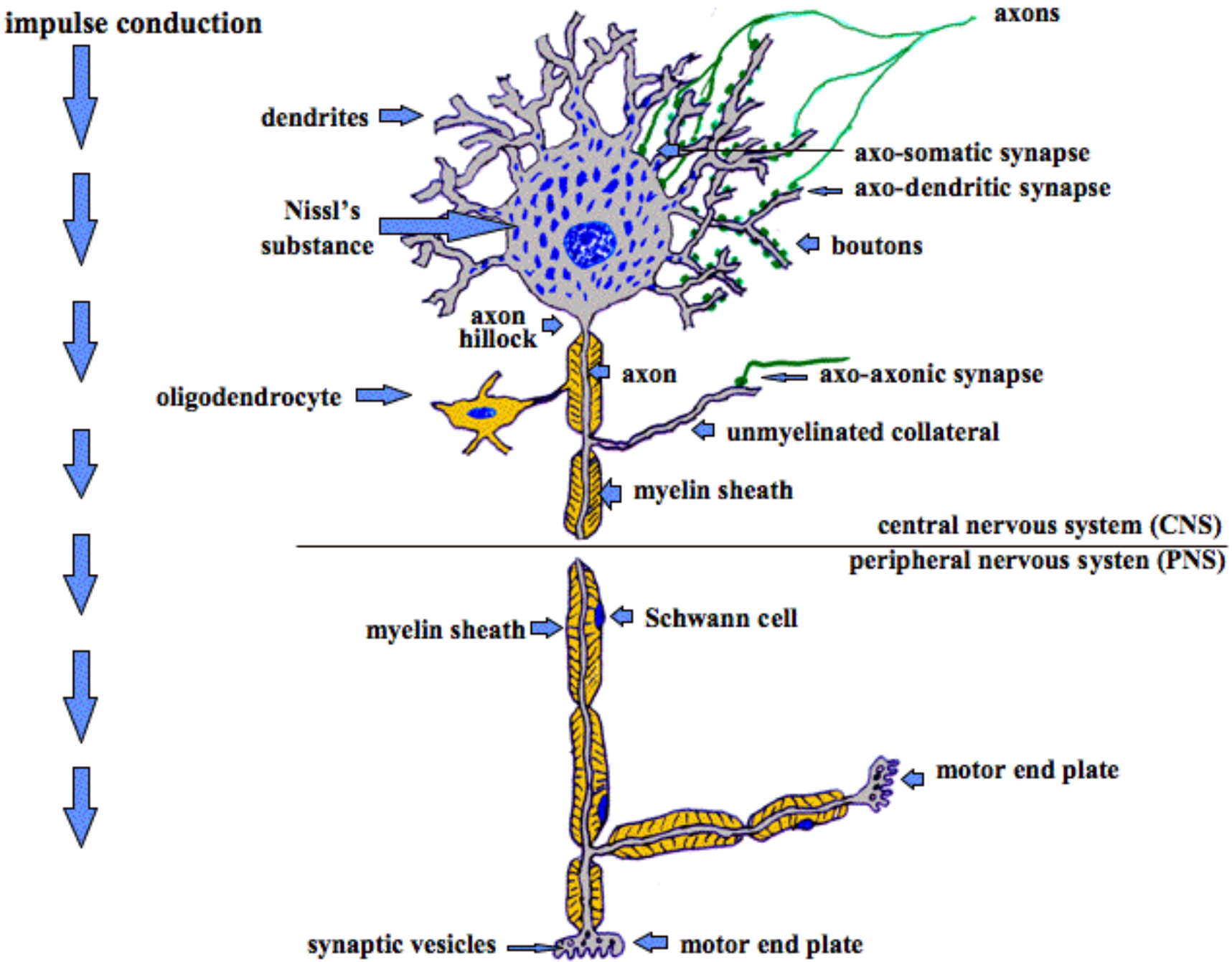


Axon

- Is a single long process (only one per neuron)
- specialized to **generate** and **conduct** nerve impulses to other cells (**nerve**, **muscle**, and **gland** cells).
- Side branches (**collaterals**) end in fine processes called **axon terminals.**
- Swollen tips called **synaptic end bulbs** contain vesicles filled with neurotransmitters.



ANATOMY OF A NEURON

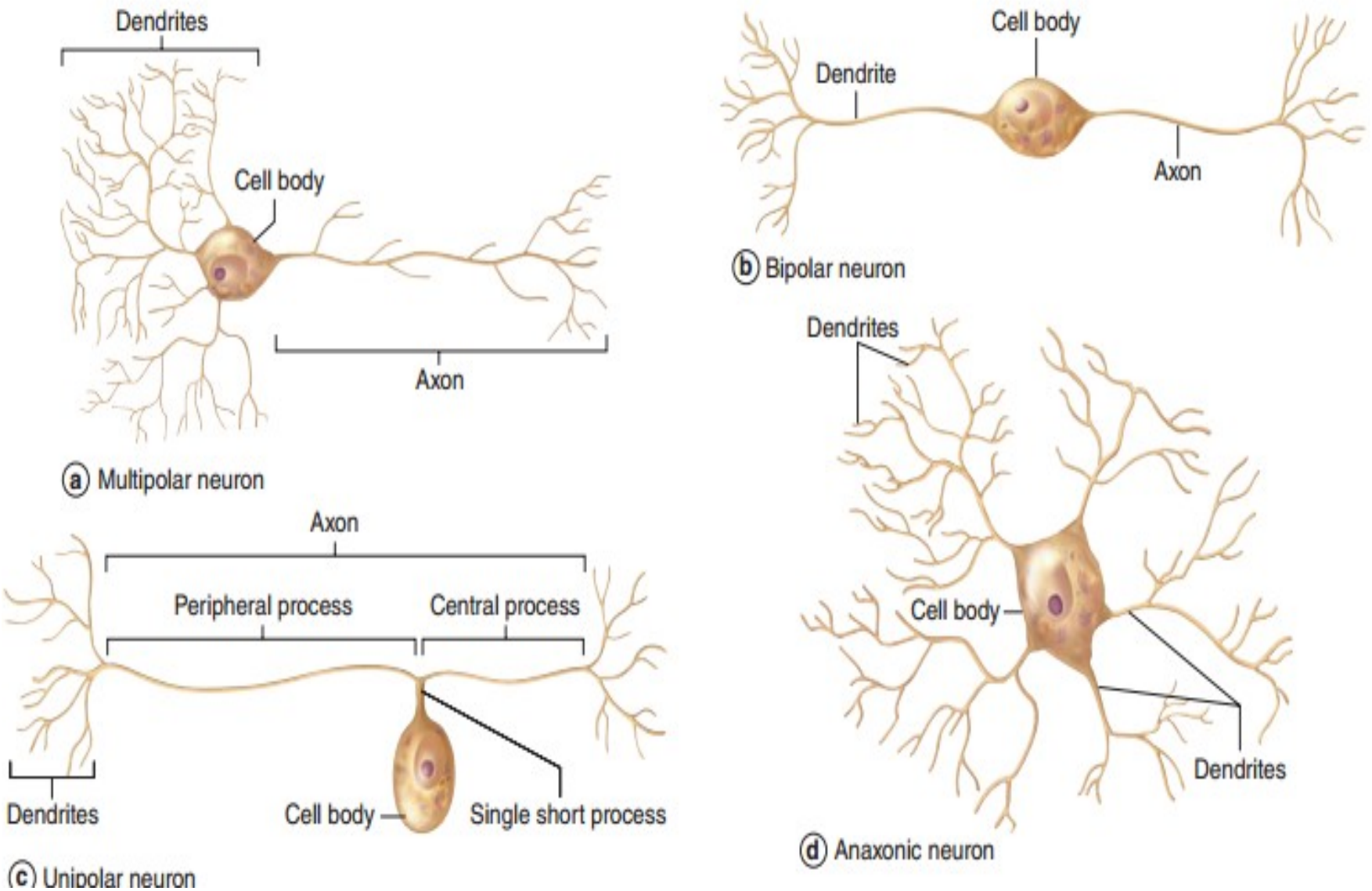


Neurons

- **Neurons** can be classified according to the number of processes extending from the cell body;

1. **Multipolar neurons -** which have one **axon** and two or more **dendrites**
2. **Bipolar neurons-** with one **dendrite** and one **axon**

FIGURE **9–4** **Structural classes of neurons.**



Neurons

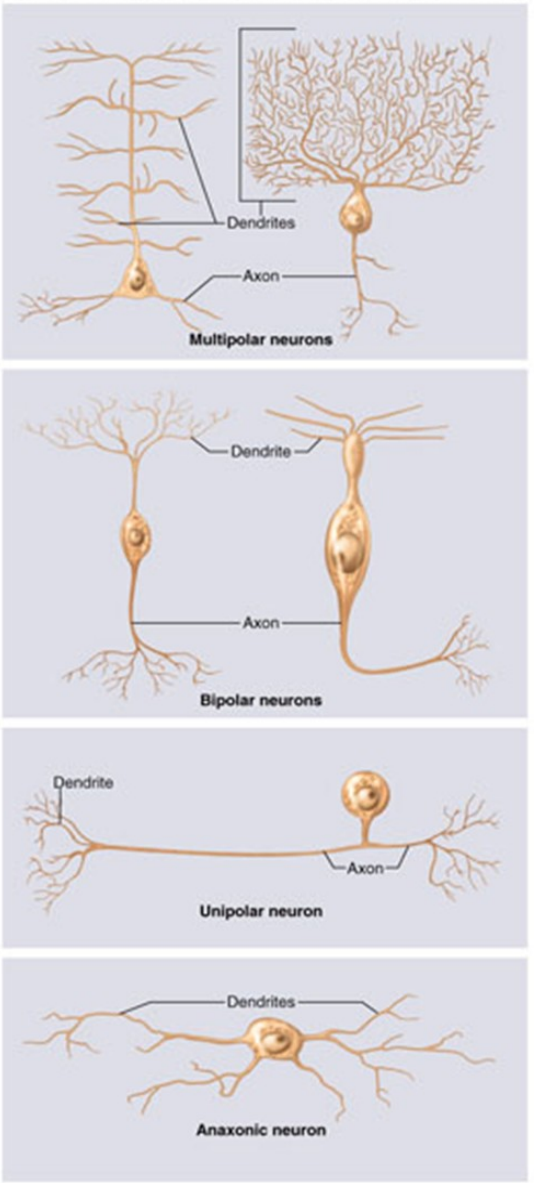
3. Unipolar or **pseudounipolar neurons**

- Which have a single process that bifurcates close to the perikaryon/cell body.

4. **Anaxonic neurons**

- with many dendrites but no true axon.

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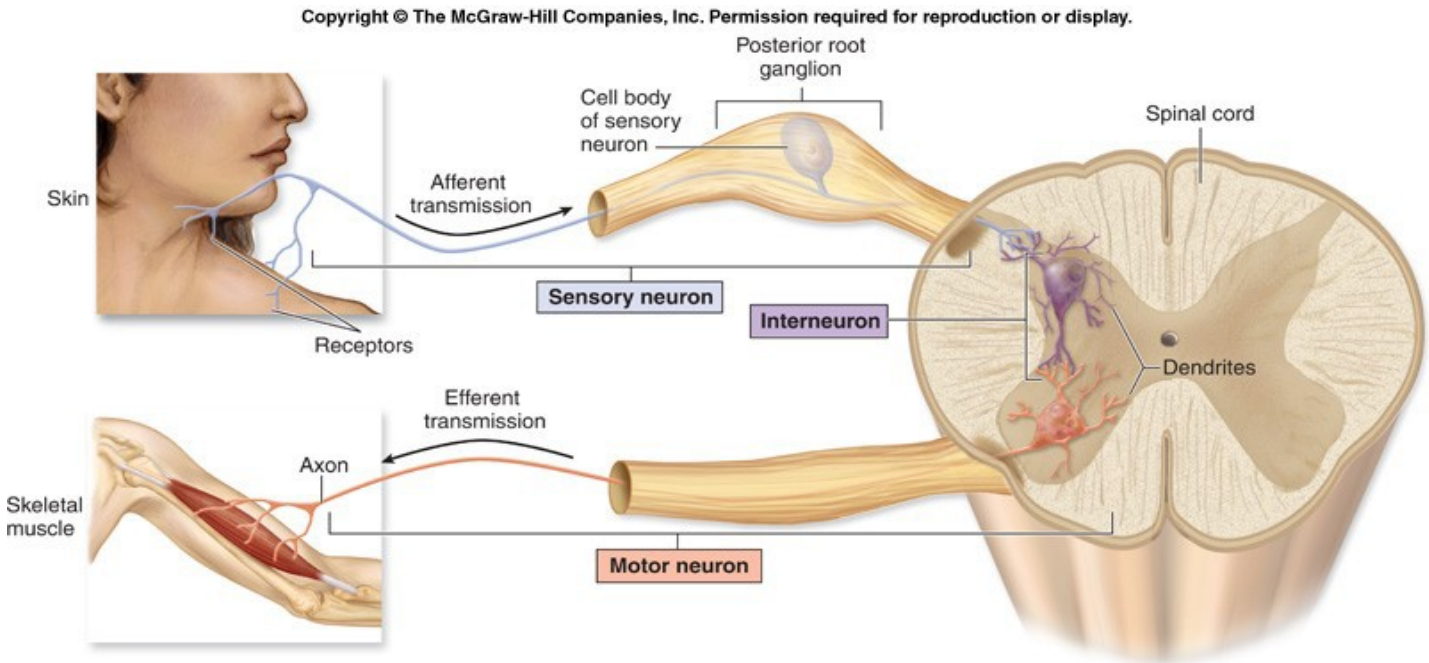
Neurons

- **Functional Classification of Neurons**
- Based on the direction of conduction

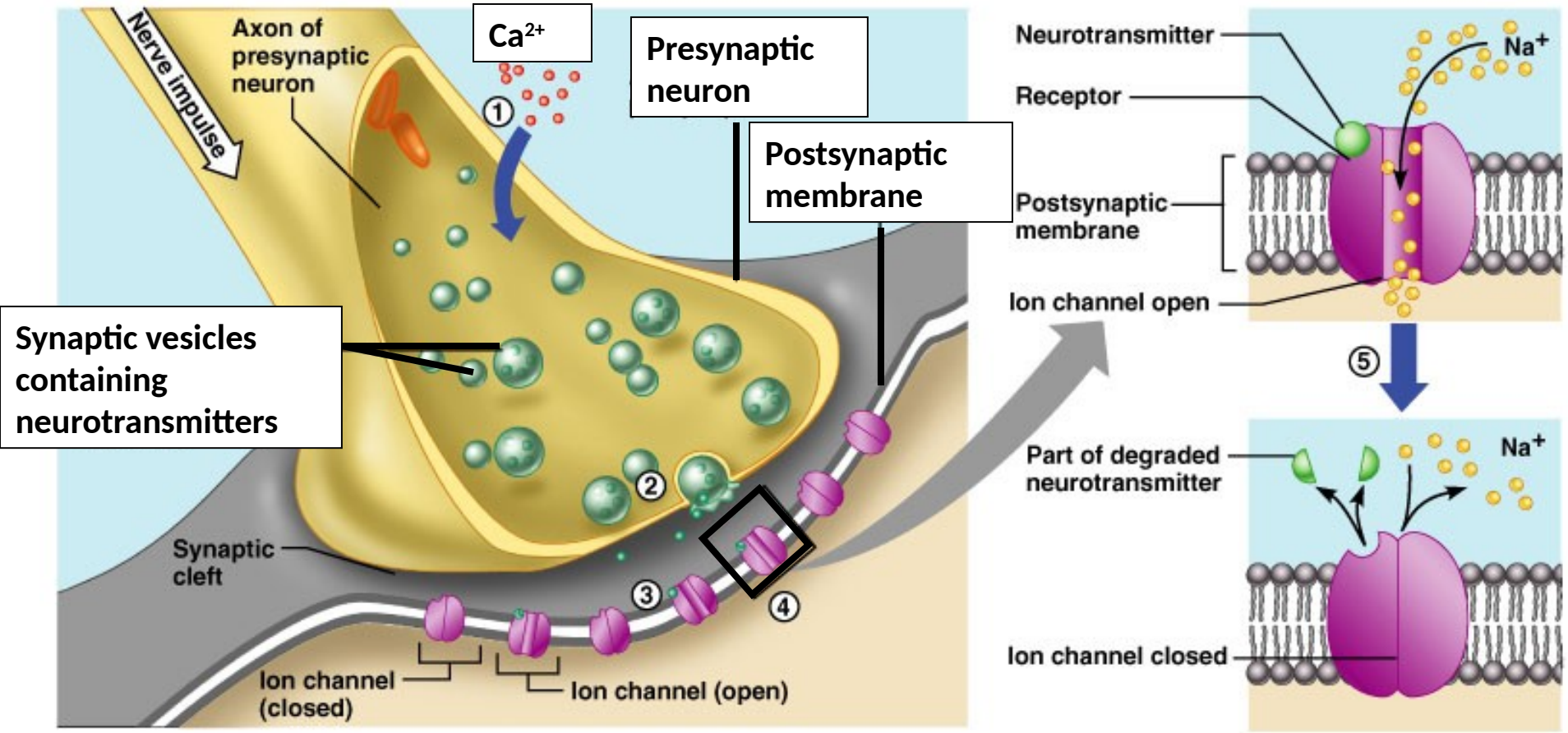
1. **Sensory or afferent -** Transmit impulses toward the CNS.
2. **Motor or efferent -** Carry impulses away from the CNS to effector organs (muscles & glands).
3. **Interneuron -** interposed between sensory and motor neurons in CNS to shuttle signals.

Neurons

- In the CNS most neuronal **cell bodies** occur in the **gray matter**, with **axons** concentrated in the **white matter**.



Synapses



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Neuroglia cells

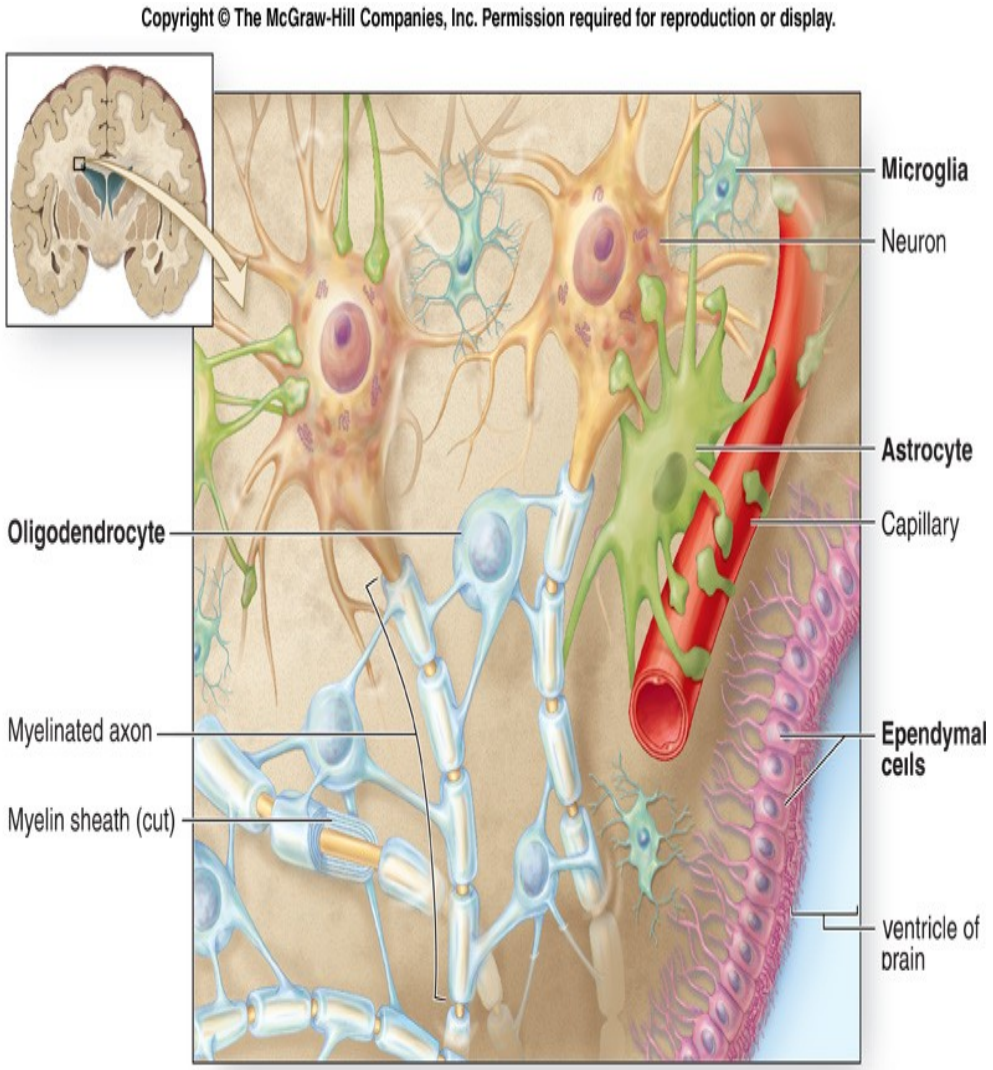
- **Found in CNS and PNS**
- Perform a supporting function for neurons

✓ **CNS**:

1. Oligodendrocytes
2. Ependymal cells
3. Astrocytes
4. Microglia

✓ **PNS**:

1. Satellite cells
2. Schwann cells



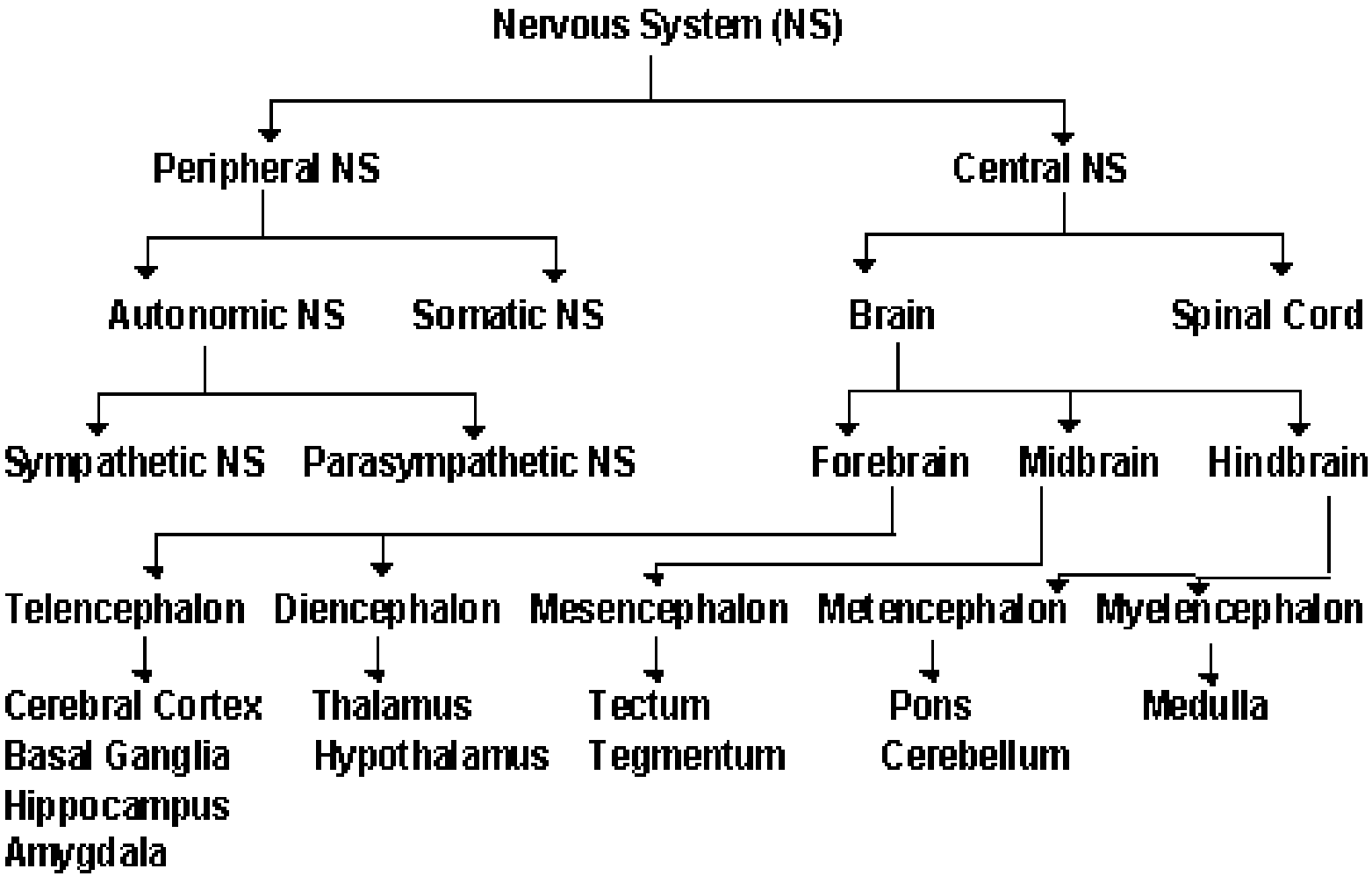
Neuroglia cells

TABLE 9–2 Origin, location and principal functions of neuroglial cells.

Glial Cell Type	Origin	Location	Main Functions
Oligodendrocyte	Neural tube	CNS	Myelin production, electrical insulation
Schwann cell (Neurolemmocyte)	Neural crest	Peripheral nerves	Myelin production, electrical insulation
Astrocyte	Neural tube	CNS	Structural and metabolic support of neurons; BBB; repair processes
Satellite cells (of ganglia)	Neural crest	Peripheral ganglia	Structural and metabolic support for neuronal cell bodies
Ependymal cell	Neural tube	Line ventricles and central canal of CNS	Aid production and movement of CSF
Microglia	Bone marrow (monocytes)	CNS	Defense and immune-related activities

Gross Anatomy of Nervous System

Nervous System



Peripheral Nervous System (PNS)

- The PNS consists of all other nervous structures that do not lie within the CNS.
- Composed of 12 pairs of ***Cranial Nerves*** & 31 pairs of ***Spinal Nerves*.**
- Unlike the CNS, the PNS is not protected by bone, leaving it exposed to toxins & mechanical injuries.
- Functionally, the PNS is divided into somatic nervous system & autonomic nervous system.

PNS

1. Somatic nervous system

- For coordinating & voluntary control of body movements thru action of skeletal muscles, in response to external stimuli, (e.g., touch, hearing & sight).
- regulates activities that are **under conscious control.**

2. Autonomic/visceral nervous system (ANS)

- acts as a control system, maintaining homeostasis in the body.
- most of its actions are involuntary, **without**

PNS

❖The **motor** portion of the autonomic nervous system has two divisions:

1. The parasympathetic division

- Is the **"housekeeping division",** controlling involuntary activities while the body is at **rest**.

- It keeps ventilation (breathing) rate and heart rate **low**, and stimulates digestion and kidney function.

PNS

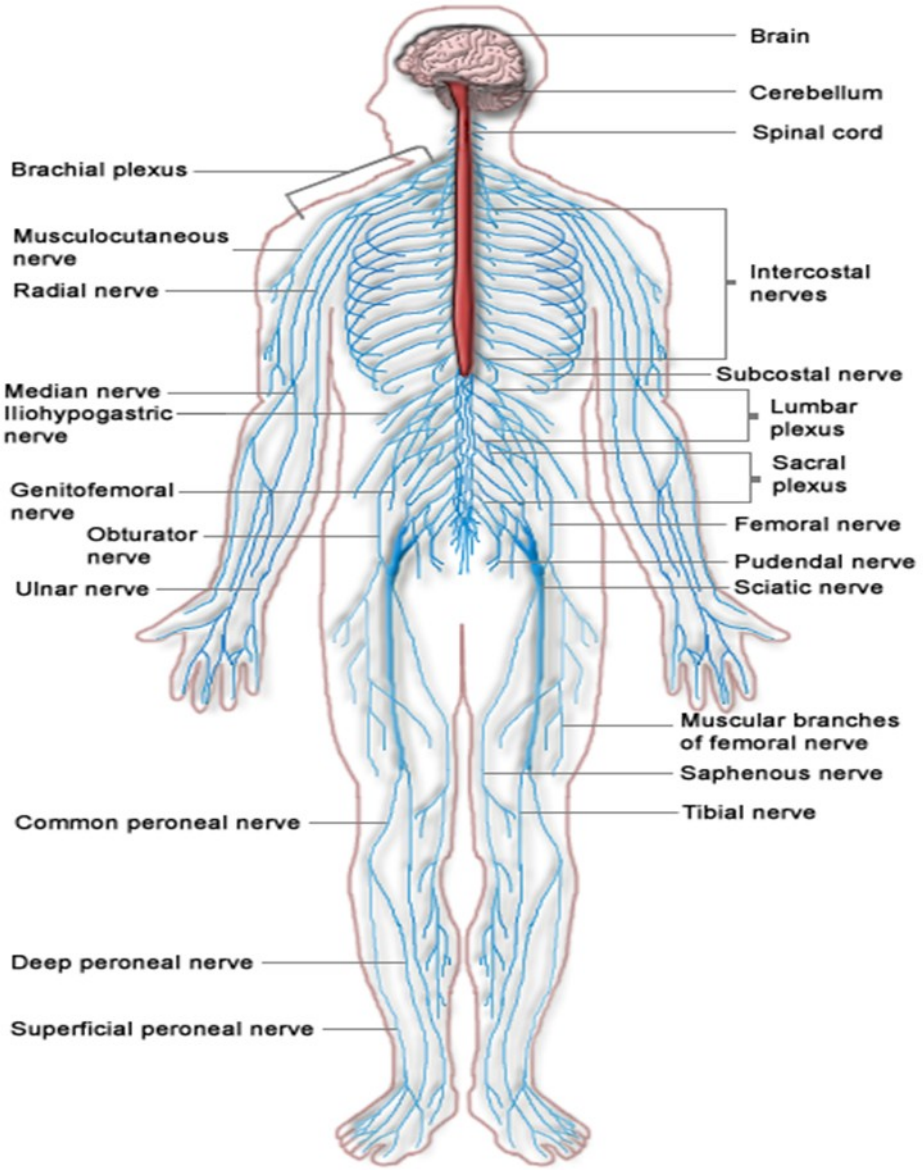
2. The sympathetic division

- controls the **"fight-or-flight** response“, which is the body's response to stress, emergencies, and exercise.

- It increases ventilation (breathing) and heart rate, increases blood flow to the brain and skeletal muscles, and slows down **digestive** and **urinary** functions.

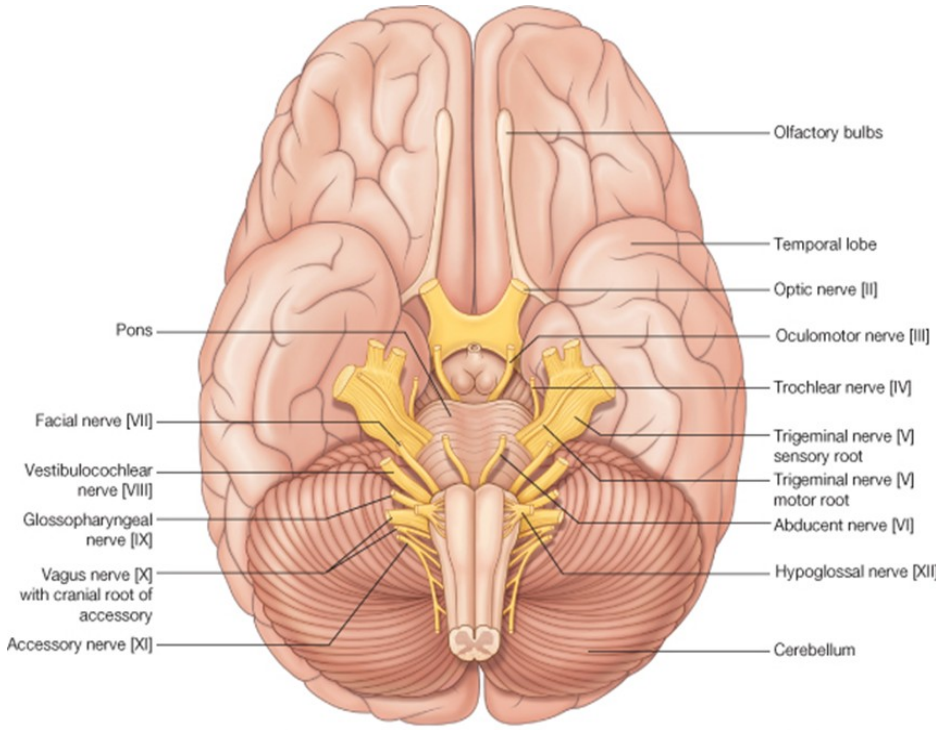
PNS

- **12 pairs of Cranial Nerves**
- **31 pairs of Spinal Nerves**



PNS

- **12 pairs of cranial nerves.**
- All are distributed in the head & neck, **except CN-X (Vagus).**
- All nerves except the spinal root of **CN-XI (accessory nerve)** originate from the brain.



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Cranial Nerves

- **Cranial nerves** can be grouped in several ways:
- **According to their central location:**
- Cranial nerves **I** & **II**, (Olfactory & Optic nerves), are connected to **telencephalon** & **diencephalon**, respectively
- Cranial nerves **III** & **IV** (Oculomotor & Trochlear nerves), are connected with the **midbrain.**
- Trigeminal (**V**), Abducens (**VI**), & Facial (**VII**) nerves are located in the **pons.**
- Cranial nerves **VIII**, **IX**, **X**, **XI**, & **XII** (Vestibulocochlear, Glossopharyngeal, Vagus, cranial root of Accessary and Hypoglossal nerves) are associated with the **medulla oblongata**.

- It is important to know this location plan because if a patient exhibits signs of a specific cranial nerve injury, then the site of the lesion can be pinpointed.

Cranial Nerves

❖ Another way to group cranial nerves is according to their **functional neuronal components**:

✓ ***Some have only sensory neurons***:

- **CN - I**, the olfactory nerve, concerned with **smell**.
- **CN - II**, the optic nerve, which deals with **vision.**
- **CN – VIII**, the vestibulocochlear nerve, concerned with **hearing** and **equilibrium**.

✓ ***Some others are composed only of motor neurons:***

- CN – III, CN – IV, CN – VI, CN – XI & CN – XII.

✓ ***Others are composed of mixed neurons:***

- CN – V, CN – VII, CN – IX & CN – X.

Central Nervous System

- The central nervous system (CNS): largest part of the nervous system,
- includes the **brain** & the **spinal cord**.

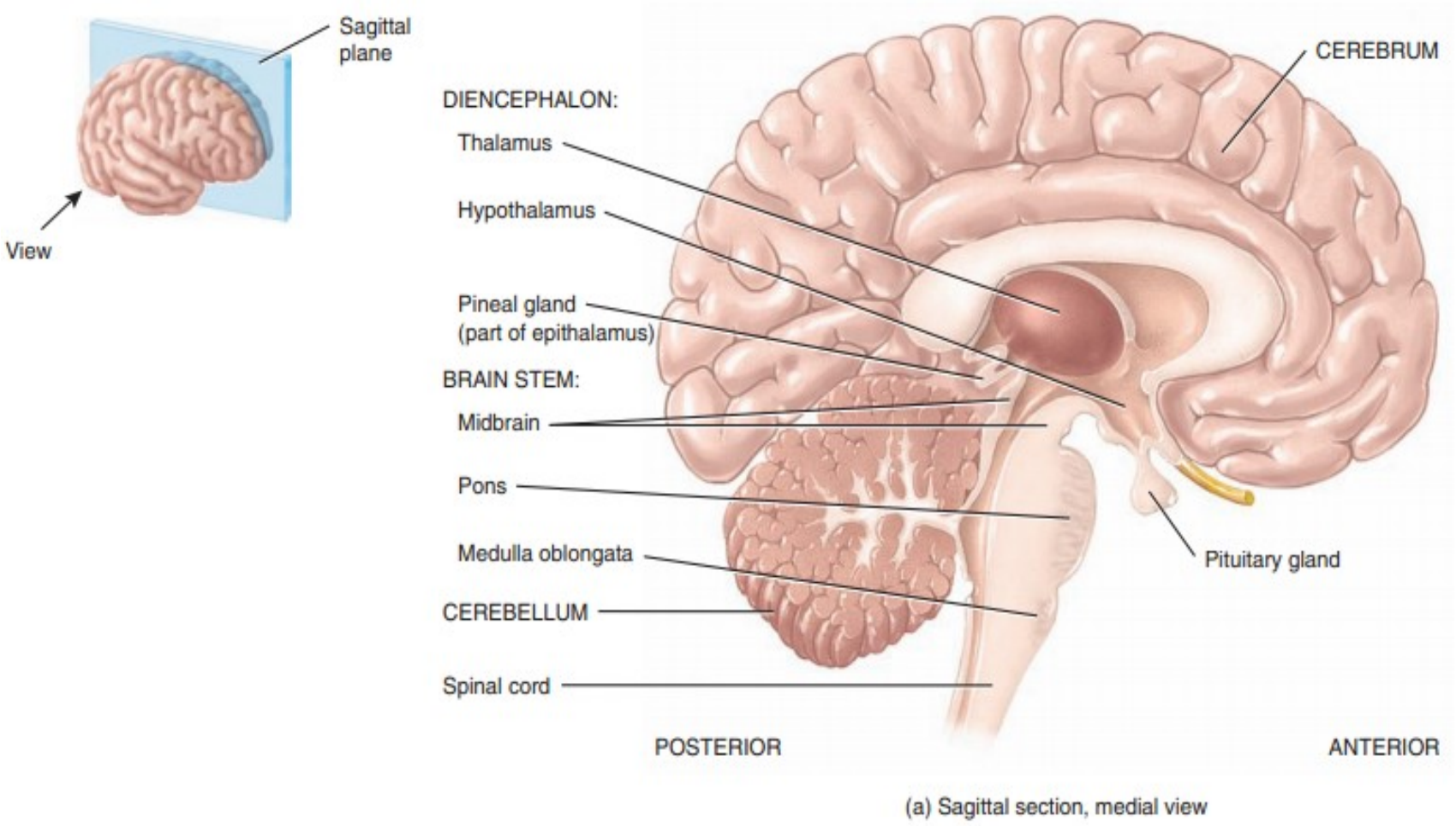
- Brain is within cranial cavity, & spinal cord in spinal cavity.

- The CNS is covered by the meninges (protective coverings: the outer **dura mater**, **arachnoid** mater and the innermost **pia mater**).

- Brain is also protected by the skull, & spinal cord by the vertebrae.

THE BRAIN

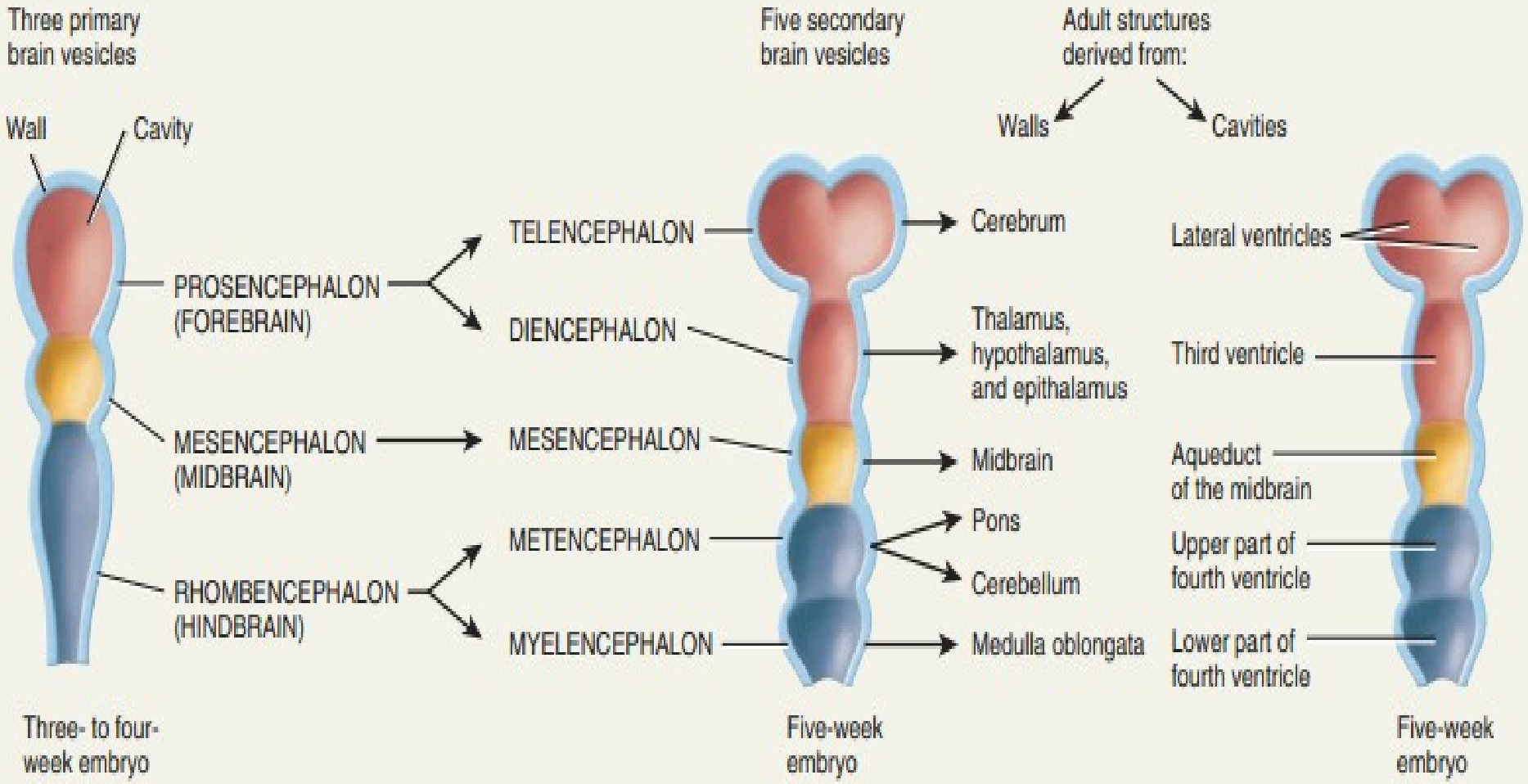
- The adult human **brain** consists of four major parts: **brain stem**, **cerebellum**, **diencephalon**, and **cerebrum**



(a) Sagittal section, medial view

TABLE 14.1

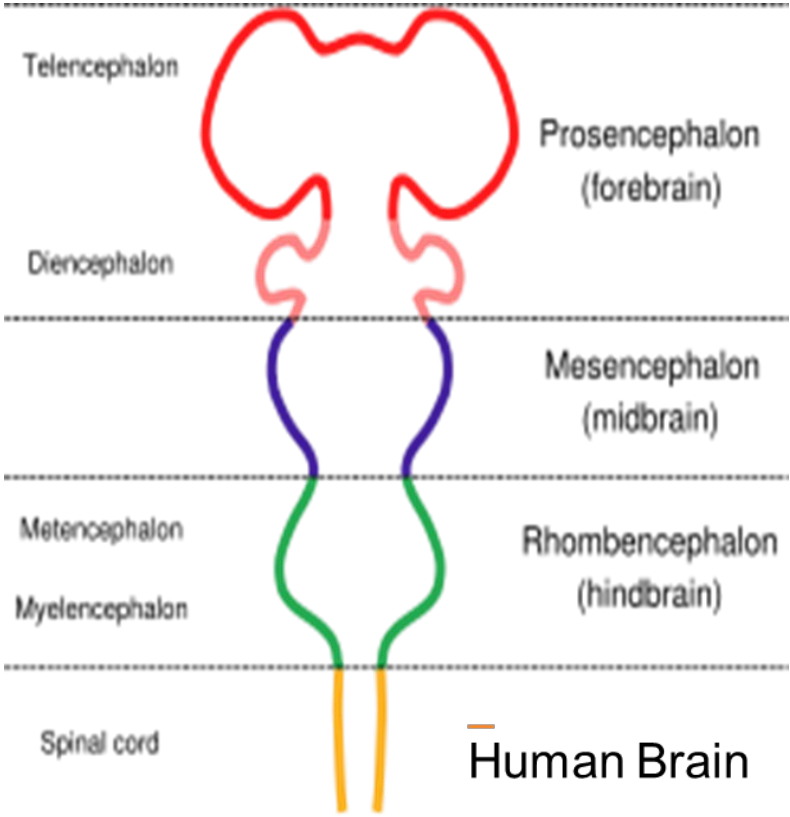
Development of the Brain



Central Nervous System

- Human brains are composed of three regions that later develop into five total divisions:

1. Prosencephalon (**Forebrain**)
   - Diencephalon
   - Telencephalon
2. Mesensephalon (**Midbrain**)
3. Rhombencephalon (**Hindbrain**)
   - Metencephalon
   - Myelencephalon



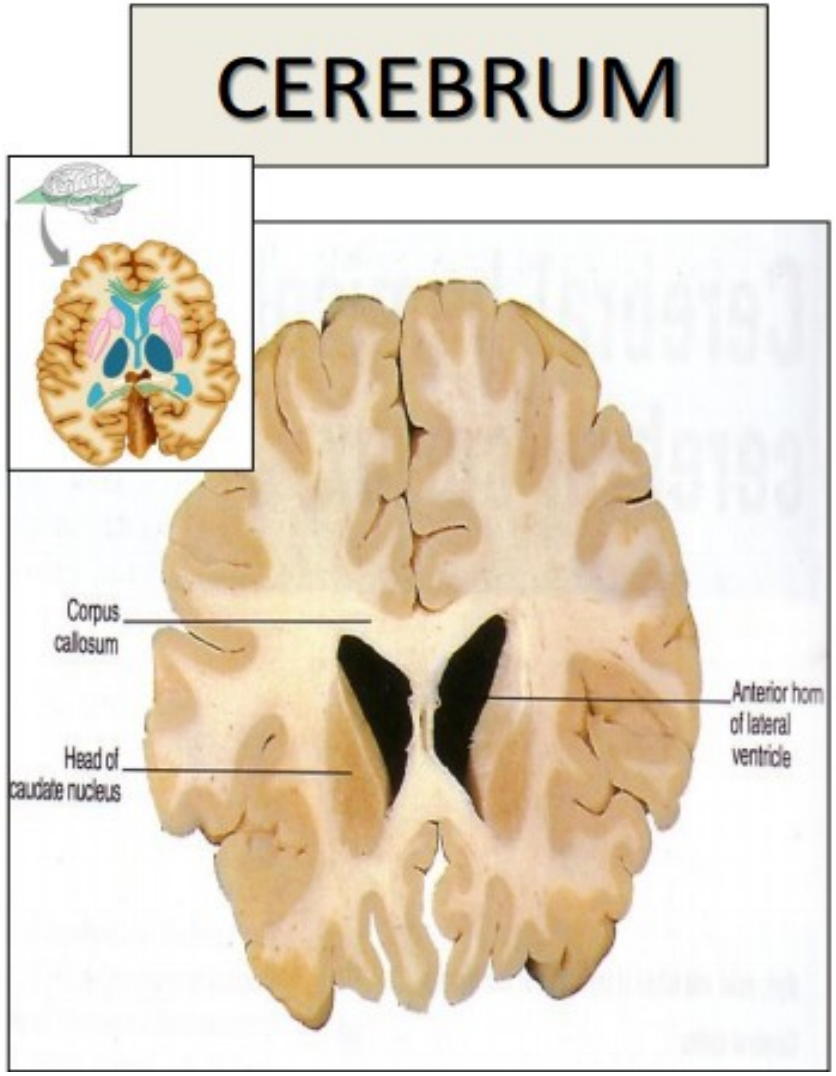
CNS: The BRAIN

- Anatomically, the brain can be divided into three parts:
  - Forebrain, Midbrain, & Hindbrain:
- **Forebrain** includes cerebral cortex that ***controls higher functions***.

- **Midbrain** & **Hindbrain:** more involved with ***unconscious, autonomic functions.***

CEREBRUM

- It is the largest & external part of the **forebrain**.
- It is derived from the **telencephalon**.
- The 2 cerebral hemisphere are incompletely separated by the **median** or **greater longitudinal fissure.**
- They are connected by the **corpus callosum**.
- Each hemisphere has a cavity called the **lateral ventricle.**



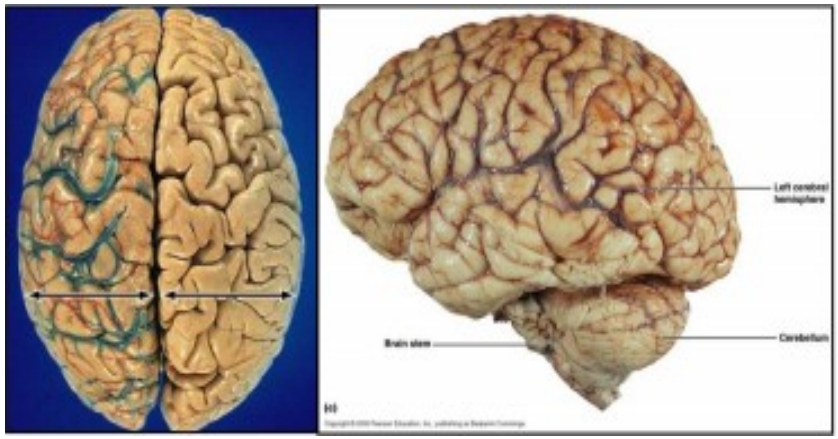
Cerebral cortex

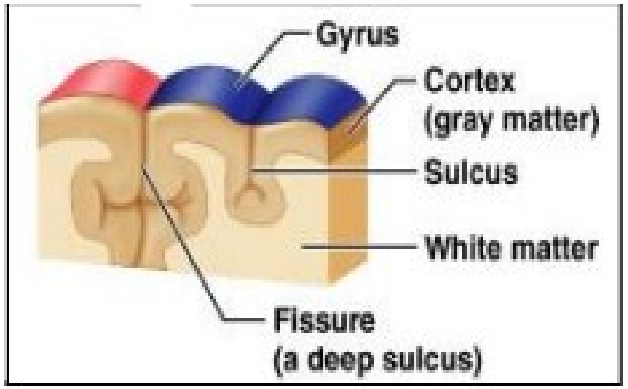
- Form the superior part of the brain

❖ **Surface Features:**

- **Ridges** called **Gyri** (Gyrus)
- Shallow **grooves** called **Sulci** (sulcus)
- Deeper **grooves** called **Fissures**

➢ They are helpful to increase surface area of the cerebrum.



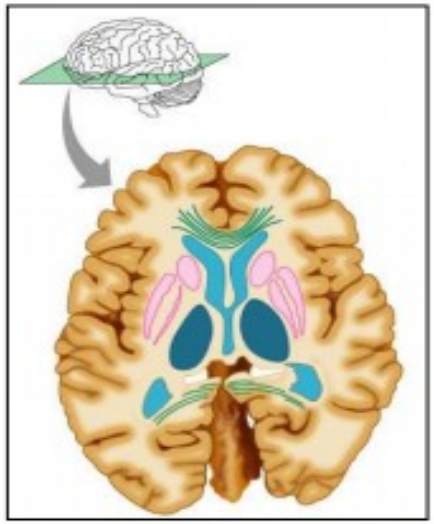


- **Hemispheres** are separated by the **Longitudinal fissure** and from **cerebellum** by the **Transverse Cerebral fissure.**

Cerebral cortex – 3 basic regions

1. **Superficial** layer of **grey matter**, the **cerebral cortex**
2. **Deeper** to the cortex, axons running to and from the cells of the cortex form an extensive mass of **white matter.**
3. Buried within the **white matter** lie a number of nuclear masses (caudate, putamenand globus pallidus) collectively known as the **basal nuclie,** islands of **grey matter** within the white matter.

- **Cortex** (40% of brain mass) consists of neuron cell bodies, dendrites, and **unmyelinated** axons (plus glial cells and blood vessels).





Cerebral White Matter

- The cerebral white matter consists primarily of myelinated axons in three types of tracts

1. **Association tracts:** contain axons that conduct nerve impulses between **gyri** in the same hemisphere.
2. **Commissural tracts** contain axons that conduct nerve impulses from gyri in one cerebral hemisphere to corresponding gyri in the other cerebral hemisphere. Three important groups of commissural tracts are the corpus callosum (the largest fiber bundle in the brain), anterior commissure, and posterior commissure.
3. **Projection tracts** contain axons that conduct nerve impulses from the cerebrum to lower parts of the CNS (thalamus, brain stem, or spinal cord) or from lower parts of the CNS to the cerebrum.

Functions of the Cerebral Cortex

- **Cerebral cortex** is necessary for:

✓ Conscious awareness and thought

✓ Reasoning & intellect

✓ Emotions

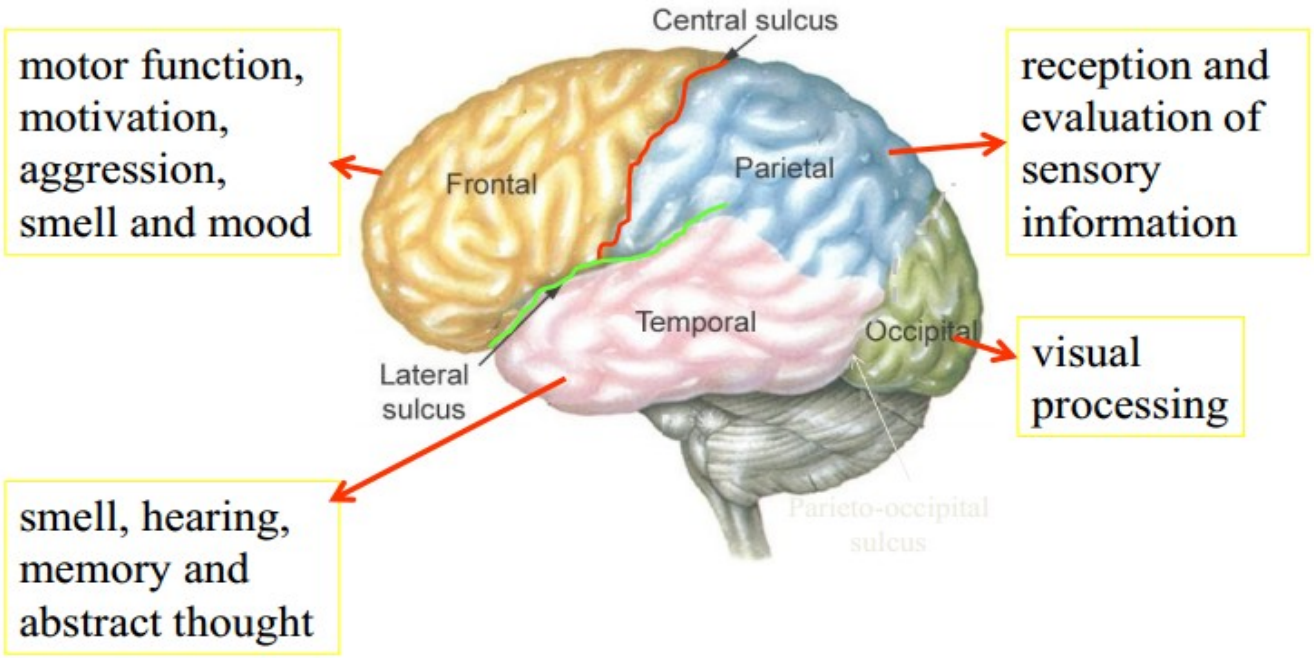
✓ Behavior & memory (stores information and retrieves when needed).

- Receives all sensory modalities (mostly through **thalamus**)
- Is the highest level where motor system is represented.

- Controls & directs the conscious motor functions of the body.

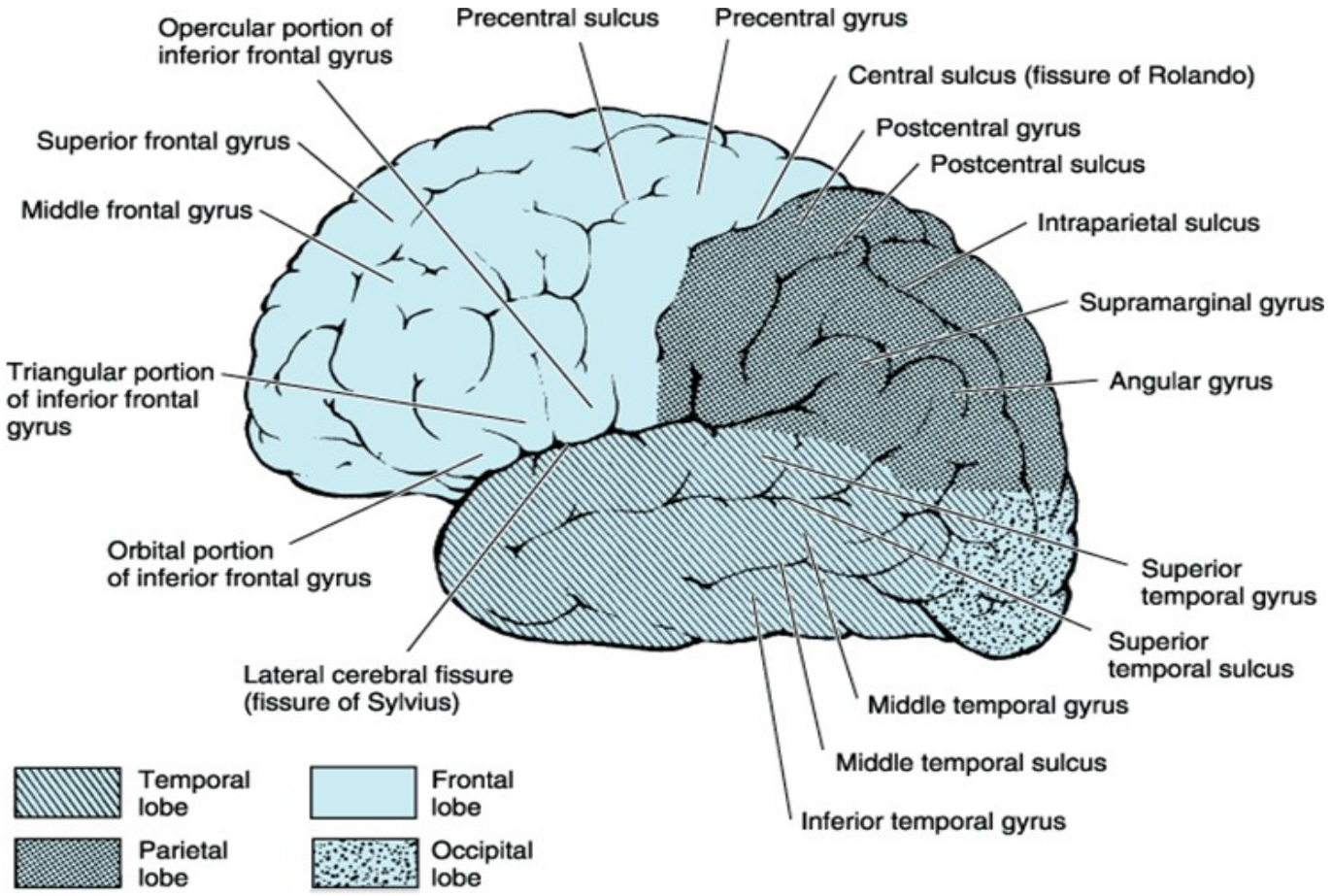
Three **sulci**, consistent in their position, divide each **hemisphere** into 4 lobes (named after overlying bones):

- Frontal, Temporal Parietal and Occipital lobes



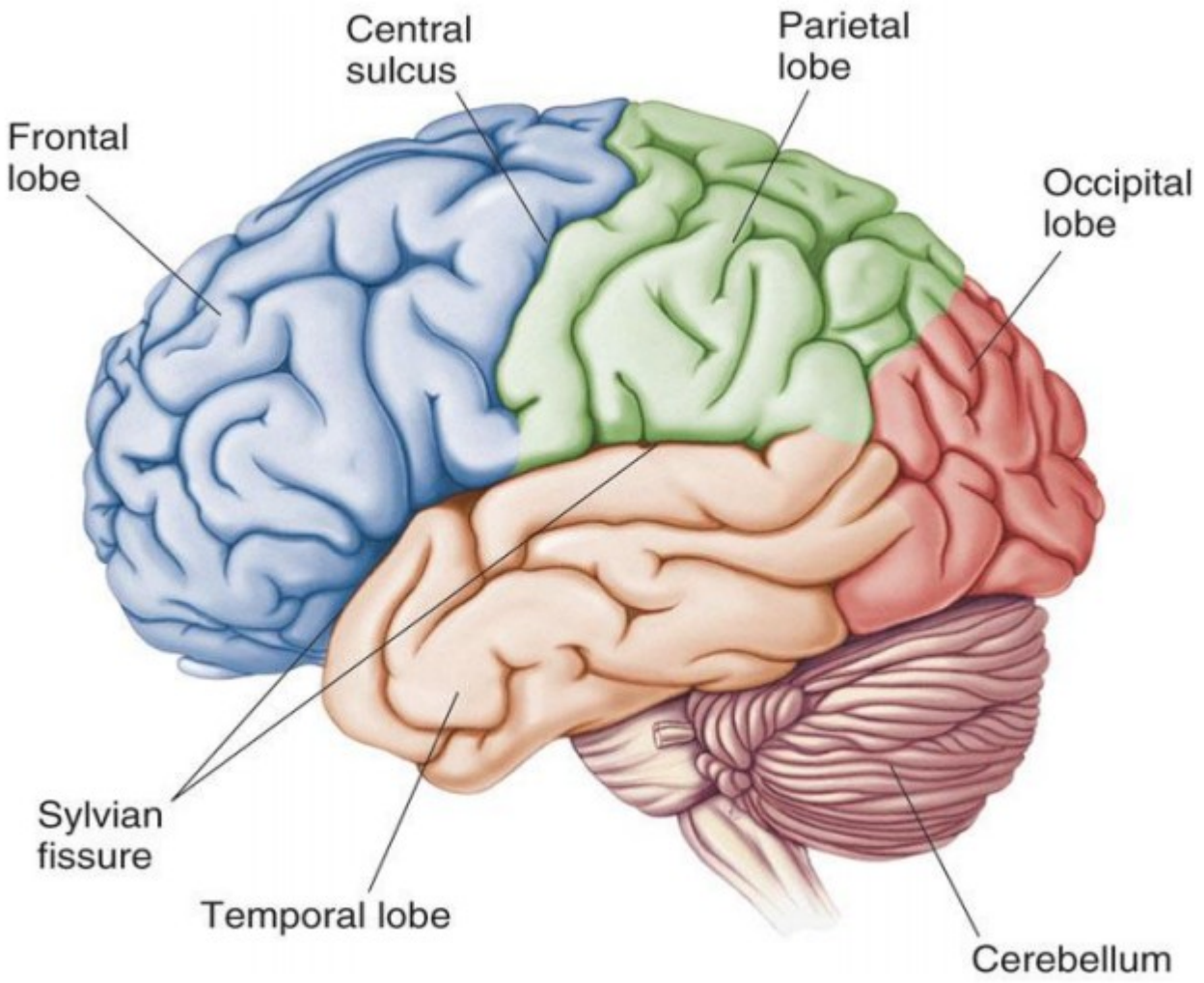
- **Central sulcus** – separates the **frontal** and **parietal** lobes
- **Parieto-occipital sulcus** – separates the **parietal** and **occipital** lobes
- **Lateral sulcus** – separates the **parietal** and **temporal** lobes

Cerebral Cortex



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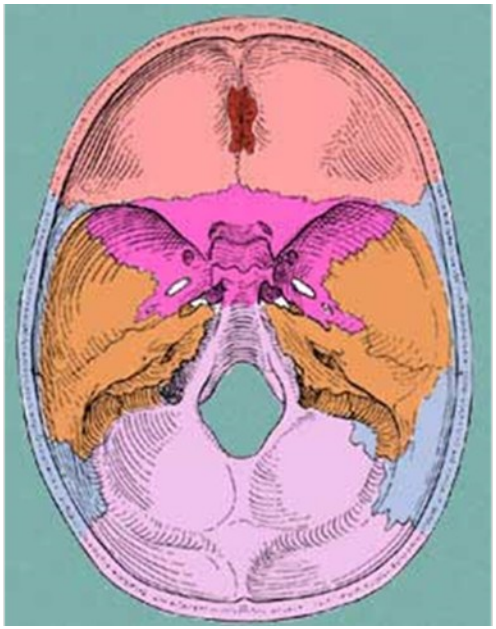
Sulci & Gyri


Central sulcus
Parietal lobe
Frontal lobe
Occipital lobe
Sylvian fissure
Temporal lobe
Cerebellum

The Brain: Lobes of the Cerebrum

- **Frontal lobes**: located in anterior cranial fossa
- **Temporal lobes**: in middle cranial fossa
- **Brainstem & Cerebellum**: in posterior cranial fossa
- **Occipital lobes**: rest on tentorium- cerebelli.







Cerebral Cortex

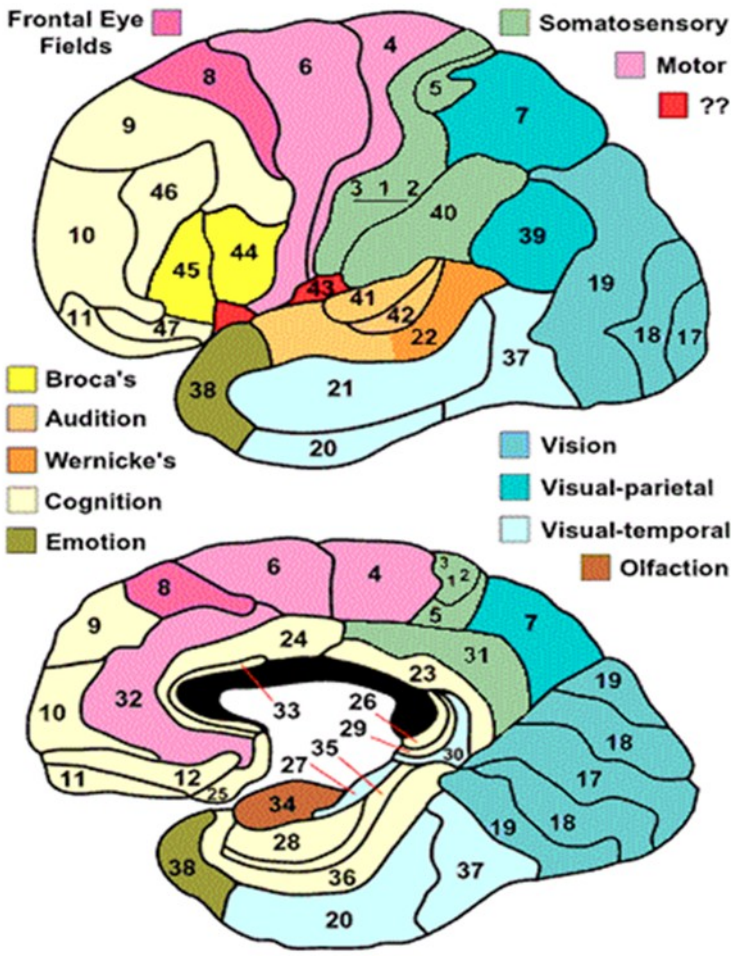
- **Three kinds** of functional areas:

1. **Motor areas** – control voluntary movement
2. **Sensory areas** – conscious awareness of sensation
3. **Association areas** – integrate diverse information, communicate “associate” with the motor cortex and sensory association areas to analyze input

Sensory & association areas

❖ **Primary Somatosensory cortex/area:**

- Located in the **postcentral gyrus** of the **parietal lobe**.
- It corresponds to **Brodmann's areas 1, 2 & 3)**
- Parts of cortex that receive **sensory inputs** from **thalamus**
- In general, the two hemispheres receive information from **opposite sides** of the body.
- For example: Rt primary **somatosensory cortex** receives information from Lt limbs & vice versa.



Conti…

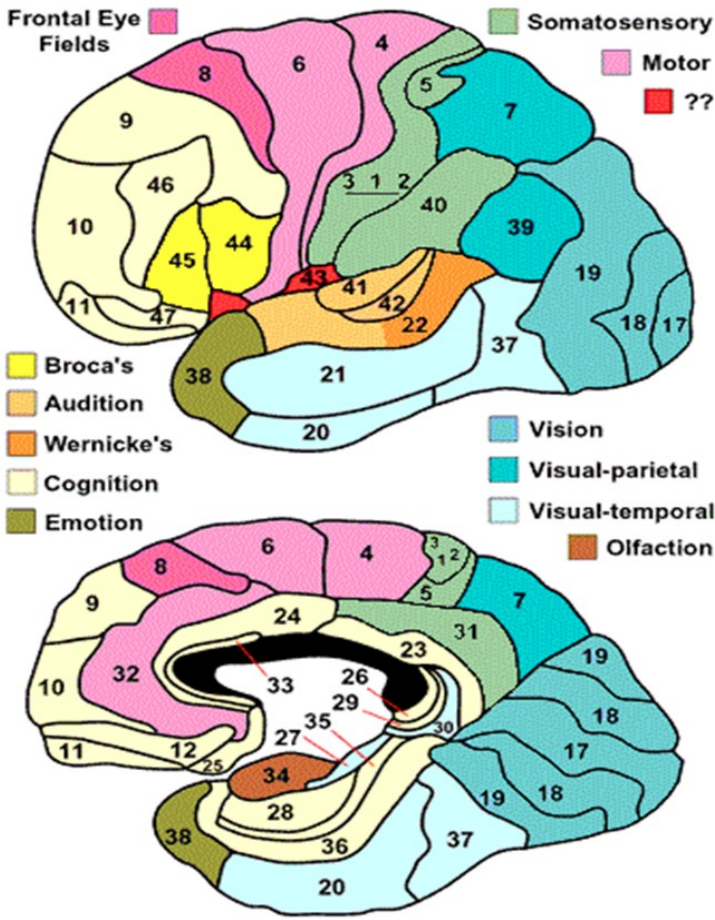
❖The **sensory association areas (B5, 7 & 40):**

- located behind **post-central gyrus**.
- Information is first processed in **primary sensory area** ⎓ then sent to secondary sensory areas.

Conti…

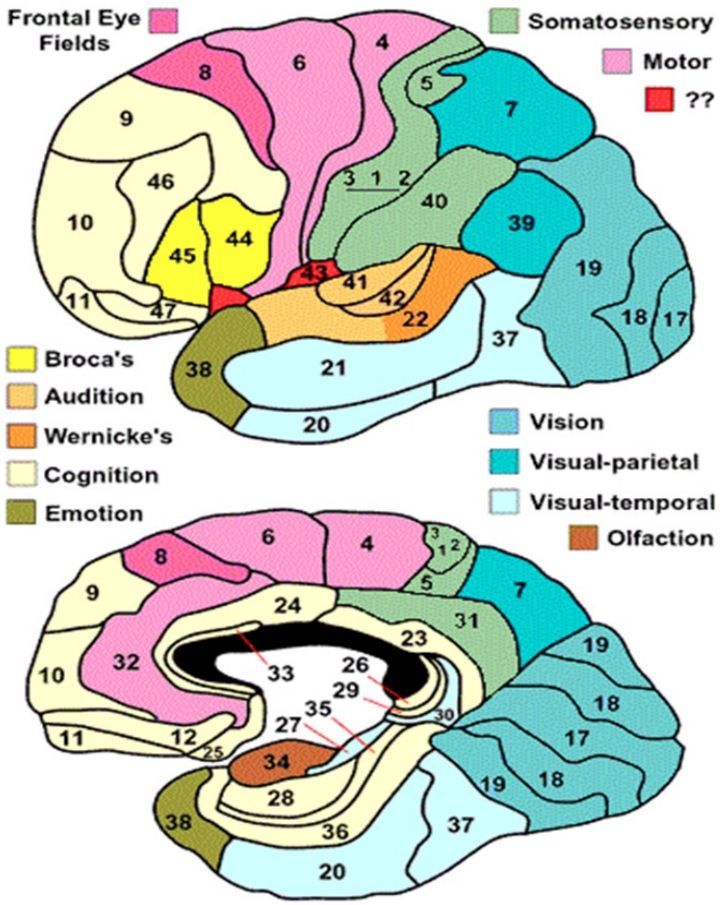
❖Primary Auditory Area

- It correspond to **Brodmann's areas 41 & 42.**
- Is the area where sound first reaches the brain ⇌ known as **primary auditory area.**



Conti…

- **Auditory Association Area (B22) or Wernicke's area**
- Is situated posterior to **primary auditory area**
- Involved in comprehension of speech/interpretation of sound information.



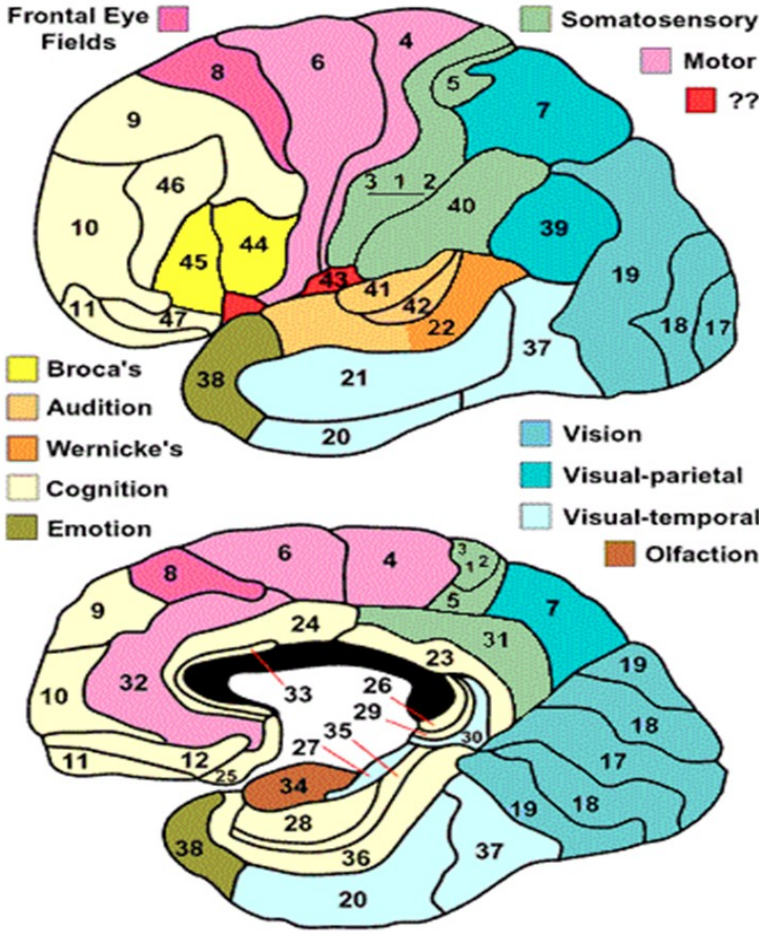
Conti…

1. Primary visual area (B17):

- Situated on either side of posterior part of calcarine sulcus.
- Receives input from thalamus via optic radiation.

2. Secondary /Association Visual Areas (B18 & 19):

- Surrounds primary visual area.
- Receives afferent fibers from area 17 & thalamus.
- integrates & interprets visual information, by relating current impulse to past experiences & knowledge.



Motor areas

- **Consists of:**

1. Primary (somatic) motor cortex
2. Premotor cortex
3. Broca's area
4. Frontal eye field

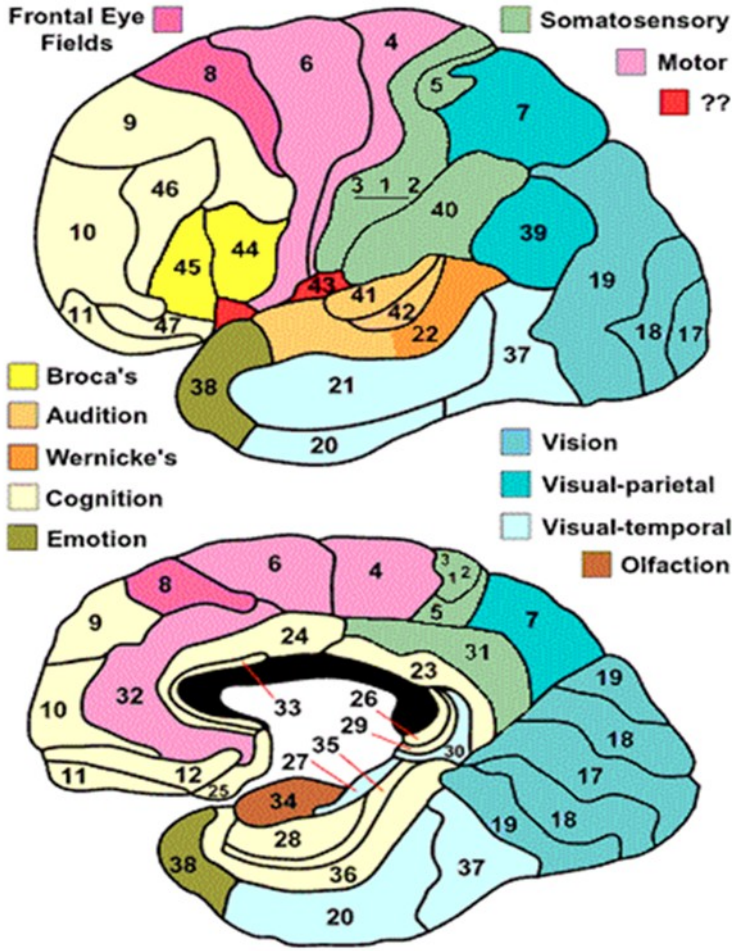
- Related to control of **voluntary movements**, especially fine movements performed by the hand.
- Rt half of ***motor area*** controls Lt side of the body & vice versa.

PRIMARY MOTOR CORTEX

❖**Primary (somatic) motor cortex**

- In precentral gyrus
- It corresponds to **Brodmann's area 4**

- It is here that actions are conceived and initiated.

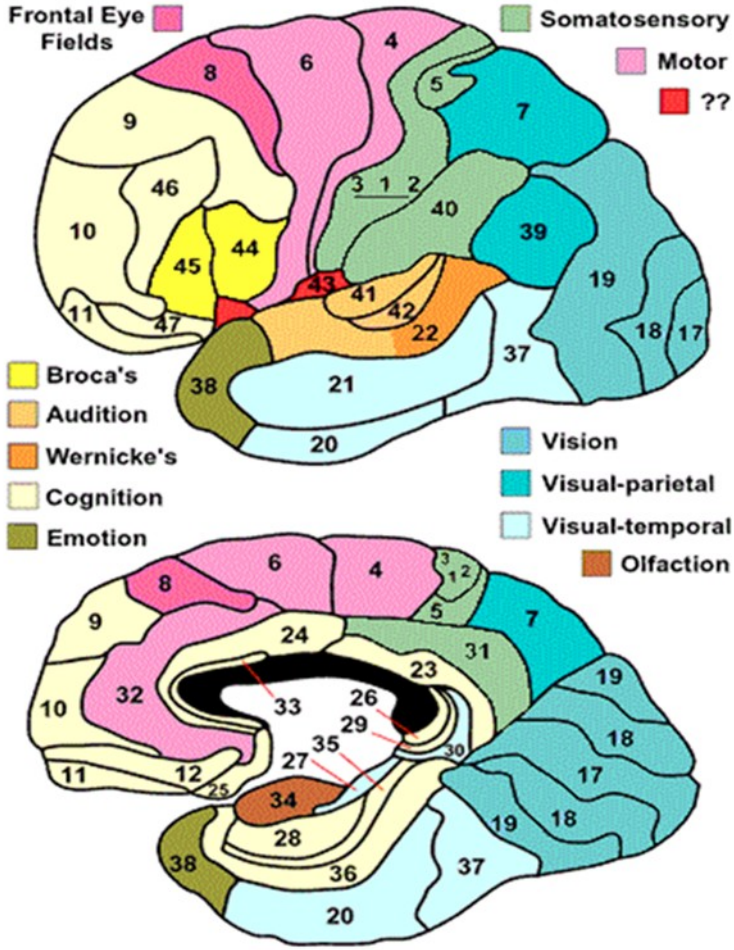


PREMOTOR CORTEX

- Lies anterior to primary motor cortex.
- **Brodmann's area 6**.

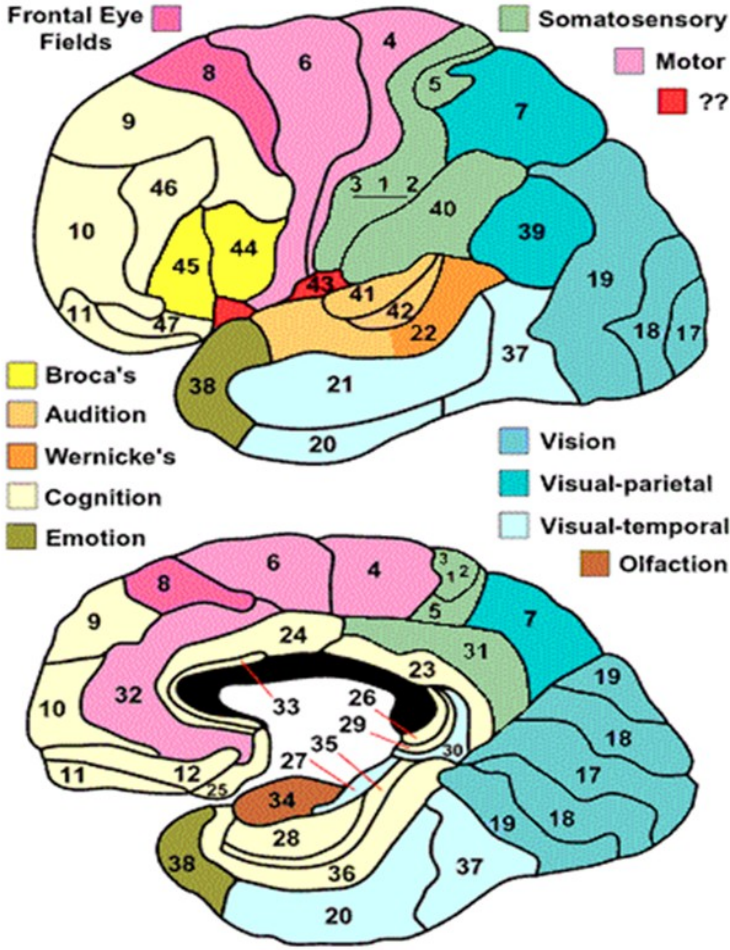
❖**Function:**

- *Programming & preparing for movement and control of posture.*



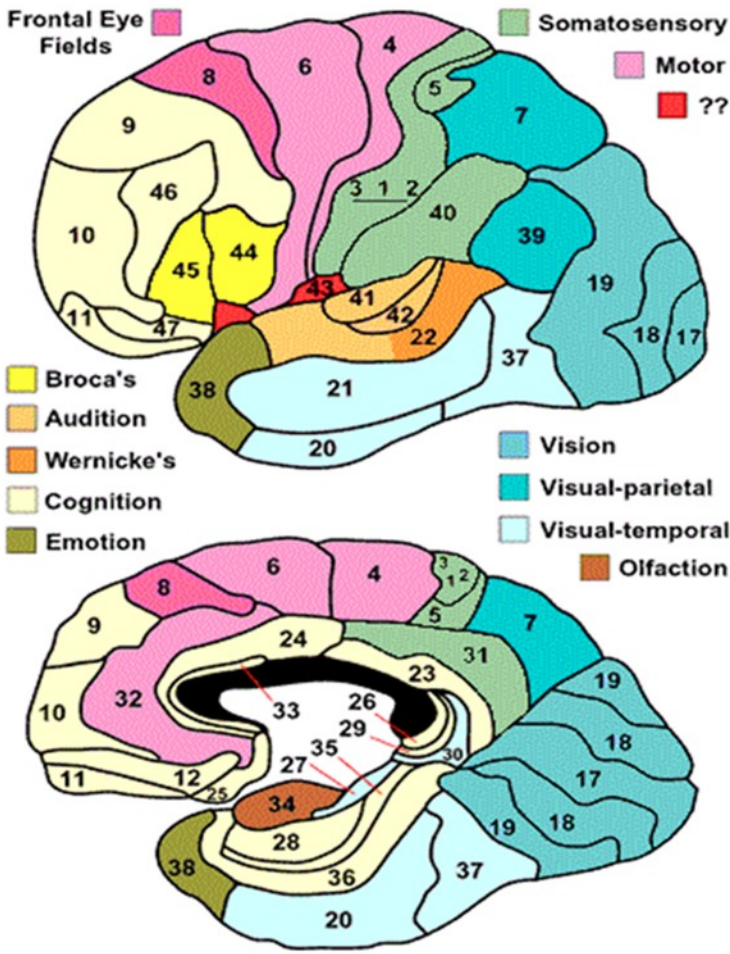
Broca's Area

- Located anterior to the inferior region of the **premotor area**
- Present in one hemisphere (usually the left)
- A motor speech area that directs muscles involved in **speech**
- Is active as one prepares to speak



Frontal Eye Field

- Located anterior to the **premotor cortex** and superior to **Broca's area.**
- **Brodmann's area 8**
- Controls **voluntary** eye movement

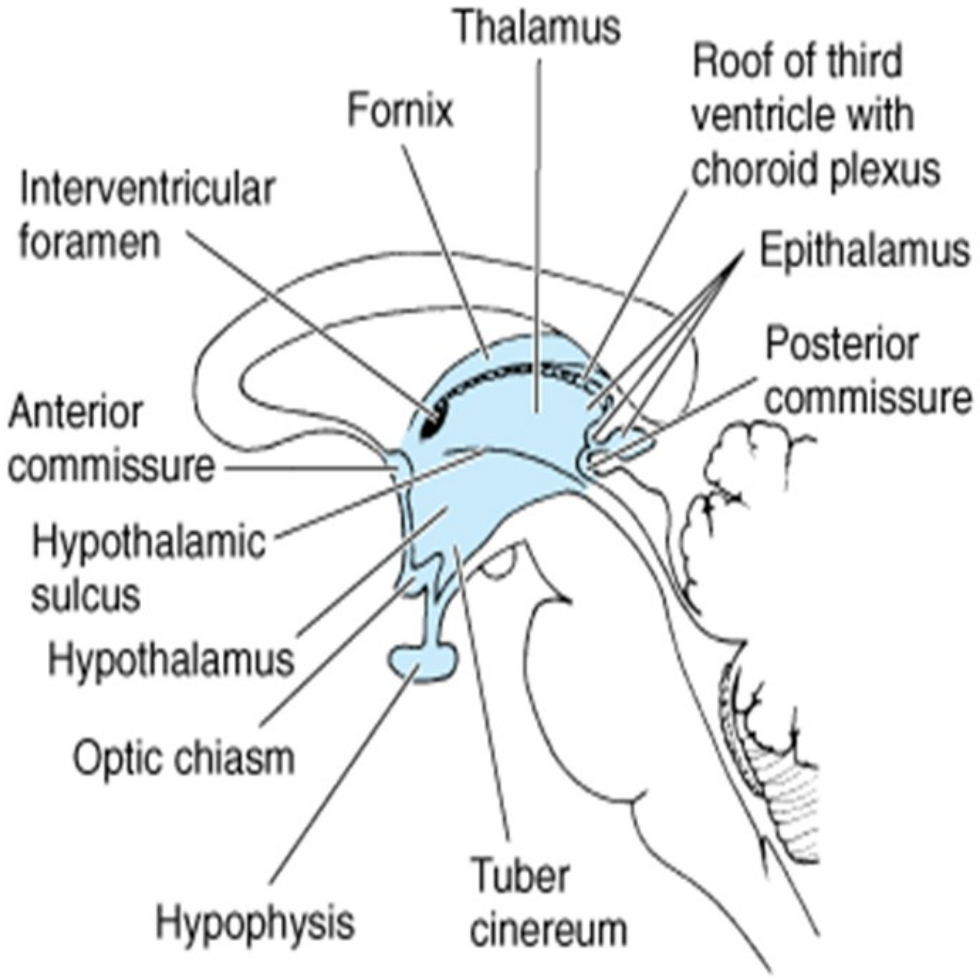


Diencephalon

- Region of brain, composed of thalamus & hypothalamus.
- Includes also epithalamus ⚌ Pineal gland, prethalamus or subthalamus.
- derived from the **prosencephalon**.
- located at midline of brain, b/n cerebral hemispheres, above mesencephalon.
- 3rd ventricle lies b/n the two halves of **diencephalon**.
- Best seen on mid-sagital view

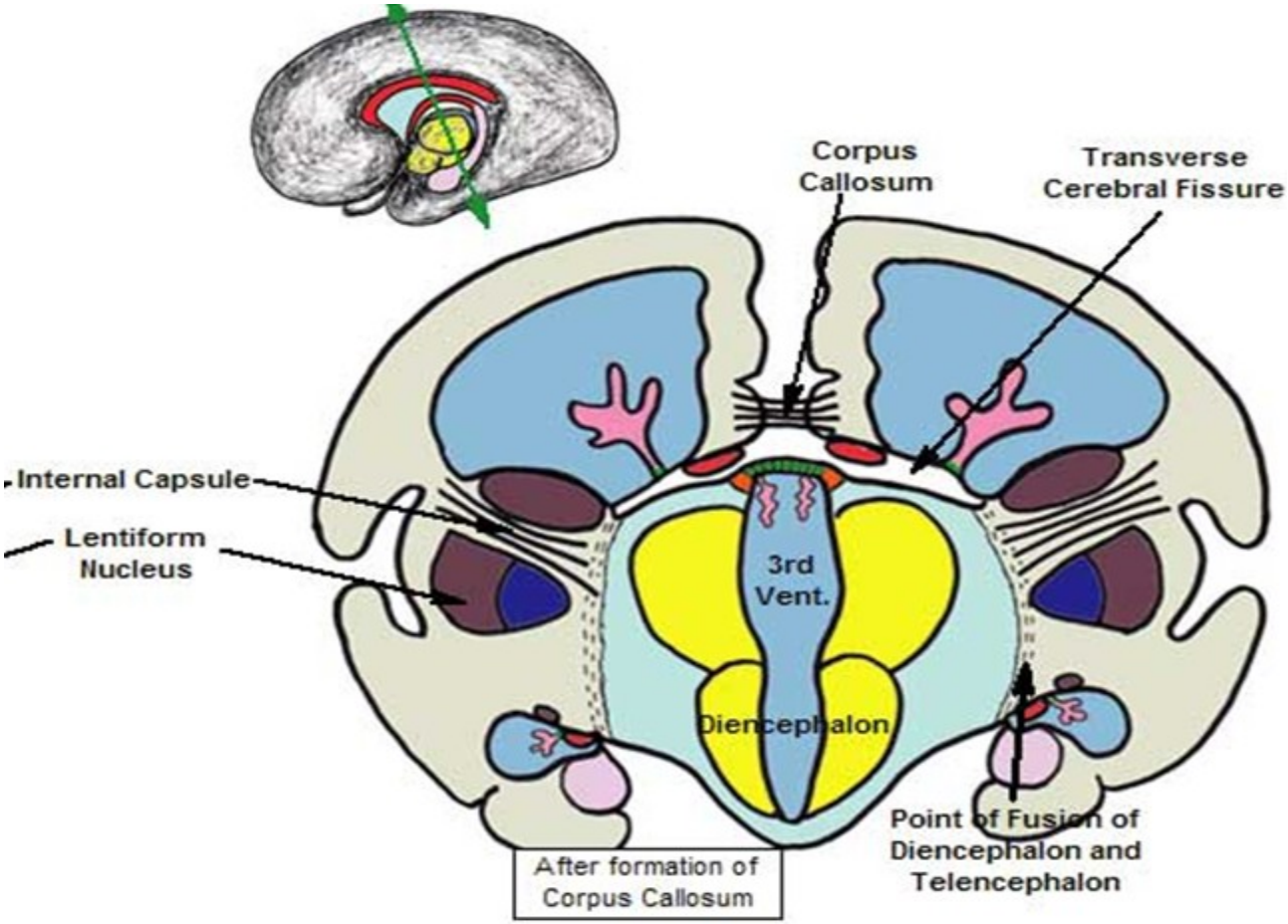
Diencephalon

- Extends posteriorly to **cerebral aquedact** & anteriorly to **interventricular foramen**.



The Thalamus

- A large, ovoid, gray matter on each half of brain
- Situated on each side of third ventricle.

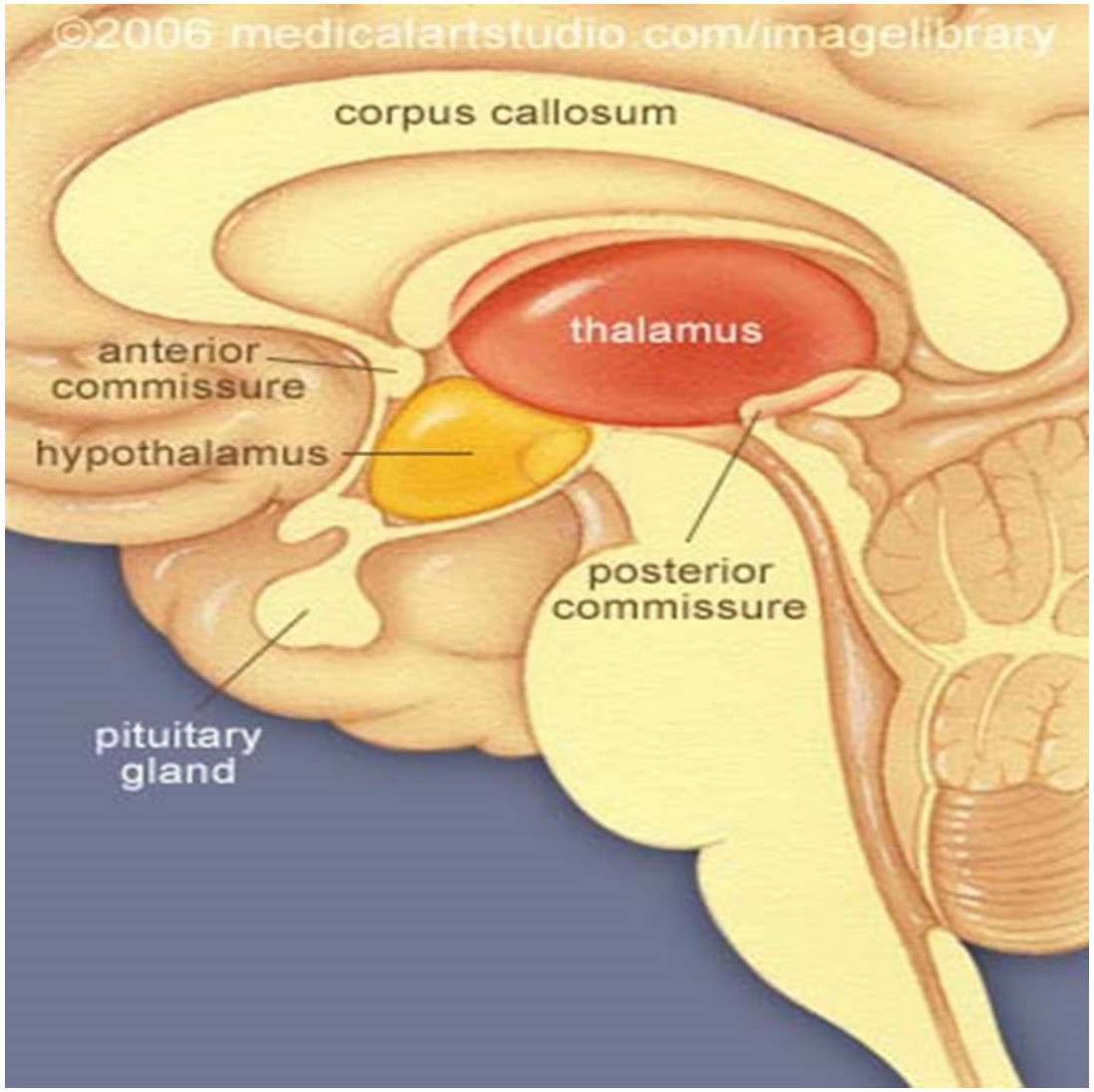


The Thalamus

❖ **Thalamus** :

- processes & relays sensory information to cerebral cortex.
- Relay center for sensory systems: auditory, **somatic**, visceral, **gustatory** & **visual system**, (except the olfactory function).
- Also has role in "motor" systems
- plays an important role in regulating states of sleep & wakefulness .
- plays a role in regulating arousal, level of awareness & activity.

Thalamus


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corpus callosum
thalamus
anterior commissure
hypothalamus
posterior commissure
pituitary gland

The hypothalamus

- A small cone-shaped structure, projecting downward, ending in **pituitary stalk**, a tubular connection to pituitary gland.

- located within **diencephalon** below thalamus just above the **brain-stem**.

- Links nervous system to endocrine system via pituitary gland (**hypophysis**).
- Regulates metabolic processes & activities of Autonomic Nervous System.

- Synthesizes & secretes **hypothalamic-releasing hormones**, which, in turn, stimulate or inhibit secretion of **pituitary hormones**.

The hypothalamus

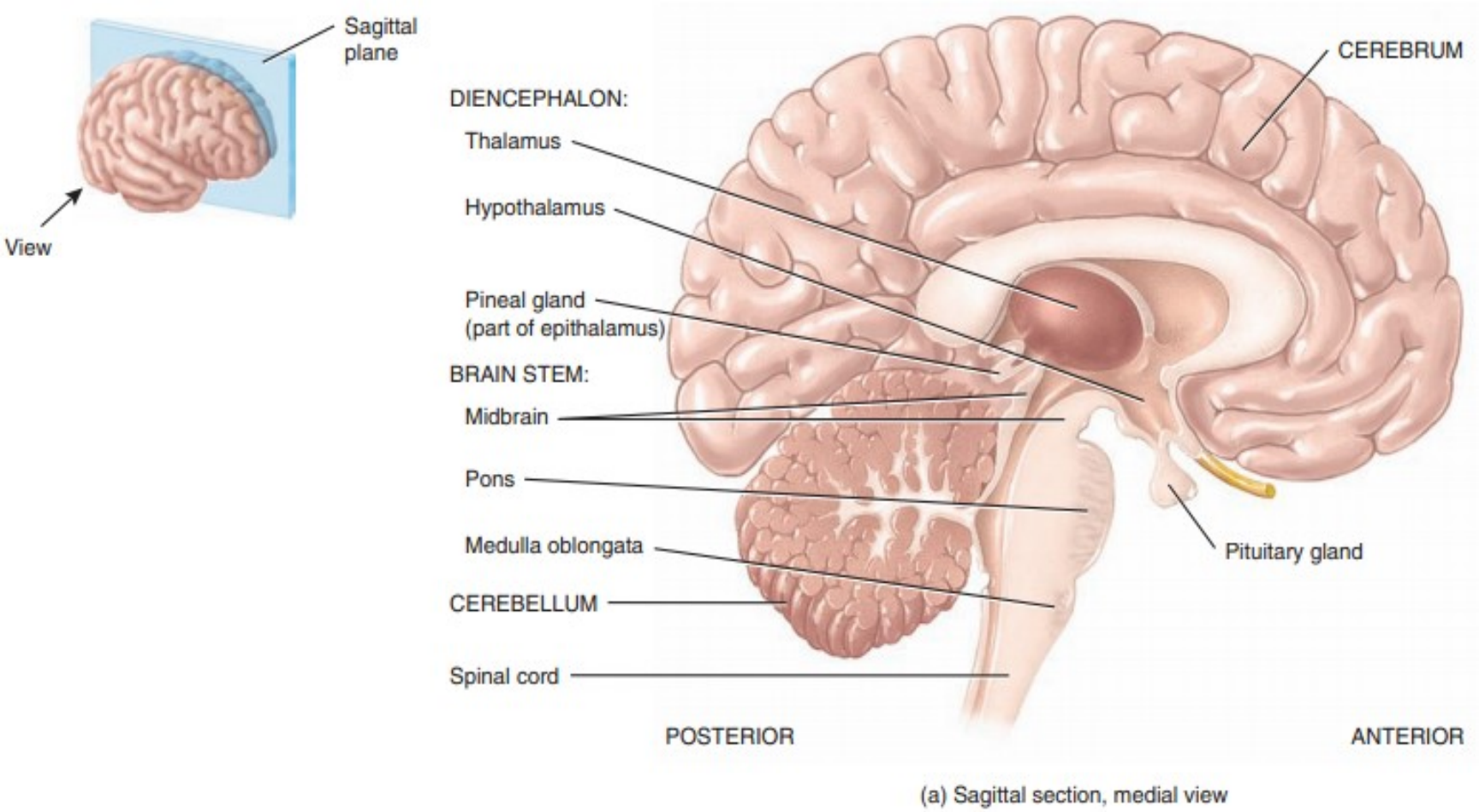
- **Hypothalamus** has important regulatory functions, including:
- Temperature
- Emotional regulation
- Growth (via thyroid stimulating hormone)
- Hunger and thirst
- Sexual behavior
- Defensive reactions: eg. fear
- Control of various endocrine and activity rhythms (via hormones)

Brain stem

- The **brain stem** is the part of the brain b/n the **spinal cord** and the **diencephalon**.
- It occupies posterior cranial fossa
- It consists of three structures:

1. Medulla oblongata
2. Pons and
3. Midbrain

Brain stem



(a) Sagittal section, medial view

Medulla Oblongata

- The medulla oblongata, is continuous with the superior part of the spinal cord.

- The medulla begins at the **foramen magnum** and extends to the inferior border of the **pons**, a distance of about 3 cm.

- The medulla's white matter contains all sensory (**ascending**) tracts and motor (**descending**) tracts that extend b/n the spinal cord and other parts of the brain.

MO

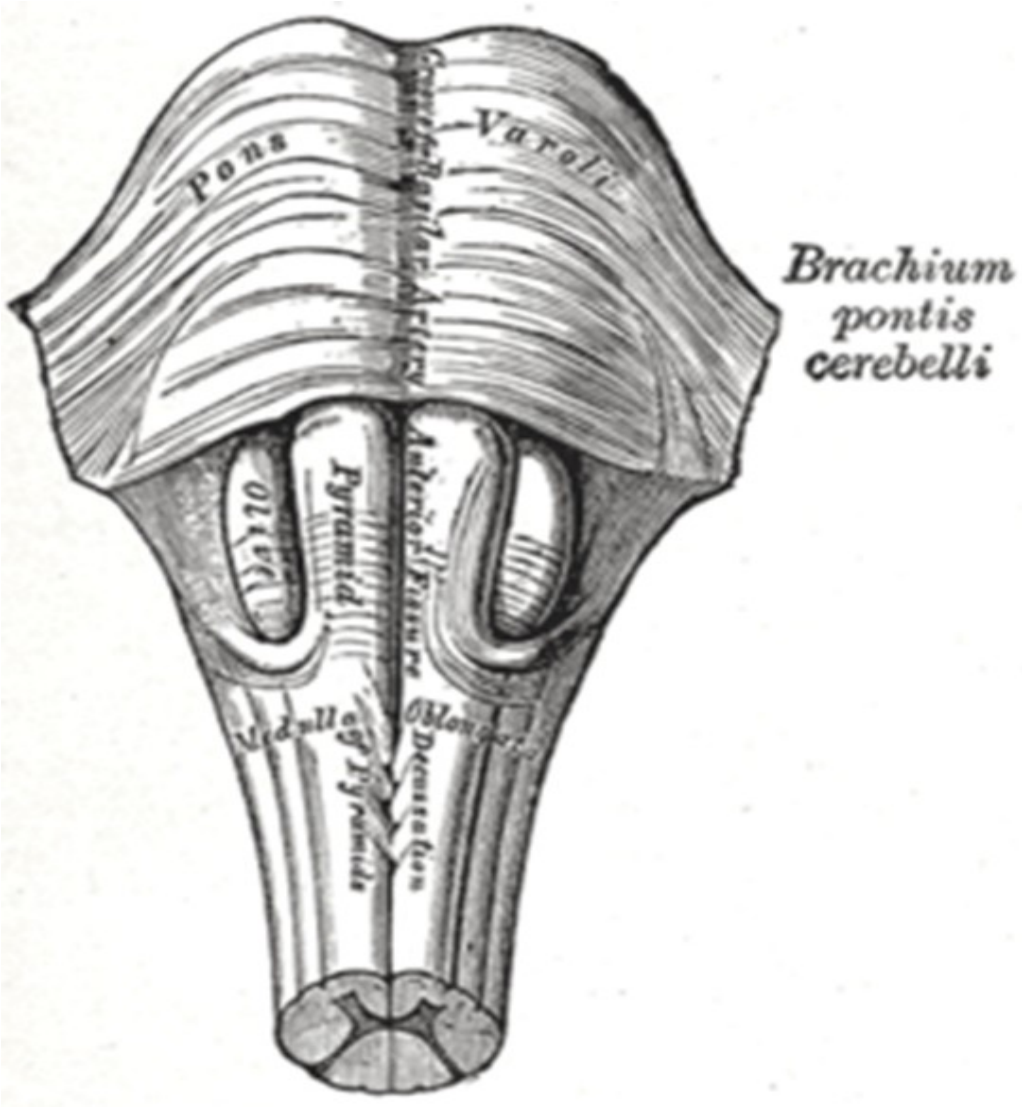
- It **Contains**:
- Cardiac & Respiratory Centers
- A portion of the fourth ventricle

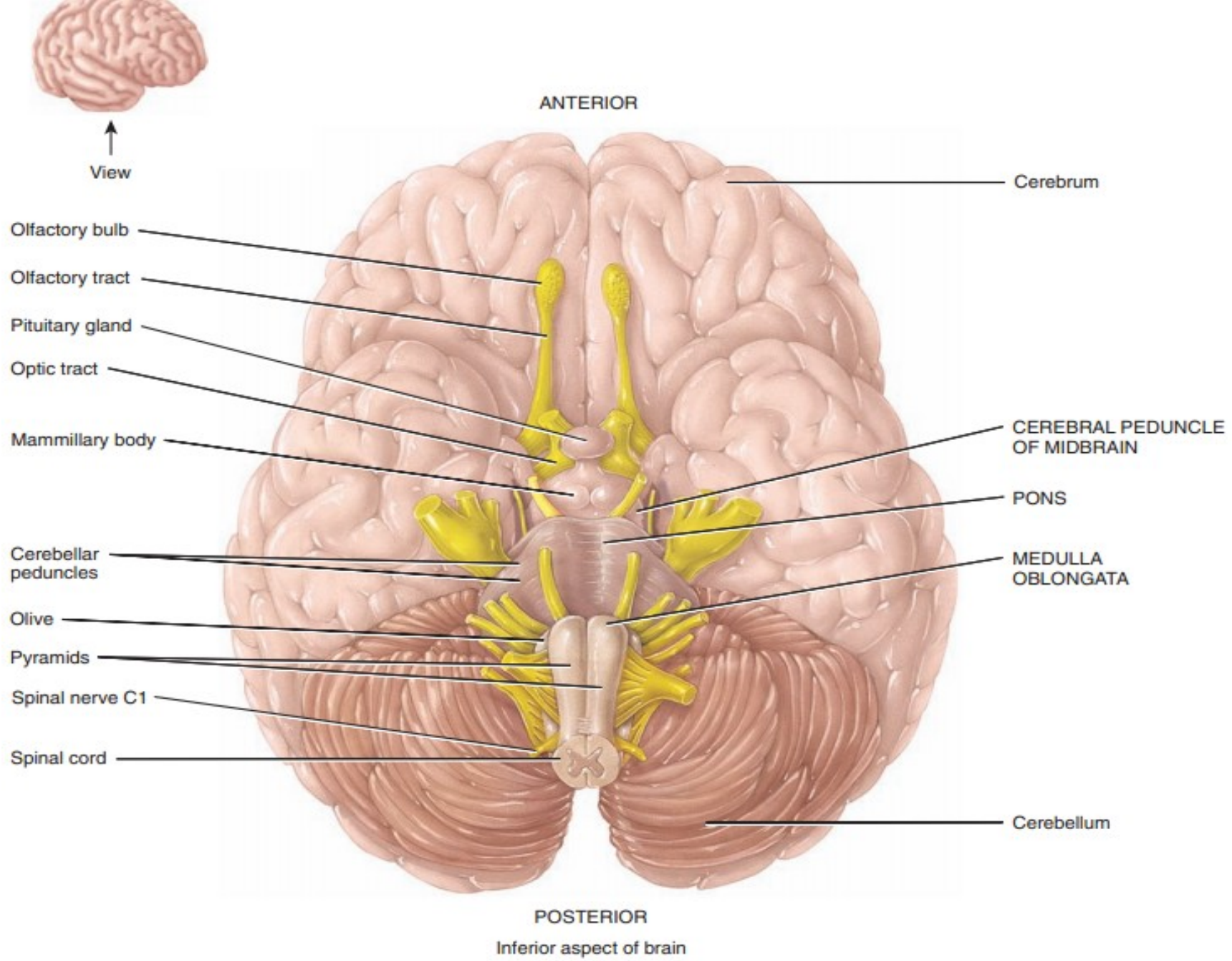
- It deals with autonomic functions (heart rate, blood pressure, respiration, vomiting, swallowing, sneezing, coughing, and hiccupping).

The Medulla

- White matter of the medulla forms bulges on the anterior aspect of the medulla, which is called the **pyramid**.
- It is formed by the large **corticospinal tracts** that pass from the **cerebrum** to the **spinal cord**.
- The corticospinal tracts control voluntary movements of the **limbs** and **trunk**.

MO


Pons
Varoli
Brachium
pontis
cerebelli
Olive
Pyramid
Anterior Fissure
Decussation



Inferior aspect of brain

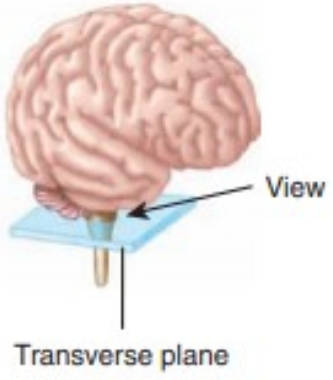
The Medulla

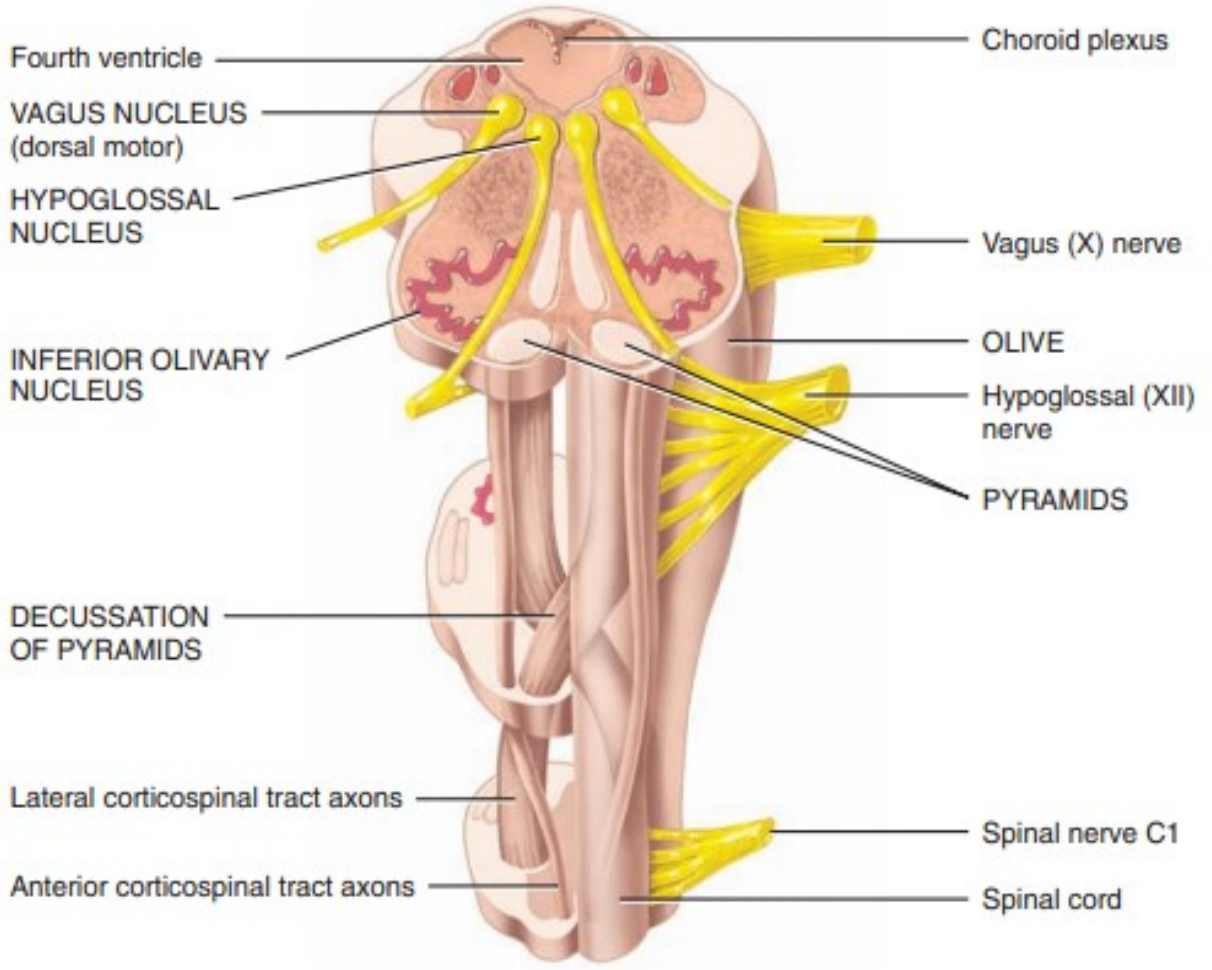
- Just superior to the junction of the medulla with the spinal cord, the axons in the left pyramid cross to the right side, and the axons in the right pyramid cross to the left side.

- This crossing is called the **decussation of pyramids**

- These explains why each side of the brain controls voluntary movements on the opposite side of the body.

MO





Transverse section and anterior surface of medulla oblongata

MO

- Just lateral to each pyramid is an oval-shaped swelling called an **olive**.

- Within the **olive** is the inferior olivary nucleus, which receives input from the cerebral cortex, the midbrain, and spinal cord.

- The **medulla** contains nuclei associated with cranial nerves of:
  - Vestibulocochlear (VIII) nerves
  - Glossopharyngeal (IX) nerves
  - Vagus (X) nerves
  - Accessory (XI) nerves (cranial portion)
  - Hypoglossal (XII) nerves

PONS

- The pons (bridge) lies directly superior to the medulla and anterior to the cerebellum and is about 2.5 cm long.
- As its name implies, the pons is a bridge that connects parts of the brain with one another.
- These connections are provided by bundles of **axons**.
- Some axons of the **pons** connect the right and left sides of the **cerebellum**. Others are part of ascending sensory tracts and descending motor tracts.

PONS

- The pons has two major structural components:
- a ventral region and a dorsal region.
- The **ventral region of the pons** forms a large synaptic relay station consisting of scattered gray centers called the **pontine nuclei**.

- Entering and exiting pontine nuclei are numerous **white matter tracts**, each of which provides a connection b/n the **cerebral cortex** and the **cerebellum**.

- This complex circuitry plays an essential role in **coordinating** and **maximizing** the efficiency of voluntary motor output throughout the body.

PONS

- The **dorsal region of the pons** is contains **ascending** and **descending** tracts along with the nuclei of cranial nerves.
- The pons also contains nuclei associated with the following four pairs of cranial nerves:
  - Trigeminal (V) nerves
  - Abducens (VI) nerves
  - Facial (VII) nerves
  - Vestibulocochlear (VIII) nerves

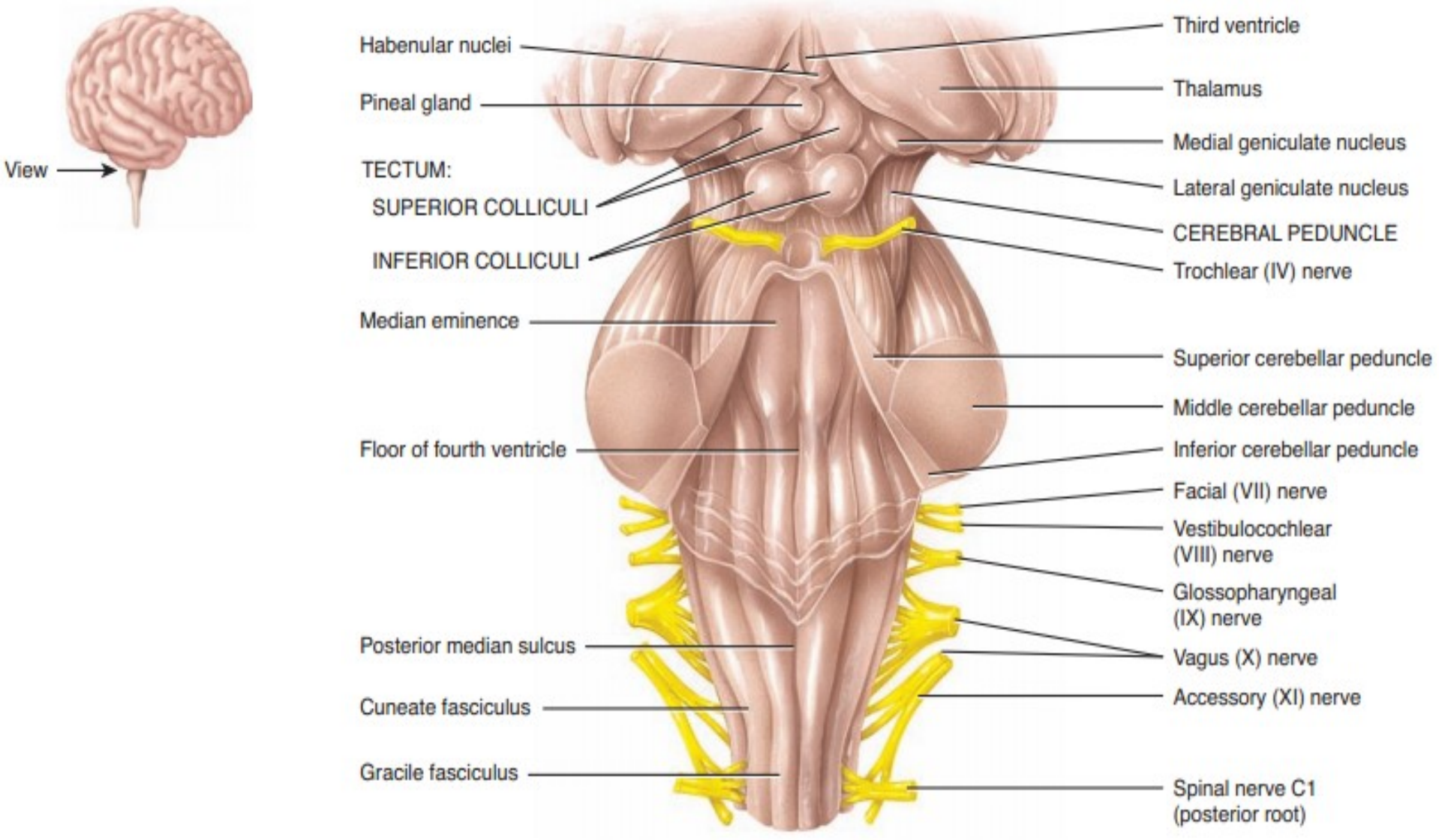
Midbrain

- The **midbrain** or **mesencephalon** extends from the **pons** to the **diencephalon** and is about 2.5 cm long.

- The **aqueduct** of the midbrain (**cerebral aqueduct**) passes through the midbrain, connecting the **third ventricle** above with the **fourth ventricle** below.

Figure 14.7 Midbrain.

6 The midbrain connects the pons to the diencephalon.



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

Midbrain

- The anterior part of the midbrain contains paired bundles of axons known as the cerebral peduncles.
- The cerebral **peduncles** consist of axons of the **corticospinal**, **corticobulbar**, and **corticopontine** tracts, which conduct nerve impulses from motor areas in the cerebral cortex to the spinal cord, medulla, and pons, respectively.

Midbrain

- The posterior part of the midbrain, called the **tectum,** contains four rounded elevations:

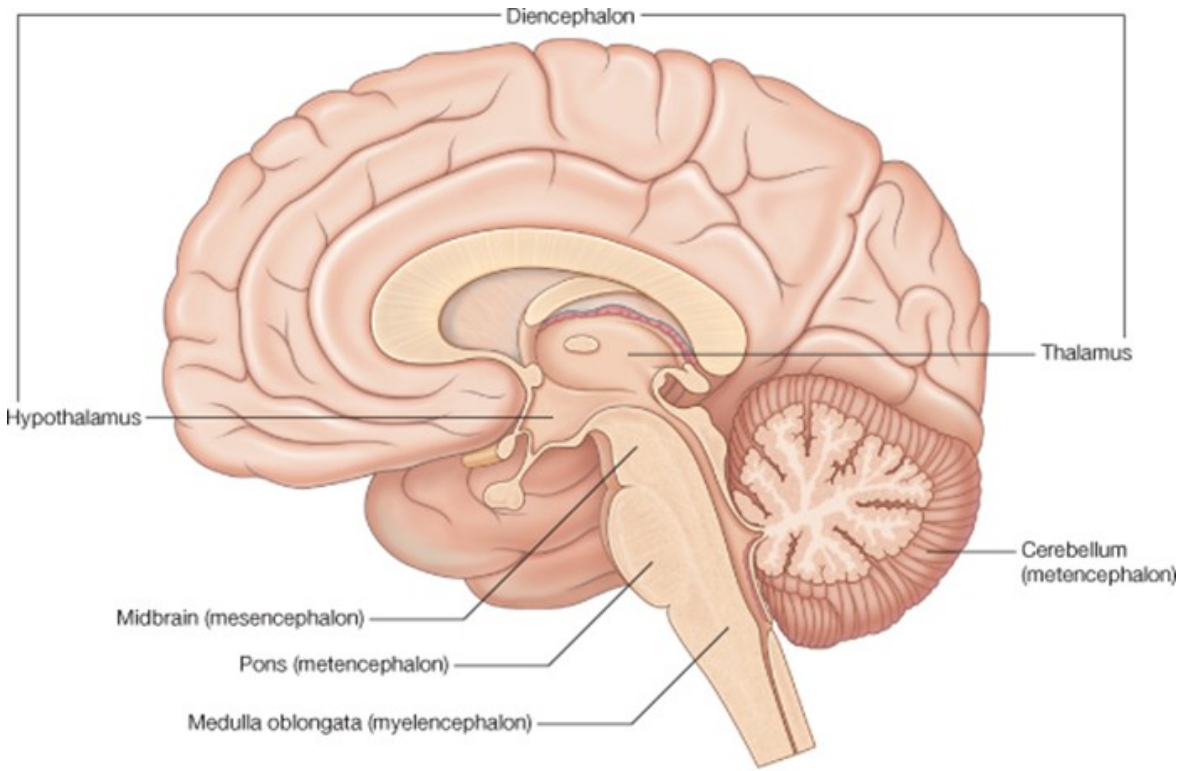
✓ The two **superior colliculi**, nuclei known as the reflex centers for certain **visual** activities.

✓ The **inferior colliculi**, are part of the auditory pathway, relaying impulses from the receptors for **hearing** in the inner ear to the brain.

✓ Nuclei that are located in midbrain which are associated with cranial nerves are:

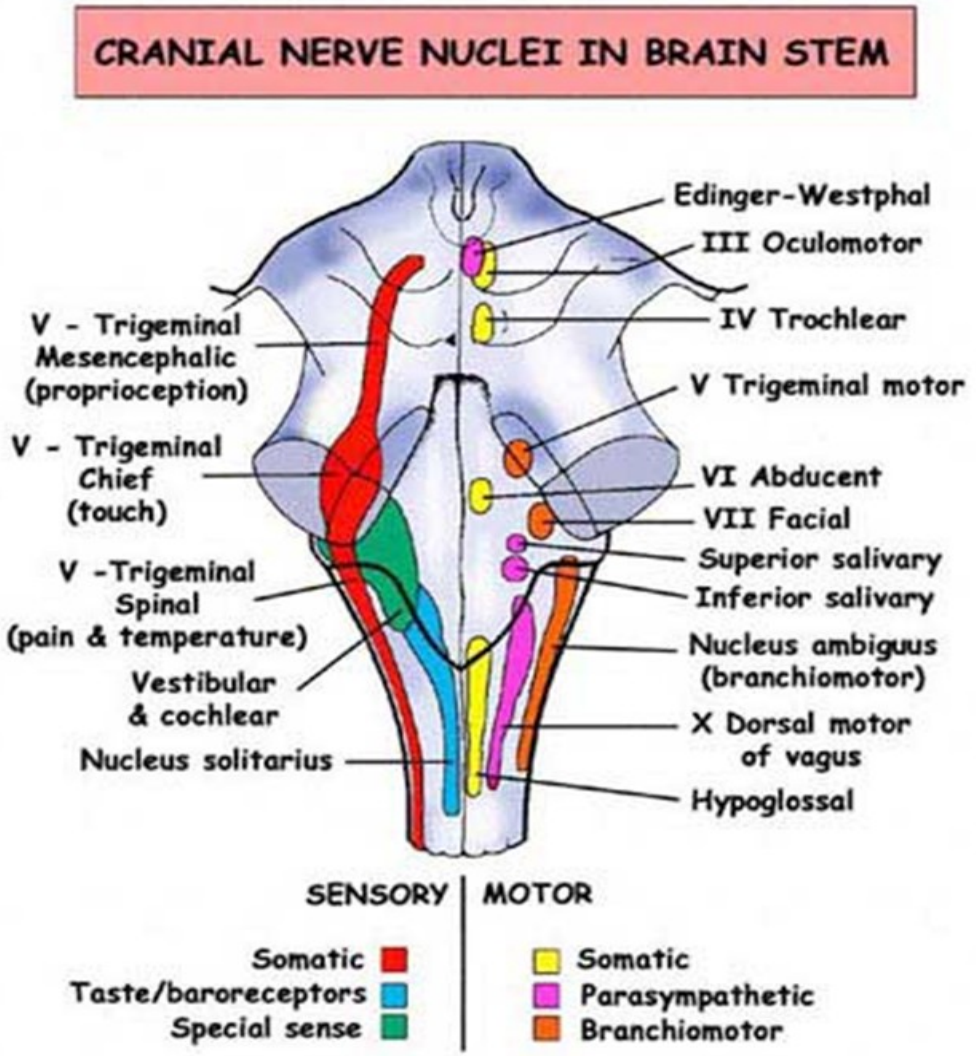
- Oculomotor (III) nerves
- Trochlear (IV) nerves

Brainstem

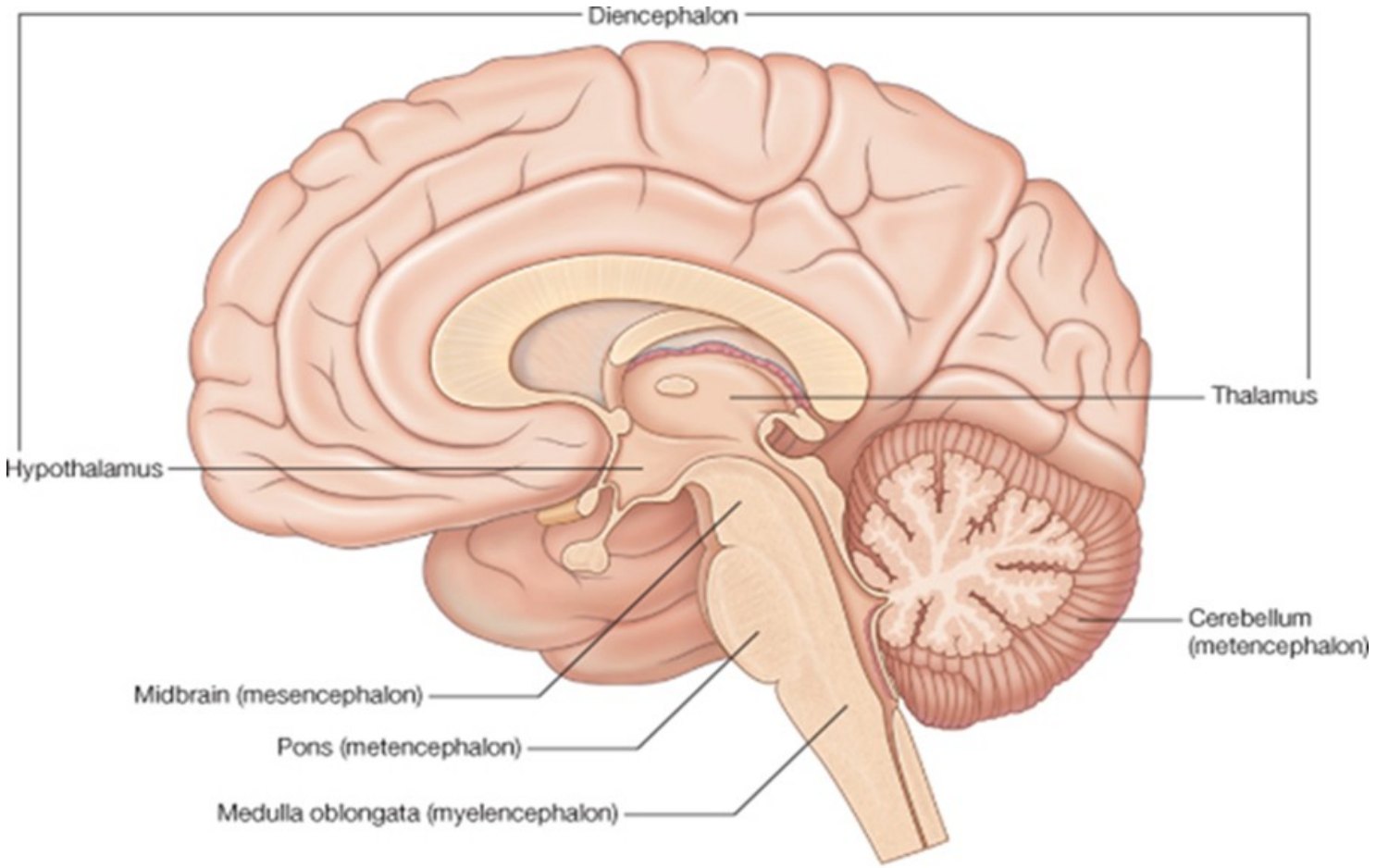


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The Pons

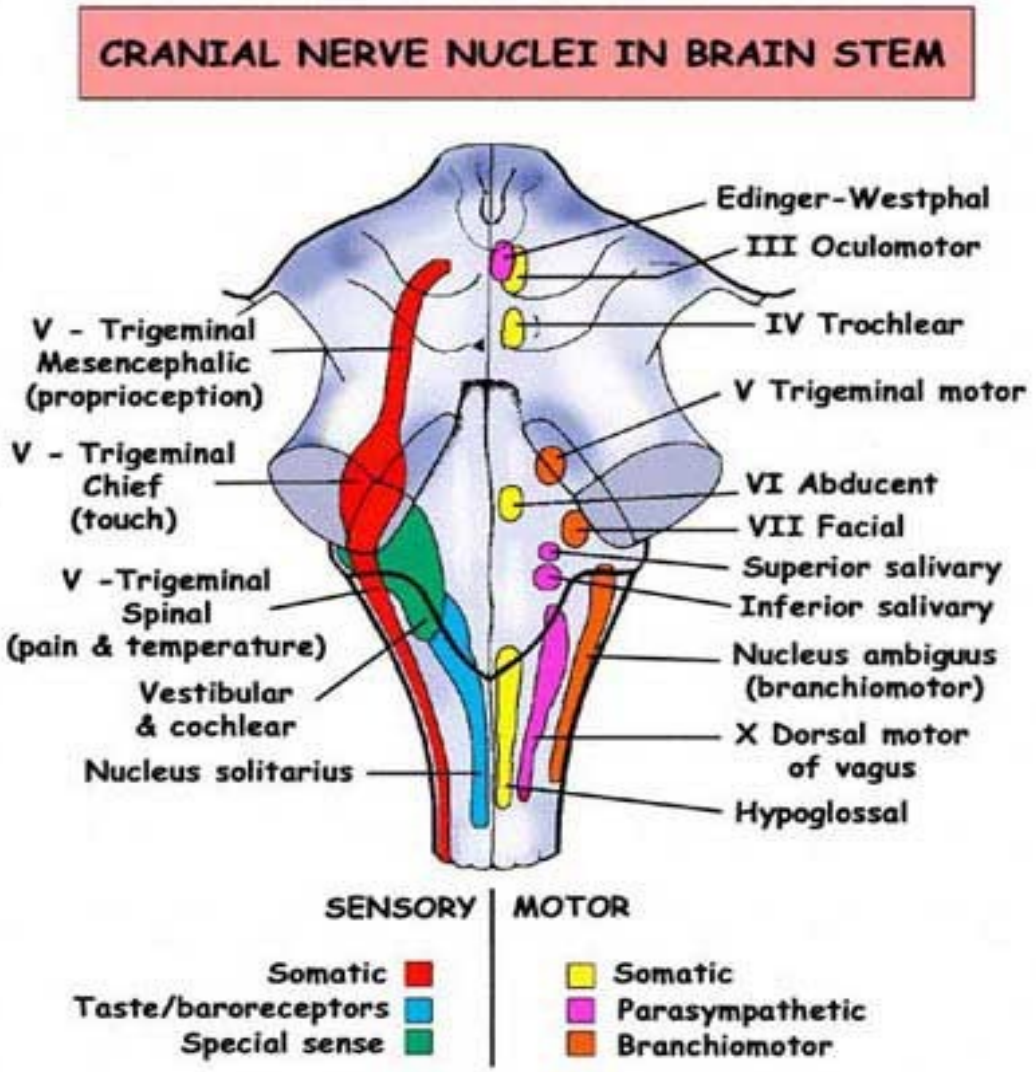

CRANIAL NERVE NUCLEI IN BRAIN STEM
Edinger-Westphal
III Oculomotor
IV Trochlear
V Trigeminal motor
VI Abducent
VII Facial
Superior salivary
Inferior salivary
Nucleus ambiguus (branchiomotor)
X Dorsal motor of vagus
Hypoglossal
V - Trigeminal Mesencephalic (proprioception)
V - Trigeminal Chief (touch)
V -Trigeminal Spinal (pain & temperature)
Vestibular & cochlear
Nucleus solitarius
SENSORY
MOTOR
Somatic
Taste/baroreceptors
Special sense
Somatic
Parasympathetic
Branchiomotor

Medulla oblongata



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MO


CRANIAL NERVE NUCLEI IN BRAIN STEM
Edinger-Westphal
III Oculomotor
IV Trochlear
V Trigeminal motor
VI Abducent
VII Facial
Superior salivary
Inferior salivary
Nucleus ambiguus (branchiomotor)
X Dorsal motor of vagus
Hypoglossal
V - Trigeminal Mesencephalic (proprioception)
V - Trigeminal Chief (touch)
V -Trigeminal Spinal (pain & temperature)
Vestibular & cochlear
Nucleus solitarius
SENSORY
MOTOR
Somatic
Taste/baroreceptors
Special sense
Somatic
Parasympathetic
Branchiomotor

Limbic System

❖**The Limbic System:**

- an interconnected system of brain nuclei associated with **basic needs & emotions** such as **hunger**, **pain**, **pleasure**, **satisfaction**, **sex**, and instinctive motivation.
- consists of brain structures including:
  - ***Amygdala***
  - ***Hippocampus***
  - ***Fornix***
  - ***Mammilary bodies***
  - ***Hypothalamus***
- most primitive part of brain, close to inner wall of each cerebral hemisphere:
- includes brain system concerned with **sense of smell**.
- The limbic system operates by influencing the **endocrine system** & **autonomic nervous system**.

- highly interconnected with the **nucleus accumbens**, the **brain's pleasure** center

The limbic system (LS)

1. **Amygdala**

- almond-shaped groups of neurons located deep within the medial temporal lobes.
- Shown in research to perform a primary role in processing & ***memory*** of ***emotional reactions***, such as those related to ***fear, anger & aggression*** in addition to social functions such as ***mating***.

2. **Hippocampus**

- a curved ridge of tissue in each cerebral hemisphere of the brain,
  - **associated with memory**
- Required for the formation of **long-term memories**

LS

3. Cingulate gyrus

- Autonomic functions regulating heart rate, blood pressure and cognitive & attentional processing.

4. Fornix

- carries signals from the hippocampus to the mammillary bodies

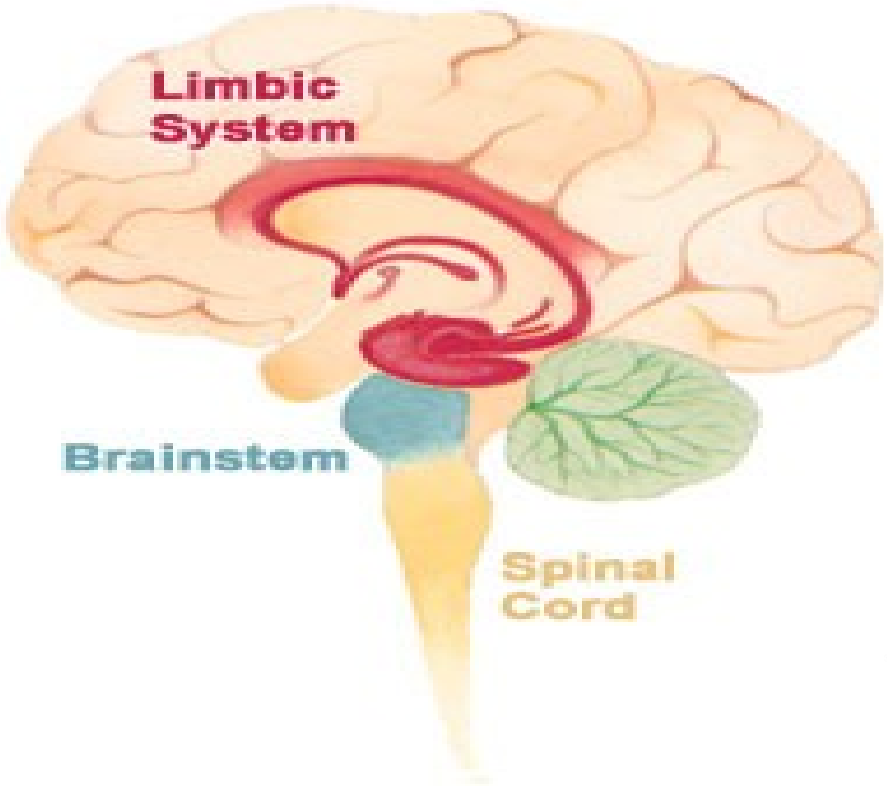
5. Mammillary body

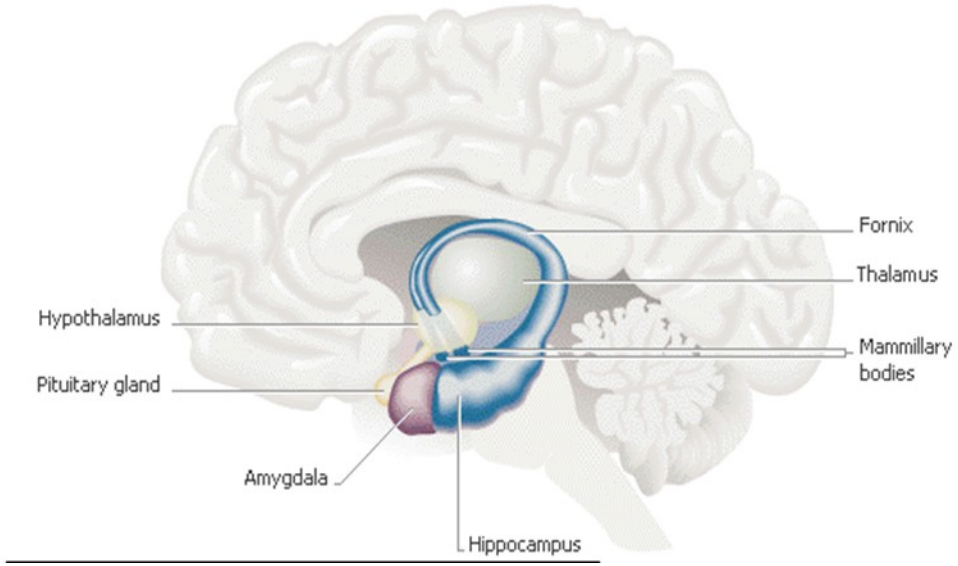
- Important for the formation of memory

6. Nucleus accumbens

- Involved in reward, pleasure, and addiction

Limbic system





Cerebellum

- The **cerebellum**: ⅟₁₁ 2nd largest
- important role in integration of sensory perception & motor control.
- to coordinate motor control of movement, there are many neural pathways linking cerebellum with: cerebral motor cortex (which sends info. to muscles), spinocerebellar tract (which provides proprioceptive feedback on body position in space) & with Vestibular System.

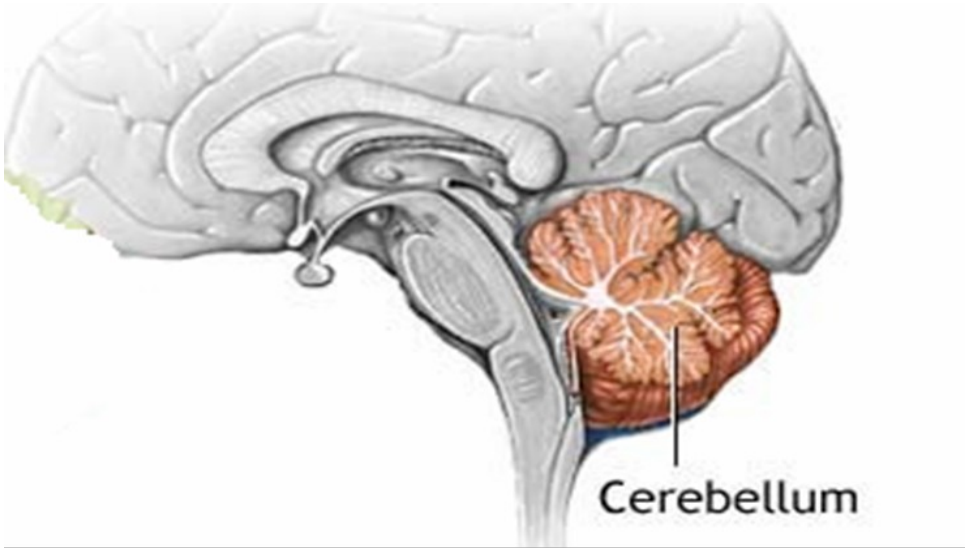
- ***Cerebellum*** integrates these pathways using constant feedback on body position to fine-tune motor movements.
- Cerebellar lesions are not debilitating as to cause paralysis, but cause feedback deficits resulting in disorders in fine movement, equilibrium, & posture.

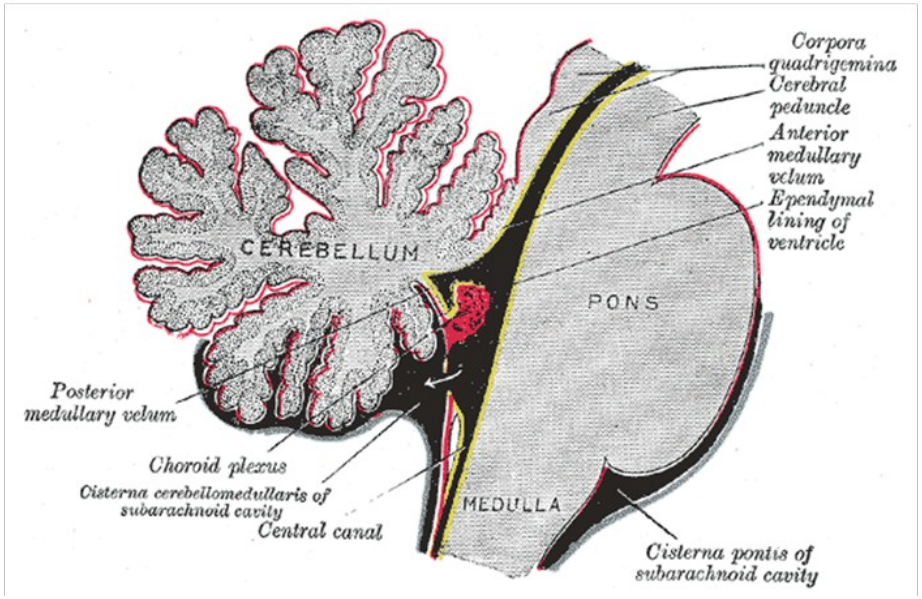
Cerebellum

➢ Cerebellum/Little Brain

- Location:
  - Posterior cranial fossa inferior to ***occipital lobe***
  - Posterior to 4th ventricle, pons &medulla
- Consists of two hemispheres, connected by the ***Vermis*** (central portion).
- Connected to posterior part of brain stem by three bundles of nerve fibers ⇊ **CPs.**

Cerebellum


Cerebellum


Corpora quadrigemina
Cerebral peduncle
Anterior medullary velum
Ependymal lining of ventricle
CEREBELLUM
PONS
Posterior medullary velum
Choroid plexus
Cisterna cerebellomedullaris of subarachnoid cavity
Central canal
MEDULLA
Cisterna pontis of subarachnoid cavity

Functions of cerebellum

- **Cerebellum** is a great reservoir for **proprioceptive** information from:
  - Body
  - Supraspinal cranial nerves
- It serves as:
  1. A coordinator of motor activity
  2. A regulator of muscle tone
  3. Functions to maintain balance and equilibrium
  4. Participates in motor planning

Meninges

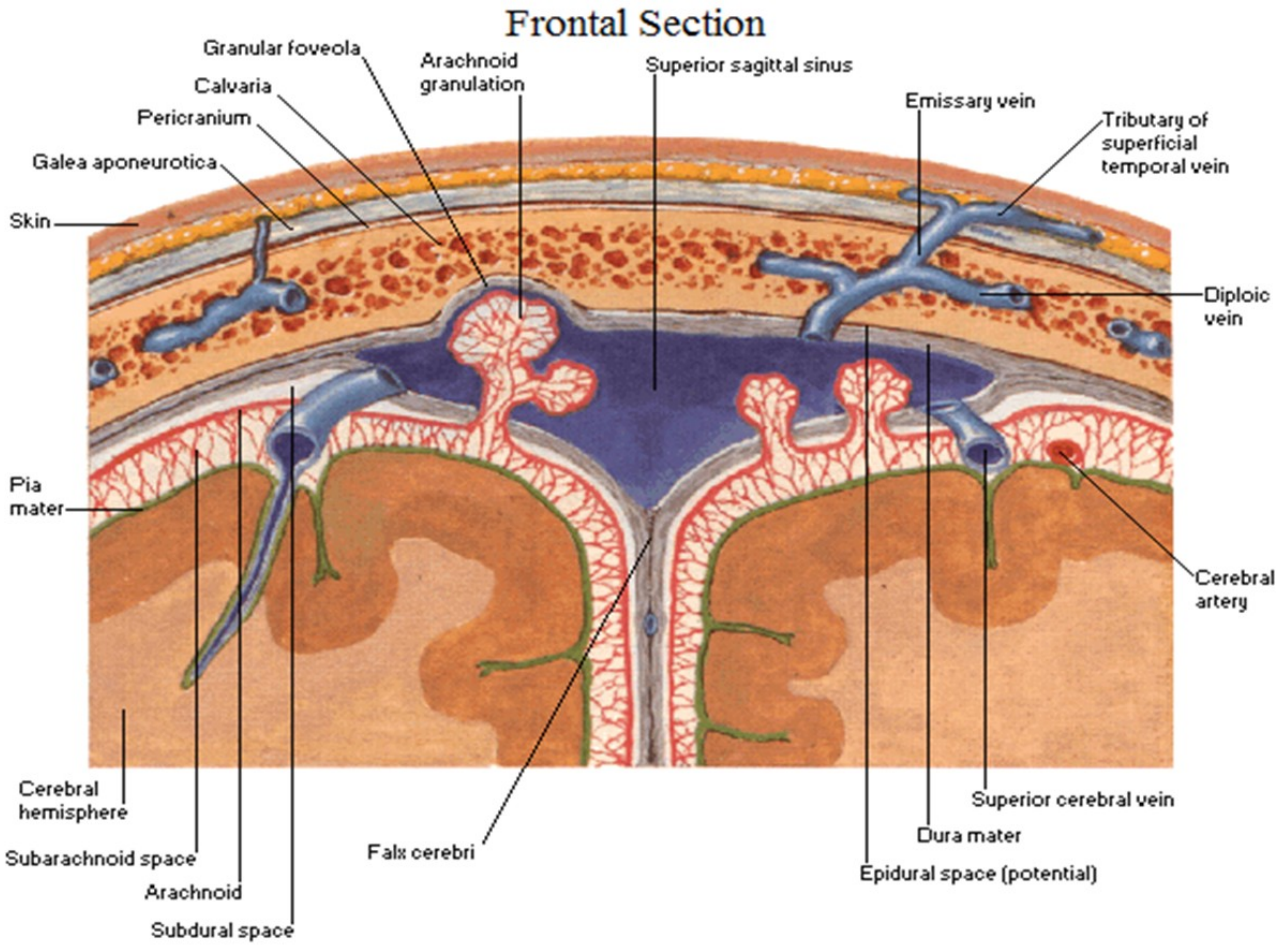
- The meninges are three connective tissue membranes that lie just external to the central nervous system organs
- Functions
  - Cover and protect the CNS organs
  - Protect blood vessels and enclose venous sinuses
  - Contain cerebrospinal fluid
  - Form partitions within the skull
- From external to internal, the meningeal layers are
  - Dura mater
  - Arachnoid
  - Pia mater

MENINGES

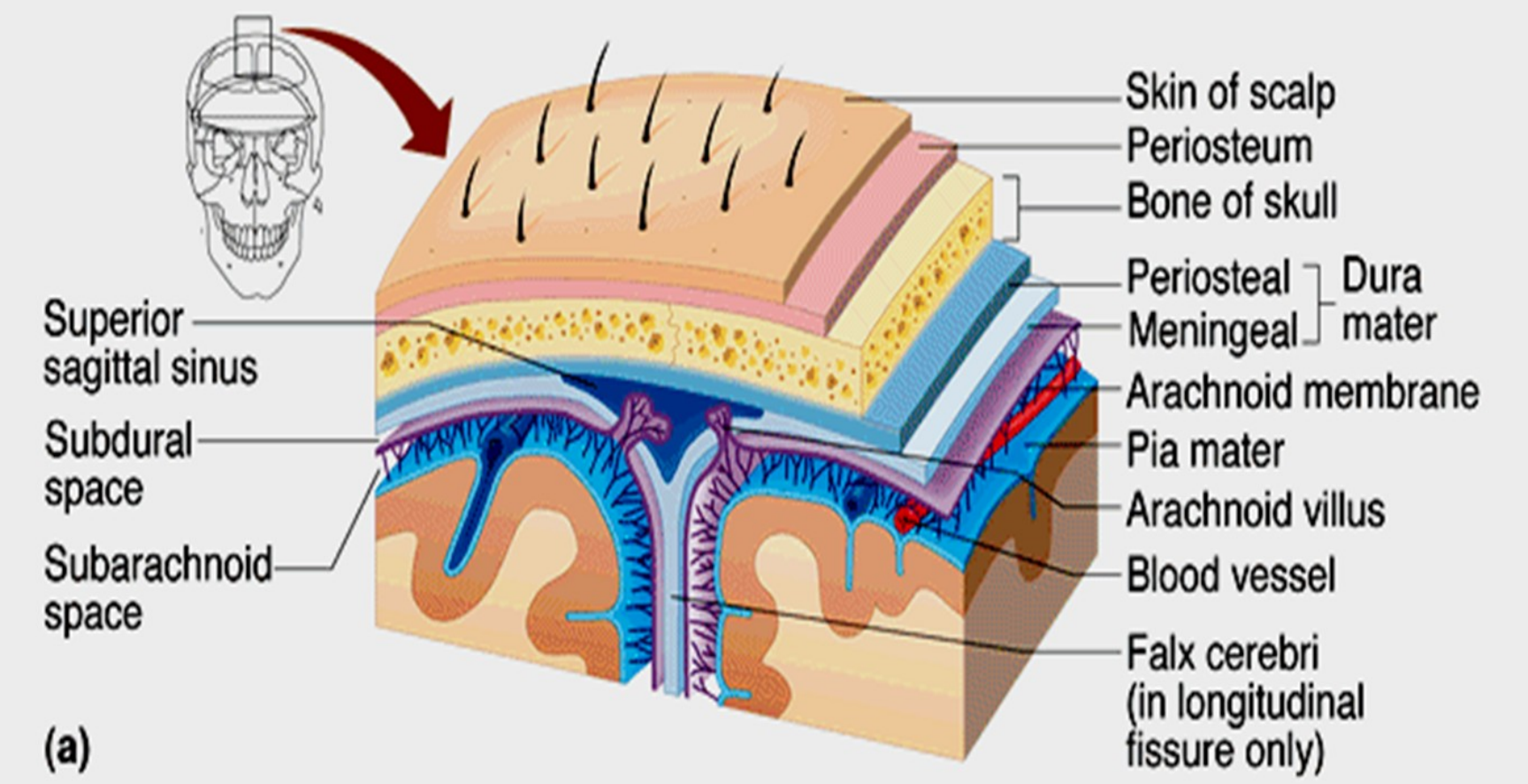
- brain & spinal cord surrounded by three layers of membranes (**meninges)** ⁼
- a tough, outer layer (**dura mater**),
- a delicate, middle layer (**arachnoid mater**),
- an inner layer firmly attached to surface of brain (the **pia mater**).

- cranial meninges are continuous with spinal meninges thru **foramen magnum**.

MENINGES


Frontal Section
Granular foveola
Arachnoid granulation
Superior sagittal sinus
Calvaria
Pericranium
Emissary vein
Tributary of superficial temporal vein
Galea aponeurotica
Skin
Diploic vein
Pia mater
Cerebral artery
Cerebral hemisphere
Superior cerebral vein
Subarachnoid space
Falx cerebri
Dura mater
Arachnoid
Epidural space (potential)
Subdural space

Meninges


Skin of scalp
Periosteum
Bone of skull
Periosteal
Meningeal
Dura mater
Arachnoid membrane
Pia mater
Arachnoid villus
Blood vessel
Falx cerebri (in longitudinal fissure only)
Superior sagittal sinus
Subdural space
Subarachnoid space
(a)

Ventricles of the Brain

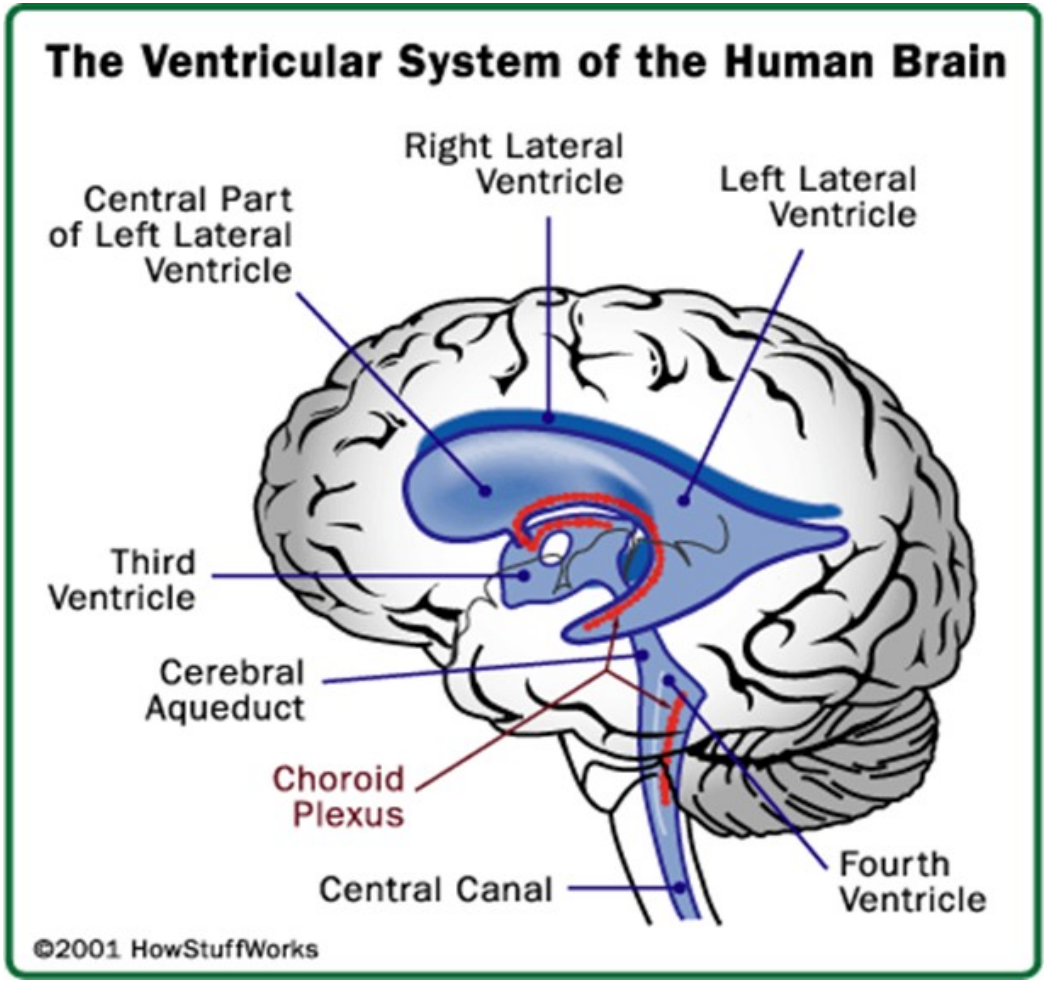
❖ **Ventricles:**

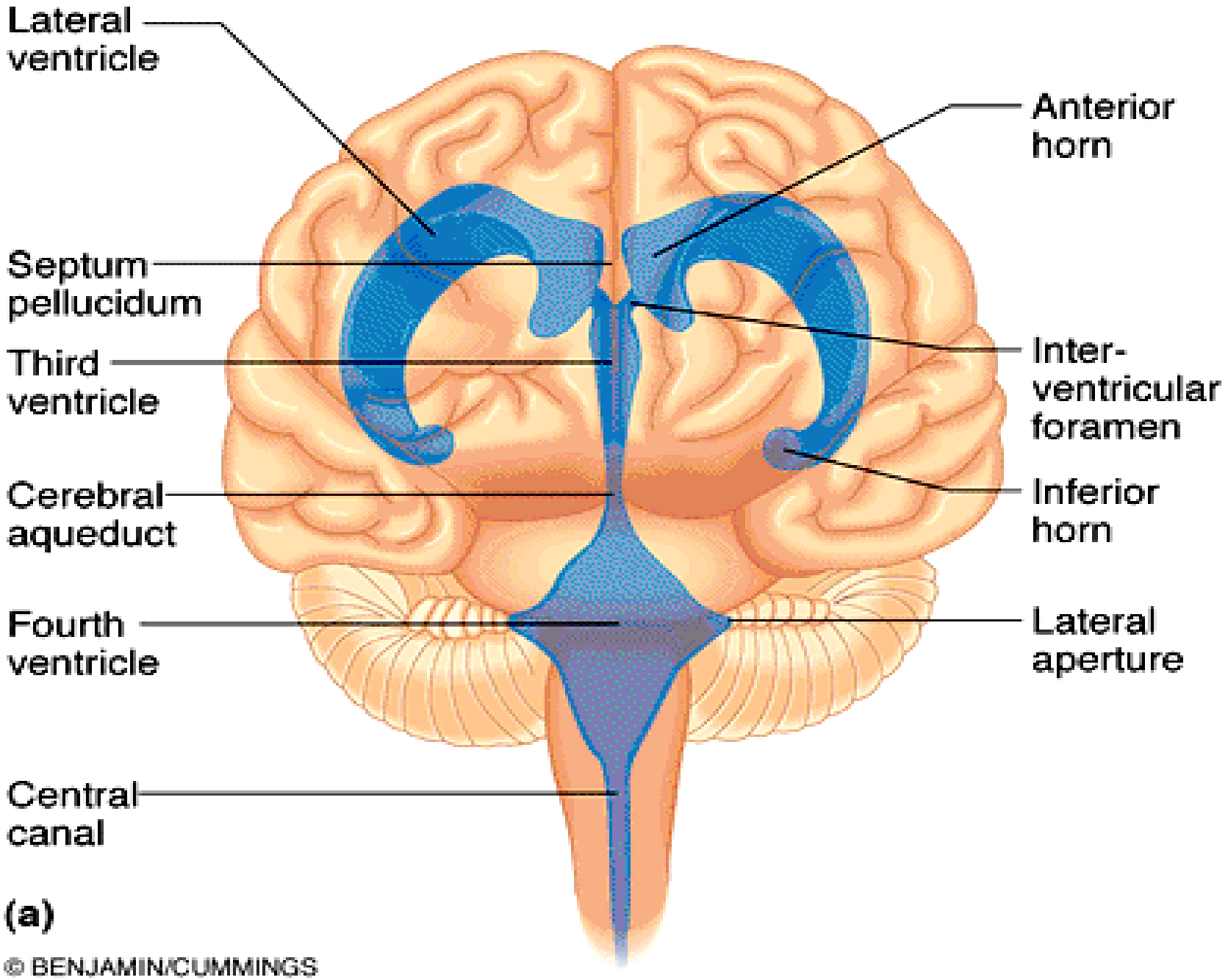
- Fluid filled cavities
- Lined with **ependymal cells**
- Derived from cavity of **neural tube**
- Filled with **CSF**, which provides:
  - **Transportation (** nutrient, waste, hormone)
  - **Protection**:
  - **Buoyancy**: net weight of the brain is reduced from about 1,400 gm to about 50 gm. ⇊ Thus, pressure at base of brain is reduced.

Ventricles of the Brain

- Cerebrum - **2 lateral** ventricles
- Diencephalon - **third**
- Between pons, medulla and cerebellum - **fourth ventricles**.
- **Choroidal fissure** – line along which choroid plexus invaginate into the ventricle
- **Tela choroidea** - invagination of the pia matter into ventricles containing plexus of blood vessels (choroid plexus)

VENTRICLES

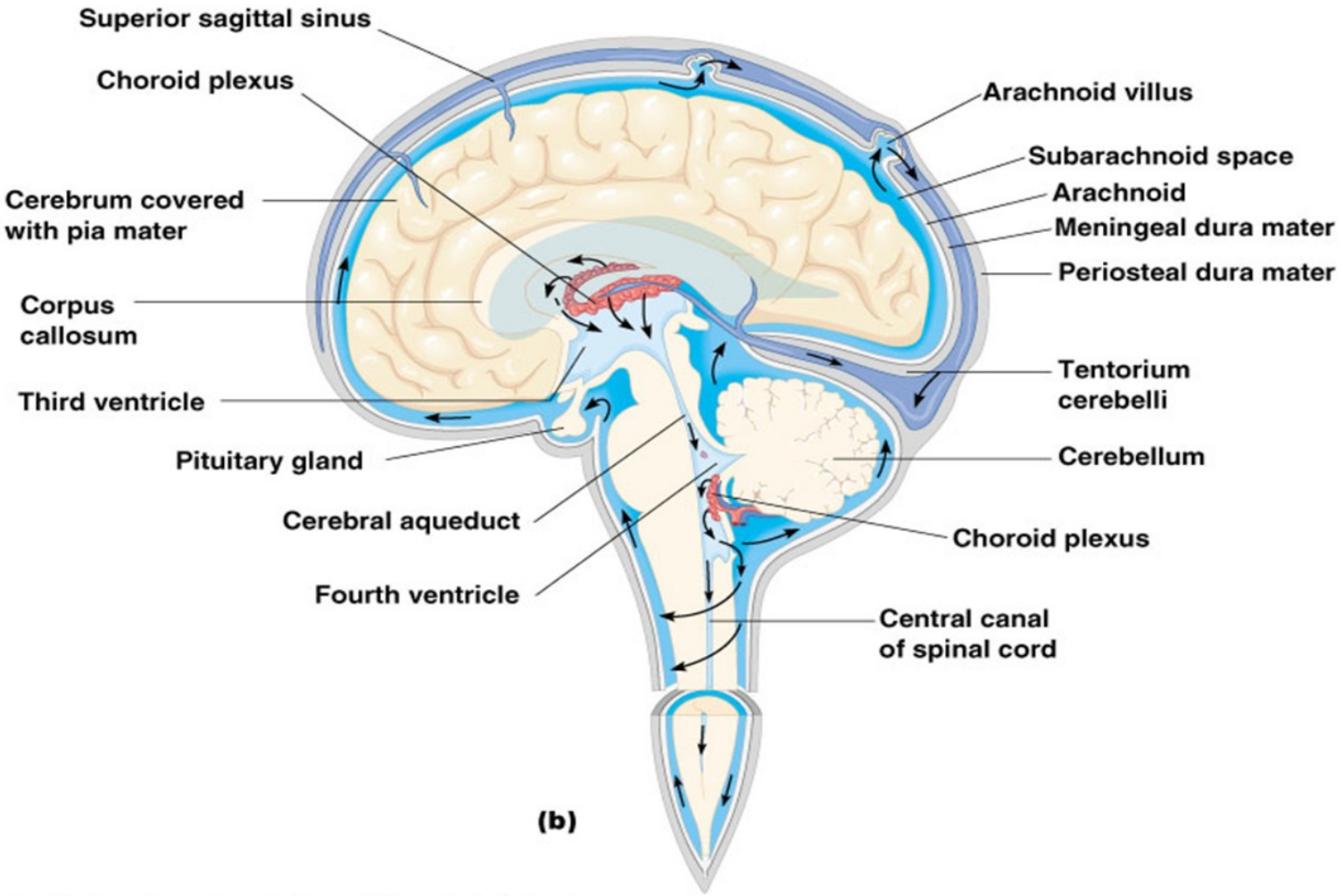

The Ventricular System of the Human Brain
Right Lateral Ventricle
Central Part of Left Lateral Ventricle
Left Lateral Ventricle
Third Ventricle
Cerebral Aqueduct
Choroid Plexus
Central Canal
Fourth Ventricle
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Circulation of CSF:

Begin in **lateral ventricles** & end by joining **dural venous sinus.**



Circulation of CSF

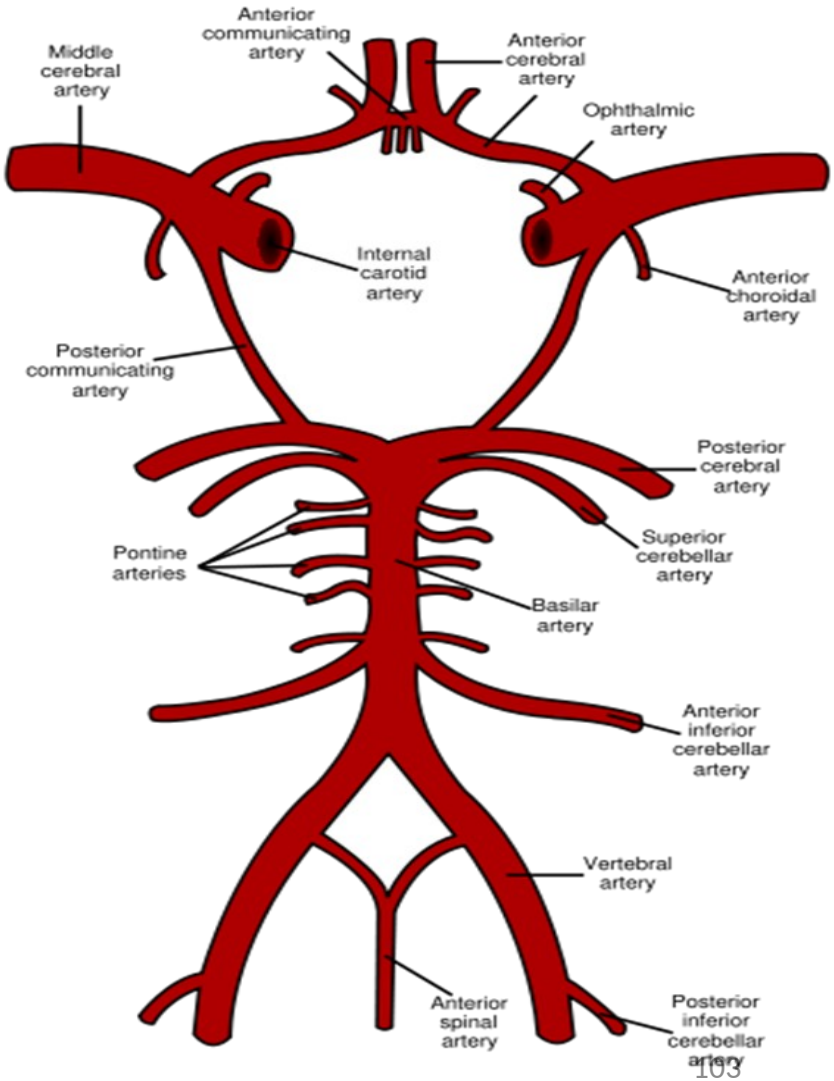
- In adults, the total CSF volume of about 150 ml is replaced every 3-4 hours
- Once produced CSF moves freely through the ventricles
- In the subarachnoid space, the CSF bathes the outer surface of the **brain** and **spinal cord**
- The motion of the CSF is aided by the long microvilli of the **ependymal cells** lining the ventricles

Blood supply of the brain

- Brain supplied by branches of two major arteries:

1. **Internal Carotid a.:**
- ***Anterior cerebral artery***
- ***Middle cerebral artery***

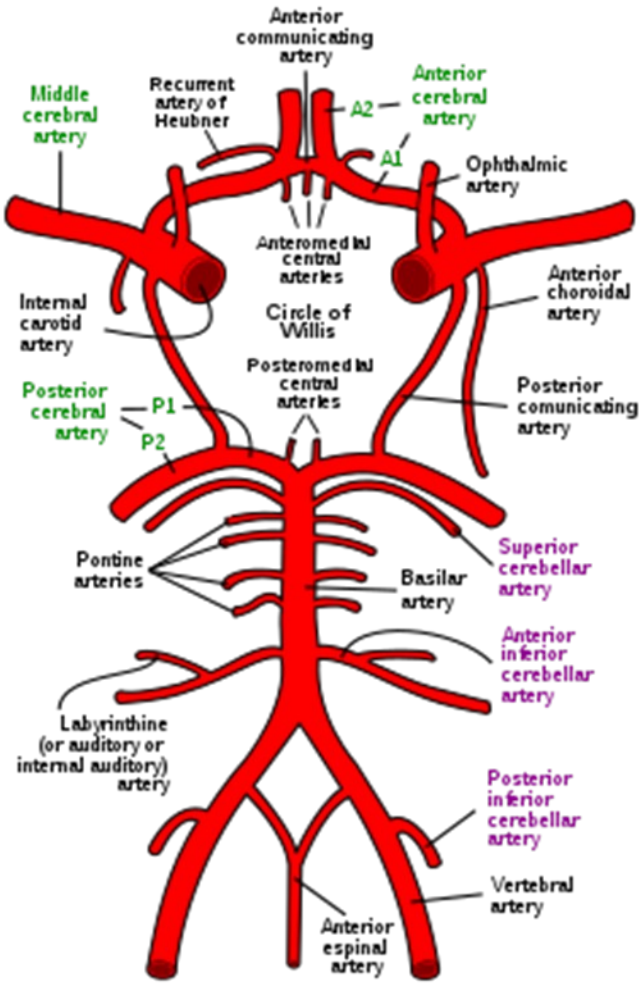
2. **Vertebral artery.**
- **Basilar a.**
- ***Posterior cerebral a.***
- **Anterior Spinal a.**



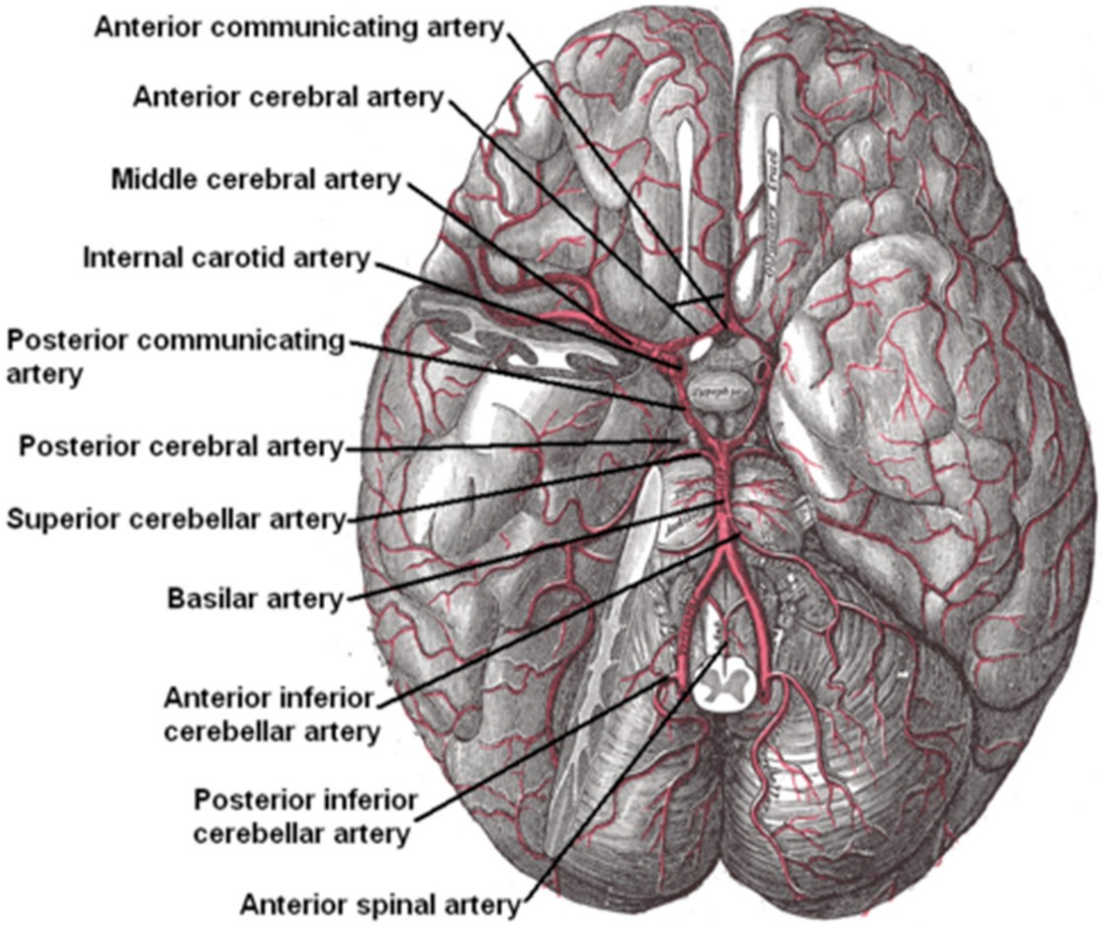
Blood supply of the brain

- The Cerebrum receives blood from:

1. ***Anterior cerebral artery***
2. ***Middle cerebral artery***
3. ***Posterior cerebral artery***



Blood supply of the brain



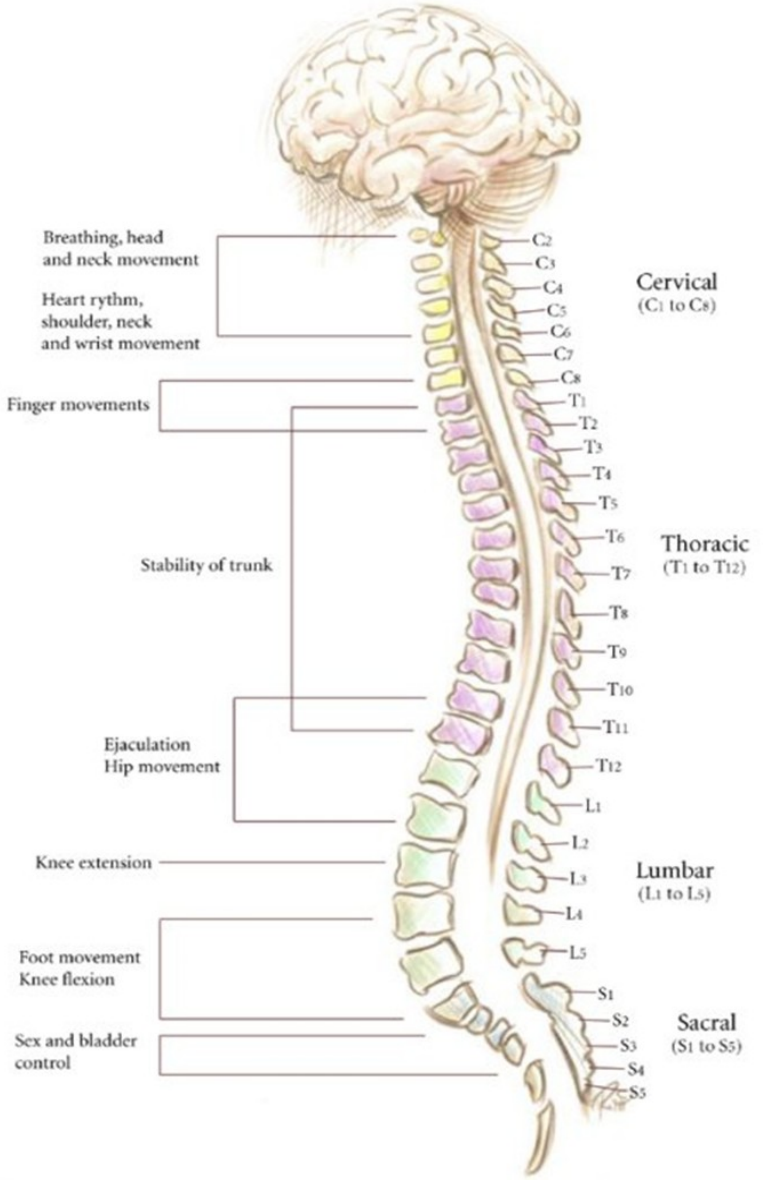
Spinal cord

❖ **Gross Appearance**

- Cylindrical in shape
- Begins at **foramen magnum** & ends at L1 (adult), L3 (child)

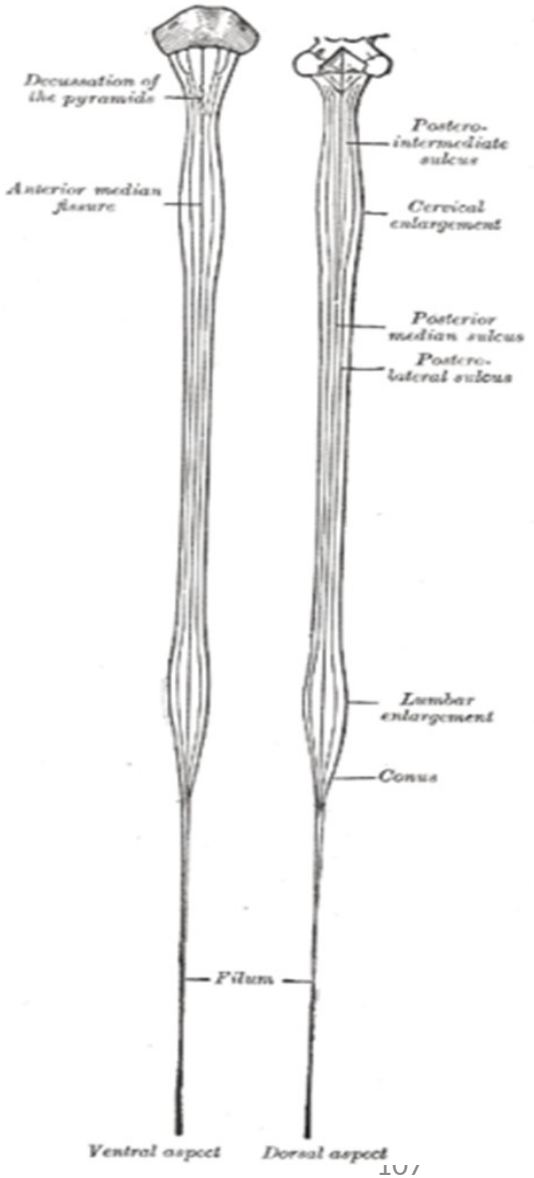
- Occupy upper 2/3 of vertebral canal; about 45 cm long

- Surrounded by
  - Meninges
  - CSF
  - Bones

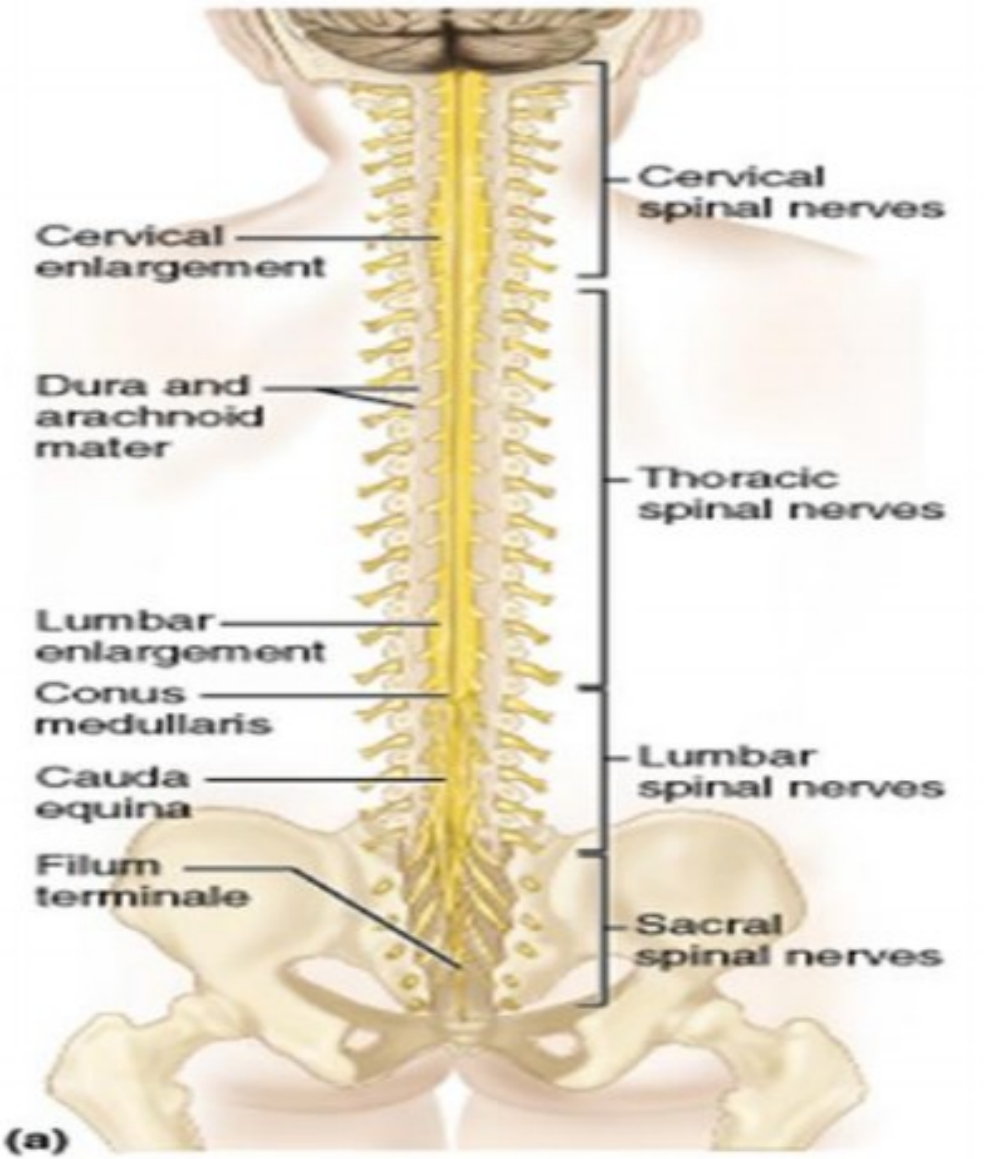


Spinal cord

- **Regions:**
- 8 - Cervical (C 1 -8)
- 12 - Thoracic (T1 -12)
- 5 - Lumbar (L1 -5)
- 5 - Sacral (S1 -5)
- 1- Coccygeal (Co1)
- Gives rise to **31 pairs** of spinal nerves
- Not uniform in diameter
  - **Cervical enlargement**: supplies upper limbs
  - **Lumbar enlargement**: supplies lower limbs
- **Conus medullaris -** tapered inferior end
  - Ends between L1 and L2
- **Cauda equina -** origin of spinal nerves extending inferiorly from conus medullaris.

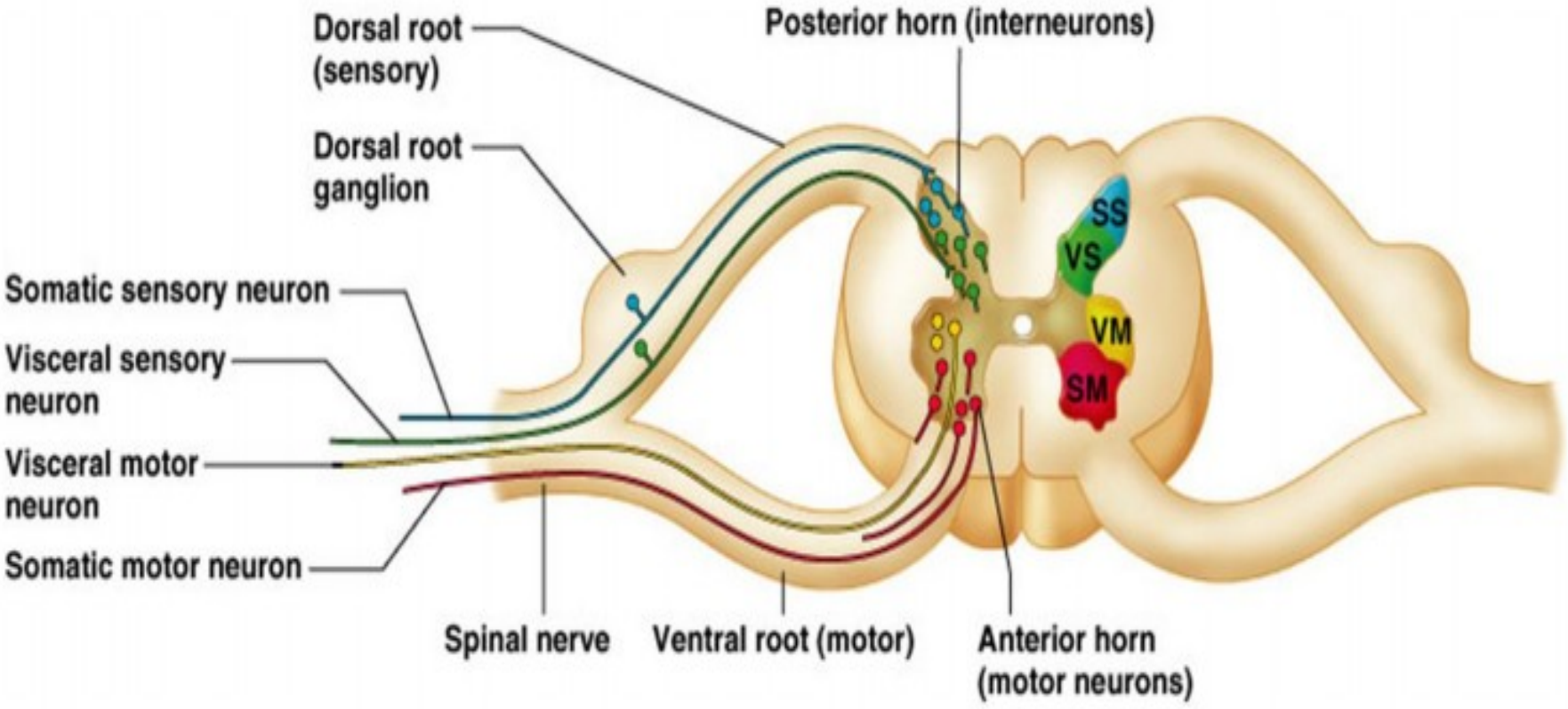


Spinal cord

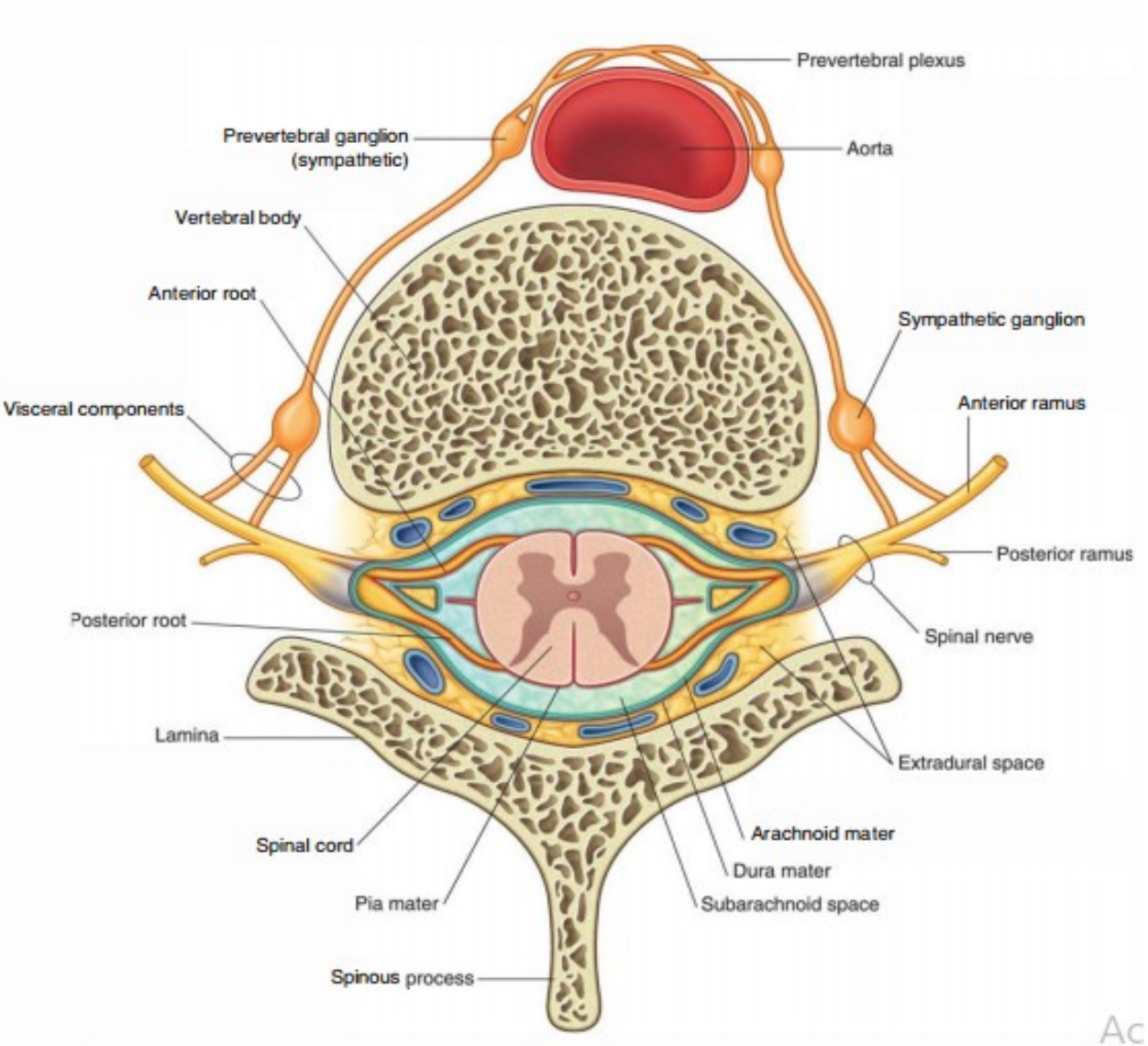

Cervical spinal nerves
Cervical enlargement
Dura and arachnoid mater
Thoracic spinal nerves
Lumbar enlargement
Conus medullaris
Lumbar spinal nerves
Cauda equina
Filum terminale
Sacral spinal nerves
(a)

Spinal nerve

- Each spinal nerve is attached to the spinal cord by two **roots** : anterior and posterior
- The **posterior** root is **sensory** and
- The **anterior** root is motor


Dorsal root (sensory)
Posterior horn (interneurons)
Dorsal root ganglion
Somatic sensory neuron
Visceral sensory neuron
Visceral motor neuron
Somatic motor neuron
SS
VS
VM
SM
Spinal nerve
Ventral root (motor)
Anterior horn (motor neurons)

Spinal nerves

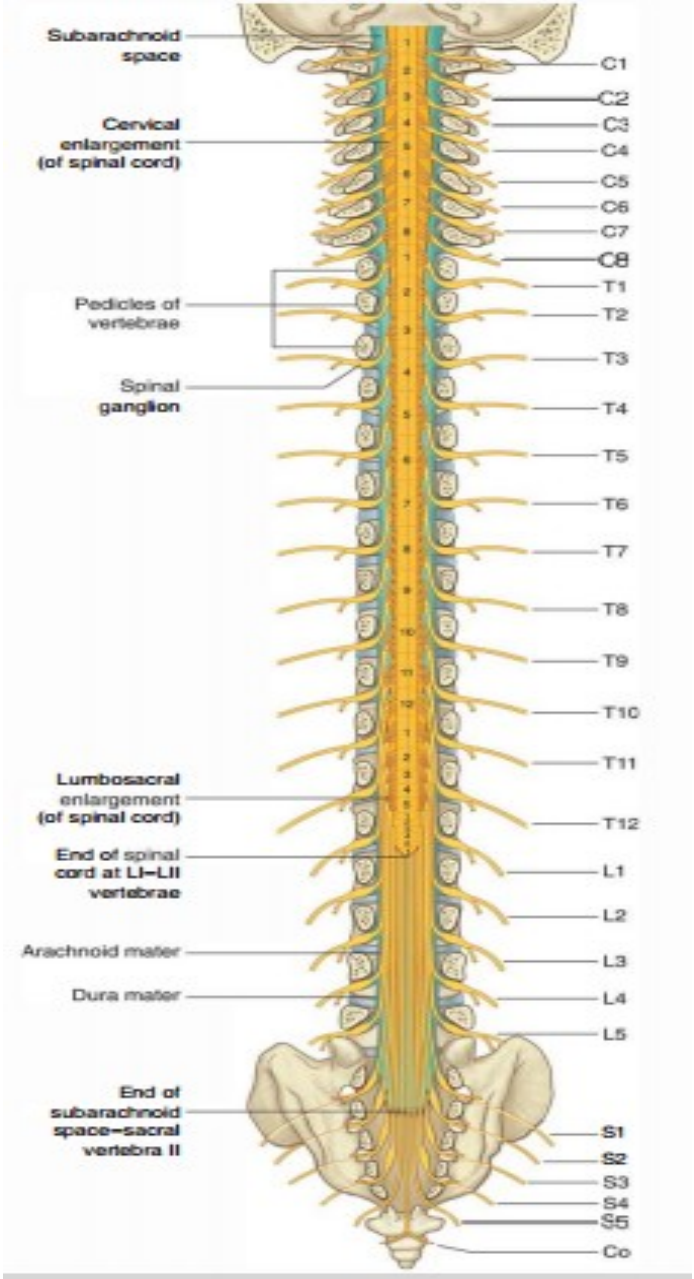


2.9 Spinal nerves (transverse section).

Spinal nerves

- At each **intervertebral foramen** the two roots unite to form the **spinal nerve** which there fore contains both kinds of fibers (**motor** and **sensory**)
- Each trunk divides in to **anterior** and **posterior rami**.
- The **anterior ramus** carries both motor and sensory fibers to the anterior aspect of the body.
- The **posterior ramus** carries both motor and sensory fibers to the posterior aspect of the body.

Spinal nerves



Spinal nerves

❖Mode of **exit** of **spinal nerves** from the vertebral canal:

- The lower six cervical, the thoracic and lumbar nerves make their exit through the intervertebral foramina.
- The upper four **sacral nerves** leave through the anterior and posterior sacral foramina.

- The upper two cervical ,the fifth sacral and the coccygeal nerve follow different course.

Spinal nerves

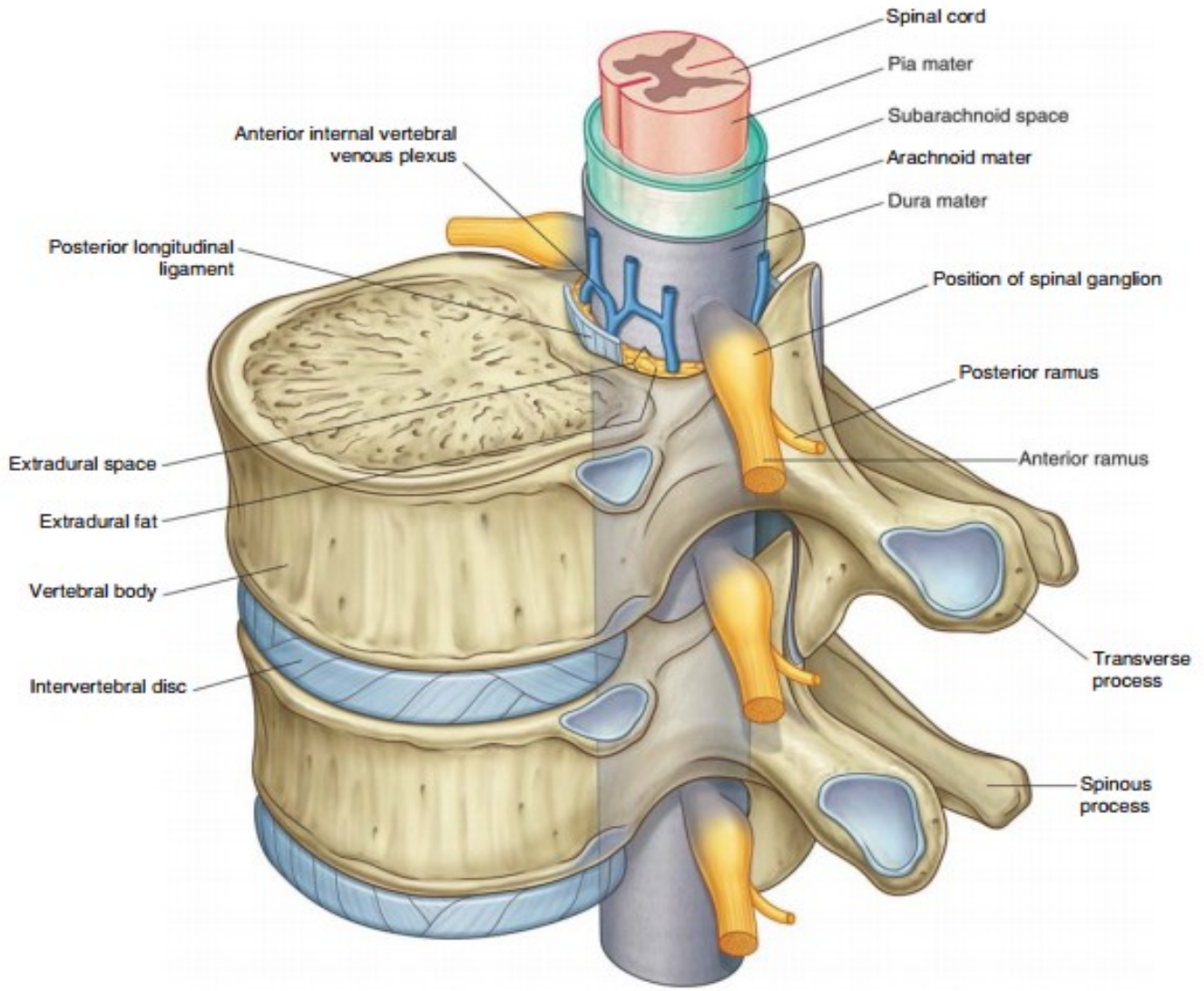


Fig. 2.8 Vertebral canal.

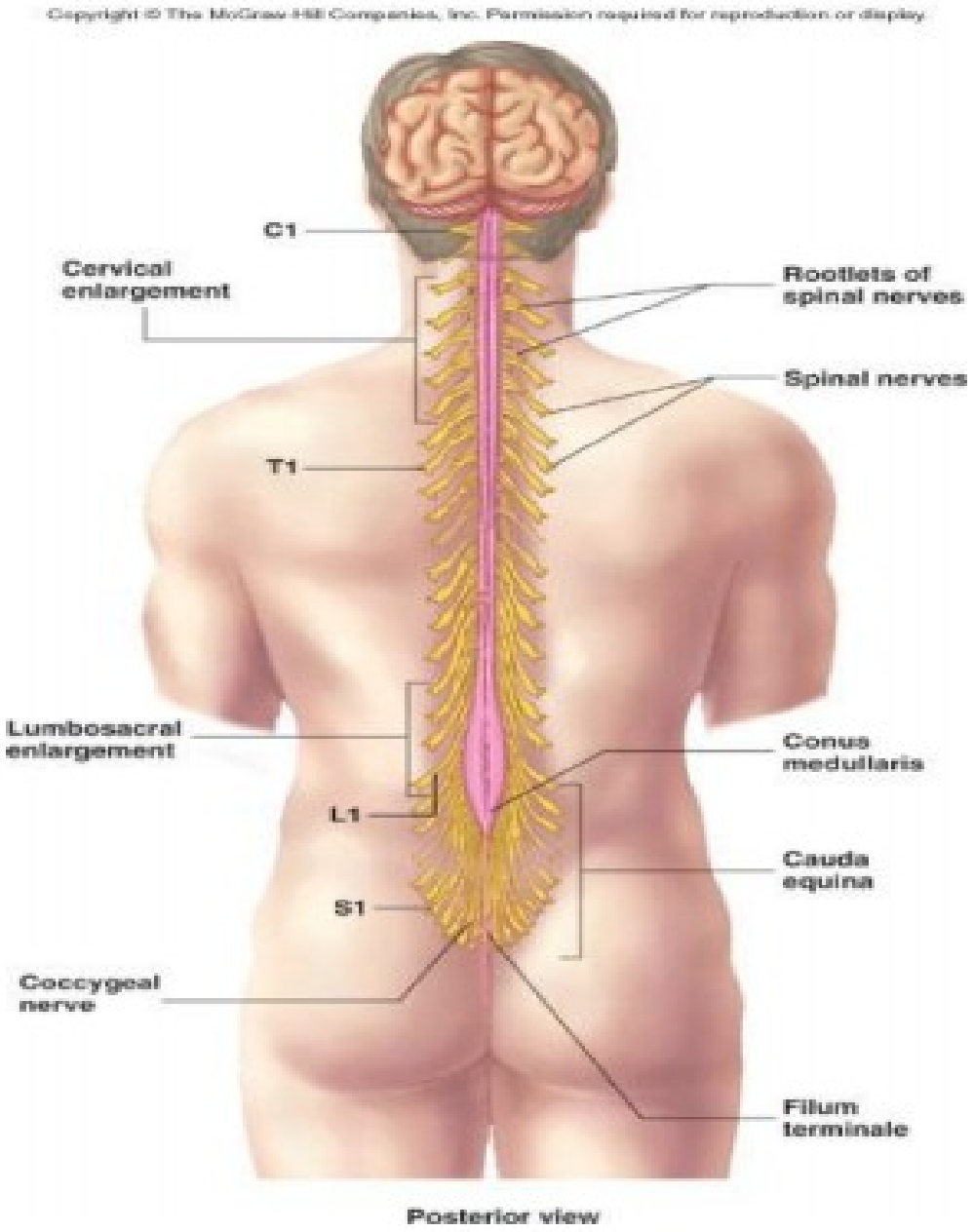
Spinal nerves

- The 1st cervical nerve emerges by passing above the posterior arch of the **atlas.**
- The 2nd cervical passes over the vertebral arch of the **axis.**
- The 5th sacral and the coccygeal nerve leave through the **sacral hiatus**.

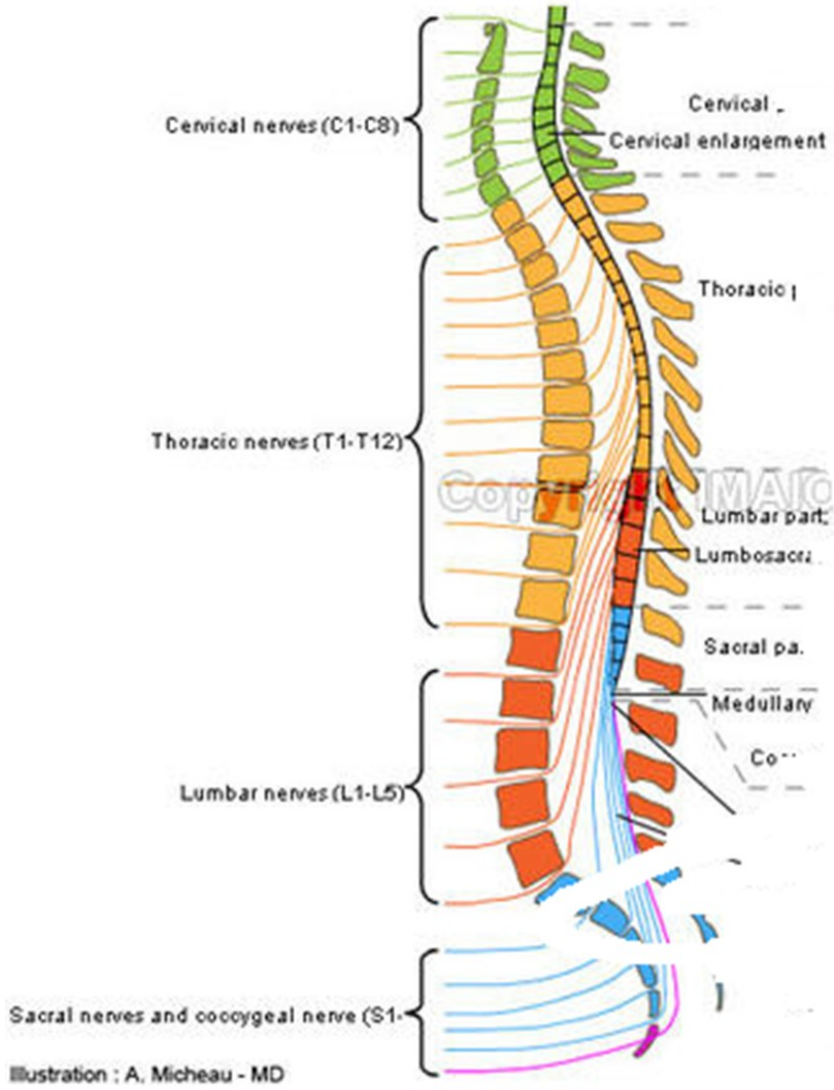
Lumbar puncture

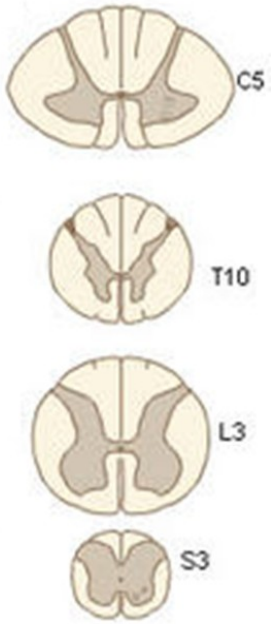
- The **subarachnoid space** below the end of the spinal cord (upper border of L-2) contains only the **cauda equine** & the **filum terminale** suspended in **C.S.F**.
- Lumbar puncture is done in this position with out fear of injuring the spinal cord.

Spinal cord

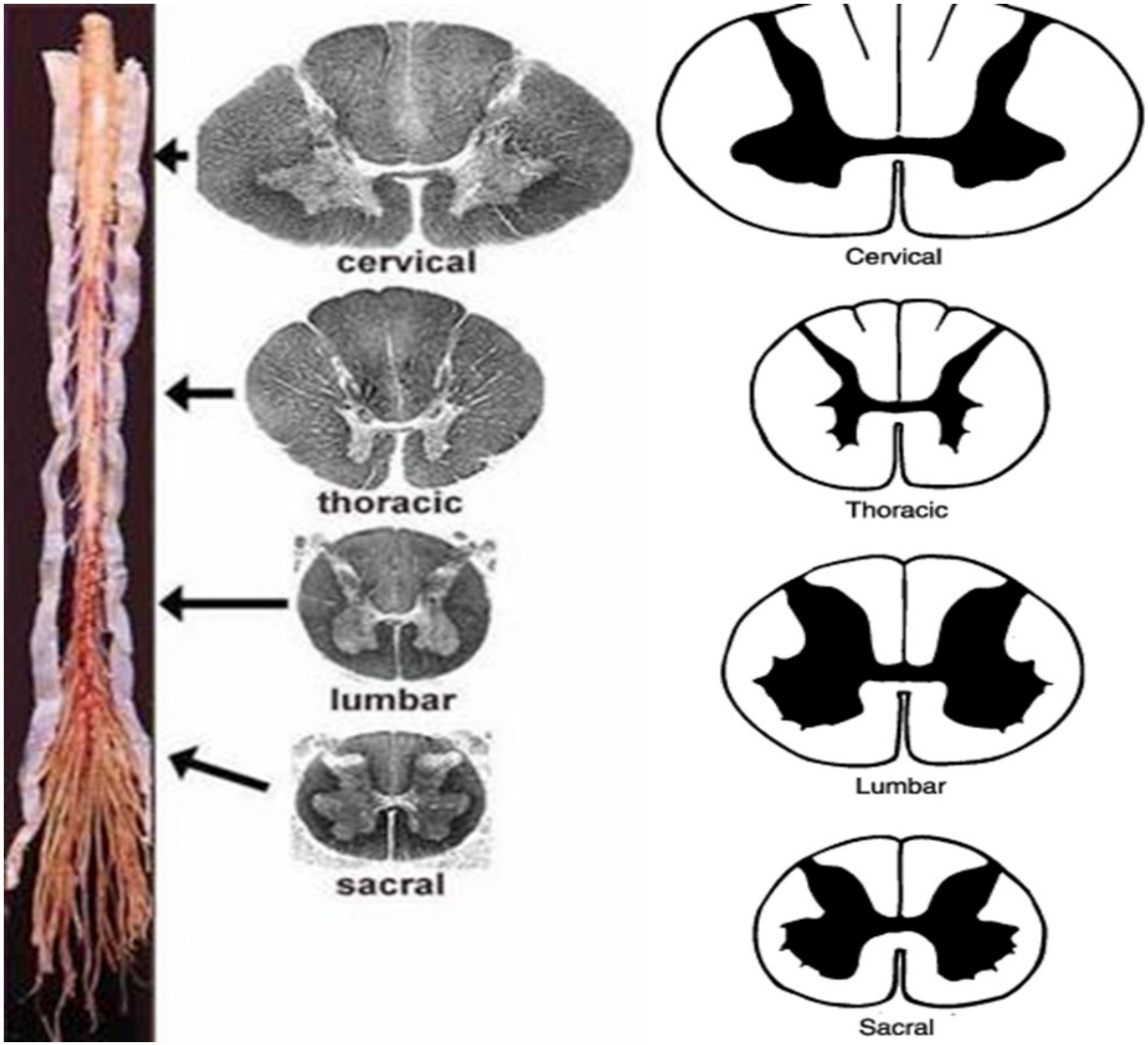

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C1
Cervical enlargement
Rootlets of spinal nerves
Spinal nerves
T1
Lumbosacral enlargement
Conus medullaris
L1
Cauda equina
S1
Coccygeal nerve
Filum terminale
Posterior view

Spinal cord


Cervical nerves (C1-C8)
Cervical
Cervical enlargement
Thoracic
Thoracic nerves (T1-T12)
Lumbar part
Lumbosacr
Sacral pa.
Medullary
Co
Lumbar nerves (L1-L5)
Sacral nerves and coccygeal nerve (S1-
Illustration : A. Micheau - MD


C5
T10
L3
S3

Spinal cord


cervical
thoracic
lumbar
sacral
Cervical
Thoracic
Lumbar
Sacral

Spinal cord

Structure of Spinal Cord:

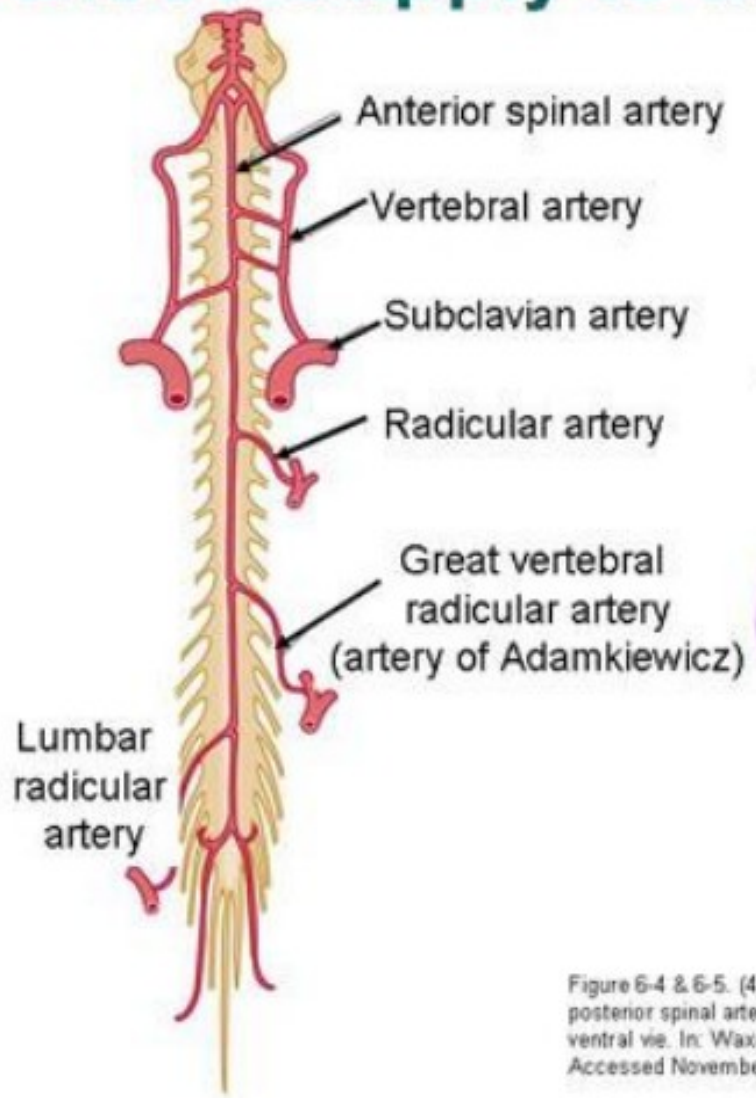
- Composed of:
  - Gray matter (inner)
  - White matter (outer)
- In cross-section, shape of spinal cord in different regions is different:
  - Cervical: oval
  - Lumbar: round to oval
  - Thoracic & sacral round



Blood supply to the spinal cord

- **Anterior spinal arteries**
- two arteries
  - each arises from the **vertebral artery**.
  - both unite to form a single artery which runs in the anterior median fissure.
- **Posterior spinal artery**

Blood Supply to the Spinal Cord



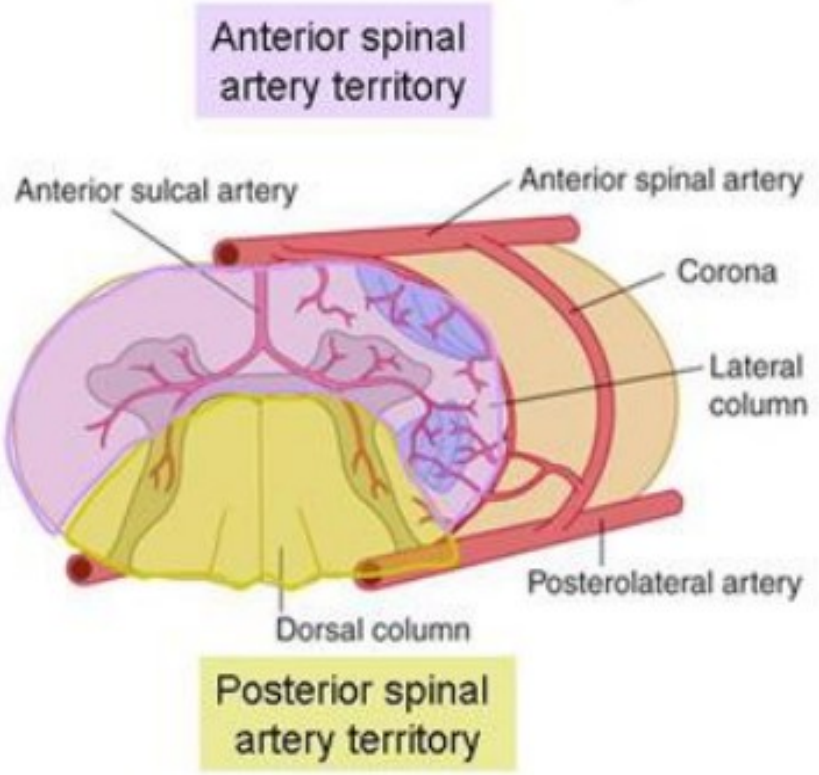


Figure 6-4 & 6-5. (4) Cross-section of the cervical spinal cord. The diagram shows the anterior and posterior spinal arteries with their branches and territories. (5) Vascularization of the spinal cord ventral vie. In: Waxman SG. *Clinical Neuroanatomy*. 26th ed. http://www.accessmedicine.com. Accessed November 2, 2009.

Blood supply of SC

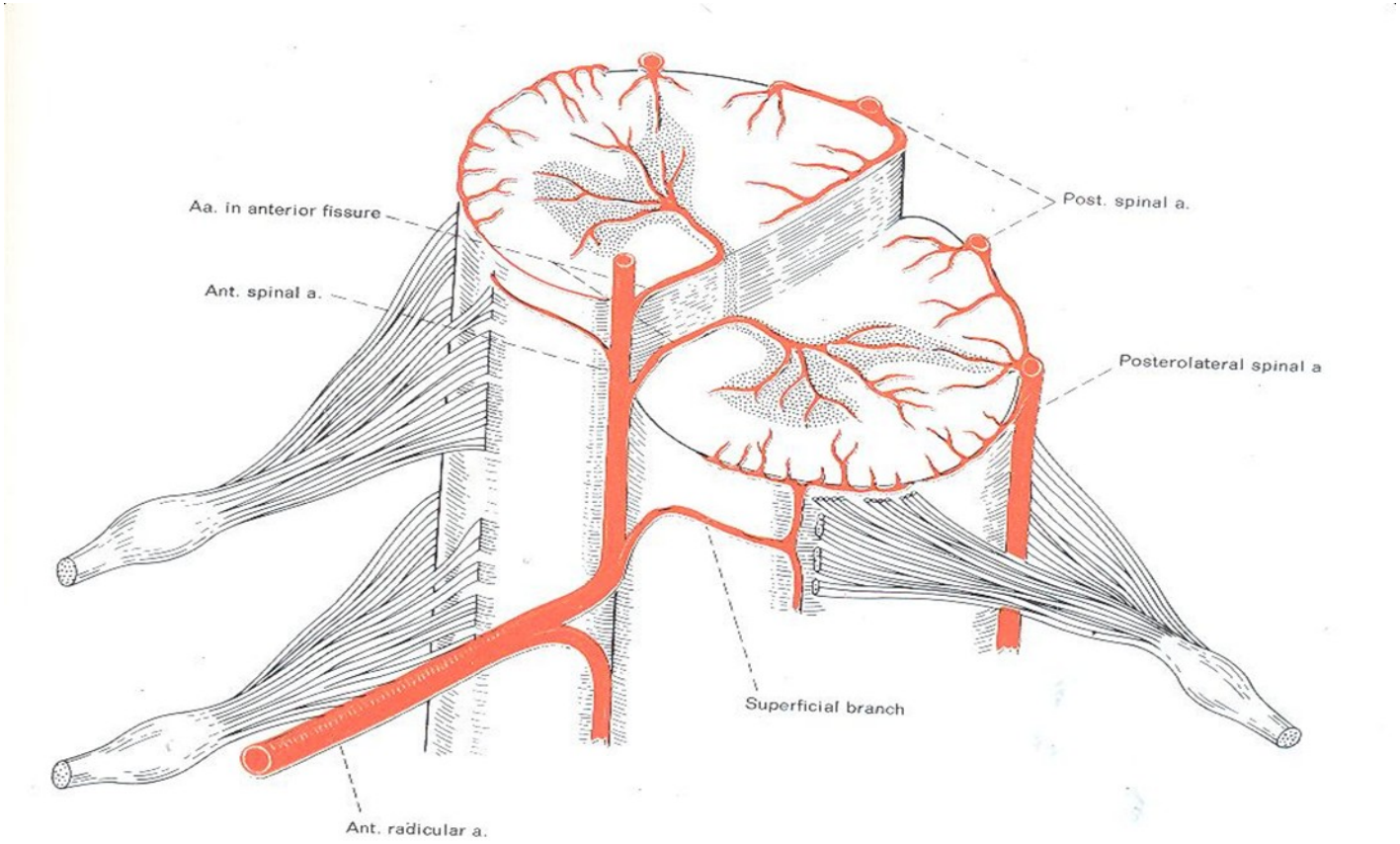


Fig. 117. Arterial supply of the spinal cord (after *K. Piscol:* Blutversorgung des Rückenmarks und ihre klinische Relevanz. Schriftenreihe Neurologie, vol. 8. Springer, München–Berlin–New York 1972).

THANKS