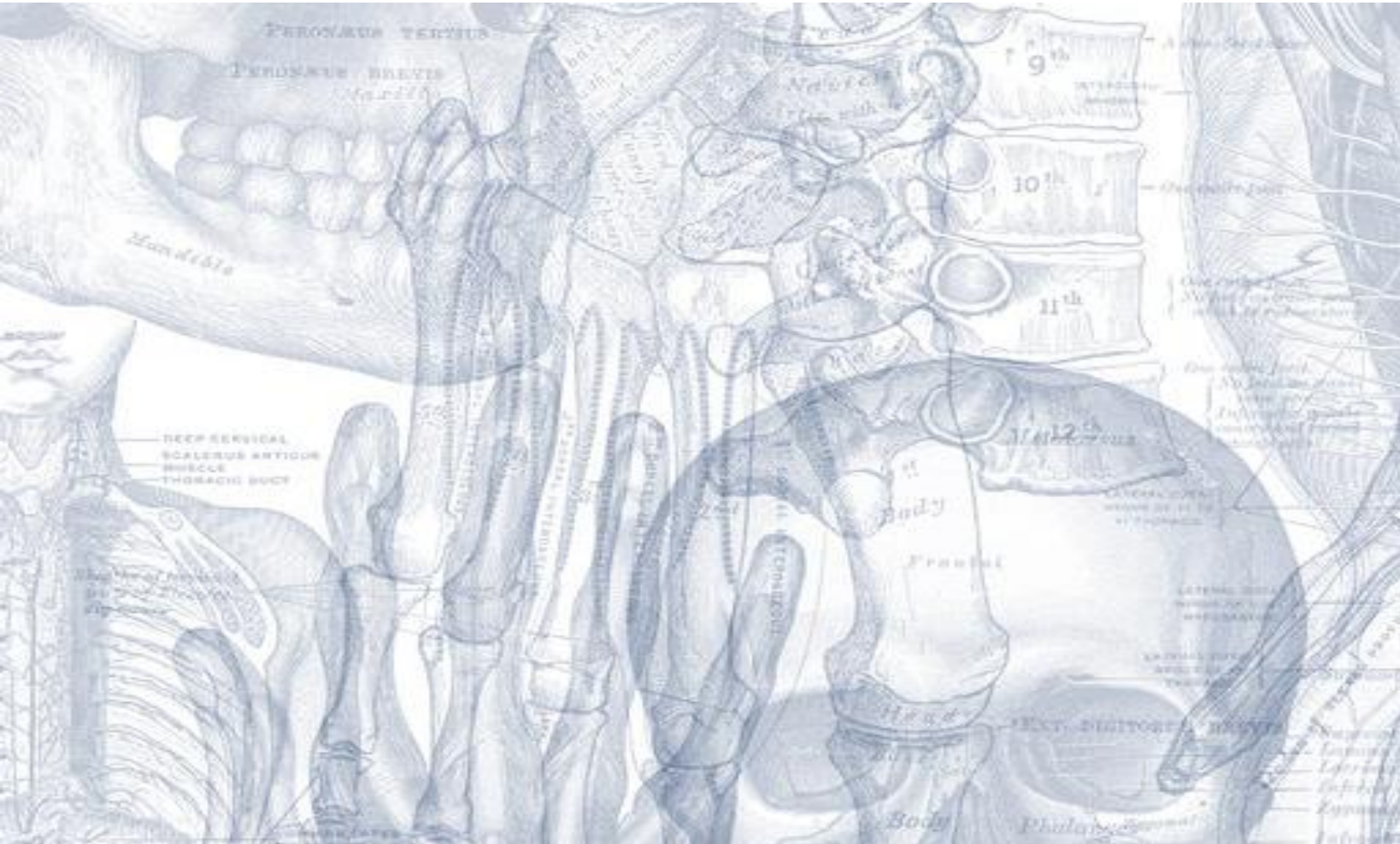


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Organization of the Nervous System

Please view our [Editing File](#) before studying this lecture to check for any changes.

Color Code

- Important
- Doctors Notes
- Notes/Extra explanation

Objectives

At the end of the lecture, the students should be able to:

- ✓ List the parts of the nervous system.
- ✓ List the function of the nervous system.
- ✓ Describe the Structural & Functional Organizations.
- ✓ Define the terms:
Nervous tissue, grey matter, white matter, nucleus, ganglion, tract, nerve.
- ✓ List the parts of the brain.
- ✓ List the structures protecting the central nervous system.

Introduction

How does the nervous system work?

The nervous system has three **general** functions:

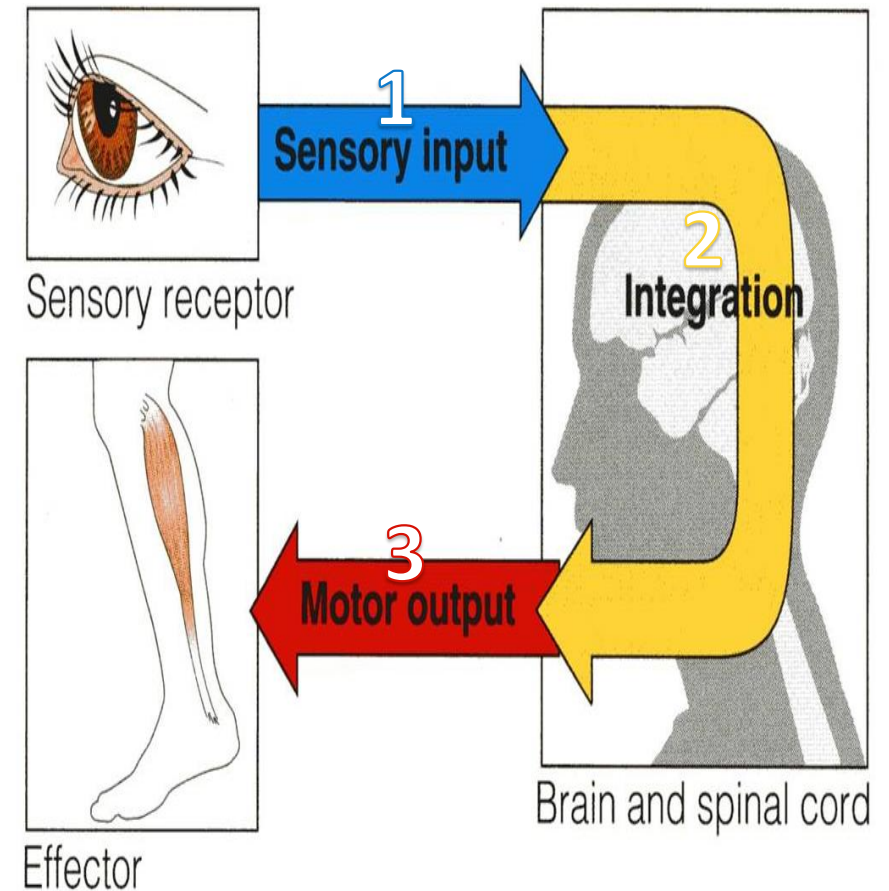
1. Collection of sensory input:

- Identifies changes occurring inside or outside the body **by using sensory receptors**. These changes are called stimuli.

2. Integration:

- Processes, analyzes, and interprets these changes and makes decisions.

3. Motor output, or response **by activating muscles or glands** (effectors).



Classification



To remember: **SAME**
Sensory: Afferent / Motor: Efferent

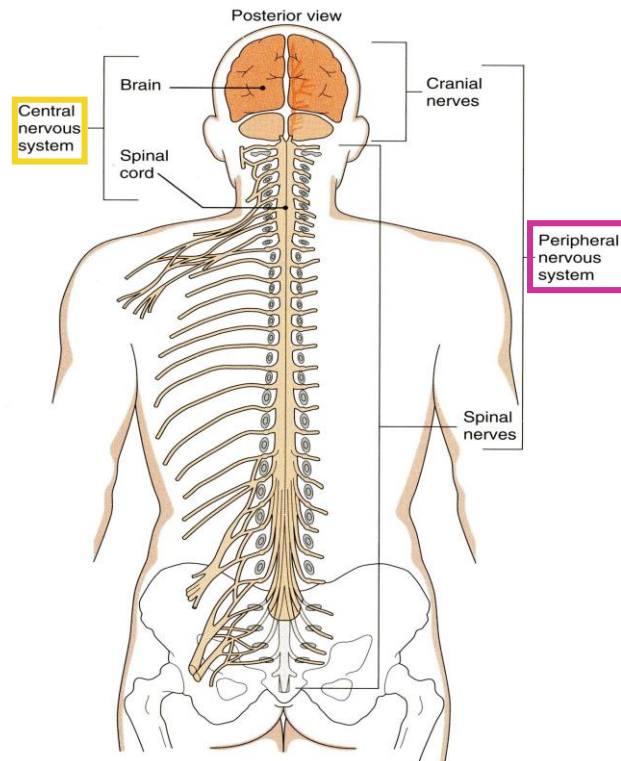
I- Anatomical or Structural classification:

1- Central Nervous System

(brain and spinal cord)

2- Peripheral Nervous System

(everything coming out of the CNS: cranial and spinal nerves, ganglia, and receptors)

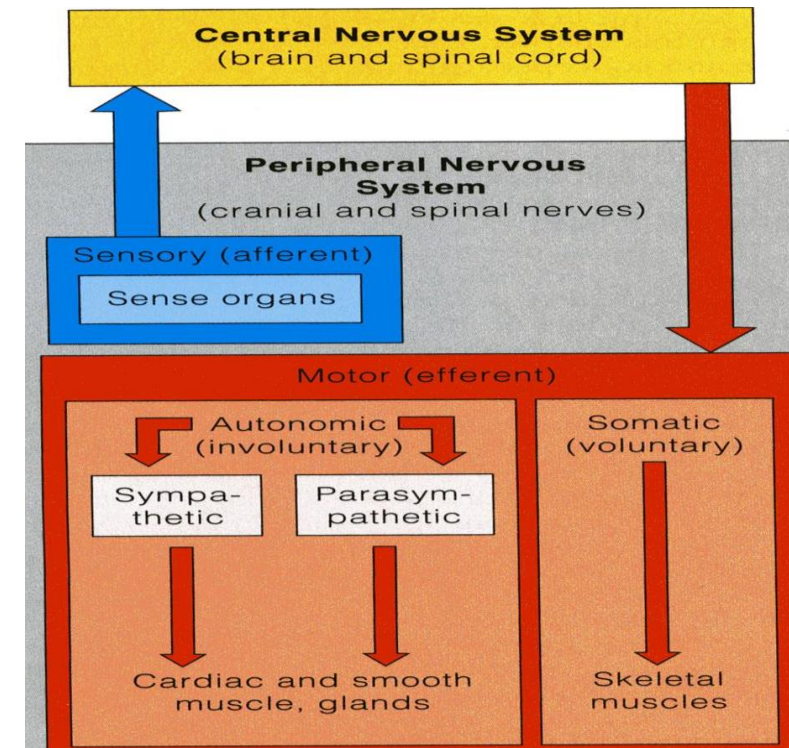


II- Physiological or Functional classification:

1- Sensory division (Afferent)

2- Motor division (Efferent):

- Somatic (voluntary)
- Autonomic (involuntary)

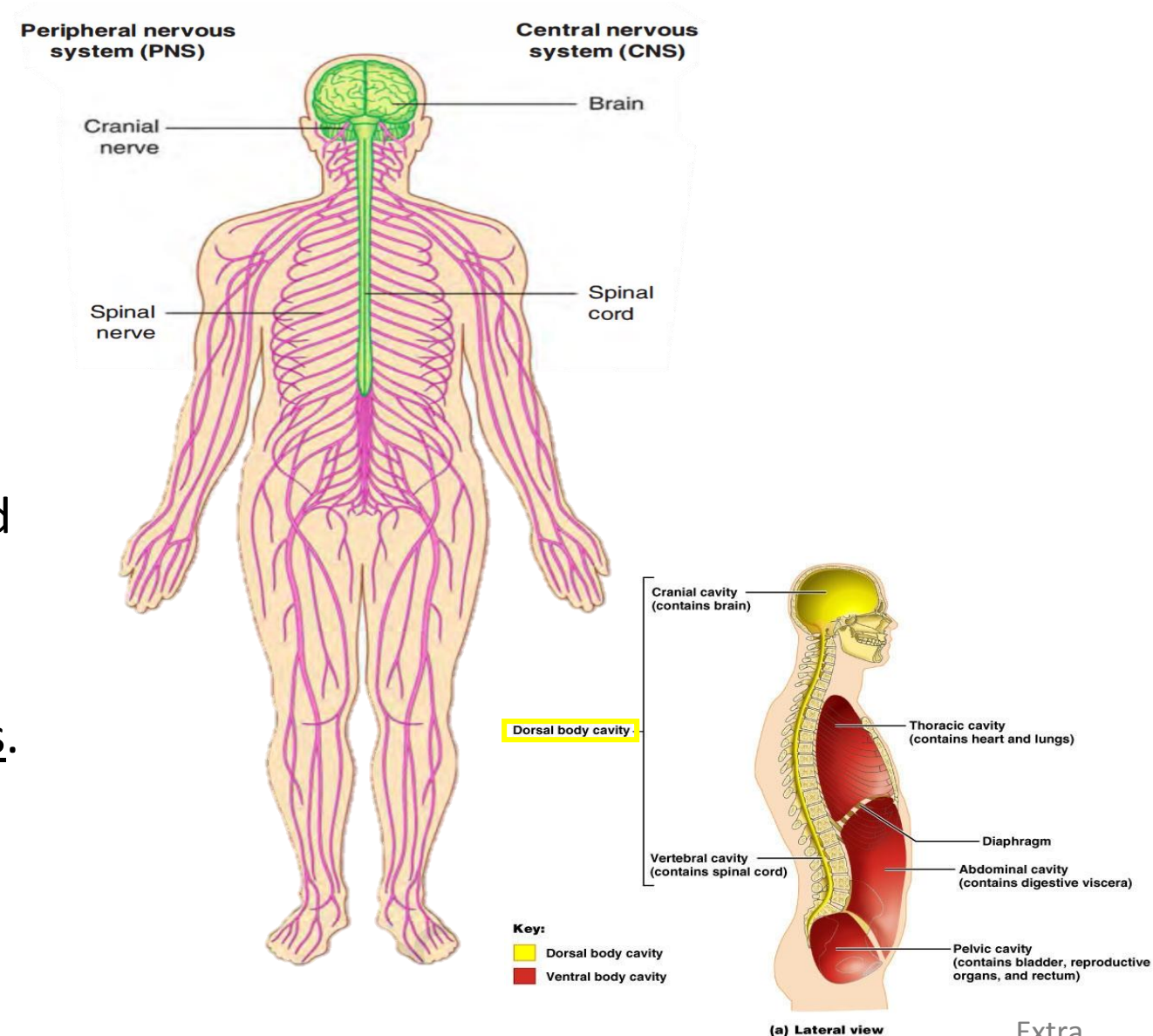


Classification

Structural Organization

Two subdivisions:

- **Central Nervous System** (CNS)
 - Consists of Brain & Spinal cord
 - Occupies the dorsal body cavity.
 - Acts as the integrating and command centers.
- **Peripheral Nervous System** (PNS)
 - Consists of nerves, ganglia, receptors.
 - It is the part of the nervous system *outside the CNS*.



Classification

Functional Organization

Afferent → approach the CNS
Efferent → exit the CNS

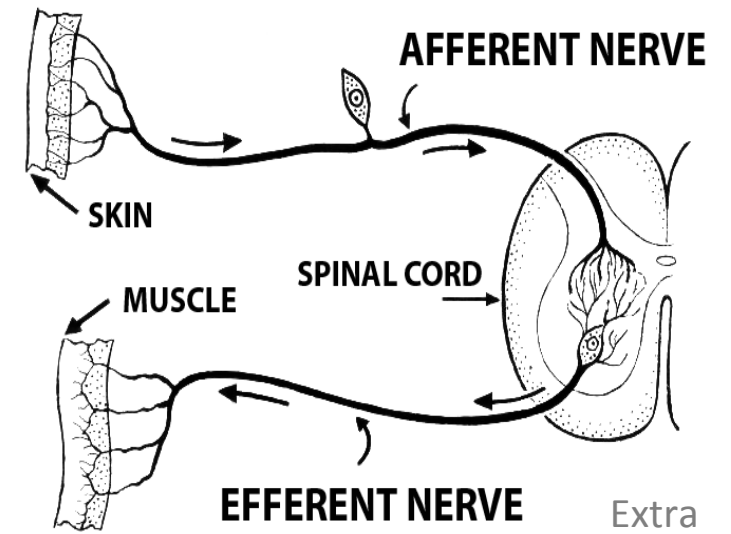
Two subdivisions:

- **Sensory** or *afferent* division:
 - Consists of nerve fibers that convey impulses from receptors located in various parts of the body, to the CNS.
- **Motor** or *efferent* division:
 - Consists of nerve fibers that convey impulses from the CNS to the effector organs, muscles and glands.

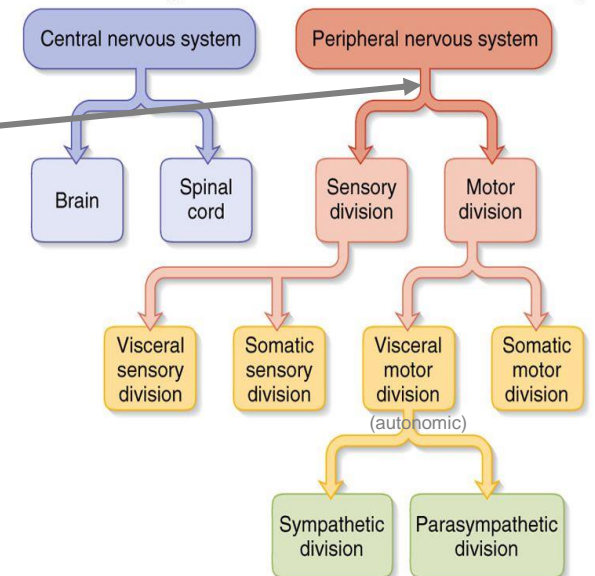
Both sensory and motor subdivisions are further divided into visceral and somatic (we will focus here on the motor subdivision)

Motor subdivision is divided into:

- Somatic division: concerned with *skin, skeletal muscles* and *joints*.
- Autonomic (visceral) division: concerned with the *visceral organs* (sympathetic and parasympathetic).

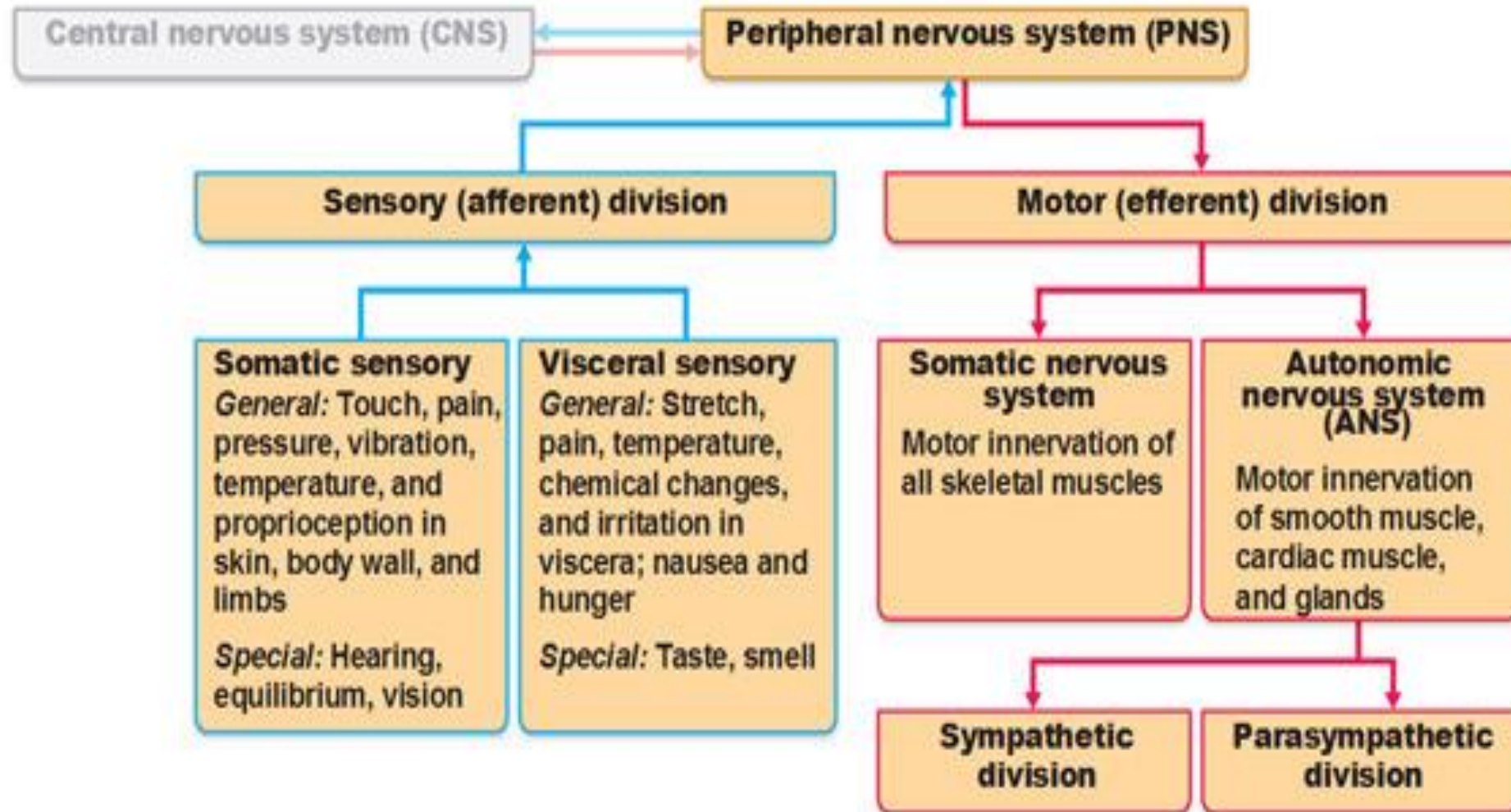


Functional Organization of the Nervous System



Extra

Functional Organization of the PNS



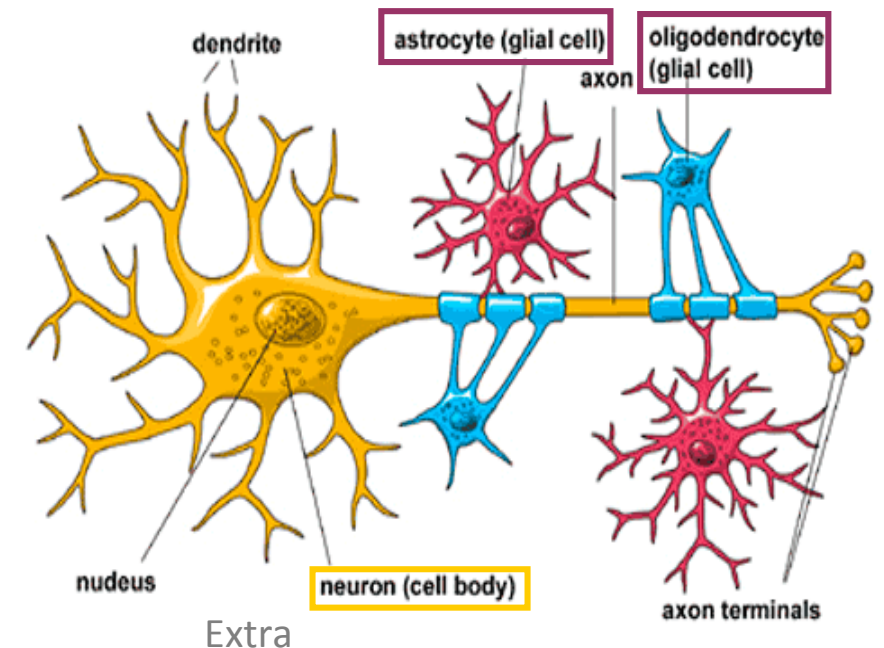
Additional picture by girls' doctor for more understanding.

The Nervous System

- It is the major controlling, regulatory & communicating system in the body.
- It is the center of all mental activity including: *Thought, Learning, Behavior and Memory*.
- Together with the endocrine system, the nervous system is responsible for regulating and maintaining **homeostasis**. (Nervous System + Endocrine System → Homeostasis)

Nervous Tissue

- Nervous system is composed of nervous tissue, which contains two types of cells:
 - 1- Nerve cells or neurons (cell bodies)
 - 2- Supporting cells or neuroglia (glia). (supporting cells)
- Nervous system contains millions of **neurons** that vary in their shape, size, and number of processes.



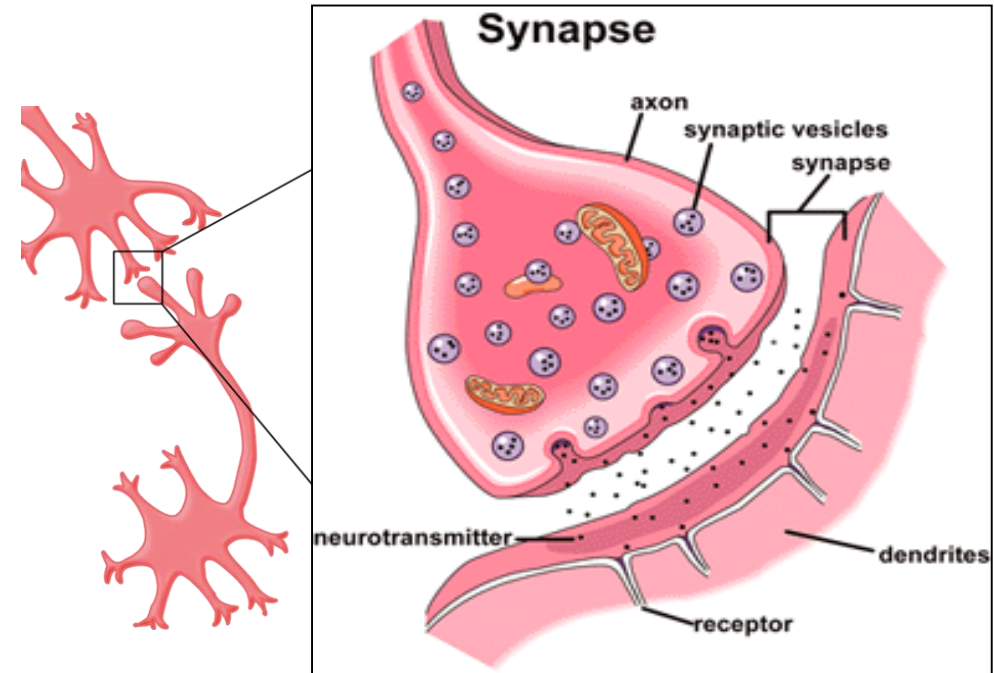
Nervous Tissue

Neurons

What is a neuron?

- It is the **basic structural (anatomical), functional and embryological unit** of the nervous system.
- The human nervous system is estimated to contain about 10^{10} .
- The junction site of two neurons is called a “**synapse or relay**”.
- In the synapses the membranes of adjacent cells are in close **apposition** (contiguity=contact, not continuity). They are adjacent to each other and may come into contact but are not continuous with one another.

(متلامسه وليست متسلسلة)

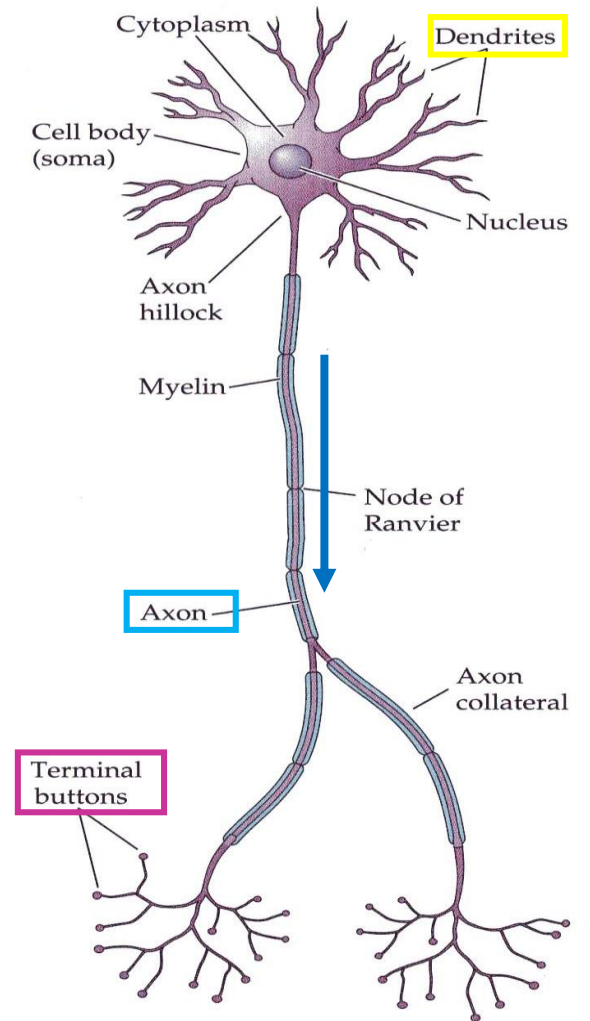


Nervous Tissue

Dendrites

Dendrites are like ears so they receive information.
Axons are like the mouth so they send information.

- The neuron has cell body with multiple processes.
- Most of the processes of the cell body are short with variable numbers and are receptive in function.
- They are known as **Dendrites**.
- One of these processes leaving the cell body is called the **axon** which carries information **away** from the cell body.
- Axons are highly *variable in length* and may *divide* into several branches or **collaterals** through which information can be distributed to a number of different destinations.
- At the end of the axon, specializations called **terminal buttons** occur where information is transferred (**neurotransmission**) to the dendrites of other neurones.



Dendrites	From other neurons toward cell body
axons	Away from cell body
Terminal buttons	To dendrites of <u>other</u> neurons

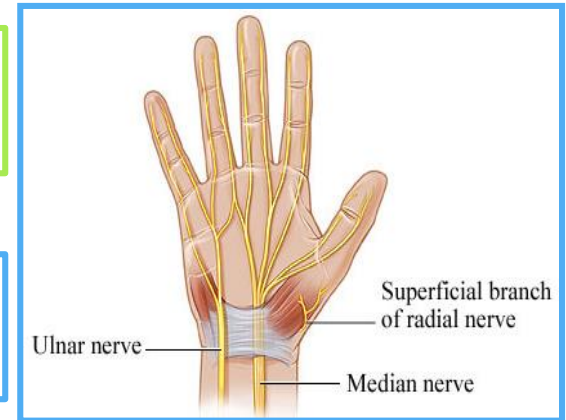
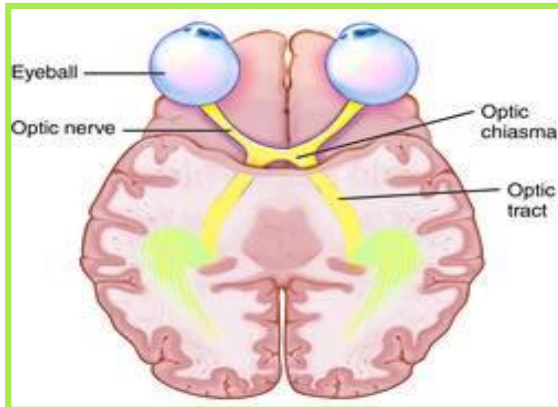
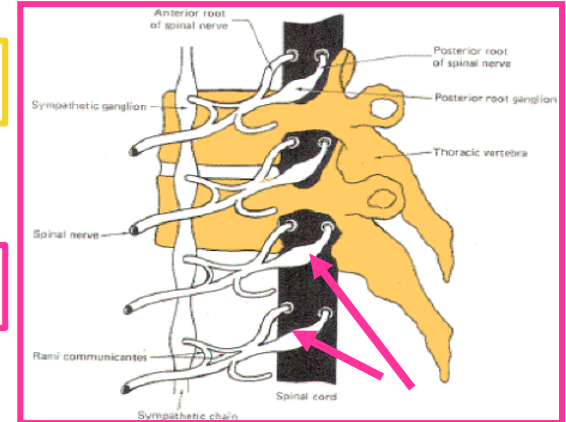
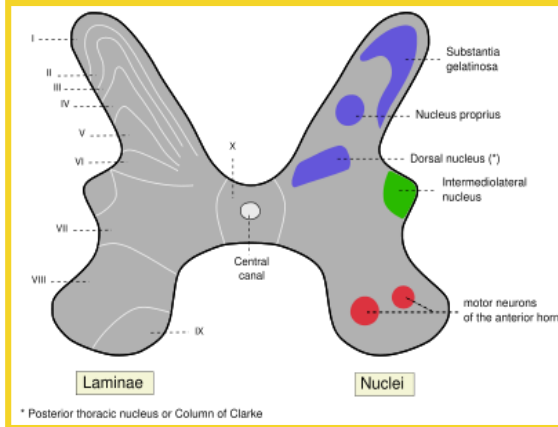
Remember the difference!

Nucleus= A group of *neurons* **within** the CNS

Ganglion= A group of *neurons* **outside** the CNS

Tract= A group of *nerve fibers (axons)* **within** the CNS

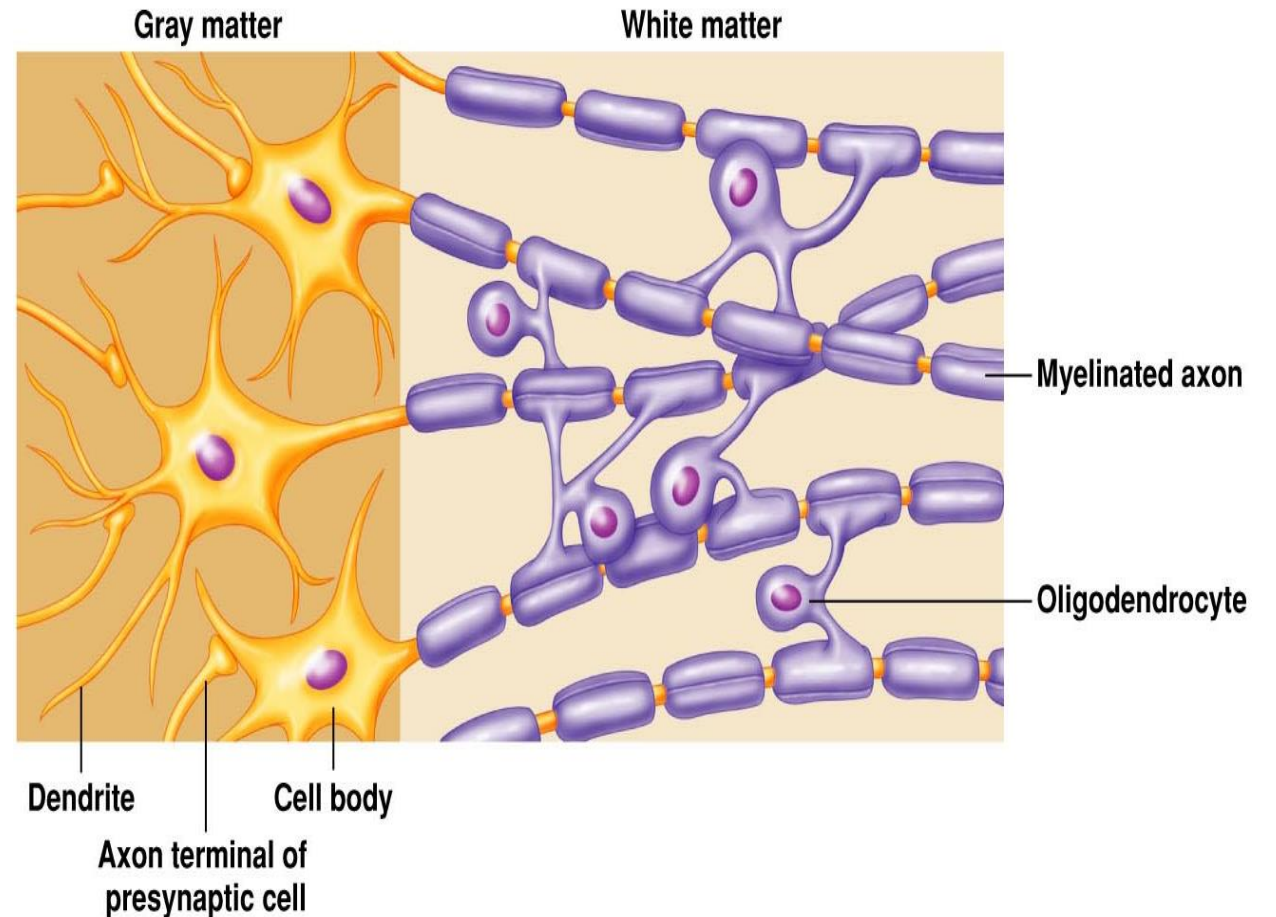
Nerve= A group of *nerve fibers (axons)* **outside** the CNS



Nervous Tissue

Nervous tissue is organized as:

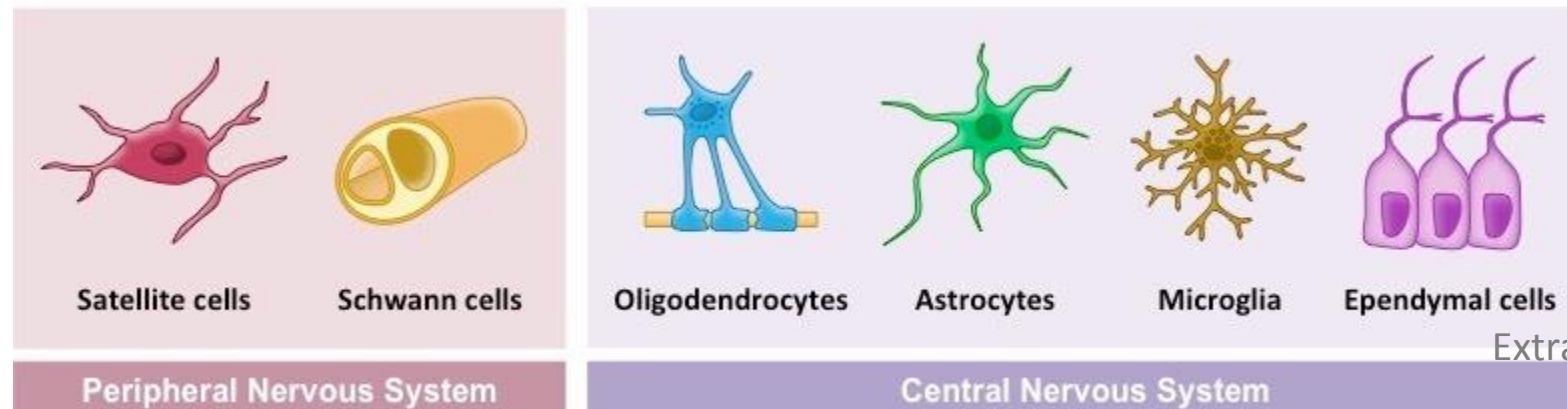
Grey Matter	White Matter
1. Cell Bodies	No cell bodies in the white matter
2. Processes of the neurons	1. Processes of the neurons
3. Neuroglia	2. Neuroglia
4. Blood Vessels	3. Blood vessels



Nervous Tissue

Neuroglia (or glia or glial cells)

- Neuroglia, or glia cells constitute the other major cellular component of the nervous tissue.
- It is a *specialized connective tissue supporting framework* for the nervous system.
- Unlike neurones, **neuroglia do not have a direct role in information processing** but they are essential for the normal functioning of the neurons, **they act as supporting and nutrition for neurons.**



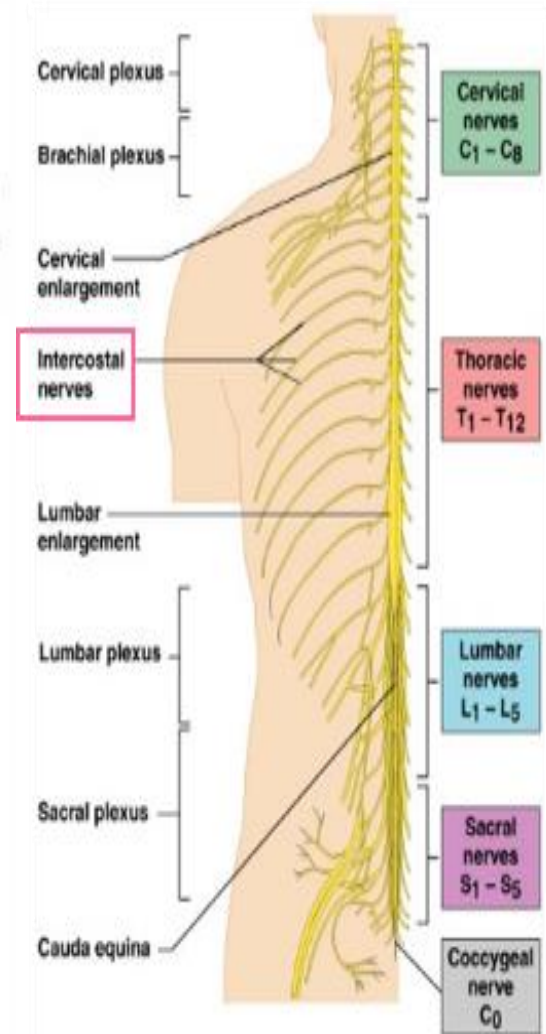
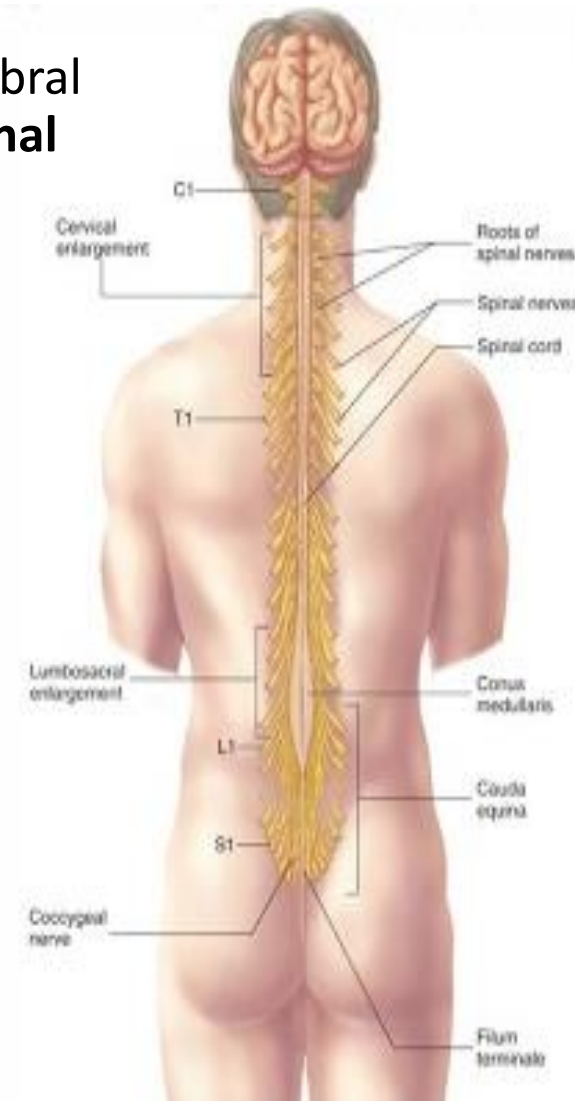
Spinal Cord

- Elongated almost cylindrical suspended in the vertebral canal, surrounded by the **meninges** and **cerebrospinal fluid**.
- Approximately 45 cm long in adult and is about the thickness of the little finger.
- It extends from the **foramen magnum** to the upper border of the **2nd lumbar** vertebra.
- Continuous *above* with the **medulla oblongata**.
- Its lower *end* is called **conus medullaris***.
- Gives rise to 31 pairs of spinal nerves:
 - 8 Cervical,
 - 12 Thoracic,
 - 5 Lumbar,
 - 5 Sacral and
 - ONE Coccygeal.

*Recall from foundation:

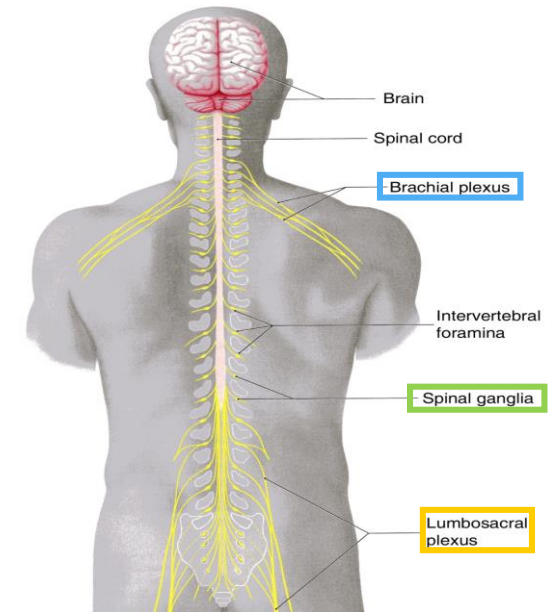
End of spinal cord: conus medullaris.

End of spinal nerves: cauda equina.



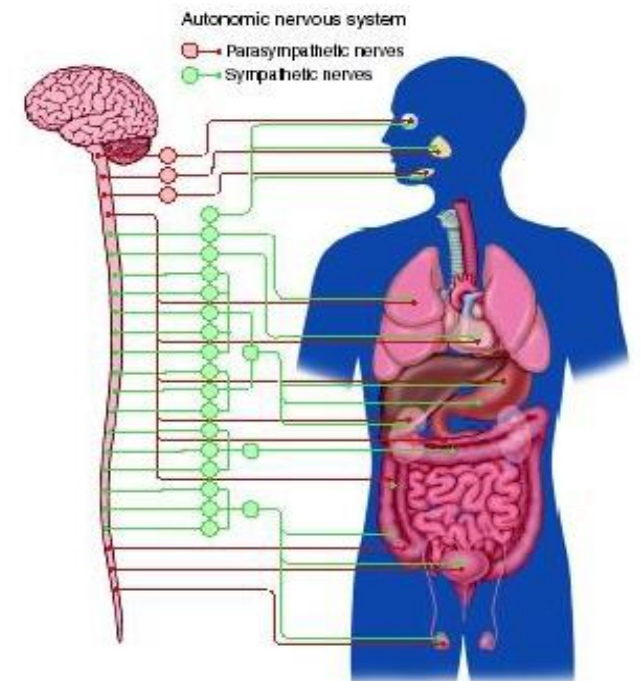
Peripheral Nervous System

- Spinal nerves supplying the upper or lower limbs form plexuses e.g. brachial or lumbar plexus.
- Nerve cell bodies that are aggregated outside the CNS are called GANGLIA.



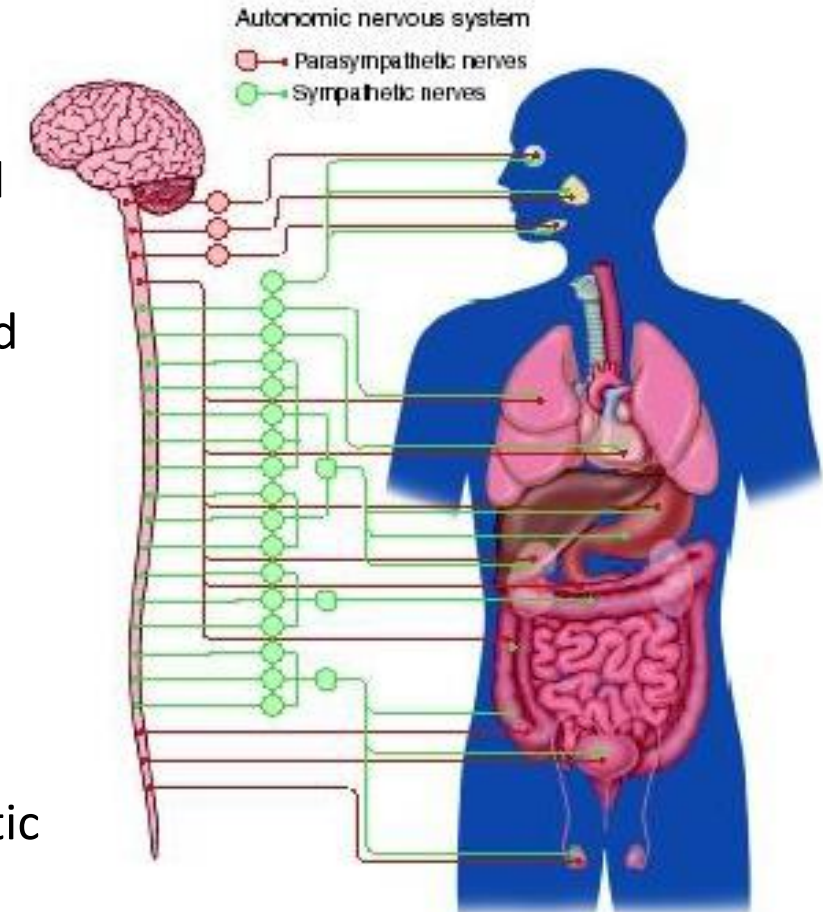
Autonomic Nervous System

- Neurons that detect changes and control the activity of the **viscera** are collectively referred to as the autonomic nervous system.
- Its components are present in **both** the central and peripheral nervous systems.



Autonomic Nervous System

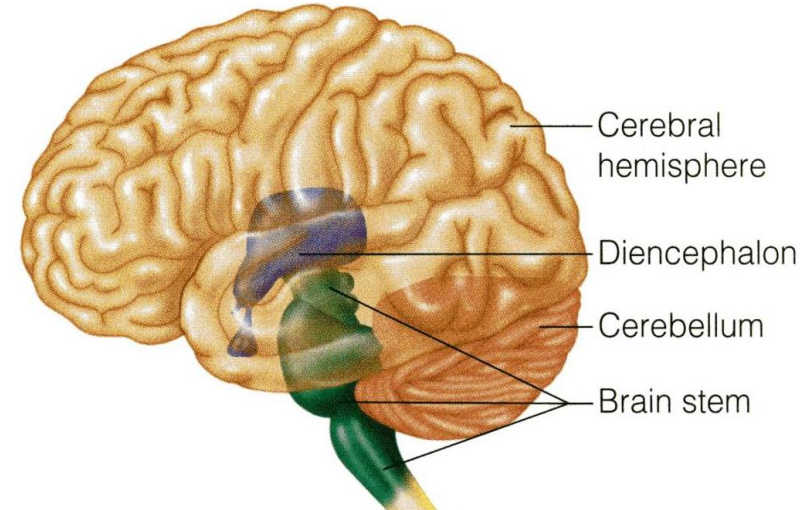
- The autonomic nervous system innervates:
 - Smooth muscles,
 - Cardiac muscle,
 - Secretory glands.
- It is an important part of the homeostatic mechanisms that control the internal environment of the body with the endocrine system.
- The autonomic nervous system is divided into two anatomically and functionally distinct parts:
 - **Sympathetic**: Or *Thoracolumbar* outflow
 - **Parasympathetic**: Or *Craniosacral* outflow.
- Sympathetic and parasympathetic , divisions are generally have antagonistic effects on the structures that they innervate.
- E.g. Sympathetic increases the heart rate, while the parasympathetic decreases the heart rate.



The Brain

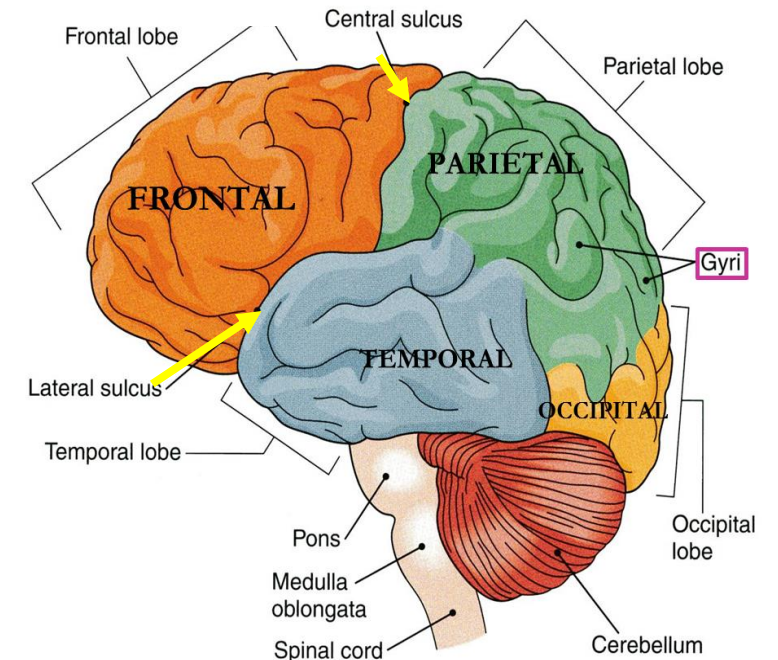


- The brain is composed of 4 parts:
 1. Cerebral hemispheres (2 cerebrum)
 2. Diencephalon
 3. Brain stem
 4. Cerebellum



1. Cerebral Hemisphere

- The largest part of the brain.
- They have elevations, called gyri (singular: gyrus)
- Gyri are separated by depressions called sulci (singular: sulcus).
- Each hemisphere is divided into 4 lobes named according to the bone of the skull above.
- Lobes are separated by deeper grooves called fissures or sulci.
Example: central sulcus separates the frontal lobe and parietal lobe.
lateral sulcus separates frontal, parietal and temporal lobes

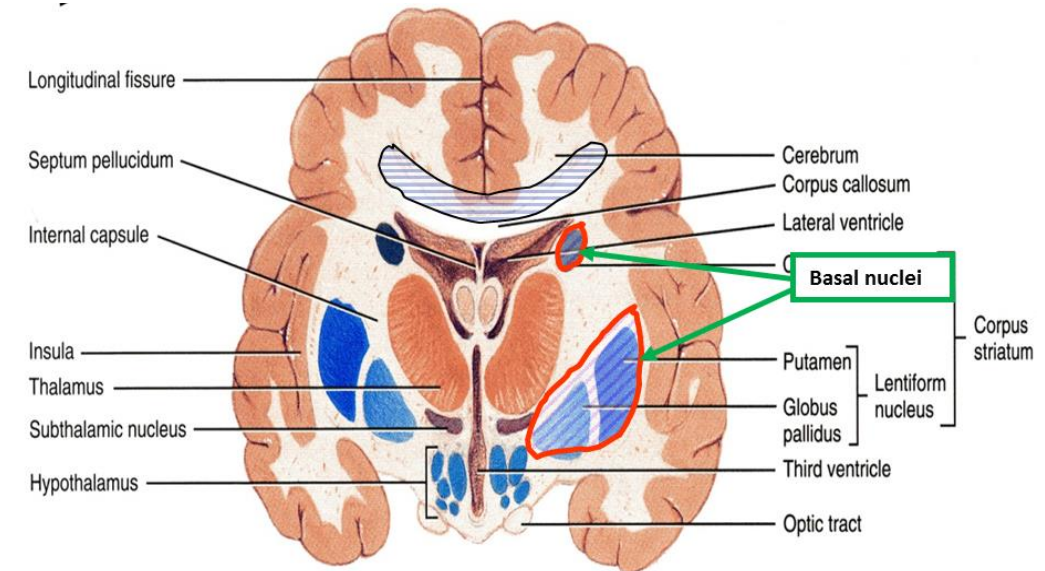
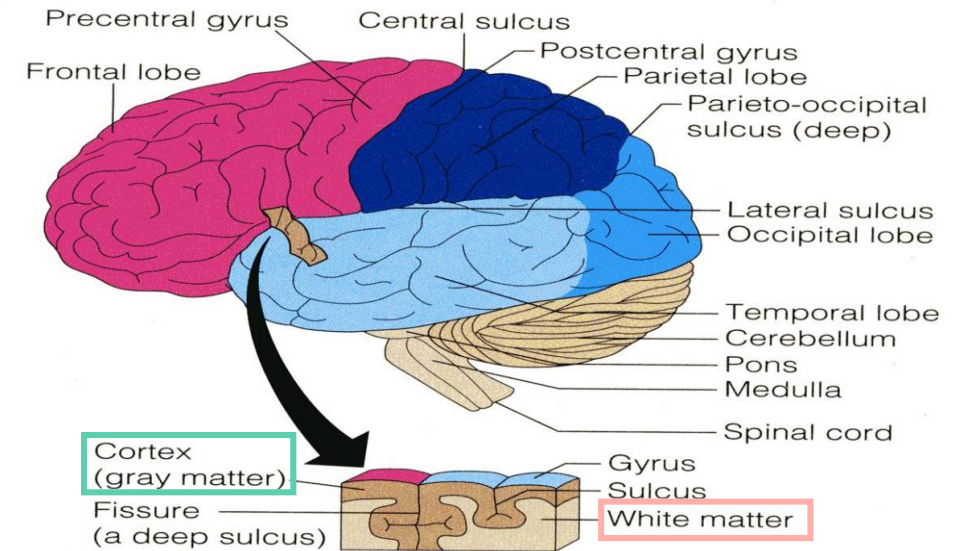


The Brain

1. Cerebral Hemispheres

Tissue of the cerebral hemispheres:

- The outer layer is the gray matter or cortex.
- Deeper is located the white matter, or medulla, composed of bundles of nerve fibers, carrying impulses to and from the cortex
- Basal nuclei are gray matter that are located deep within the white matter. (they are an exception because white matter should only contain fibers)
- They help the motor cortex in regulation of *voluntary motor activities*.

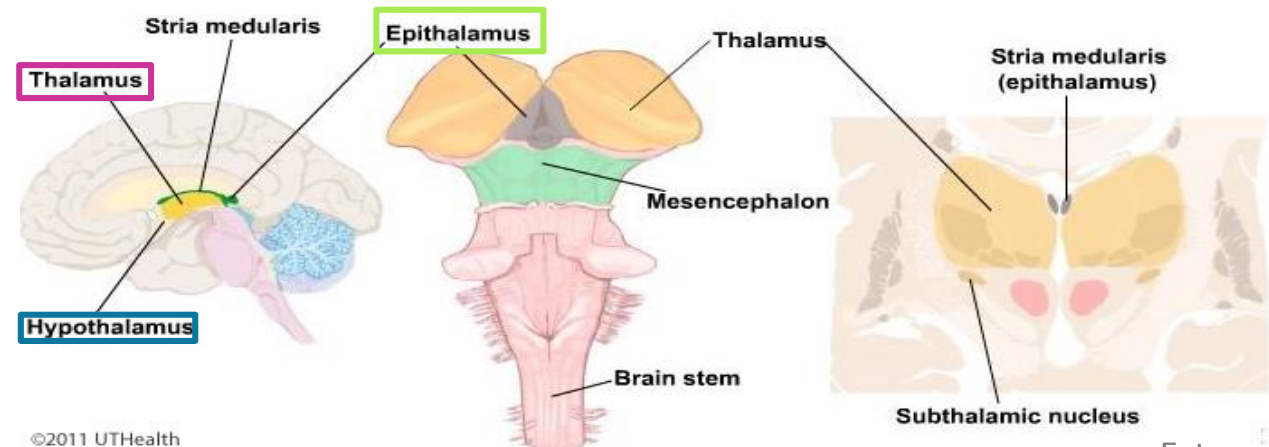
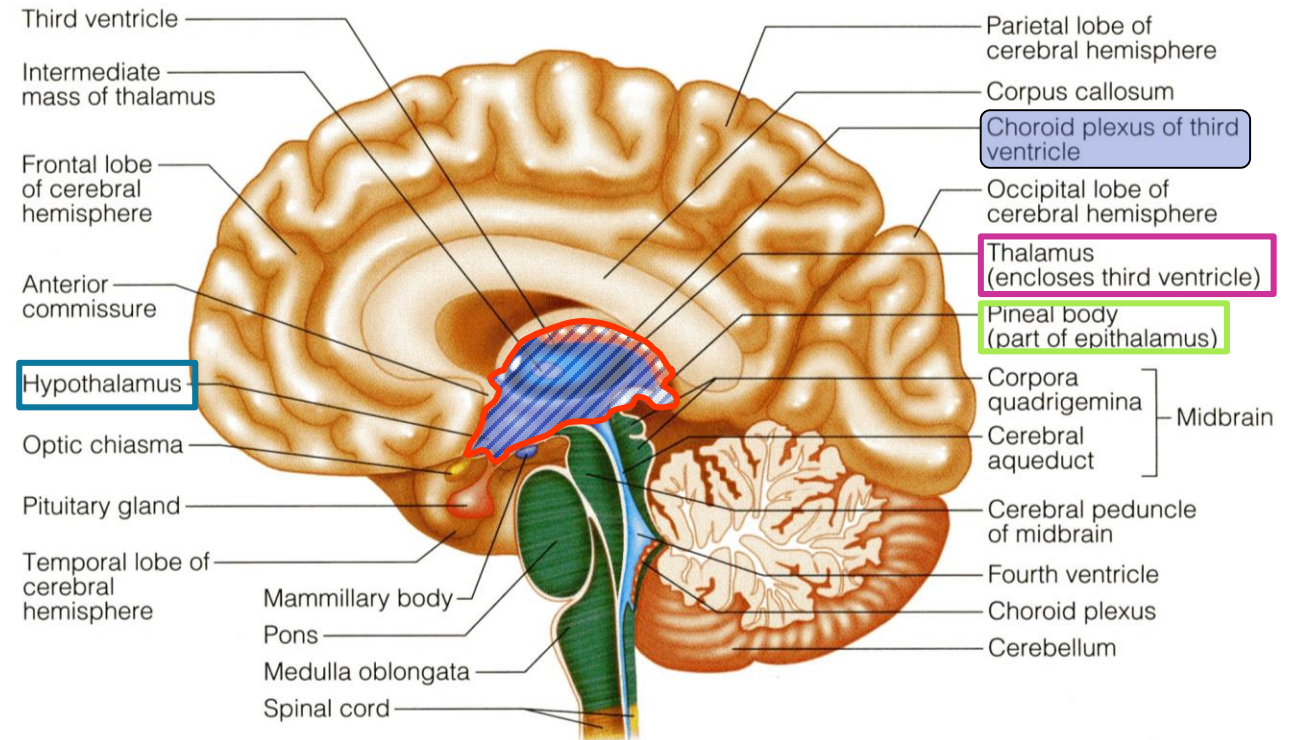


(b) Anterior view of frontal section

The Brain

2. Diencephalon

- The diencephalon is located between the 2 cerebral hemispheres and is linked to them and to the brainstem.
- The major structures of the diencephalon are the **Thalamus**, **Hypothalamus**, **Subthalamus** and **Epithalamus**.



The Brain

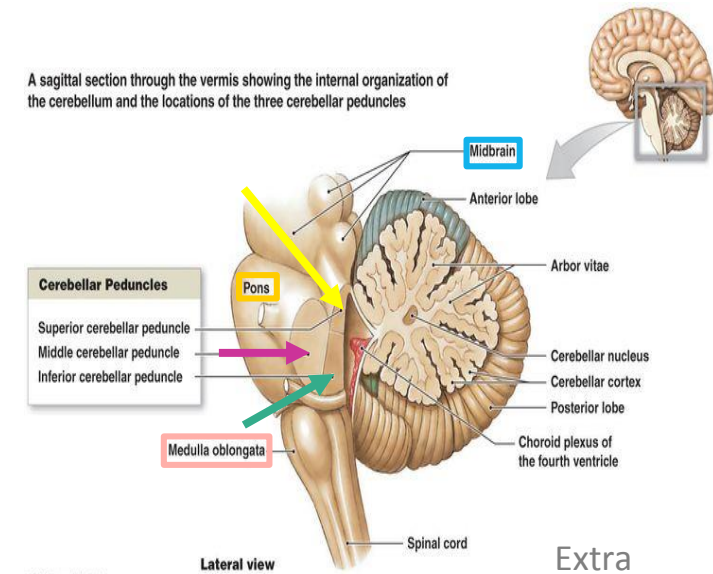
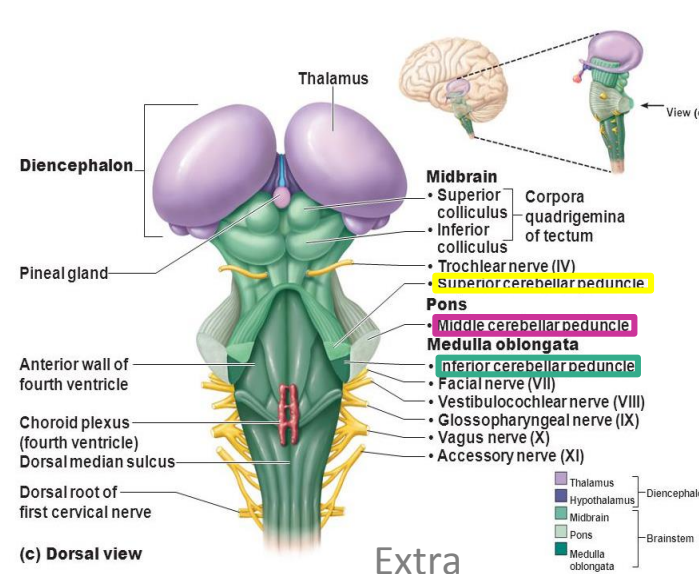
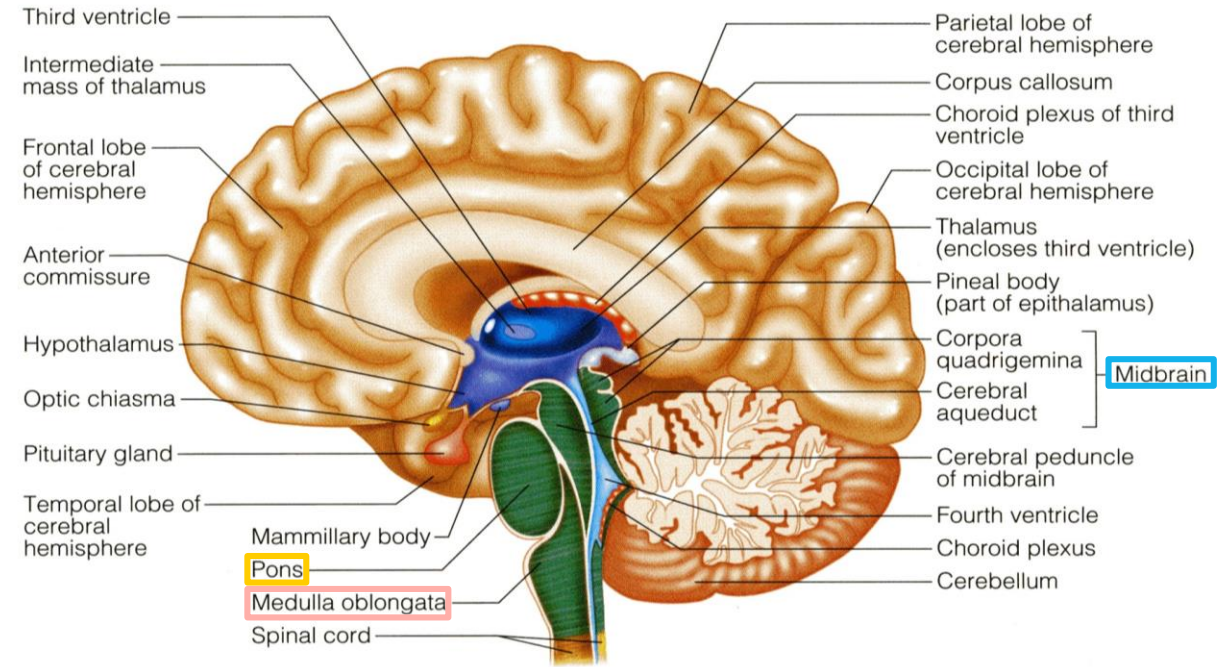
3. Brainstem

- The brainstem has three parts: **midbrain**, **Pons** and **medulla oblongata** (continues as the spinal cord).
- It is connected to the **cerebellum** with 3 paired peduncles: **Superior**, **middle** and **inferior**.

Superior peduncle connects **midbrain** with cerebellum

Middle peduncle connects **pons** with cerebellum

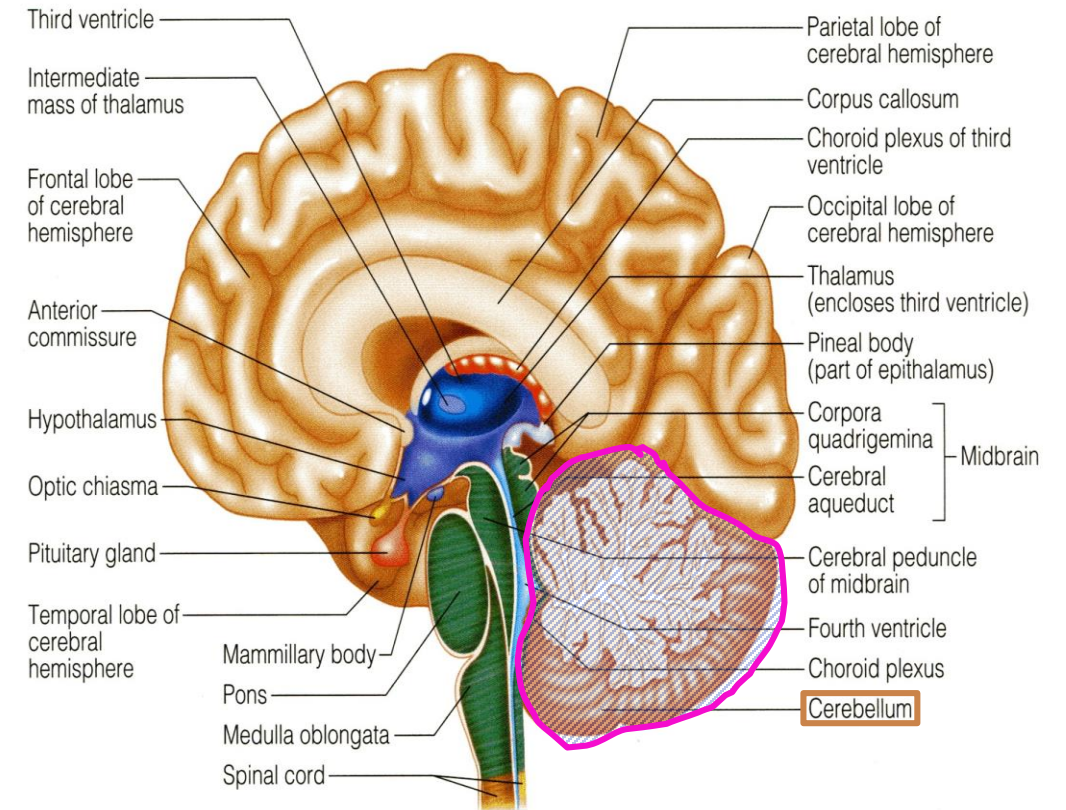
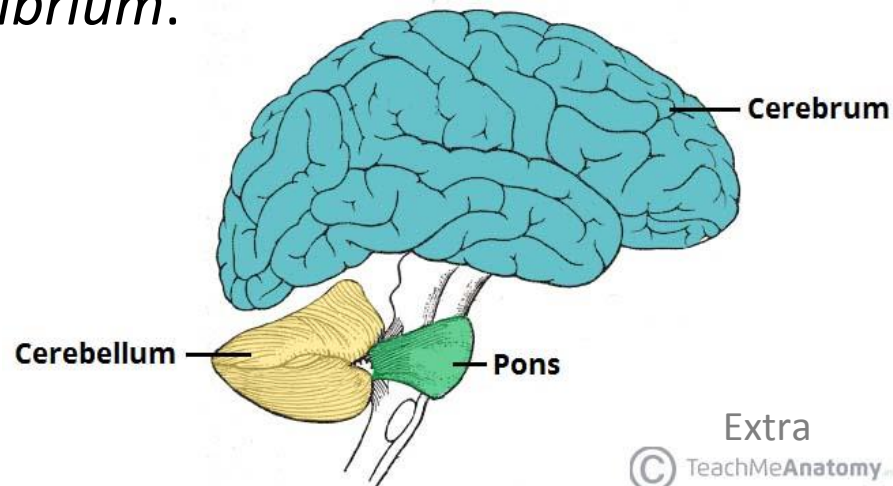
Inferior peduncle connects **medulla oblongata** with cerebellum



The Brain

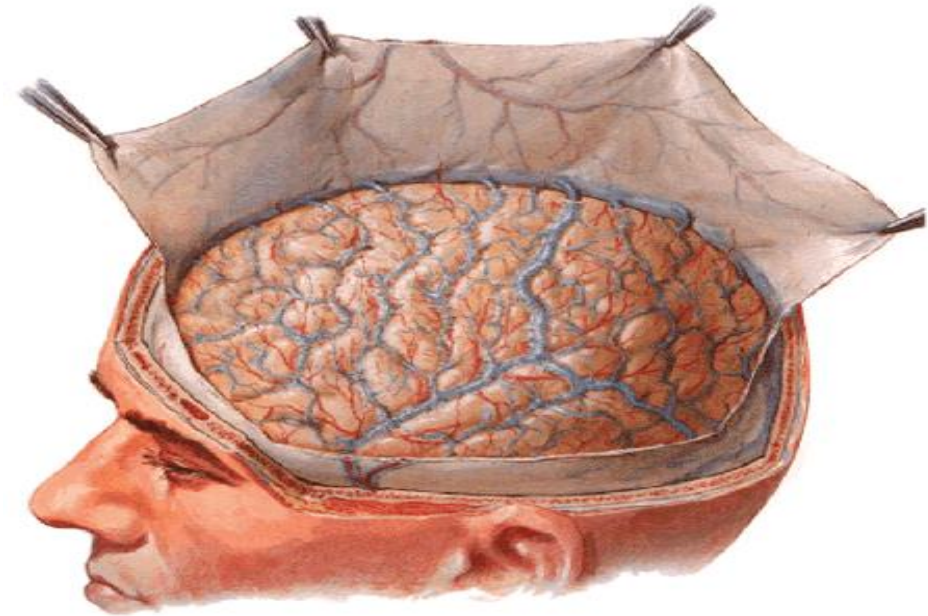
4. Cerebellum

- Cerebellum has 2 cerebellar hemispheres with convoluted surface.
- It has an **outer** cortex of **gray** matter and an **inner** region of **white** matter.
- It provides *precise coordination for body movements* and helps *maintain equilibrium*.



Meninges

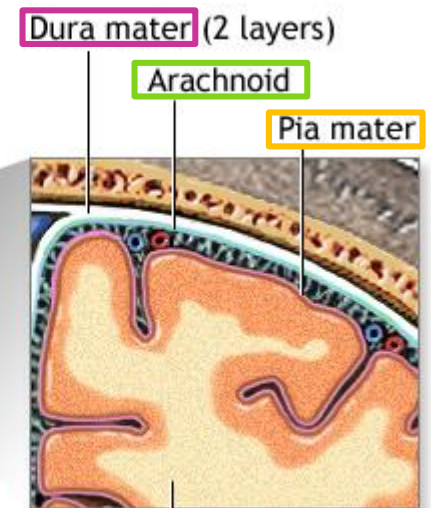
- There are three connective tissue membranes invest the brain and the spinal cord.
- These are from *outward to inward* are:
 - 1- Dura mater.
 - 2- Arachnoid mater.
 - 3- Pia mater.
- The space between the arachnoid mater and pia mater is the subarachnoid space for the CSF (cerebrospinal fluid).



The meninges are the membranes covering the brain and spinal cord



Extra



Brain

Dura → Outside
Pia → Iinside

To remember the order from outside to inside:
Dora Ate Pie

Brain Ventricles



02:02

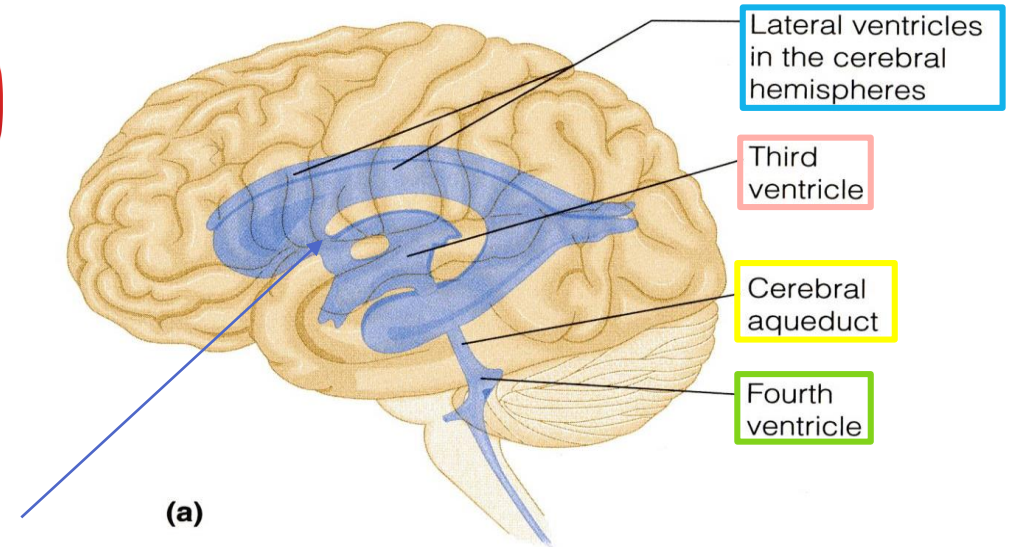
- Brain is bathed by the cerebrospinal fluid (CSF).
- Inside the brain, there are 4 ventricles filled with CSF.

○ The 4 ventricles are:

- **2 lateral ventricles:** One in each hemispheres.
- **3rd ventricle:** in the Diencephalon.
- **4th ventricle:** between Pons, Medulla oblongata & Cerebellum.

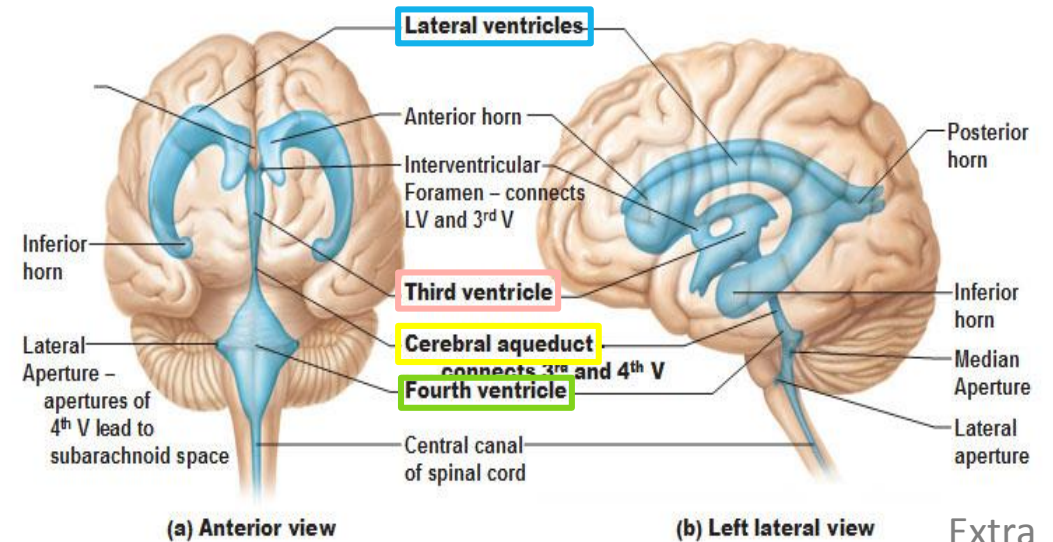
N.B. Cerebral aqueduct* (within midbrain): connects the 3rd to the 4th ventricle.

*cerebral aqueduct is also a channel for CSF but is not considered a ventricle.



Interventricular foramen

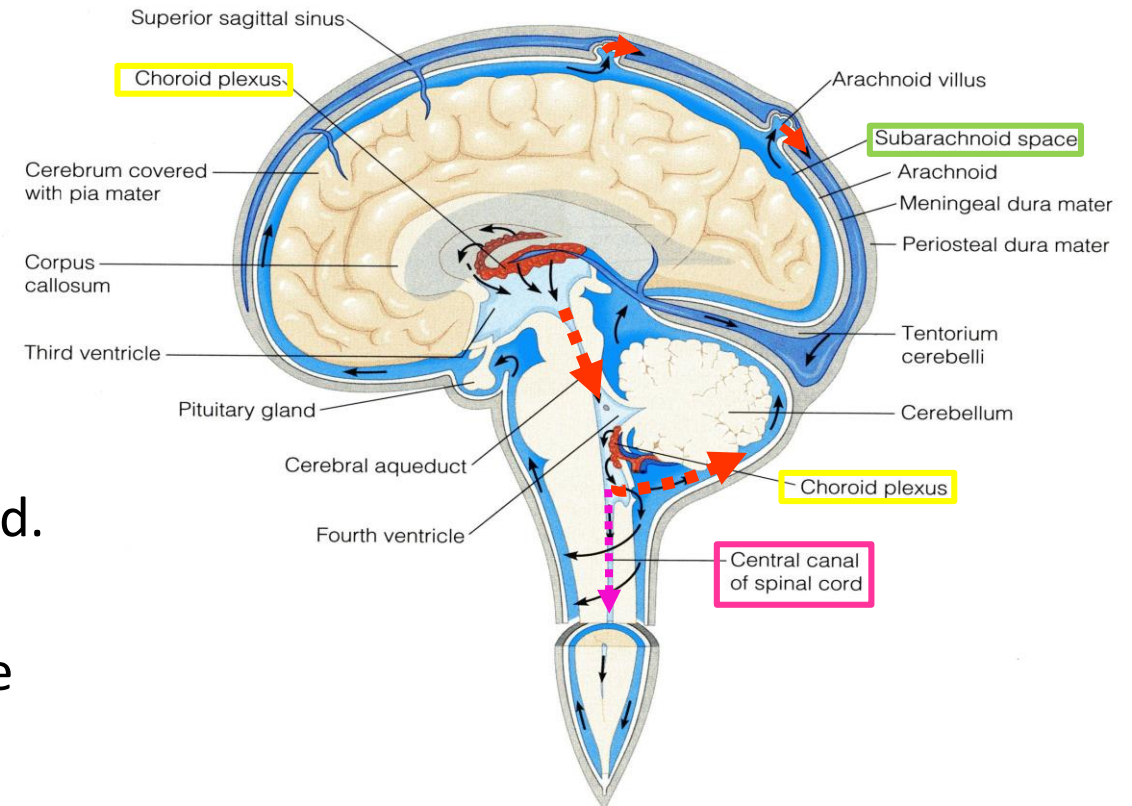
Ventricles of the Brain



Extra

Cerebrospinal Fluid (CSF)

- CSF is constantly **produced** by the **choroid plexuses** inside the **ventricles**.
- Inside the brain, CSF flows from the **lateral ventricles** to the **3rd** and **4th ventricles***
- From the 4th ventricle, a **small** part of the CSF flows down in the **central canal** of the spinal cord.
- Most of the CSF drains from the 4th ventricle to distribute in the **subarachnoid space** around the brain and returns to the **dural sinuses** through the **arachnoids villi**.
- Arachnoid villi are small protrusions of the arachnoid.
- Villi absorb cerebrospinal fluid and **return** it finally to the **dural venous circulation**.

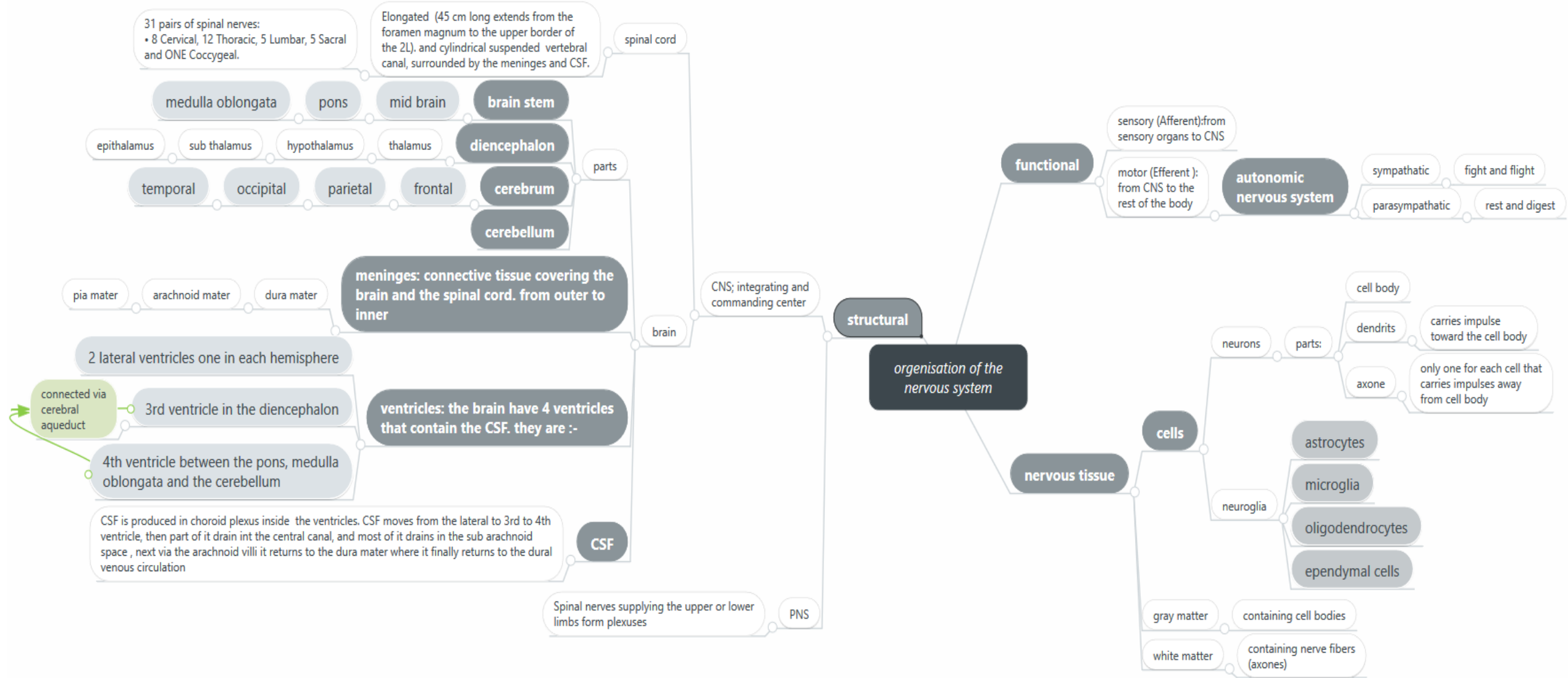


Pathway of CSF: (produced by choroid plexus)
Lateral ventricle → 3rd ventricle → 4th ventricle → central canal (small portion)

remaining (large portion)

Subarachnoid space → through arachnoid villi → dural venous sinuses

Summary



MCQs

1. CSF is constantly produced by:

- A- cerebral aqueduct
- B- choroid plexuses
- C- diencephalon
- D- brachial plexuses

Answer: B

2. What is the final drainage of CSF:

- A- arachnoids villi
- B- subarachnoid space
- C- dural sinuses
- D- choroid plexuses

Answer: C

3. The 3rd ventricle lies in:

- A- cerebral hemisphere
- B- diencephalon
- C- cerebellum
- D- brain stem

Answer: B

4. Autonomic nervous system is present in:

- A- central nervous system
- B- peripheral nervous system
- C- A&B

Answer: C

5. Which one of the following is related to the nucleus:

- A- Neurons outside the CNS.
- B- Neurons inside the CNS.
- C- Nerve fibers within the CNS.
- D- Nerve fibers outside the CNS.

Answer: B

6. What is the functional unit of nervous tissue:

- A- neuron
- B- neuroglia
- C- nephron

Answer: A

7. Which component is NOT found in white matter:

- A- cell body
- B- Blood vessels
- C- processes of the neuron
- D- neuroglia

Answer: A

8. Which one is NOT innervated by ANS:

- A- skeletal muscle
- B- smooth muscle
- C- cardiac muscle
- D- secretory glands

Answer: A

SAQs

1. How does the cerebrospinal fluid circulate?

Cerebrospinal fluid (CSF) is produced in the choroid plexus of the lateral ventricles to the 3rd ventricle then 4th ventricle via cerebral aqueduct. Part of **CSF** then **circulates** down in the central canal of the spinal cord. But most of the CSF drains from the 4th ventricle to distribute in the subarachnoid space around the brain and returns to the dural sinuses through the arachnoids villi

2. What does peripheral nervous system consist of?

Consists of nerves, ganglia, receptors.

3. What are the three layers of the meninges from outward to inward? Which layer of the meninges contains the cerebrospinal fluid?

1- Dura mater.

2- Arachnoid mater.

3- Pia mater.

Cerebrospinal fluid is located in the subarachnoid space between the arachnoid **mater** and the pia **mater**.

