



الجامعة الهاشمية
The Hashemite University



General Anatomy

Lecture 21 & 22: Nervous System

**Dr. Mohamed Fathi
Elrefai**

Ass. Professor of Anatomy & Embryology
mohamed@hu.edu.jo

Structure of Nervous Tissue

- It is formed of 2 types of cells :

1. Neurons : The neuron is the anatomical, embryological & functional unit of the nervous tissue. It is capable of the transmission of nerve impulses.

2. Neuroglia cells : They help in nutrition, support & protection of the neurons. They are unable for the transmission of nerve impulses.

The Neuron (Nerve Cell)

- It is formed of :

1. Cell body : contains the nucleus.

2. Processes :

a. axon (nerve fiber) : a single long process which carries nerve impulse away from cell body.

b. Dendrites : short multiple processes which carry nerve impulses towards cell body.

Important Definitions

1. Nucleus : a group of cell bodies in CNS.

2. Ganglion : a group of cell bodies in PNS.

3. Tract : a group of nerve fibers in CNS.

4. Nerve : a group of nerve fibers in PNS.

5. Synapse : it is the site of contact between the axon of one neuron & the dendrites of another neuron. It is also the where a nerve impulse passes from one neuron to another neuron.

6. Grey matter : formed of cell bodies + neuroglia cells.

7. White matter : formed of nerve fibers + neuroglia cells.

8. Meninges : these are the 3 membranes which cover the brain & spinal cord. These are from outside inwards; **a. dura matter**, **b. arachnoid matter** & **c. pia matter**.

Between dura & arachnoid matter lies subarachnoid space which contains **cerebro-spinal fluid (CSF)**.

The Nervous system is formed of:

- 1. Central nervous system (CNS) :** includes the brain & spinal cord.
- 2. Peripheral nervous system (PNS) :** supplies somatic structures
 - 12 pairs of cranial nerves and the sensory ganglia related.
 - 31 pairs of spinal nerves and the dorsal root ganglia.
- 3. Autonomic nervous system (ANS) :** is formed of the sympathetic and parasympathetic systems.
The ANS supplies the smooth muscles, heart and glands.

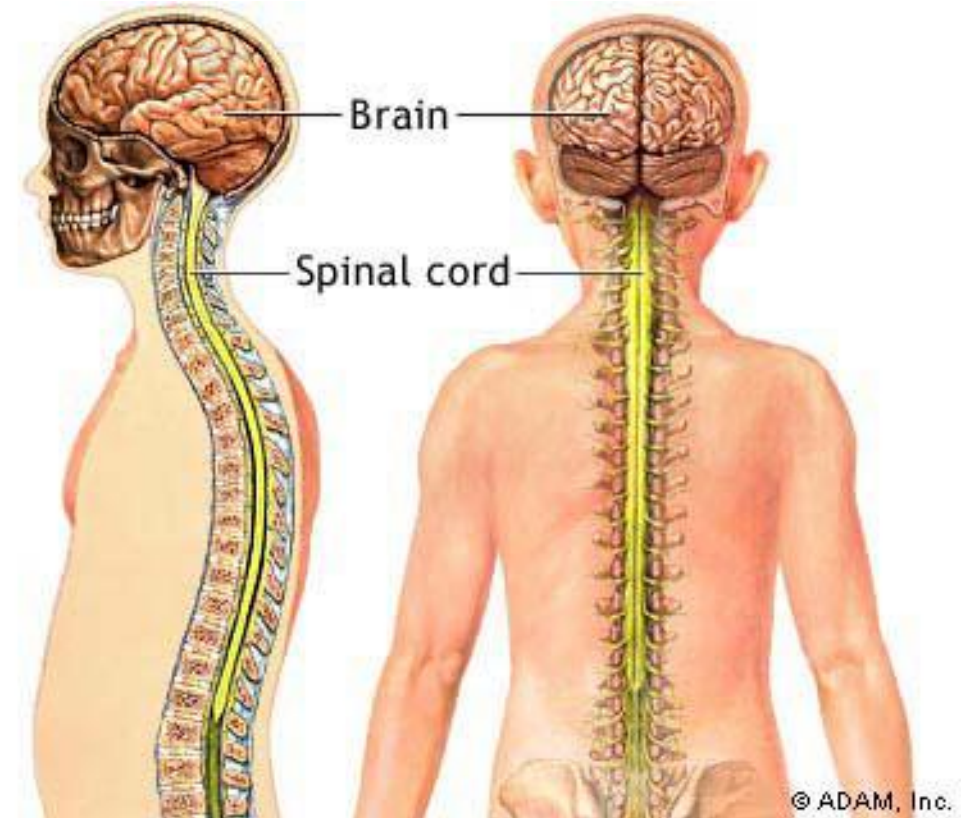
Central nervous system (CNS)

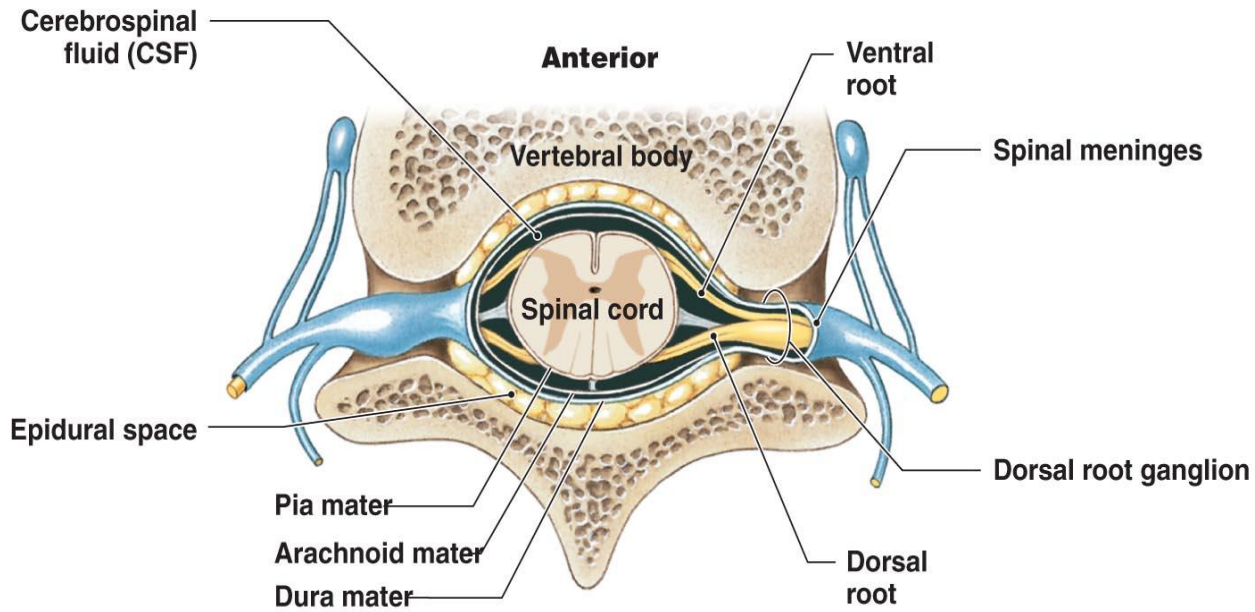
-It is the part of the nervous system which is protected by bones and bathed in cerebrospinal fluid (C.S.F.) .

a) The **brain** is protected by the skull.

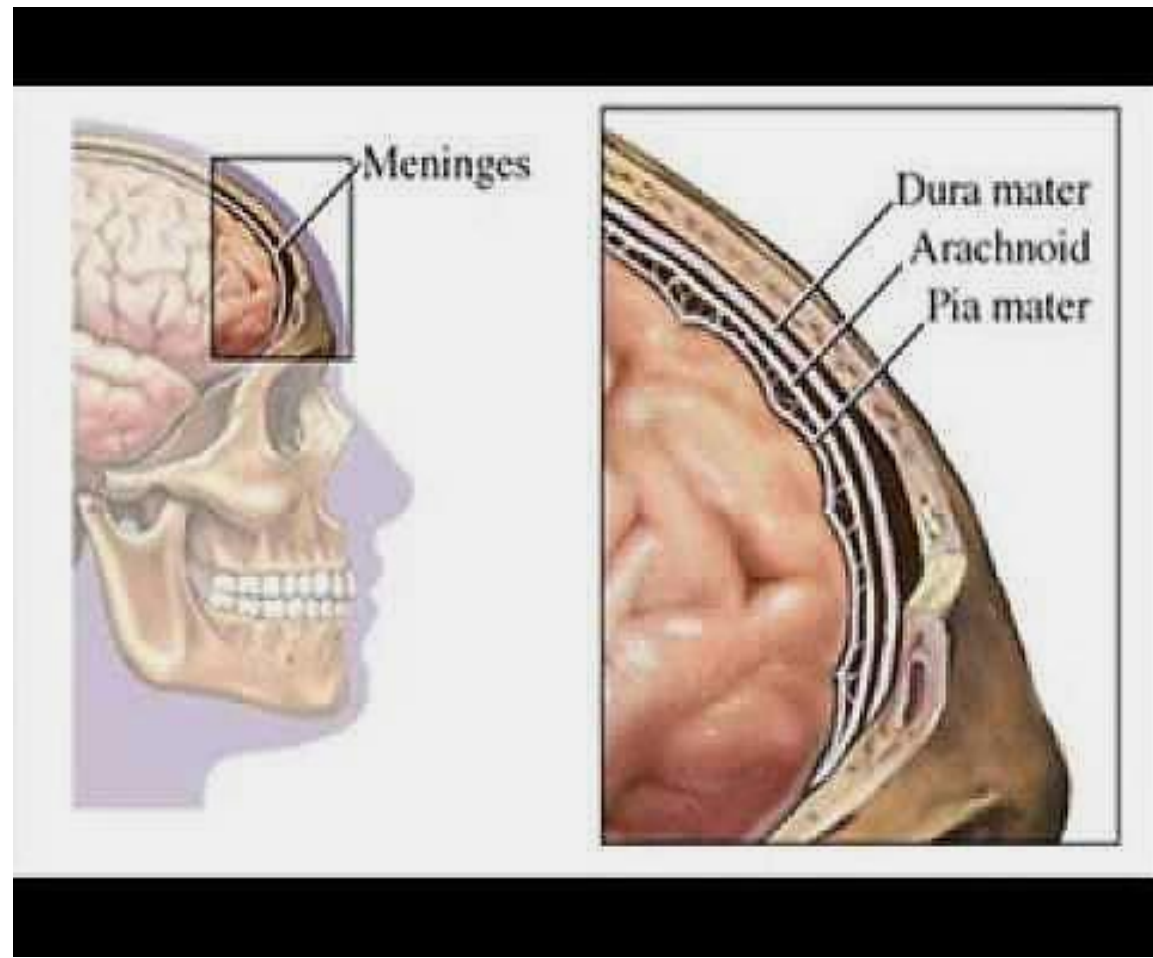
b) The **spinal cord** is protected by the vertebral canal.

-CNS can not regenerate if injured





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The brain and the spinal cord are surrounded by three covering membranes called the meninges (**pia, arachnoid and dura matter**)

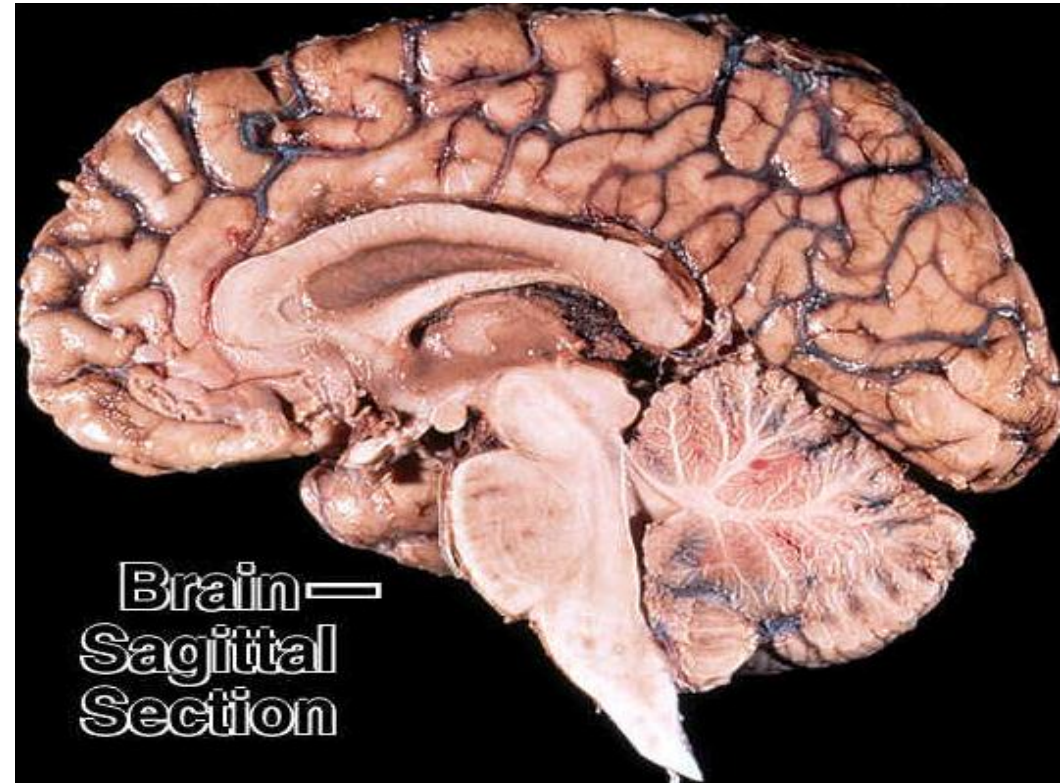
Subdivisions of the brain :

1. **Cerebrum:** formed of the 2 cerebral hemispheres and the diencephalon.



2. **Brain stem:** formed of midbrain, pons and medulla oblongata.

3. **Cerebellum.**

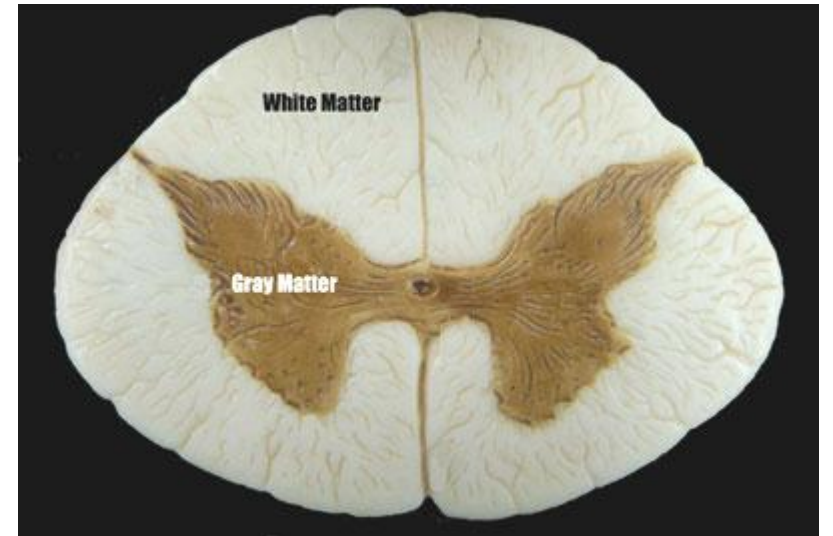


In cross section

The brain shows:

- a. **Grey matter:** dark areas which contain the cell bodies. The grey matter on the surface of the cerebrum is called the cerebral cortex.
- b. **White matter:** light areas which contain nerve fibers (axons).

The Spinal cord is made up of outer layer of **white matter** and an inner layer of **grey matter** (H-shaped). through which runs the central canal.



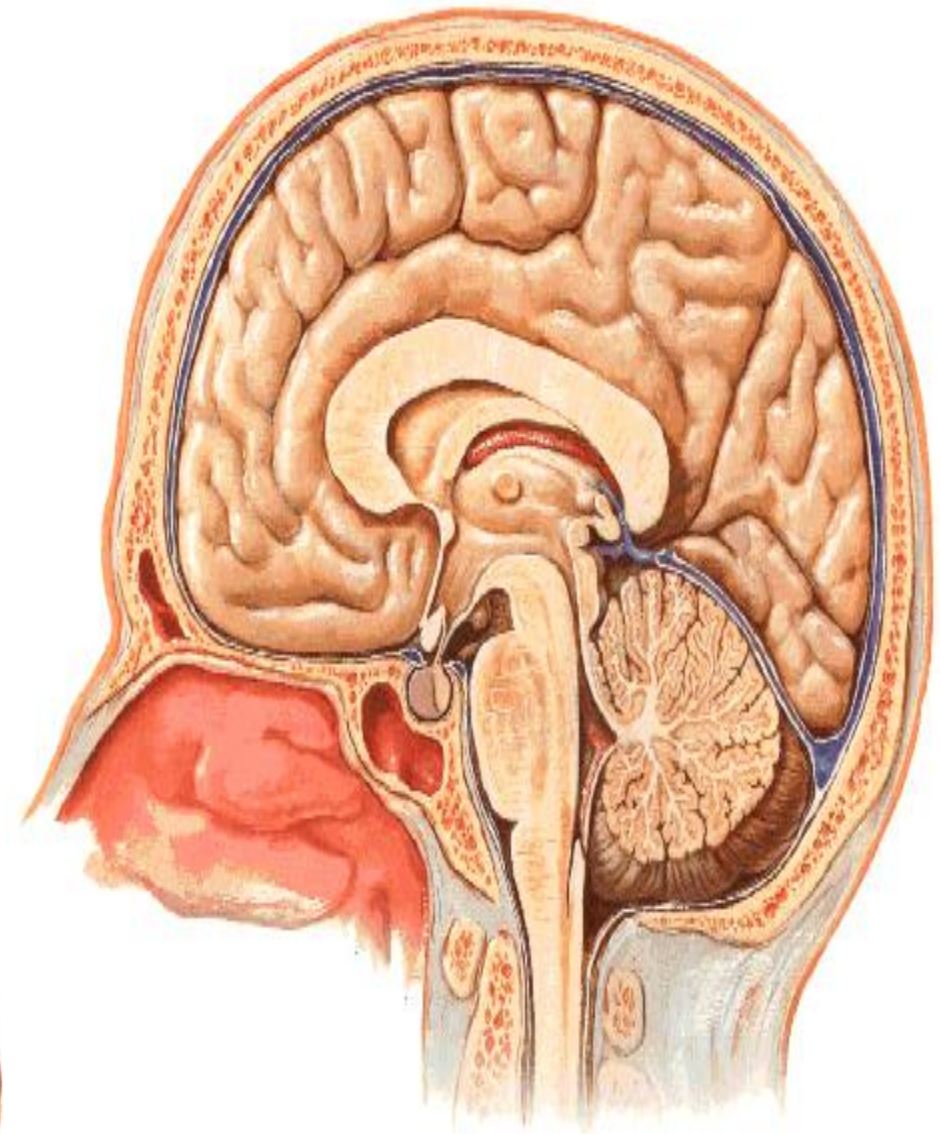
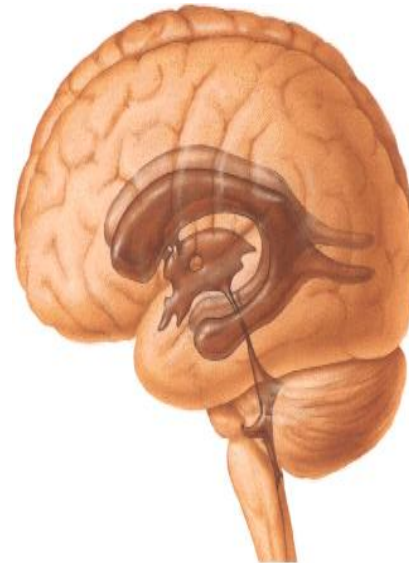
BRAIN

● The brain is formed of :

1. Cerebrum → formed of 2 cerebral hemispheres with diencephalon (interbrain) in between.

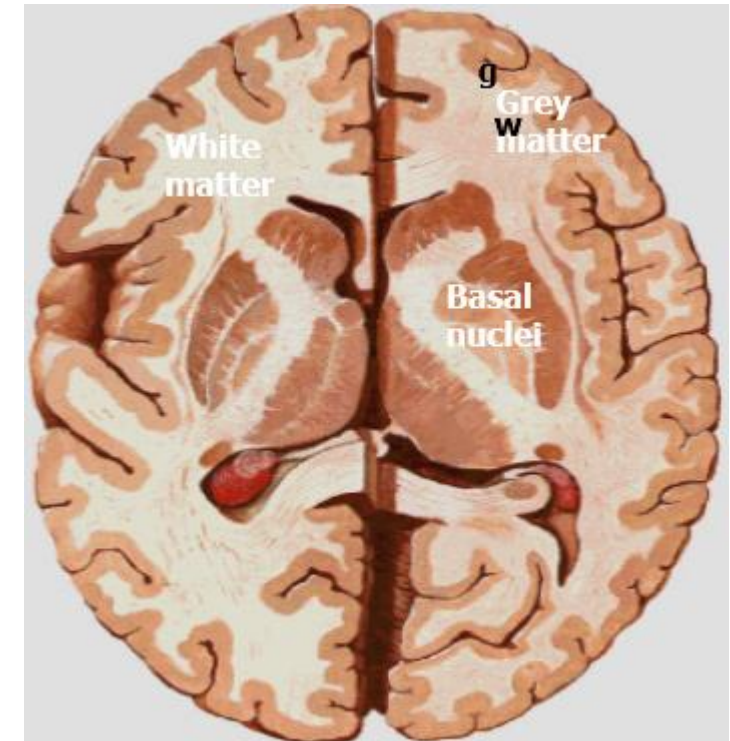
2. Brain stem: Which is formed of : midbrain, pons & medulla oblongata; from above downwards.

3. Cerebellum.



Cerebral Hemispheres

- The 2 cerebral hemispheres are separated from each other by a median longitudinal fissure.
- Each cerebral hemisphere is formed of :
 1. Outer layer of grey matter called cerebral cortex; which show gyri (elevations) & sulci (depressions), to increase surface area of the cortex.
 2. Inner core of **white matter**.
 3. Inner masses of grey matter called basal nuclei.
 4. A cavity called lateral ventricle.



Types of nerve fibers in white matter of cerebral hemispheres

- 1. Association fibers** : connect gyri within the same cerebral hemisphere.
- 2. Commissural fibers** : connect certain gyri in one hemisphere with corresponding areas in other hemisphere. The largest one of these fibers is called **corpus callosum**.
- 3. Projection fibers** : connect cortical areas with subcortical areas (thalamus, brain stem, spinal cord). They form ascending & descending tracts.

Each cerebral hemisphere has:

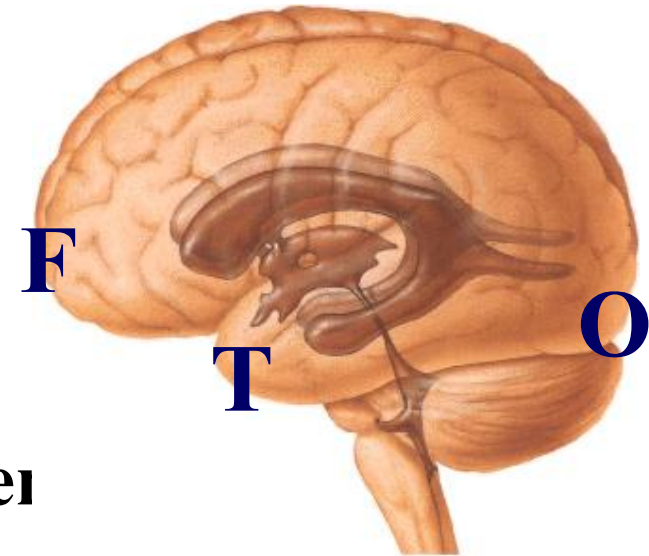
(A) 3 Surfaces:

1. Superolateral surface.
2. Medial surface.
3. Inferior surface → Divided into 2 parts; orbital & tentorial.

(B) 3 borders:

1. Superomedial border.
2. Infrolateral border.
3. Medial occipital border.

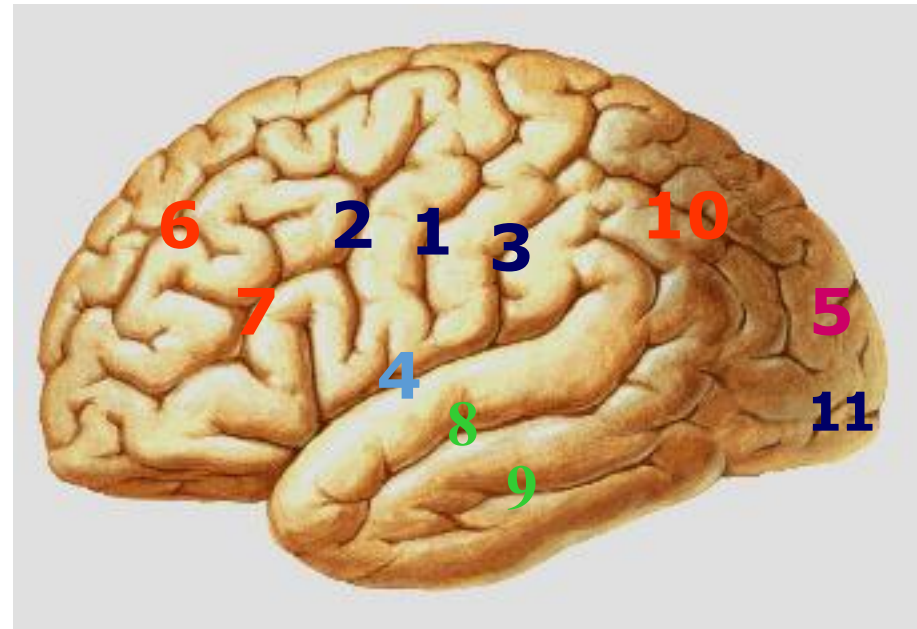
(C) 3 poles: → Frontal, occipital & te



Superolateral surface

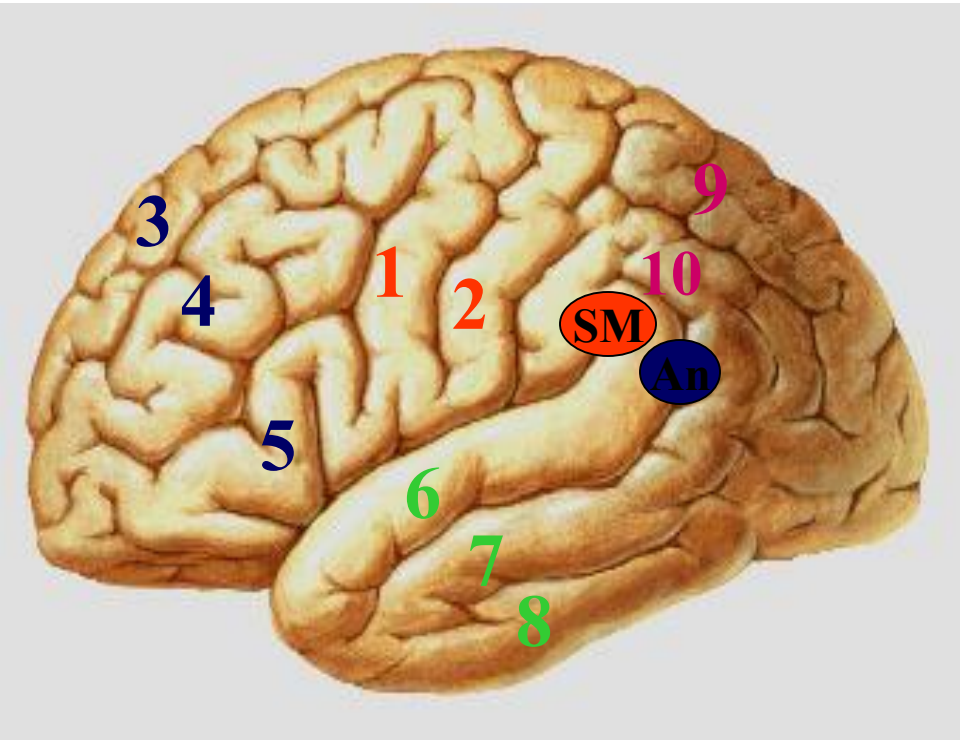
▪ Sulci on the superolateral surface:

1. Central, 2. precentral & 3. postcentral sulci.
4. Lateral sulcus.
5. Parieto-occipital sulcus.
6. Superior & 7. inferior frontal sulci.
8. Superior & 9. inferior temporal sulci.
10. Intraparietal sulcus.
11. End of calcarine sulcus.



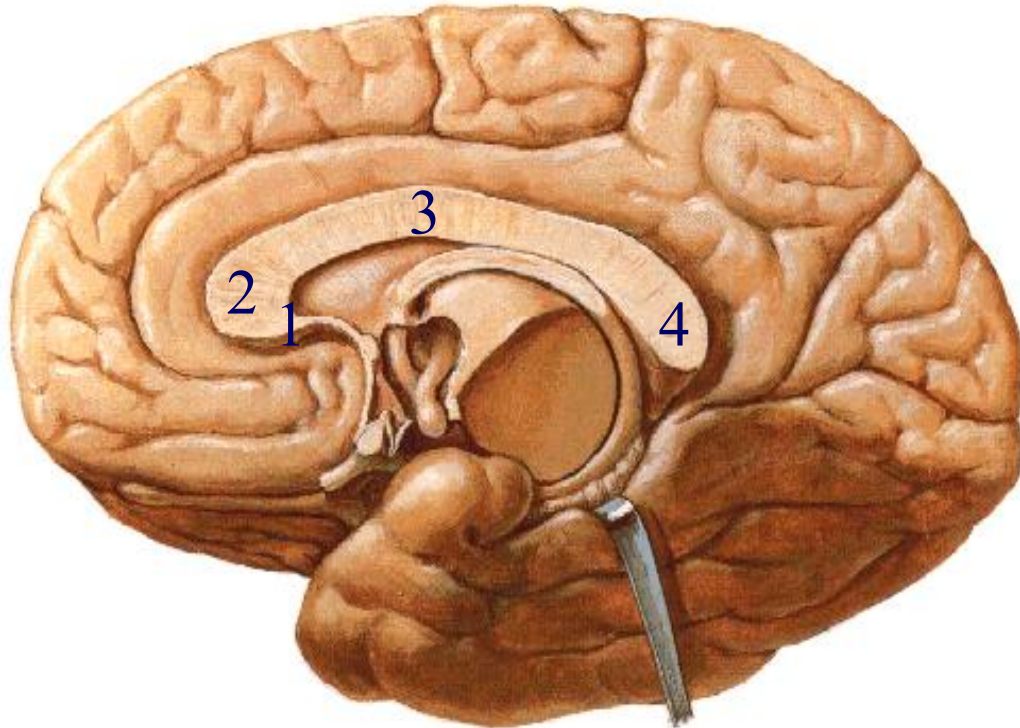
▪ **Gyri on the superolateral surface:**

1. Precentral & 2. Postcentral gyri.
3. Superior, 4. Middle & 5. Inferior frontal gyri.
6. Superior, 7. Middle & 8. Inferior temporal gyri.
9. Superior & 10. Inferior parietal lobules.
11. Angular gyrus (An).
12. Supramarginal gyrus (SM).



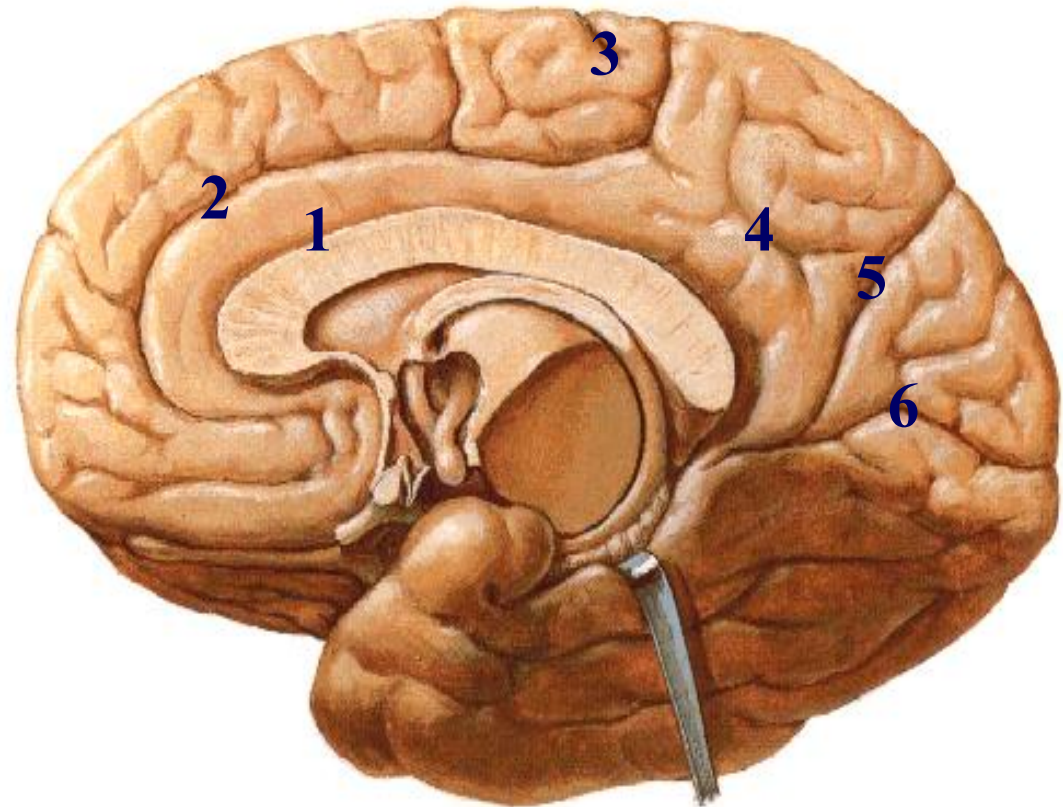
Medial surface

- The medial surface presents the *corpus callosum* formed of white matter & is divided into 4 parts; from anterior to posterior. These parts are:
 1. Rostrum.
 2. Genu.
 3. Body (trunk).
 4. Splenium.



▪ **Sulci on the medial surface:**

1. **Callosal sulcus.**
2. **Cingulate sulcus.**
3. **Central sulcus.**
4. **Subparietal (suprasplinal) sulcus.**
5. **Parieto-occipital sulcus.**
6. **Calcarine sulcus.**



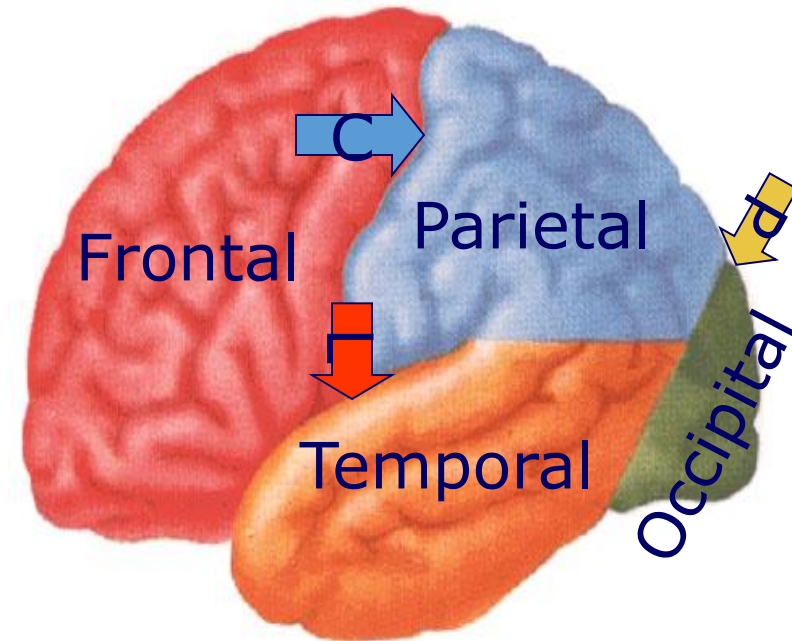
Each cerebral hemisphere is divided into 4 lobes by means of 3 major sulci.

● The lobes are:

1. Frontal lobe.
2. Parietal lobe.
3. Temporal lobe.
4. Occipital lobe.

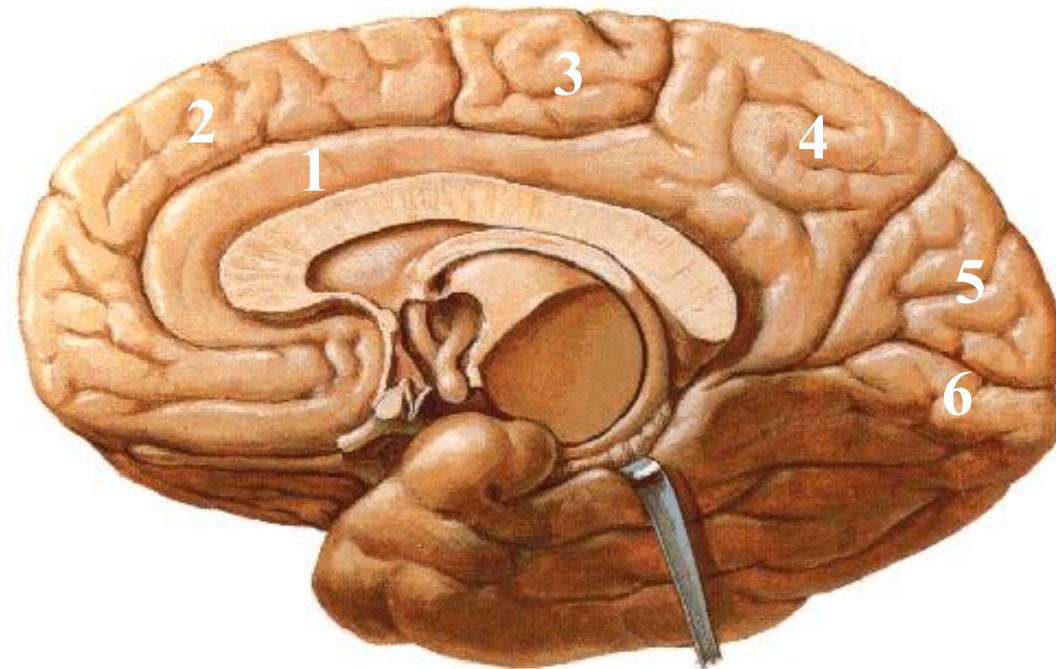
● The 3 major sulci are:

1. Central sulcus.
2. Lateral sulcus.
3. Parieto-occipital sulcus.



▪ **Gyri on the medial surface:**

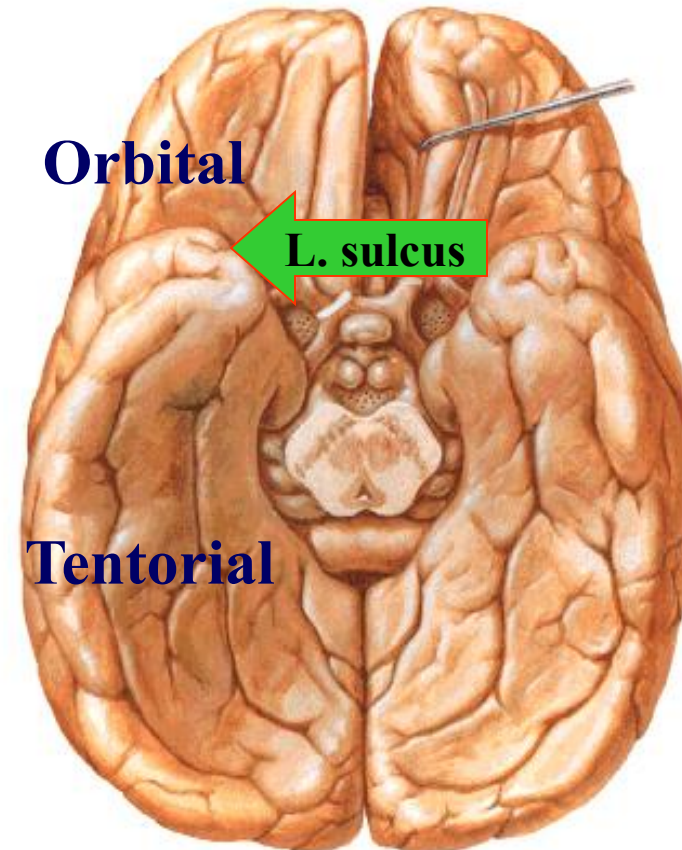
1. Cingulate gyrus.
2. Medial frontal gyrus.
3. Paracentral lobule.
4. Precuneus.
5. Cuneus.
6. Lingual gyrus.



Inferior surface

- The inferior surface is divided by the stem of lateral sulcus into 2 parts:

1. Orbital part.
2. Tentorial part.



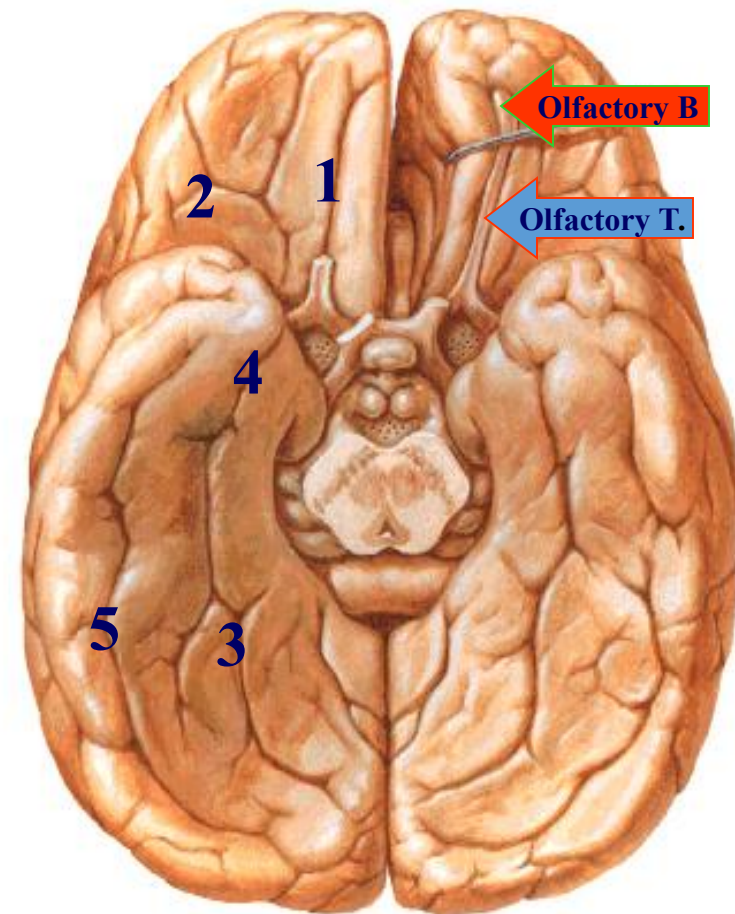
▪ **Sulci on the inferior surface:**

A) On the orbital part:

1. Olfactory sulcus → Enclosing the olfactory bulb & olfactory tract.
2. H-shaped orbital sulcus.

B) On the tentorial part:

3. Collateral sulcus.
4. Rhinal sulcus.
5. Occipito-temporal sulcus.



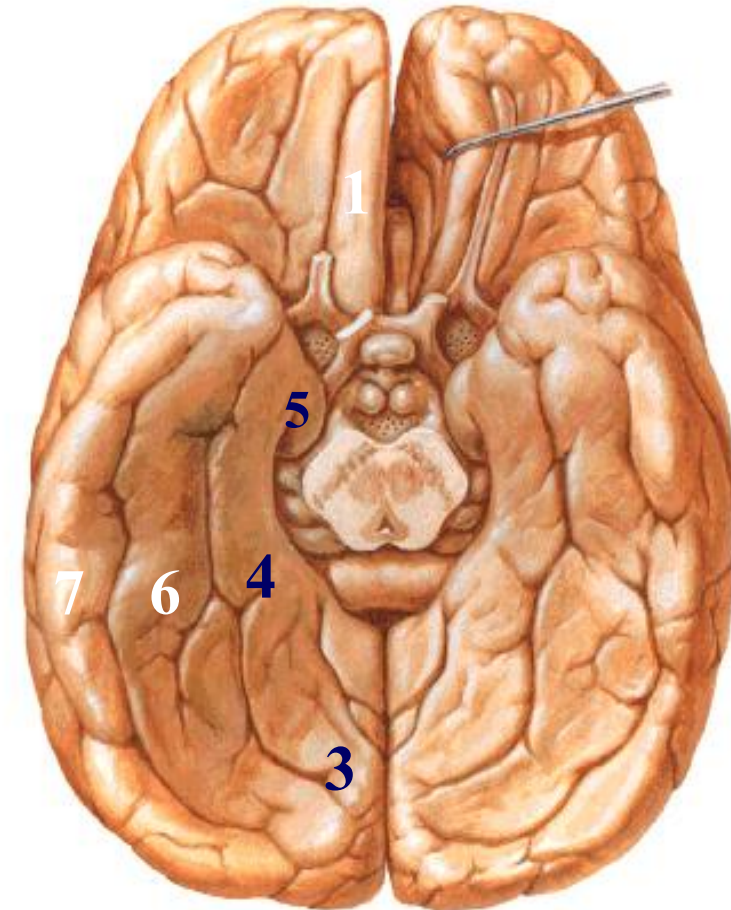
▪ **Gyri on the inferior surface:**

A) On the orbital part:

1. Gyrus rectus.
2. Anterior, posterior, medial & lateral orbital gyri.

B) On the tentorial part:

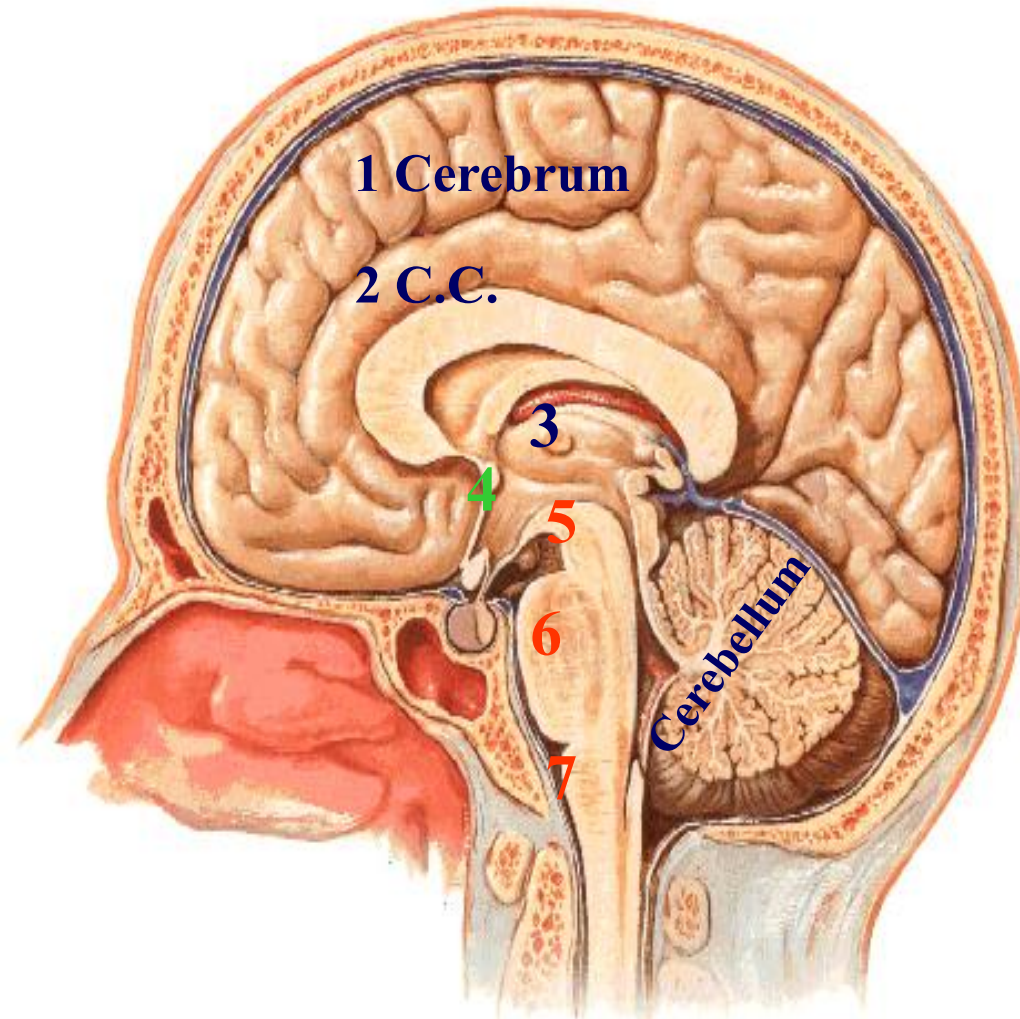
3. Lingual gyrus.
4. Parahippocampal gyrus.
5. Uncus.
6. Medial occipito-temporal gyrus.
7. Lateral occipito-temporal gyrus.



Median sagittal section of the brain

From above downwards the following areas could be identified:

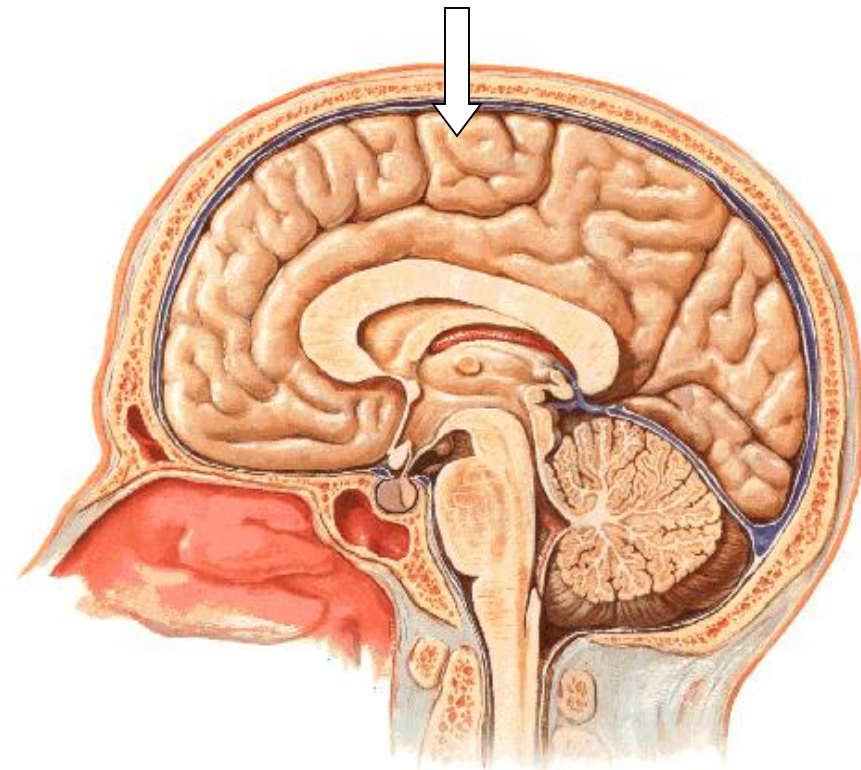
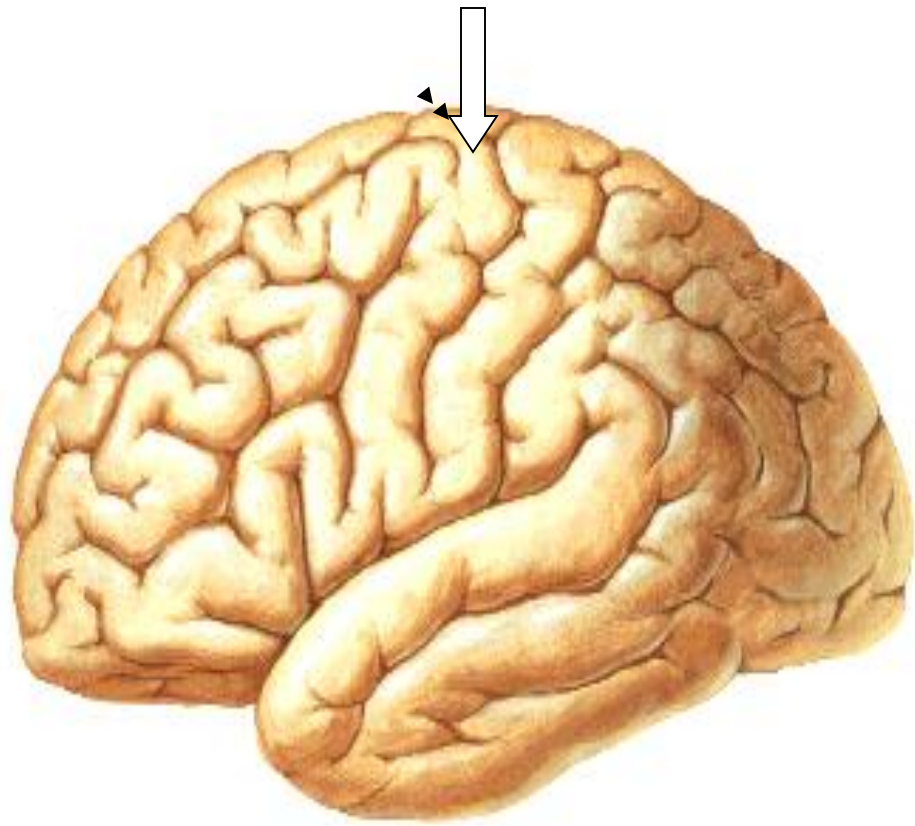
- 1- Medial surface of the cerebrum.
2. Corpus callosum with its parts.
3. Thalamus.
4. Hypothalamus.
5. Mid brain.
6. Pons.
7. Medulla oblongata.
8. Cerebellum.



Important Functional Areas of Cerebral Hemispheres

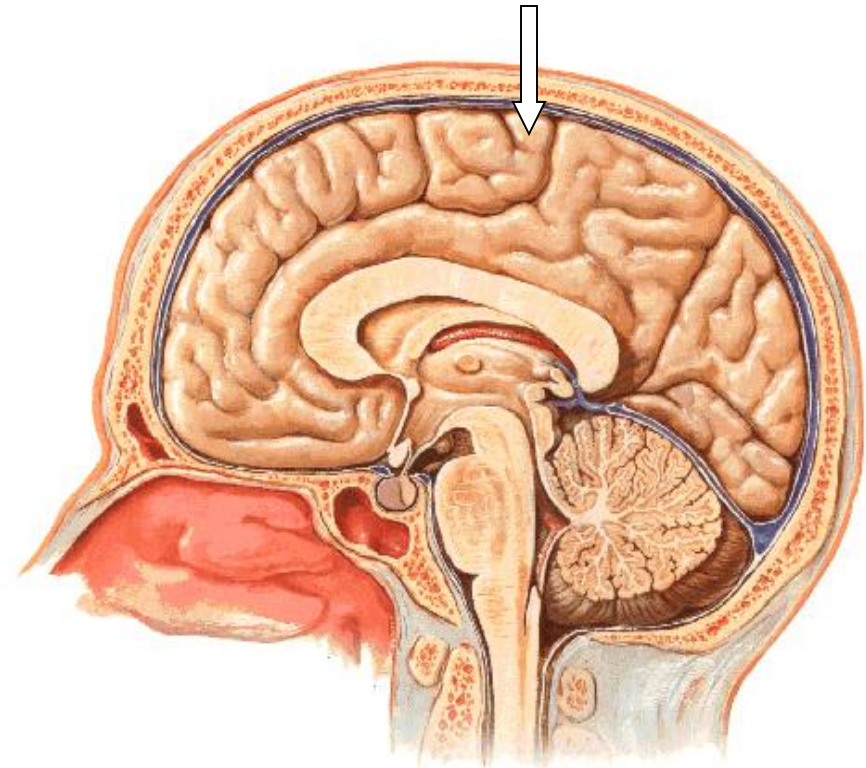
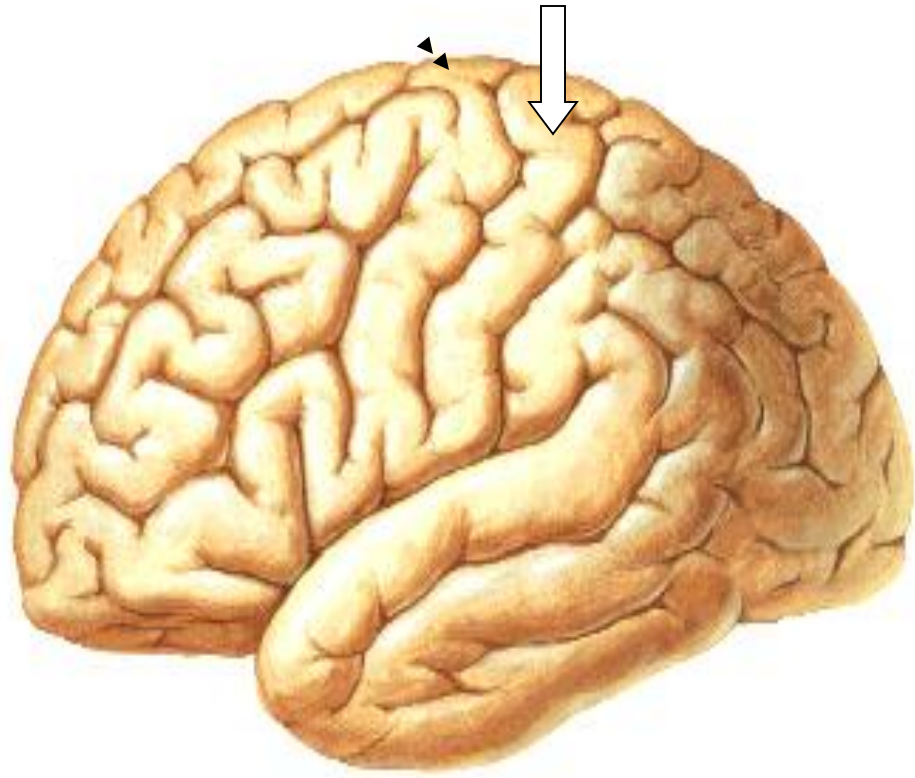
1. Primary motor area :

- It lies in precentral gyrus & ant. part of paracentral lobule.
- It controls voluntary movement of opposite side of the body.
- Body is represented upside down.
- Representation is according to skill of movement.
- Its lesion causes contralateral paralysis



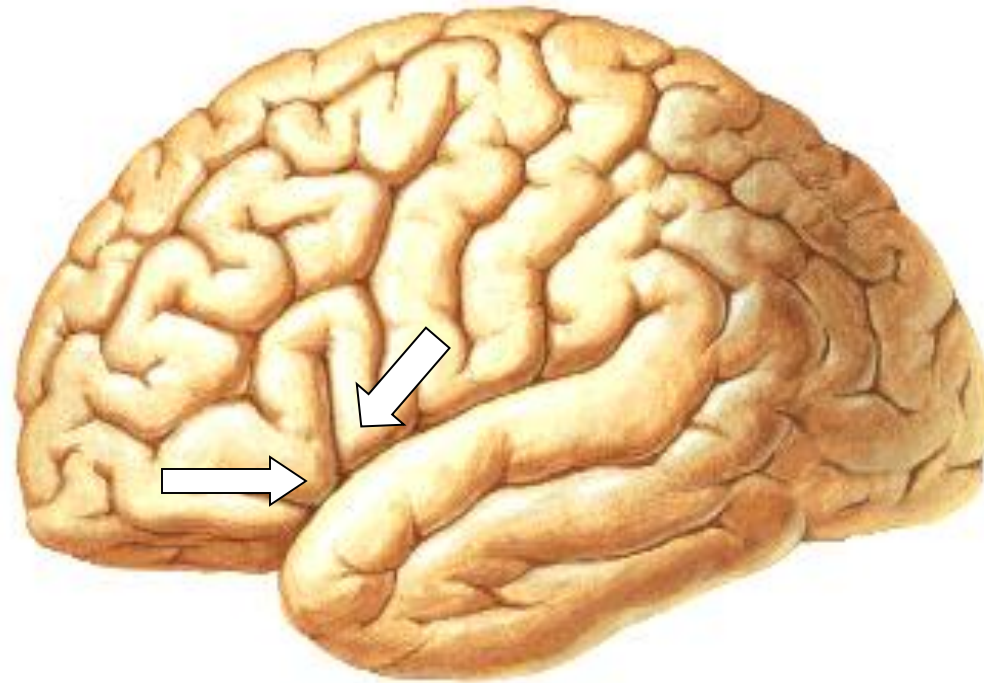
2. Primary sensory area :

- **It lies in postcentral gyrus & post. part of paracentral lobule.**
- **It receives sensations from opposite side of body (after passing through thalamus).**
- **Body is represented upside down.**
- **Its lesion causes contralateral loss of sensations.**



3. Broca's motor area for speech :

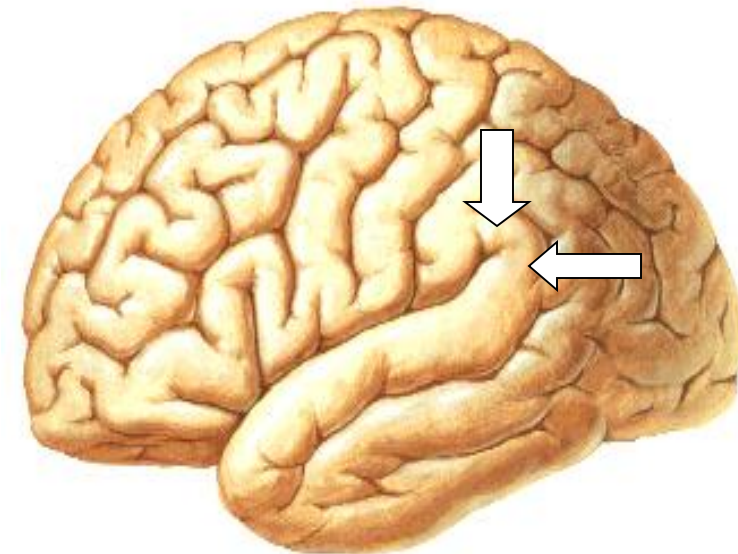
- It lies in inferior frontal gyrus.
- It lies in dominant hemisphere.
- It is responsible for speech.
- Its lesion causes motor (expressive) aphasia



4. Wernicke's sensory area for speech :

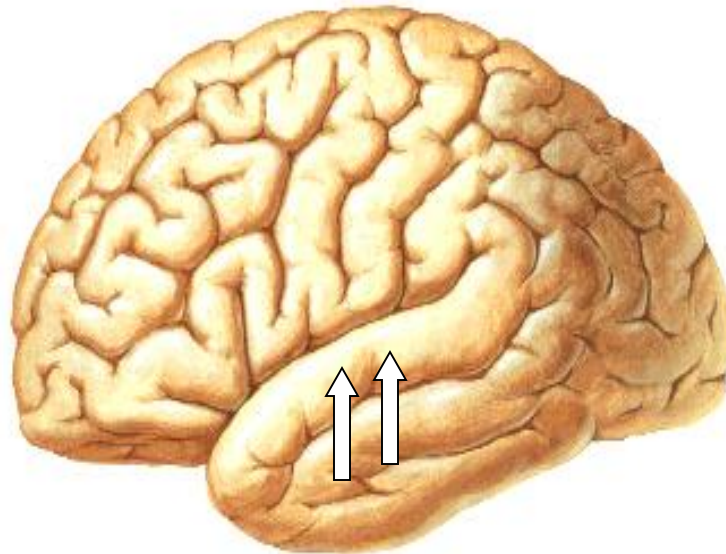
- IT lies in supramarginal & angular gyri (in inferior parietal lobule & post. part of sup. temporal gyrus).
- It lies in dominant hemisphere.
- It is responsible for understanding what we hear
- Its lesion causes sensory aphasia

standing
& what we read.



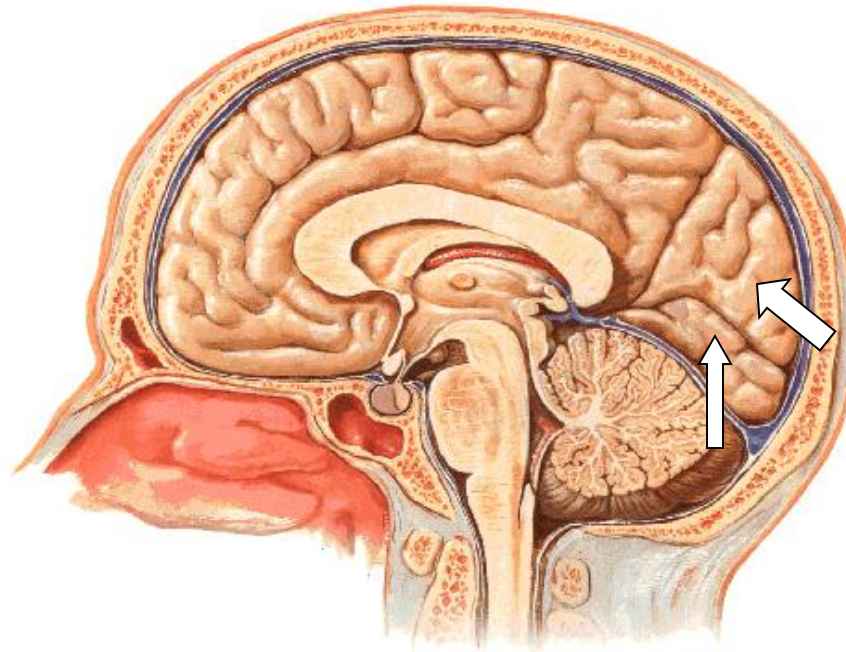
5. Auditory area :

- **It lies in superior temporal gyrus.**
- **It is responsible for hearing.**
- **It is bilaterally represented.**
- **Its lesion causes weakness in hearing.**



6. Visual area :

- It lies in occipital lobe; in cuneus & lingual gyrus.
- It is responsible for vision.
- Its lesion cause loss of vision.

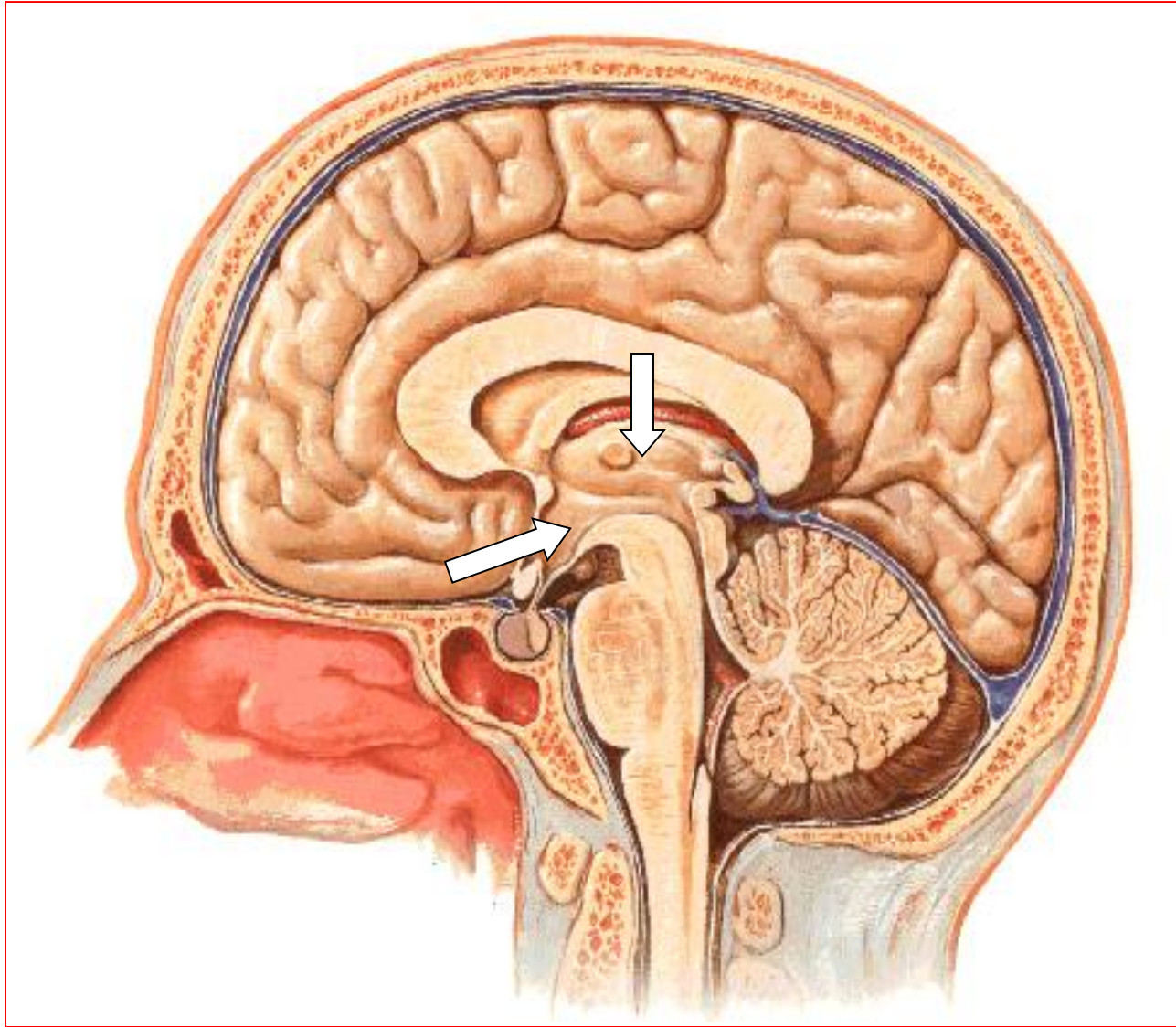


Diencephalon

- **It is formed of gray matter & lies between the 2 cerebral hemispheres.**
- **It has a cavity called 3rd ventricle.**
- **It is formed of thalamus & hypothalamus.**

Thalamus

- **It is an oval mass of gray matter.**
- **It is formed of several nuclei.**
- **It is a relay station of all sensations before reaching cerebral cortex (except smell).**



Hypothalamus

- **It lies** below the thalamus.
- **It has the following functions :**
 1. Control of endocrinal system.
 2. Control of autonomic nervous system.
 3. Secretion of 2 hormones; oxytocin (which stimulates contraction of uterus) & anti-diuretic hormone (which decreases amount of urine).
 4. Control of body temperature.
 5. Control of food & water intake.
 6. Plays a role of behavior & mood.

Ventricular system

- * They are cavities that lie within the brain.
- * They are filled with C.S.F.

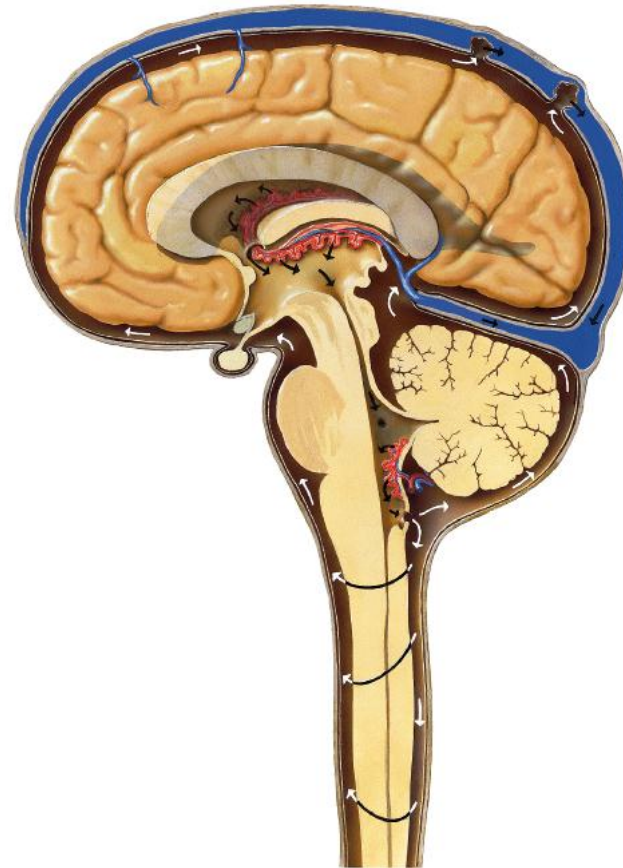
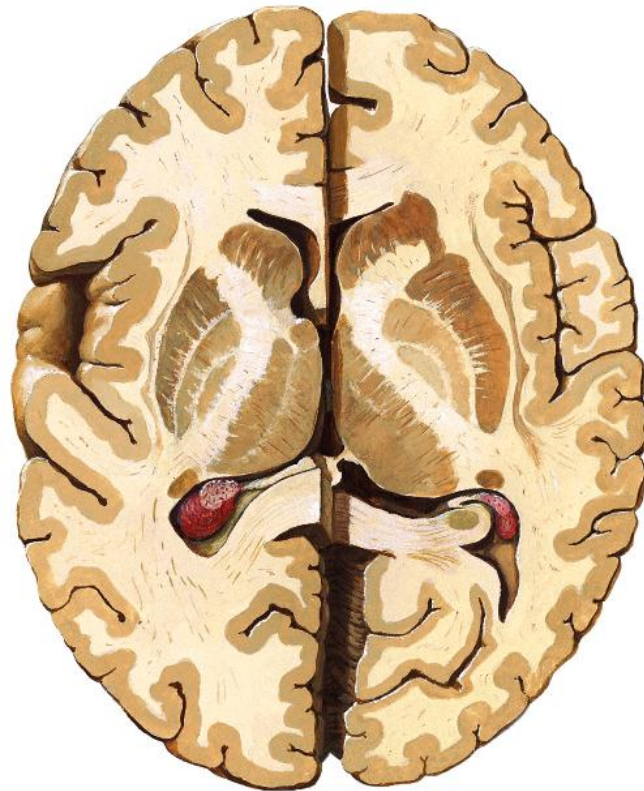
A. Lateral ventricle:

- * It is the cavity of cerebral hemisphere.
- * It has anterior horn, body, posterior horn and inferior horn.
- * It is connected to 3rd ventricle via inter-ventricular foramen of Monro.



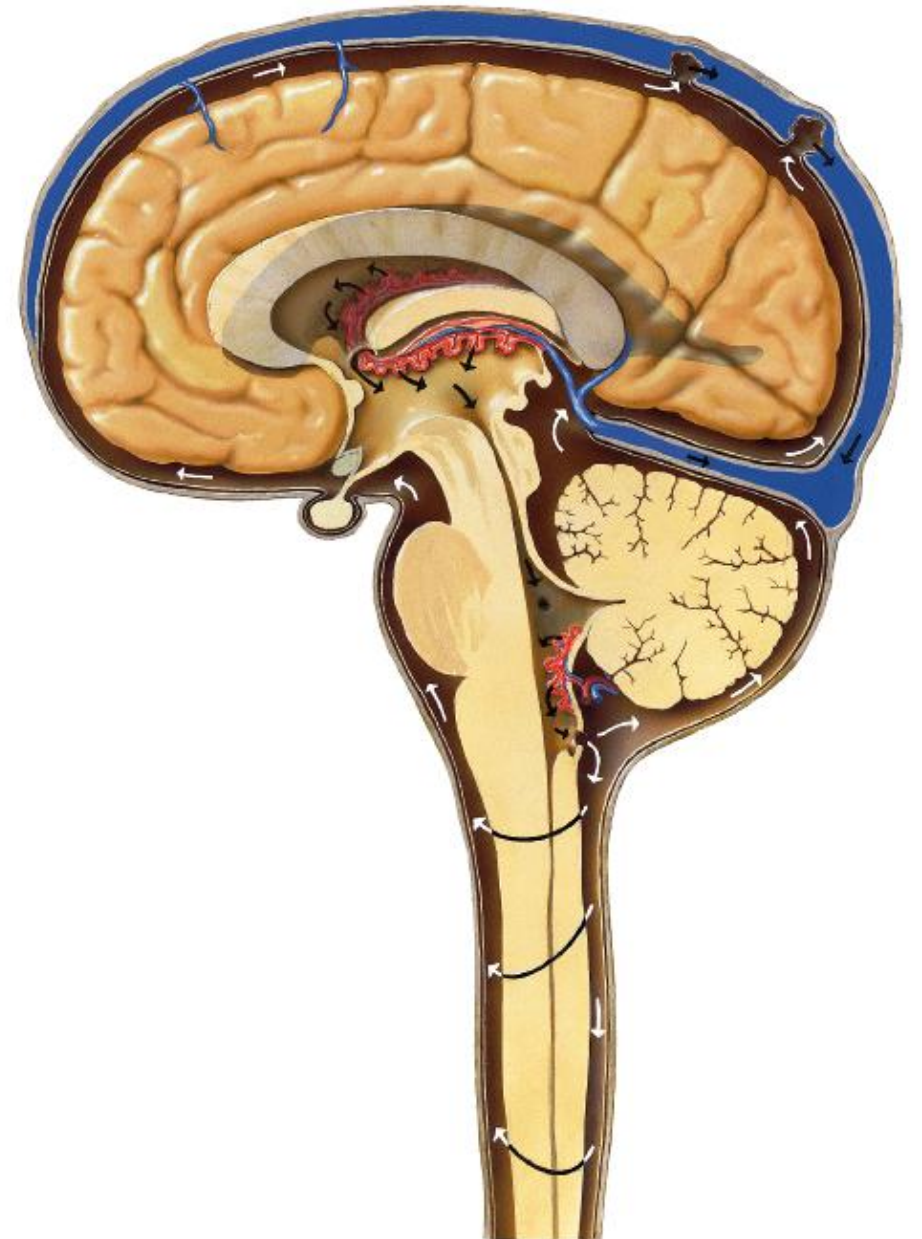
B. Third ventricle:

- * It is the cavity of diencephalon.**
- * It is connected to lateral ventricle via inter-ventricular foramen and connected to 4th ventricle via cerebral aqueduct.**



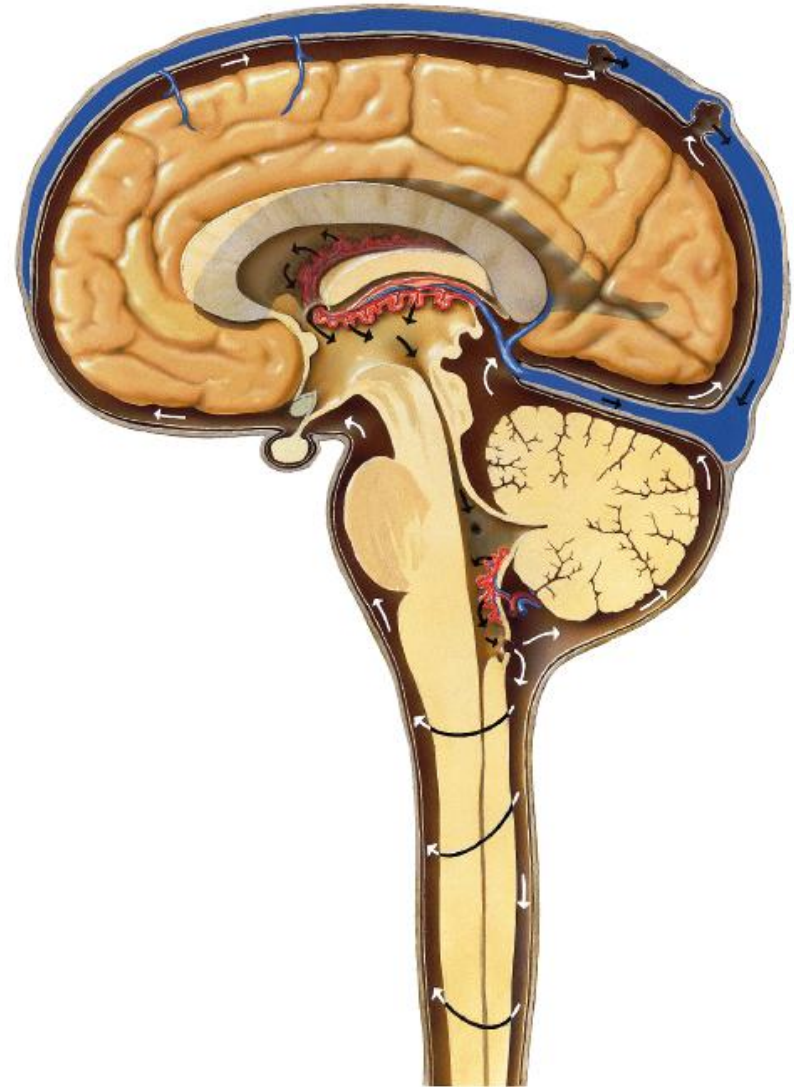
C. 4th Ventricle:

- * It lies between:**
- *** Cerebellum → posteriorly & pons & medulla → anteriorly.**
- * It is connected to 3rd ventricle by cerebral aqueduct and with central canal of medulla & spinal cord.**



Cerebrospinal Fluid (C.S.F)

- * It is a clear colorless fluid that lies within the ventricles and subarachnoid space.
- * **Volume:** 150 ml.
- * **Formation:** choroid plexus of lateral ventricle.

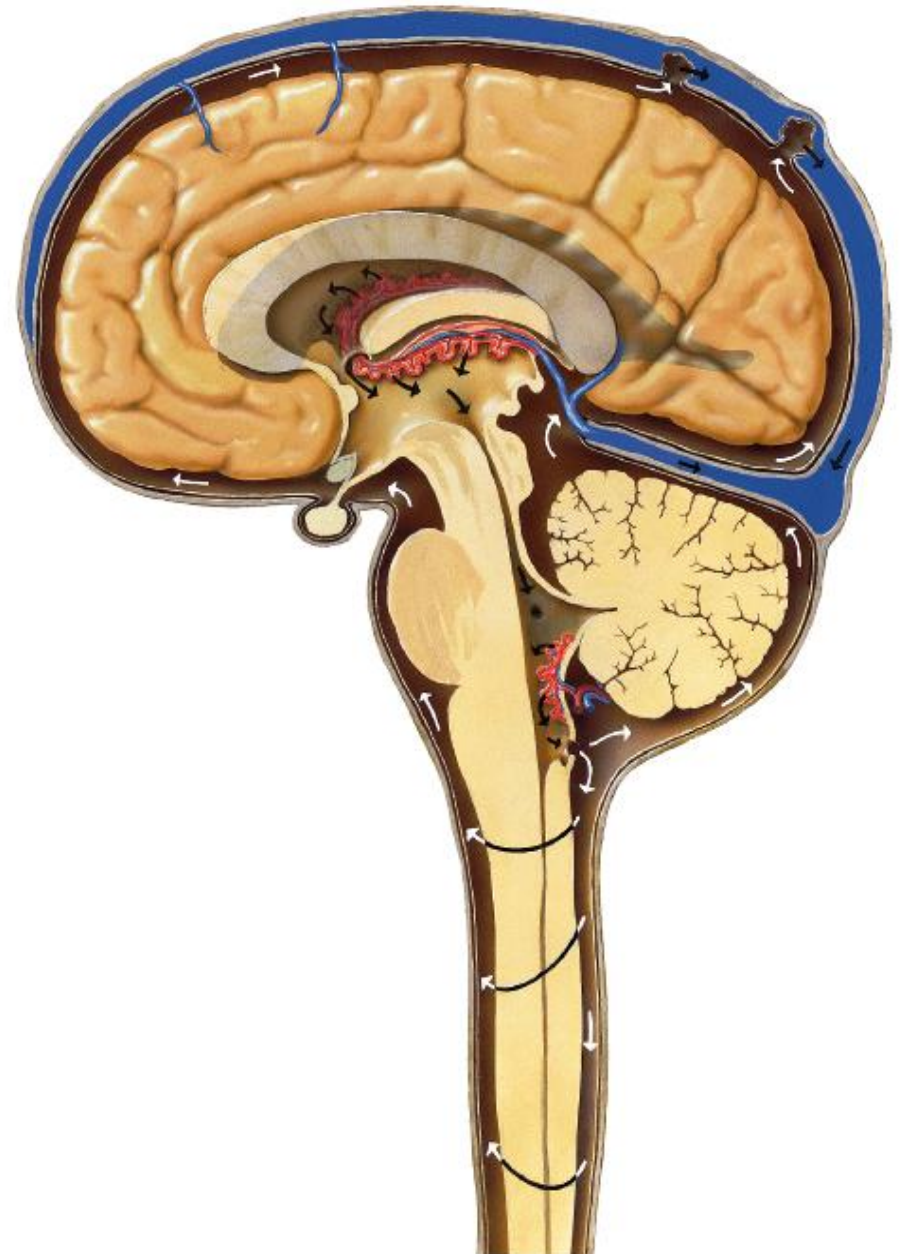


* **Circulation:** CSF passes from lateral ventricle to third ventricle via inter-ventricular foramen and from third ventricle to 4th ventricle by cerebral aqueduct. It escapes from 3 foramina in 4th ventricle to subarachnoid space.

* **Absorption:** Arachnoid villi.

* **Function:**

1. Protection of brain.
2. Removal of metabolites.

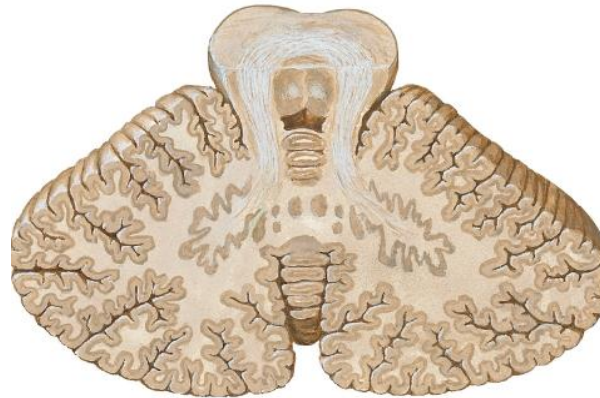
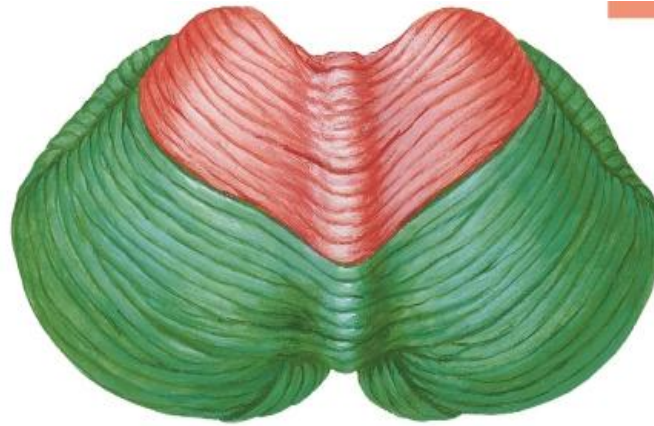


Cerebellum

- It is formed of 2 cerebellar hemispheres, connected together by a vermis.
- It is formed of :
 - a. an outer layer of gray matter called cerebellar cortex.
 - b. an inner core of white matter.
 - c. some scattered masses of gray matter inside white matter & are called cerebellar nuclei.

Functions of cerebellum:

1. Regulation of muscle tone.
2. Equilibrium.
3. Coordinated smooth voluntary movement.

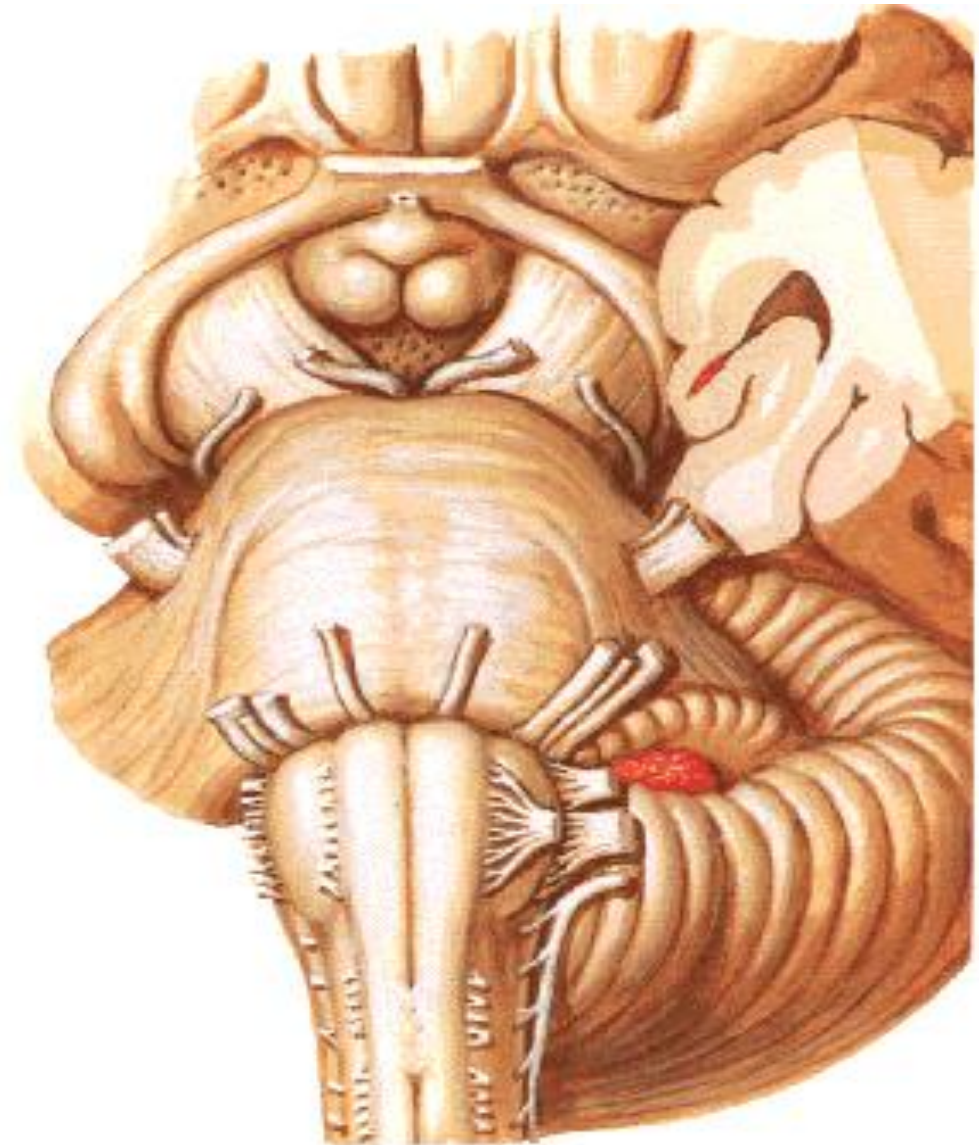


A lesion of cerebellum leads to :

1. Hypotonia (weakness in ms. tone).
2. Dysarthria (slow irregular speech).
3. Tremors & non-coordinated movements.
4. Ataxia (non-balanced gait).

Brain Stem

- It is formed of 3 parts; from above downwards; **midbrain, pons & medulla oblongata.**
- Between it & cerebellum, there's a cavity called the 4th ventricle.
- It contains the nuclei of the cranial nerves
(from 3rd – 12th).
- All cranial nerves exit from its anterior surface except 4th C.N., which exit from its posterior surface.



Cranial Nerves

I. Olfactory N. : smell.

II. Optic N. : vision.

III. Oculomotor N., IV. Trochlear N. & VI. Abducent N. : motor to muscles of eye.

V. Trigeminal N. : mixed N. (mostly sensory to face, teeth, nasal cavity & oral cavity & motor to muscles of mastication).

VII. Facial N. : mainly motor to all muscles of facial expression (including all ms. of face).

VIII. Vestibulo-cochlear N. : sensory for hearing & equilibrium.



IX. Glossopharyngeal N.: motor to ms. of palate, pharynx & larynx.

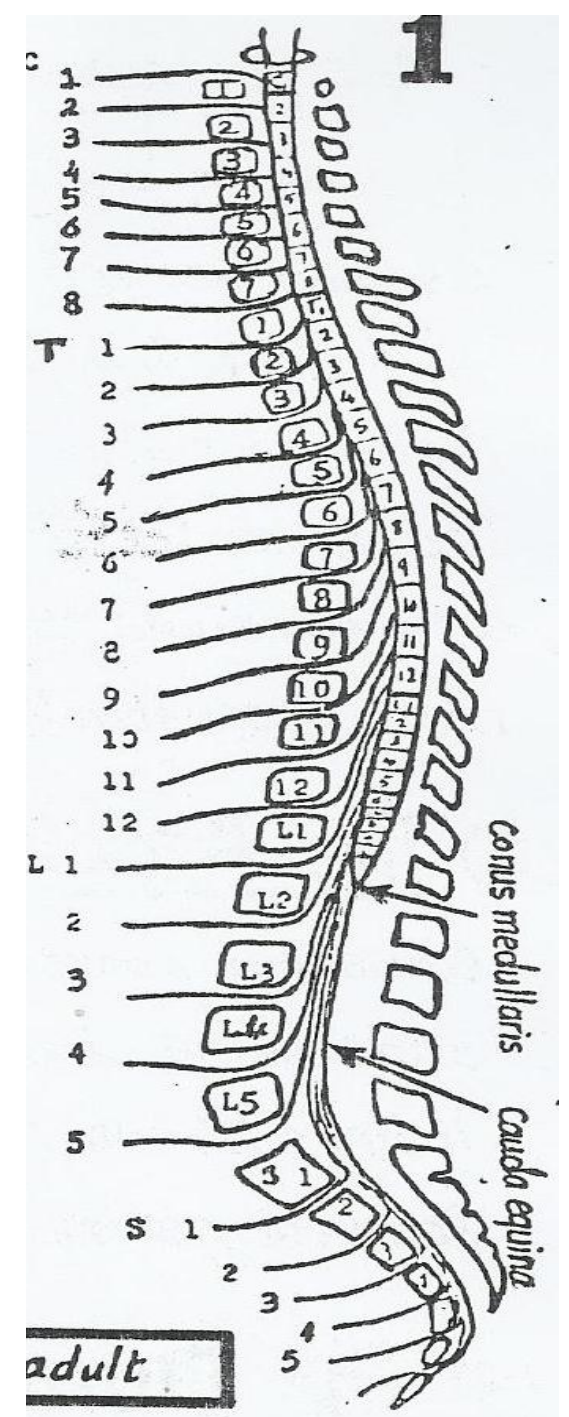
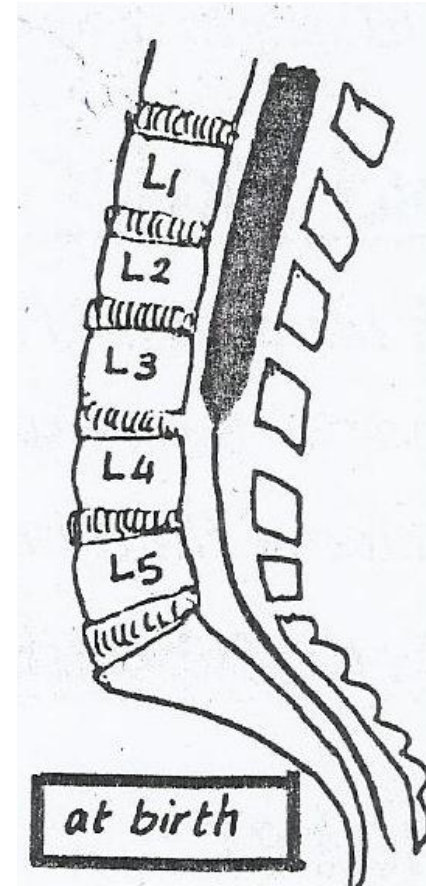
X. Vagus N. : mainly motor, parasympathatic

XI. Accessory N. : mainly motor.

XII. Hypoglossal N. : motor to muscles of tongue.

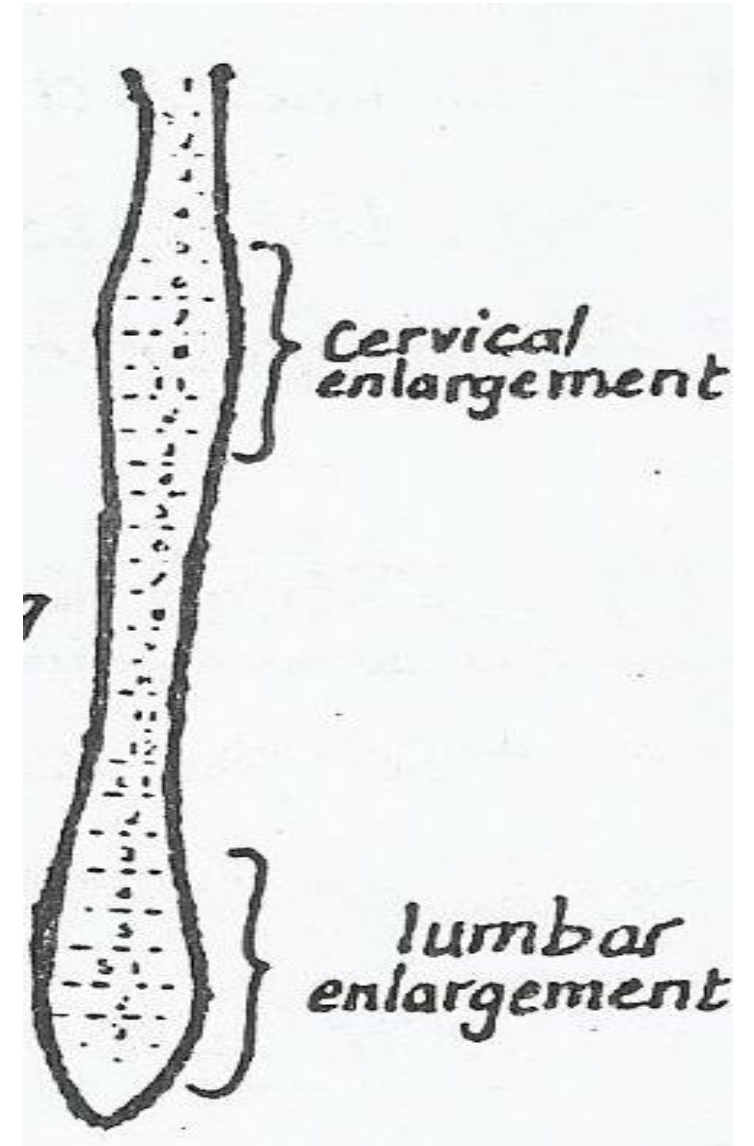
SPINAL CORD

- ** It is a part of C.N.S that lies within the vertebral canal.
- ** Begins: at foramen magnum as direct continuation of medulla.
- ** Ends: at lower border of L1.
- ** In children → it ends at upper border of L3 while in fetal life → the spinal cord and vertebral canal are equal in length. This variation is due to the differences in rate of growth of vertebral canal & spinal cord.

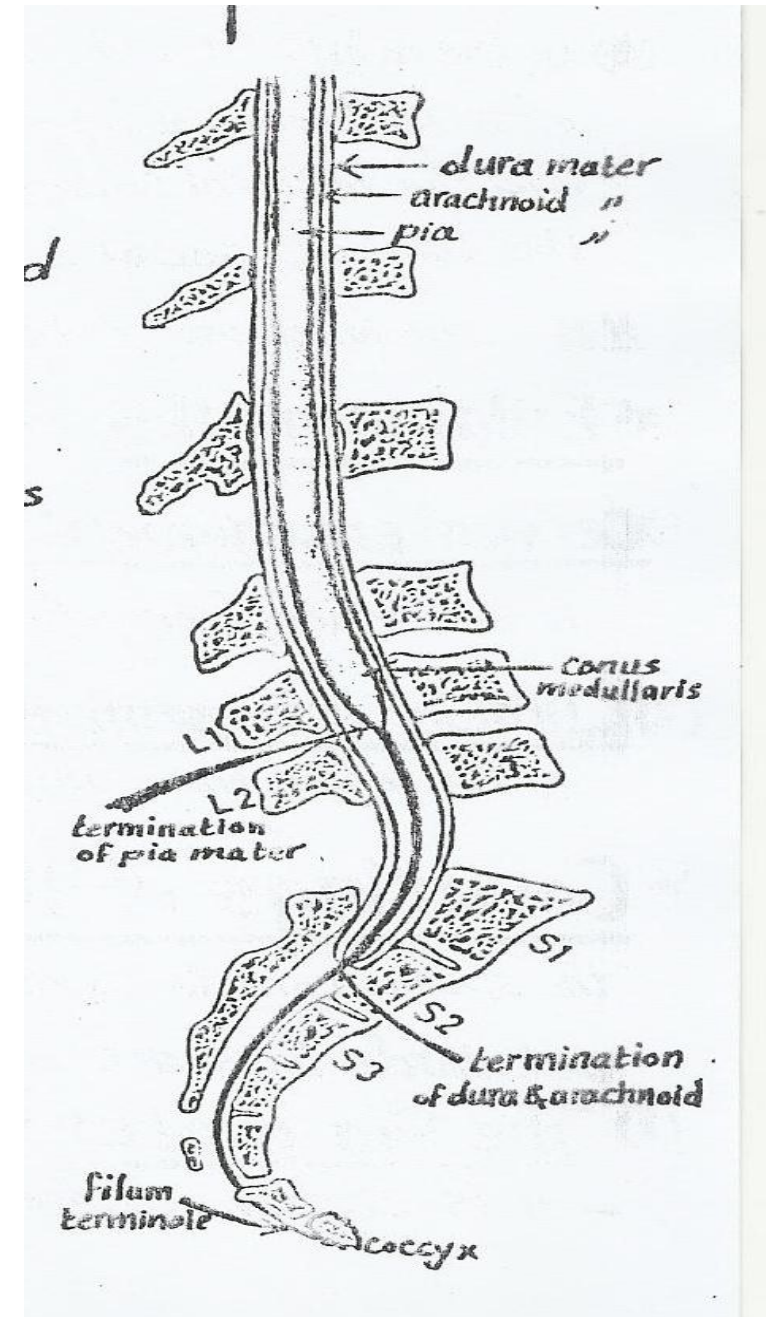


SPINAL CORD (Contd)

**** Shape: cylindrical in shape, but it shows 2 enlargements; cervical and lumbar enlargements which are the source of nerve supply to upper & lower limbs respectively. The lower end is tapering and is called conus medullaris.**

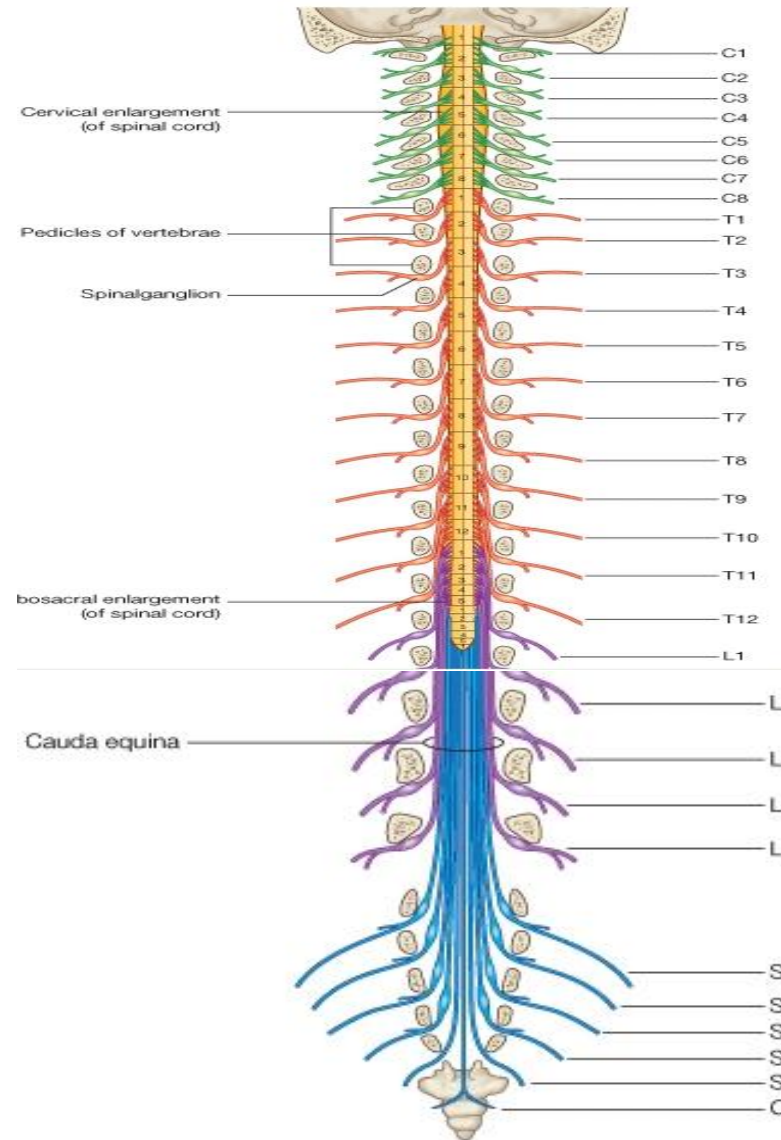


- * Length: 45 cms.
- * Spinal cord coverings: It has 3 coverings: dura, arachnoid & pia matter.
- * Dura and arachnoid ends at S2.
- * Pia matter forms a prolongation called filum terminale which extends from apex of conus medullaris to be attached to the back of coccyx.
- * C.S.F lies in the subarachnoid space.



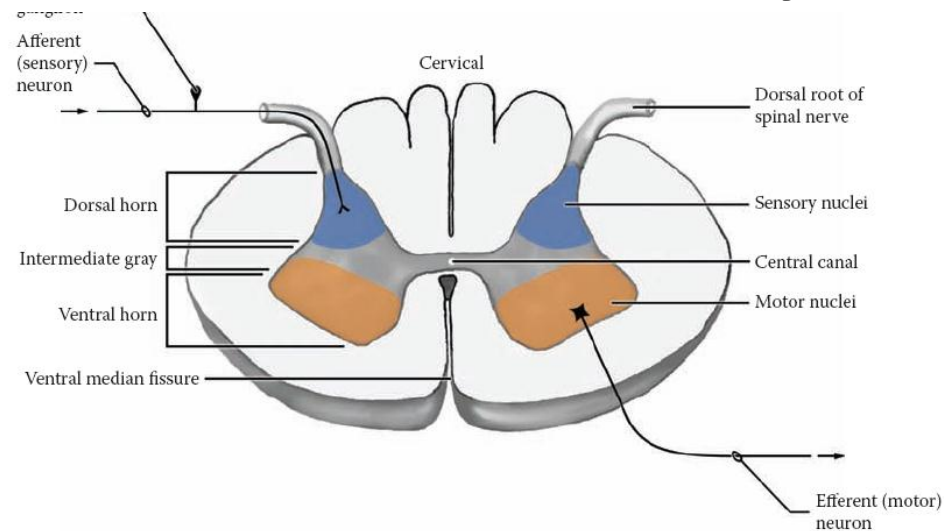
**** Spinal nerves:**

- * 31 pairs of spinal nerve are attached to the spinal cord, (8 cervical, 12 thoracic, 5 lumbar, 5 sacral and one coccygeal).**
- * Cauda equina: formed by lower lumbar, sacral and coccygeal nerves that descend in the vertebral canal below level of L1.**



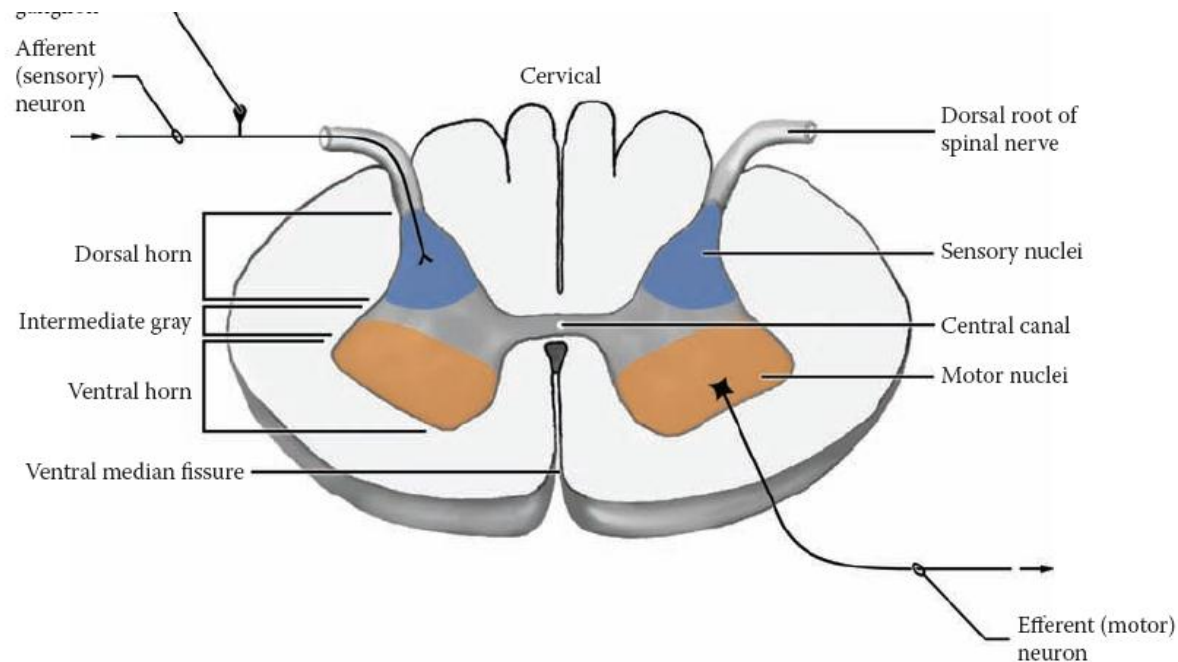
Structure of spinal cord

- ** It is formed of an inner core of grey matter surrounded by an outer white matter.**
- ** The grey matter: is H shaped with an anterior (ventral) horn containing motor nuclei and posterior (dorsal) horn containing sensory nuclei. Both horns are joined by a thin grey commissure which is traversed by a central canal.**
- ** A small lateral horn is present only in thoracic and upper 3 lumbar segments. It contains sympathetic nucleus and is considered the only source of preganglionic sympathetic fibers in the whole body.**



b. White matter is divided into:

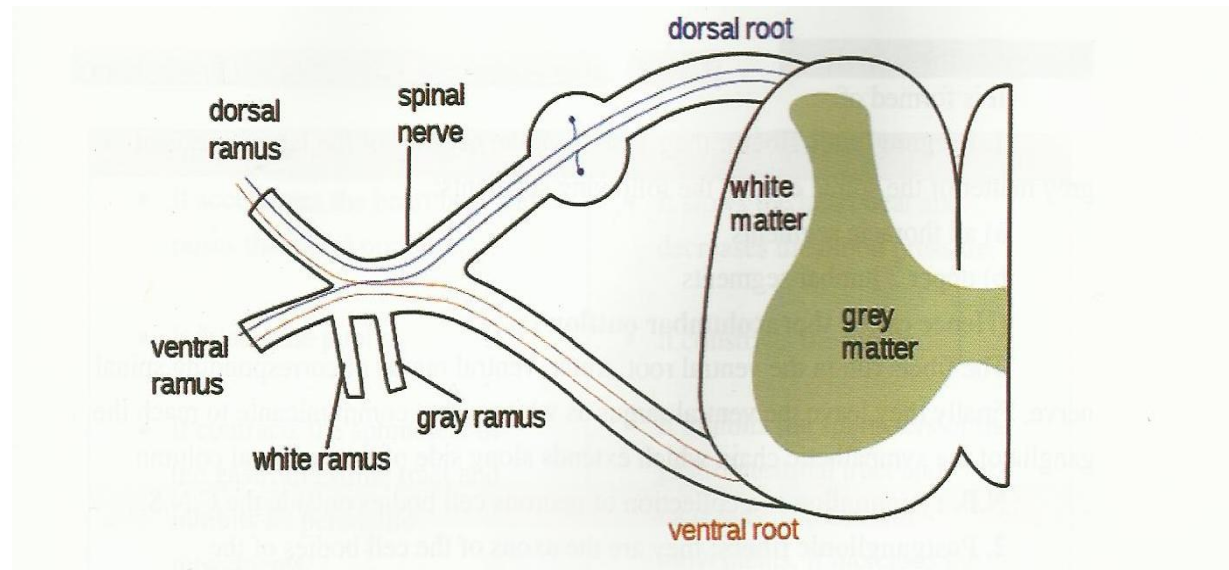
- i. Anterior white column: between mid line and exit of ventral root of spinal nerves.**
- ii. Lateral white column: lies between exist of ventral and dorsal roots of spinal nerves.**
- iii. Posterior white column: lies between the dorsal root of spinal nerves and mid line.**



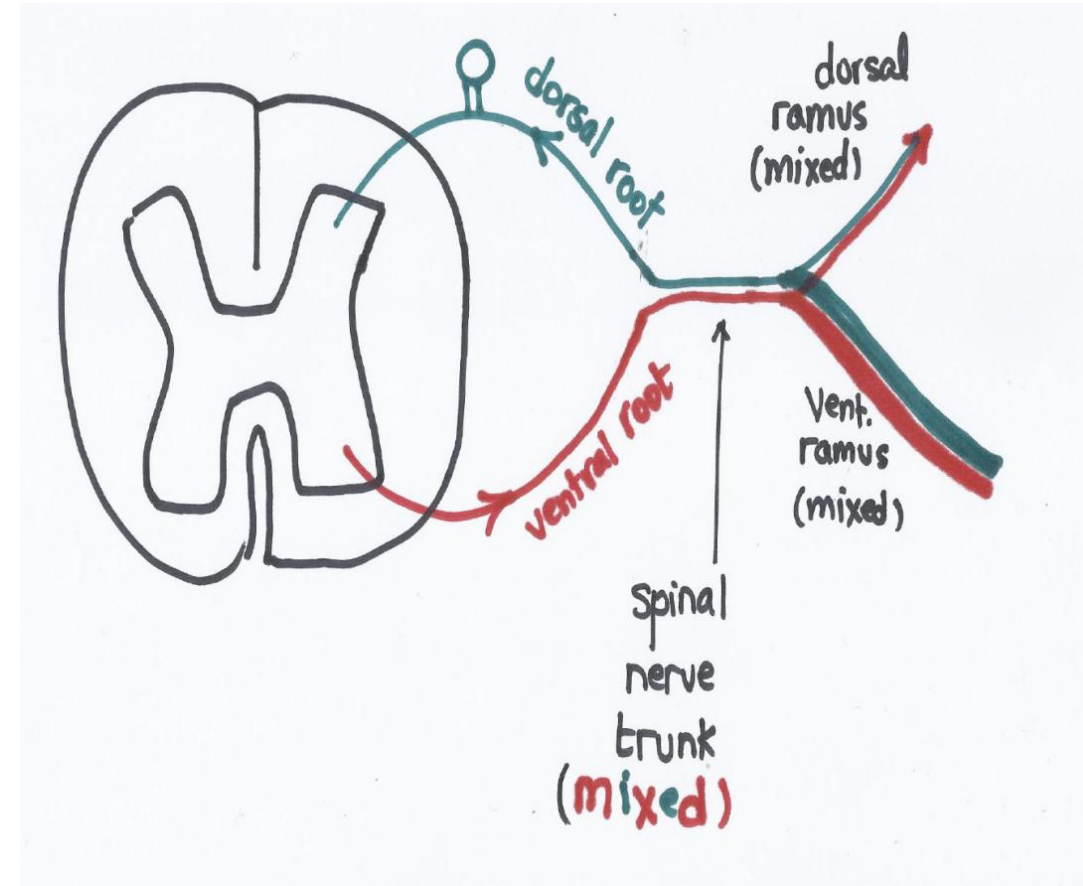
Structure of spinal nerve

**** Each spinal nerve is attached to the cord by 2 roots:**

- 1. Ventral root: it is formed of motor fibres which carry impulses away from spinal cord. It is the axons of motor nuclei present in anterior (ventral) horn.**
- 2. Dorsal root: It is formed of sensory fibers which carry impulses to the spinal cord. It is the axons of cells of dorsal root ganglia present on dorsal roots.**



- * Union of dorsal & ventral roots forms the spinal nerve which is mixed; it is very short and exits form the vertebral canal via the intervertebral foramina .
- * The spinal nerve divides into large ventral ramus (mixed) & small dorsal ramus (mixed).
- * Ventral rami: supply skin & muscles of anterolateral region of trunk and limbs. Ventral rami tend to form plexuses (cervical – brachial – lumbar & sacral).
- * Dorsal rami: supply the skin & muscles of back of the neck and trunk.



Peripheral nervous system (PNS)

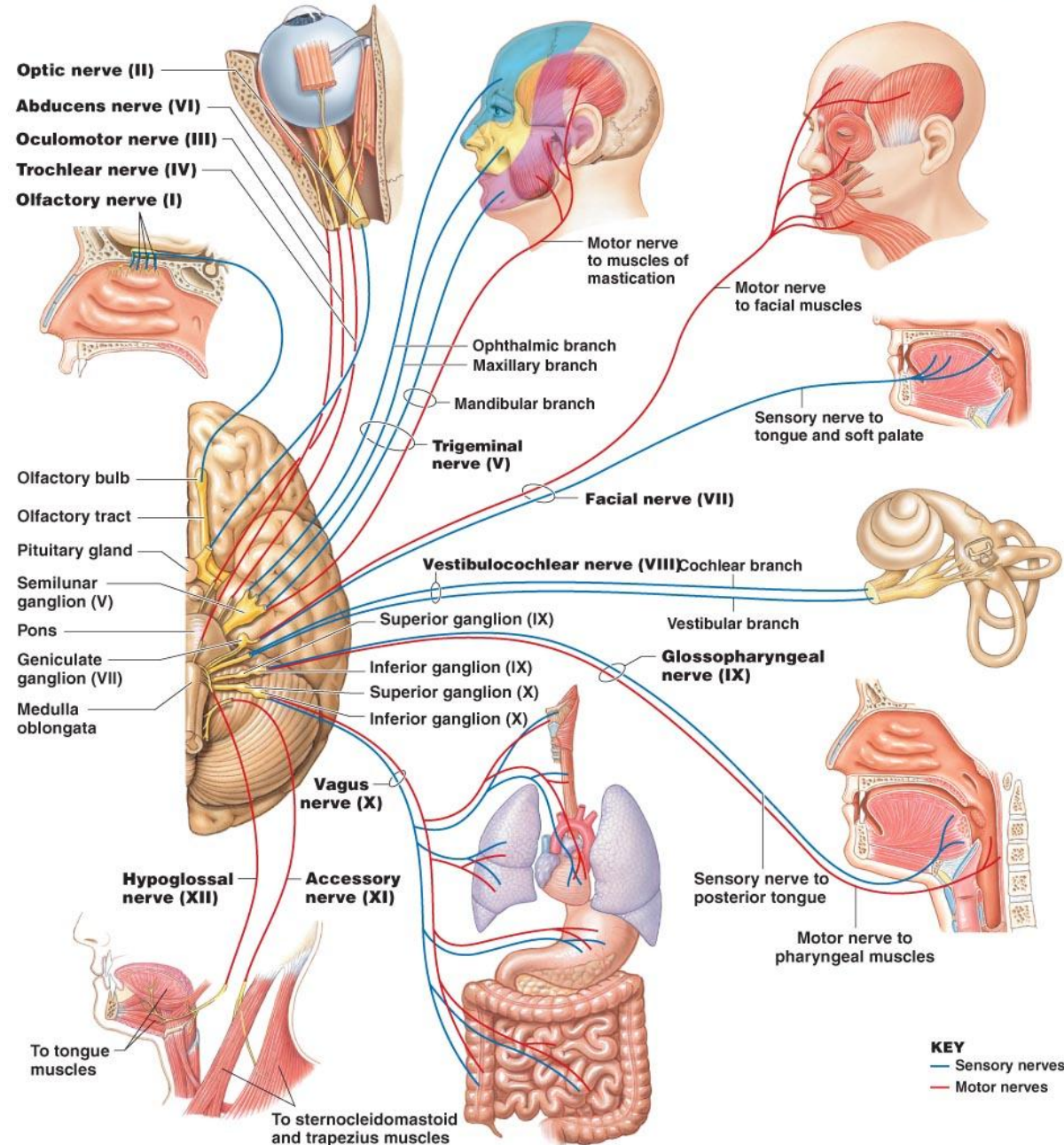
Cranial nerves

There are 12 pairs of cranial nerves

- 1-Olfactory
- 2-Optic
- 3-Oculomotor
- 4-Trochlear
- 5-Trigeminal
- 6-Abducent

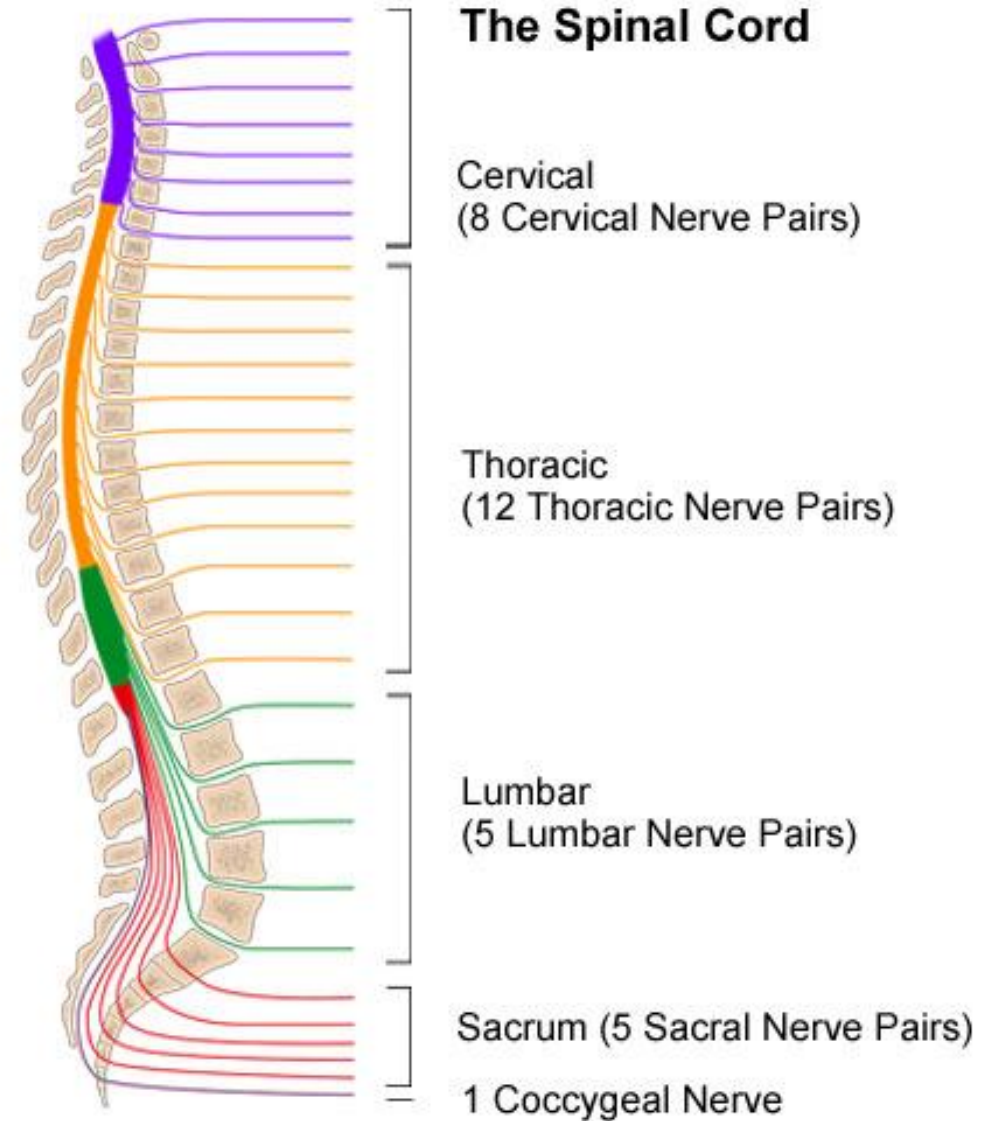
- 7-Facial
- 8-Vestibulo-cochlear
- 9- Glossopharyngeal
- 10-Vagus
- 11-Accessory
- 12-Hypoglossal

The branches of the 12 cranial nerves, their functions (motor, sensory, or mixed), and the structures they innervate

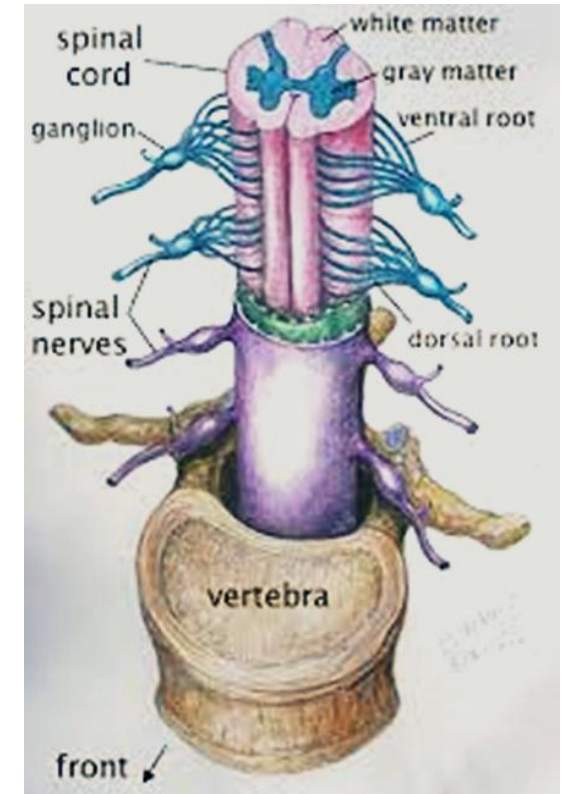
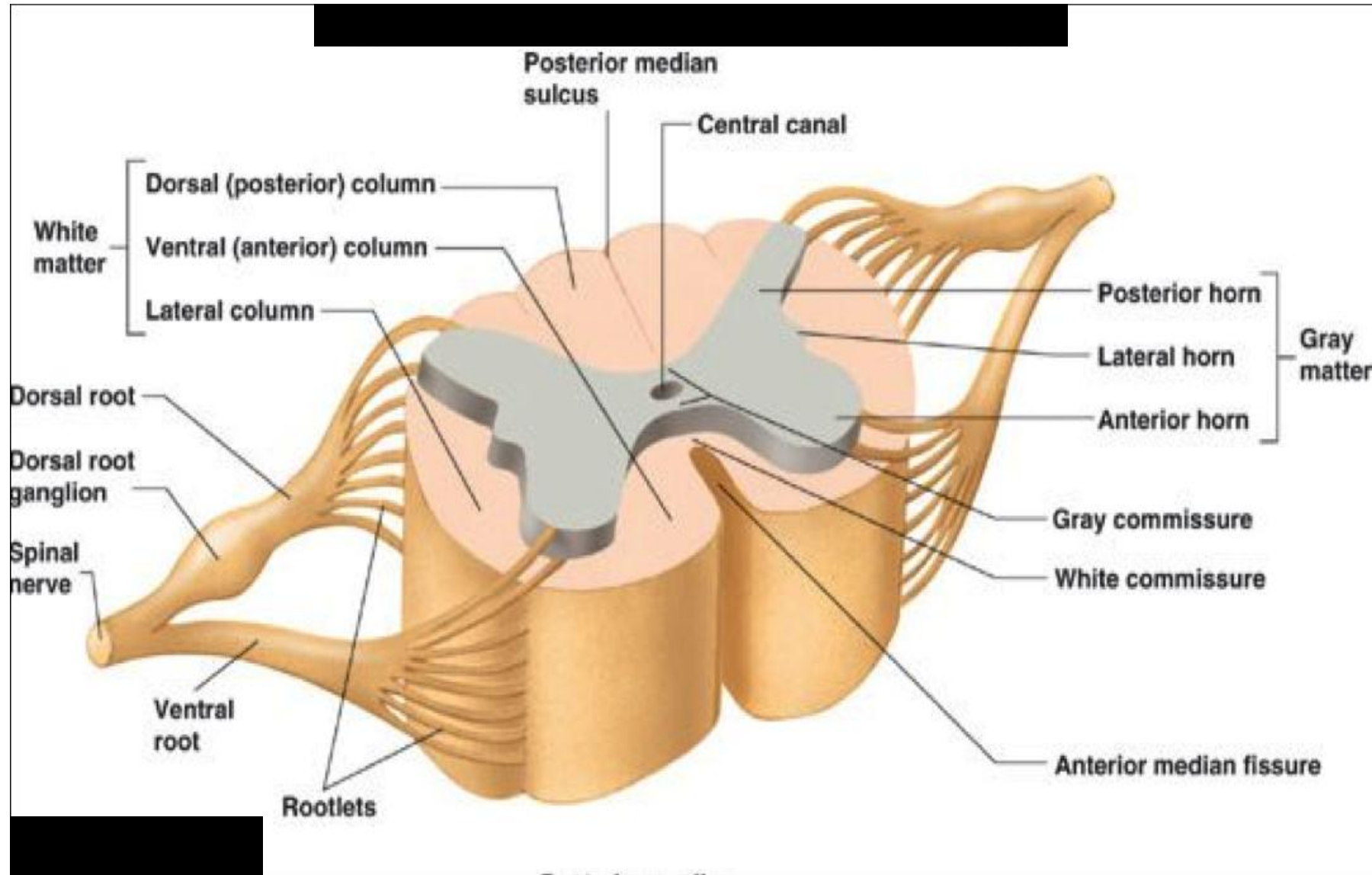


Spinal nerves

The spinal cord gives 31 pairs of spinal nerves



Each spinal nerve is connected to the spinal cord by two roots , *Anterior* & *Posterior roots*

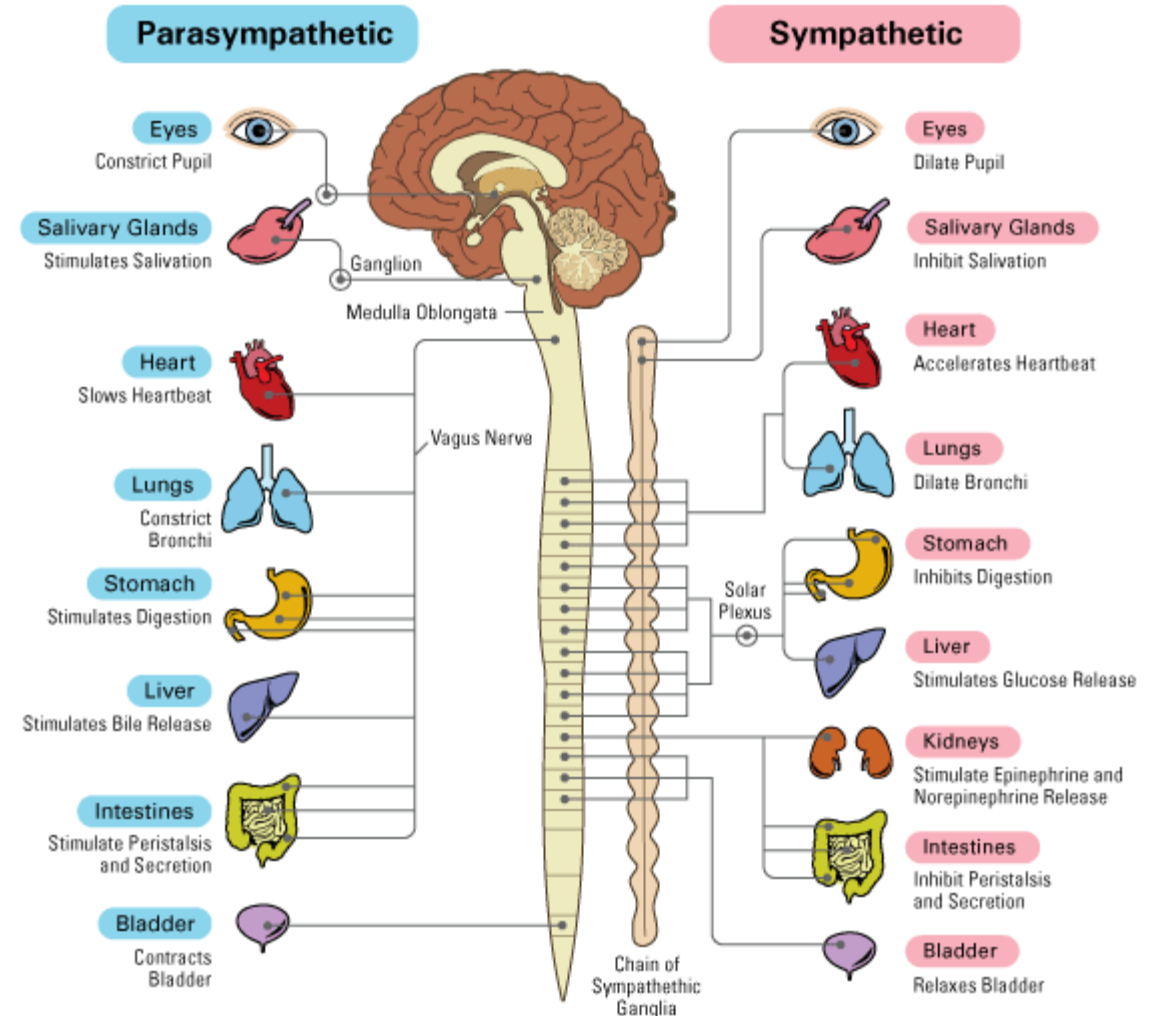


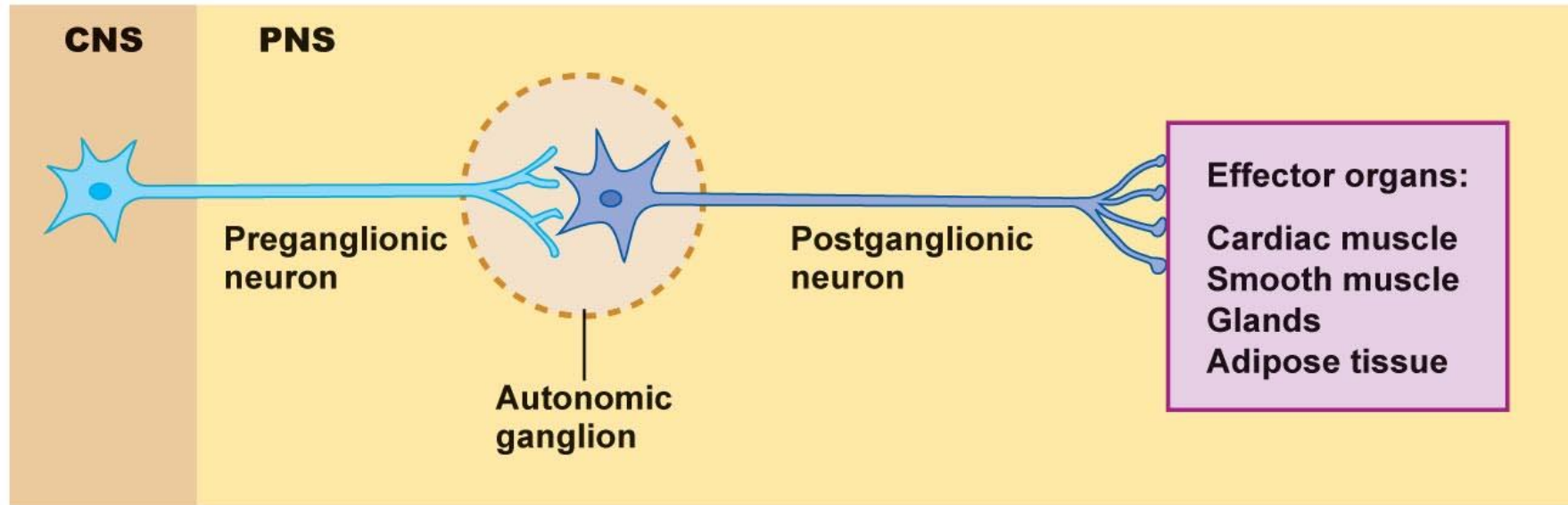
The Autonomic Nervous System (ANS)

It is the involuntary component of the nervous system which is concerned with the control of the smooth muscles, heart and glands.

The ANS is composed of the sympathetic system and parasympathetic system. They are antagonistic yet complementary to each other as they work in harmony.

Schema Explaining How Parasympathetic and Sympathetic Nervous Systems Regulate Functioning Organs





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The ANS needs 2 sets of neurons:

- a) Preganglionic neurons: they carry the impulses from the C.N.S. to ganglia outside the C.N.S.**
- b) Postganglionic neurons: they carry the impulses from the ganglia to the smooth muscles and glands.**

In the ganglia, the pre and postganglionic neurons meet by making synapses

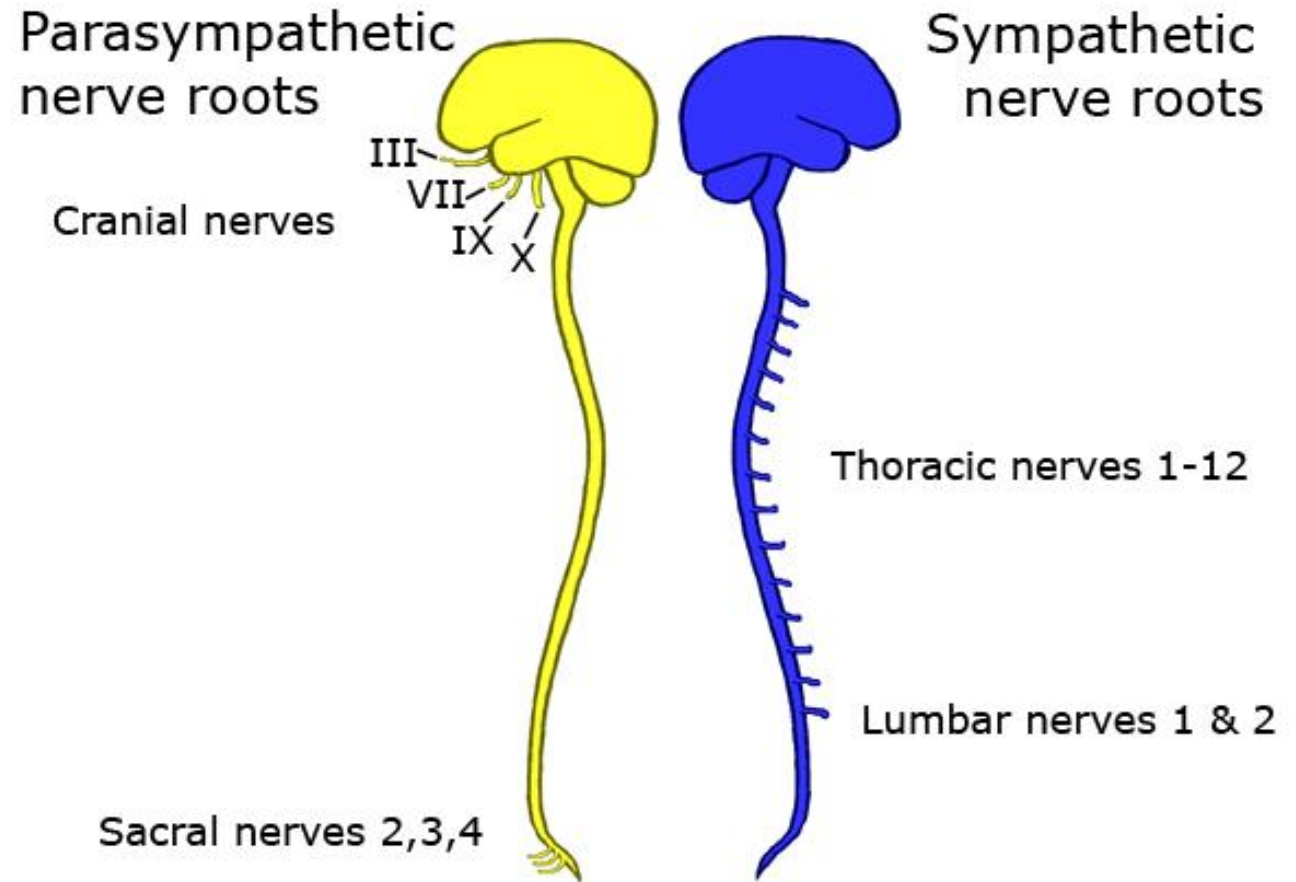
Preganglionic sympathetic fibers: arise from the neurons of the lateral horns of grey matter of the spinal cord (thoracolumbar outflow).

- a) all thoracic segments
- b) upper 2 lumbar segments

Preganglionic parasympathetic fibers: they arise from C.N.S. in 2 sites:

a- With cranial nerves number **3,7,9,10**

b- From the neurons of lateral horn of 2nd , 3rd , 4th sacral segments of spinal cord (craniosacral outflow).



The sympathetic system

- It is formed of:

1. Preganglionic fibers:

They arise from the neurons of the lateral horns of the gray matter of the spinal cord in the following segments:

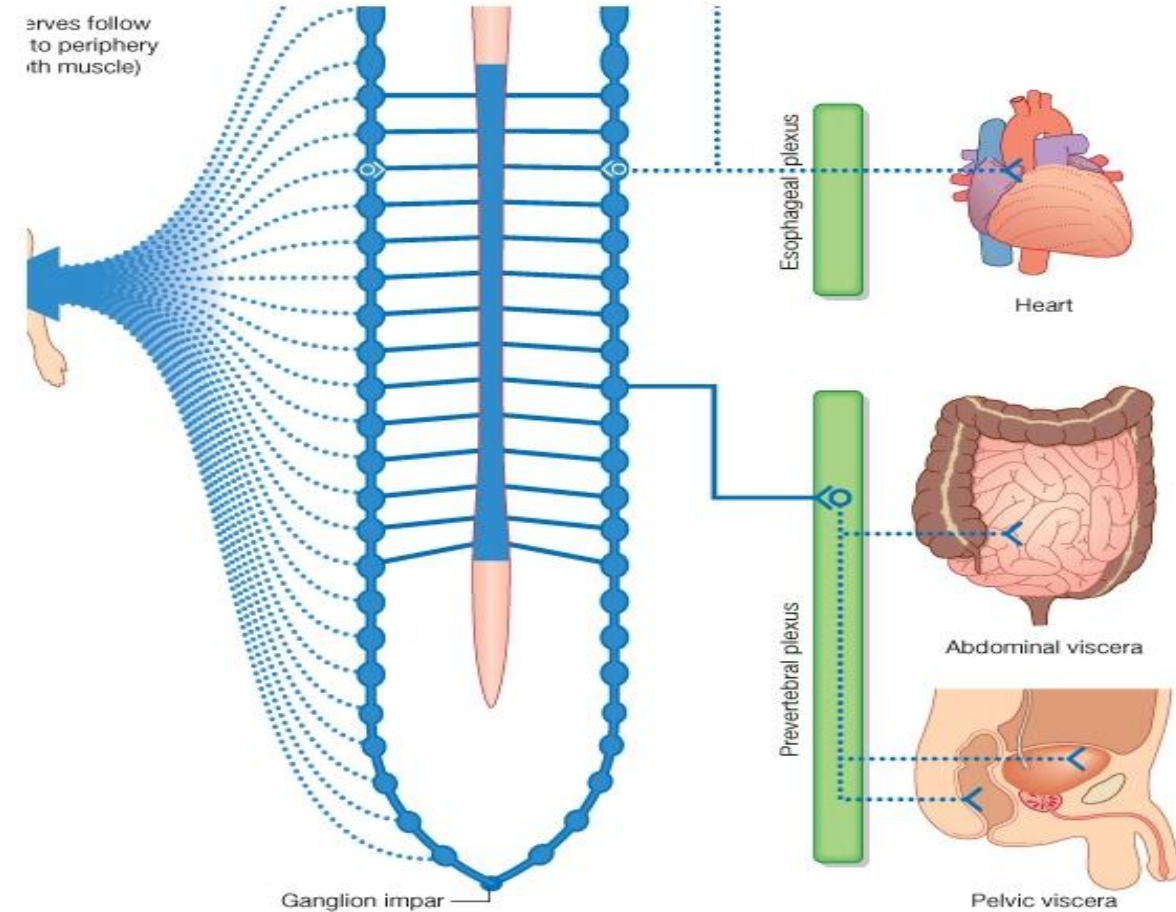
1. All thoracic segments.
2. Upper 2 lumbar segments.

Hence, the name
thoracolumbar outflow

- The fibers run in the ventral root, trunk & ventral primary ramus of the corresponding spinal nerve. Finally, the preganglionic fibers leave the ventral primary ramus as white ramus communicans to reach the ganglia of the sympathetic chain.

▪ 2. The sympathetic chain:

- 2 chains on both sides of the vertebral column.
- Each chain is formed of 21 – 23 interconnected ganglia.
- The thoracic and upper lumbar parts of the chain receive the white rami communicants of the preganglionic fibers.
- Inside each chain, the white rami communicants are divided into:
 - a. **Ascending group:** These are fibers which make synapses with the cell bodies of the upper ganglia of the chain.
 - b. **Transverse group:** These are fibers which make synapses with the cell bodies of the same level ganglion.
 - c. **Descending group:** These are fibers which make synapses with the cell bodies of the lower ganglia of the chain.



3. The postganglionic fibers: These are the axons of the cell bodies of the sympathetic ganglia. They leave the ganglia to reach the different parts of the body by one of 3 methods:

1. By rejoining the ventral & dorsal primary rami to be distributed via them. These connections between the ganglia and the ventral primary rami are called *grey rami communicants*.
2. By passing along the blood vessels.
3. By reaching the viscera directly.

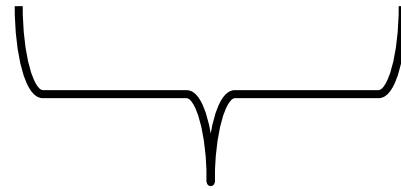
The parasympathetic system

▪ It is formed of:

1. Preganglionic fibers: They arise from C.N.S. in 2 sites:

a. With cranial nerves number 3, 7, 9 & 10.

b. From the neurons of lateral horn of sacral spinal segments number 2, 3 & 4.



Hence the name *craniosacral outflow*

2. Parasympathetic ganglia: They are found close to the parts to be innervated (e.g. the ciliary ganglion close to the eye ball). They receive the preganglionic fibers which make synapses inside the ganglion.

3. Postganglionic fibers: They are the axons of the cell bodies inside the ganglia. They leave the ganglia to reach their targets.



Thank You
Thank You
Thank You!!!!