



# ***Neurons, Nerve Fibers and Peripheral Nerves***



**Curriculum : Phase 2/Semester2/TOB /Session 11**

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### *References:*

- Histology Textbooks ‘Basic Histology’, Junqueira, 13<sup>th</sup> Edition chapter 1,2,3.pp:1-72
- ‘Colour Atlas of Histology’ Gartner and Hiatt 5<sup>th</sup> Edition.
- <http://www.histologyguide.com/>

## Objectives of the lecture:

Having revised this lecture you should be able to:

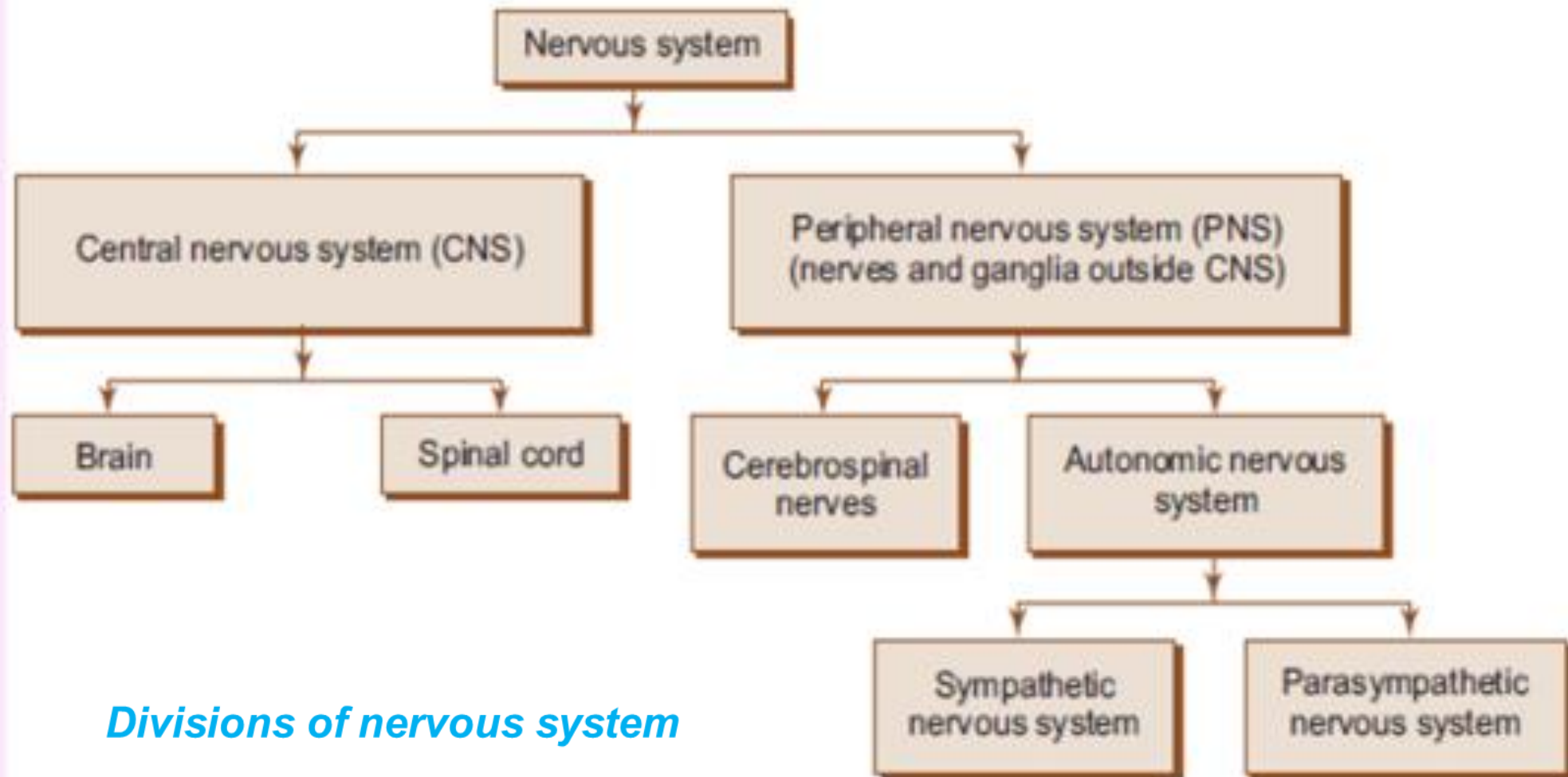
- ✓ describe the structure of a peripheral nerve.
- ✓ recognise the difference between myelinated and non-myelinated nerve fibres and ascribe particular roles to each.
- ✓ outline the great variety of synaptic connections in the nervous system.
- ✓ identify nerve fibres in both cross and longitudinal section.
- ✓ relate demyelination to a slowing of conduction velocity within a nerve.

## Terminology

- *Neuron = nerve cell.*
- *Neuroglia = supporting cell.*
- *Nerve fiber = long axon.*
- *Nerve = collection of nerve fibers (axons) in PNS.*
- *Tract = collections of nerve fibers (axons) in CNS.*
- **Nucleus = cluster of cell bodies in CNS.**
- **Ganglia = cluster of cell bodies in PNS.**

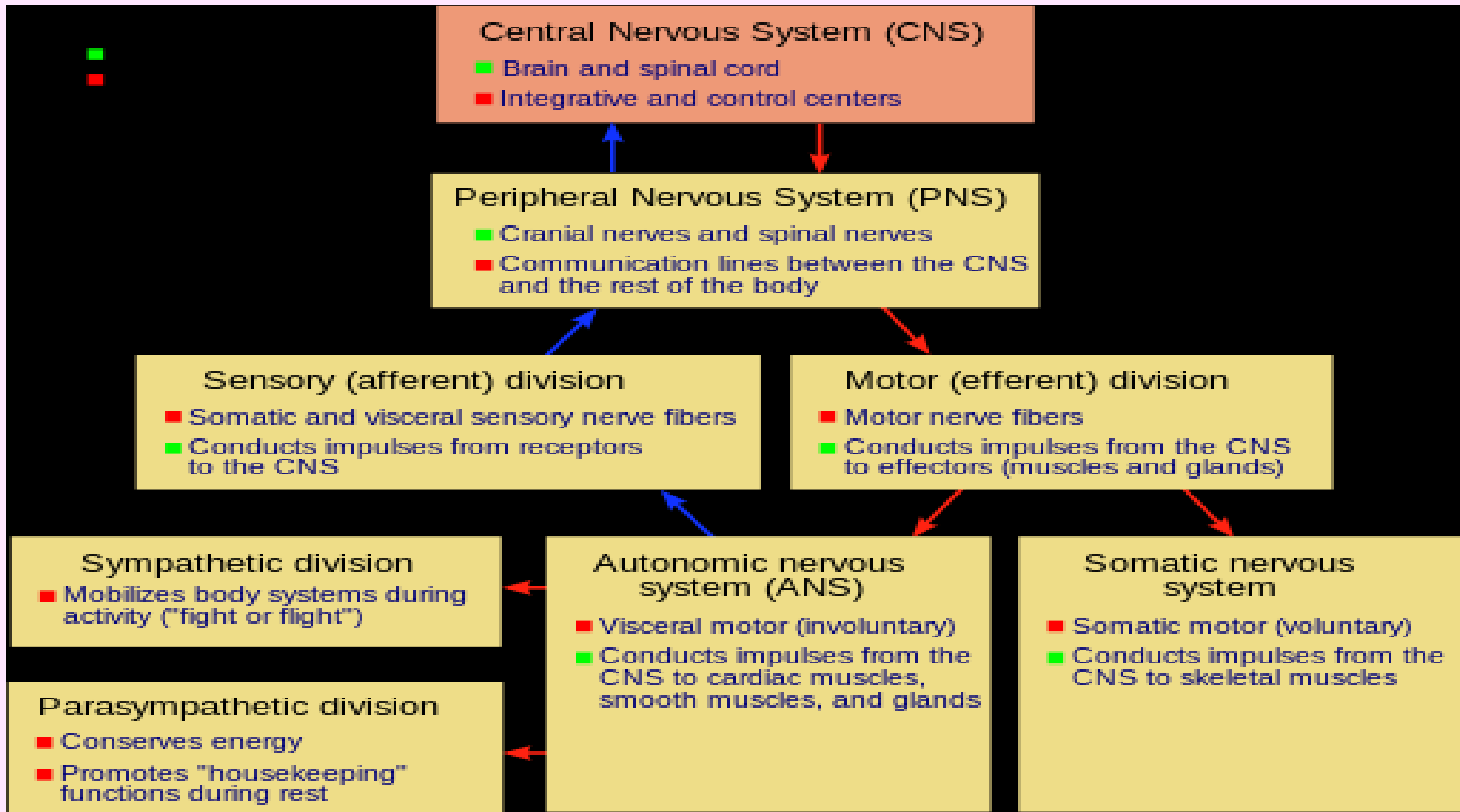
## **Remember also:**

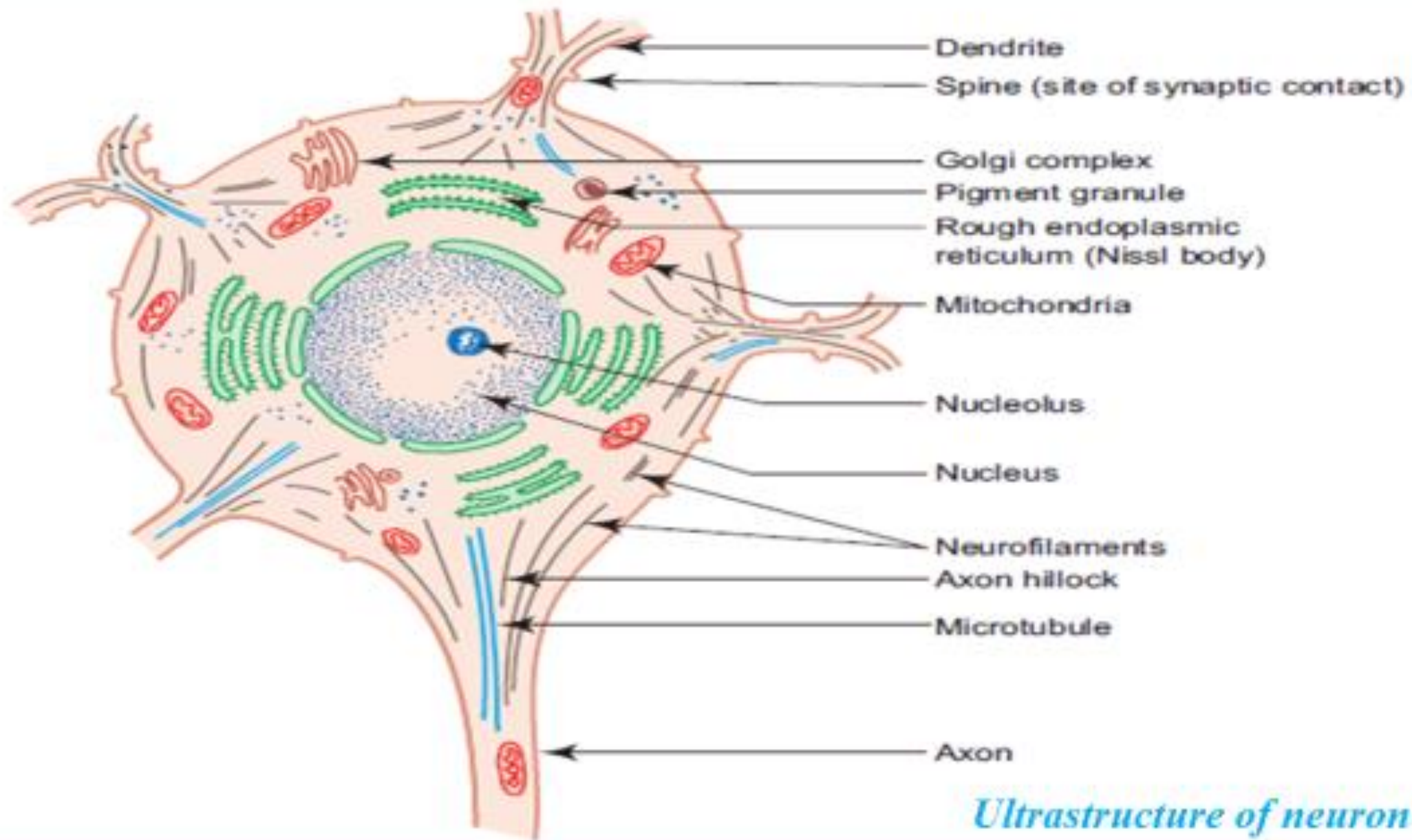
- *CNS vs PNS.*
- *Input: sensory: afferent: to brain.*
- *Output: motor : efferent: from brain.*
- *Dense network of fibers from processes of both neurons and glial cells fills the interneuronal space of the CNS and is called the neuropil .*



*Divisions of nervous system*

- The nervous tissue is composed of :  
*neurons* (nerve cells) & supported *neuroglial cells*.
- (About 10 million neurons in human beings).
- The function of neurons:





*Ultrastructure of neuron*

## **Structure of a neuron:**

**Cell body = Soma = Perikaryon :**

- **The cell bodies of all neurons are situated in the grey matter of the CNS and in the ganglia of PNS.**
- **Soma contains the nucleus and the following organelles and inclusions :**
  - ***Nucleus***
  - ***Nissl bodies* (large aggregations of rough endoplasmic reticulum **RER**):**

- ***Golgi complex***—are found near the nucleus.
- ***Mitochondria***—are numerous and rod shaped.
- ***Neurofilaments* & microtubules** form neuronal cytoskeleton (structural support and intracellular transport).
- ***Melanin pigments*.**
- ***Lipofuscin pigments*** [residual bodies not digested by lysosomes (increase with age)].

## Dendrites:

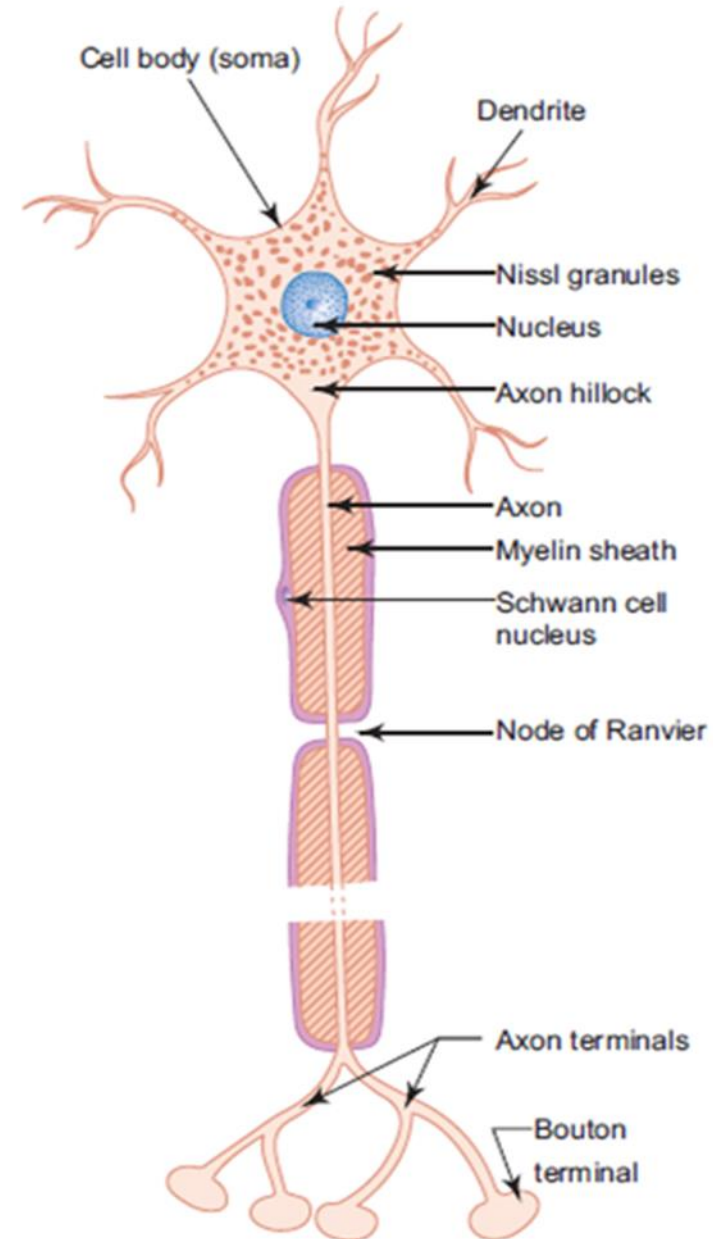
- branched, tapering processes of a neuron. diameter is not uniform.
- covered by *gemmules* (sites of synaptic contact).
- Receive stimuli from sensory cells and other neurons and transmit them towards the soma.

## **Axon:**

- Single, long, cylindrical ,diameter is uniform.
- Does not branch (give rise to collaterals).
- Arises from **axon hillock**, (which is devoid of Nissl bodies, but contains bundles of microtubules).
- The cytoplasm of the axon (**axoplasm**) & the plasma membrane (**axolemma**).
- Terminates by **axon terminals**, ending in small **swellings—terminal buttons**.
- Conducts impulses away from the cell body
- Axons are commonly referred to as *nerve fibers*.
- surrounded by *myelin sheath*, which is derived either from Schwann cells (PNS) or oligodendrocytes (CNS).
- When an axon is cut, peripheral part degenerates.
- Regeneration of the axon is possible only when the cell body of the neuron is intact.

**Note:**

***Neurons do not regenerate in the event of cell body death, they do not multiply***

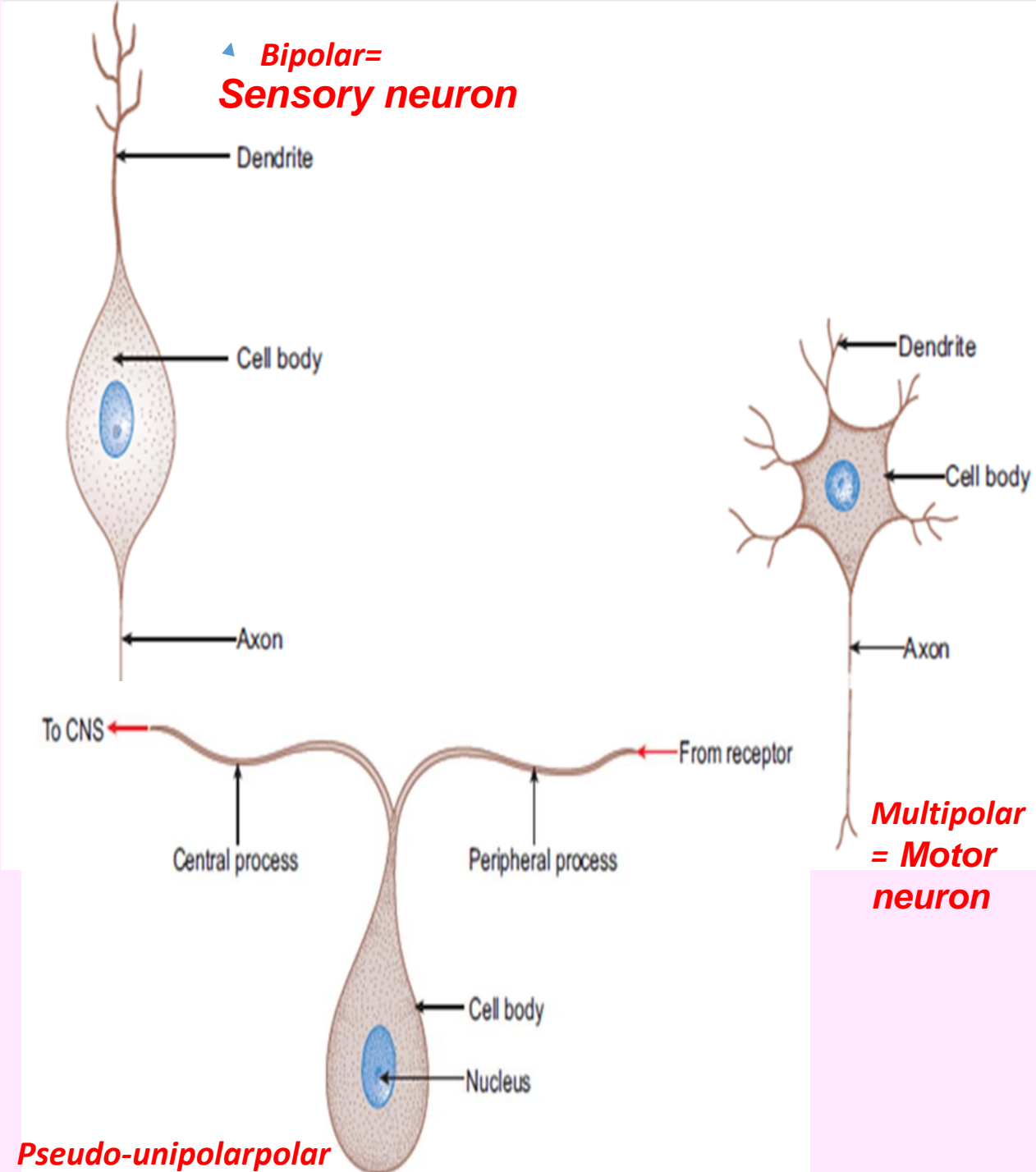


***Structure of a neuron***

## Classification of Neurons:

### **A. Morphological (based on the number of processes)**

- 1. Unipolar neuron**—(rare), e.g. mesencephalic nucleus of V cranial nerve.
- 2. Bipolar neuron**— spiral ganglion, bipolar cells in retina .
- 3. Multipolar neuron**—autonomic ganglia motor neurons.
- 4. Pseudo-unipolar neuron**cranial and spinal ganglia (sensory neurons).



## B. Functional (based on the function):

1. **Sensory neuron**—receives stimuli from receptors and conducts impulses to CNS, e.g. *sensory ganglia*.
2. **Motor neuron**—(conducts impulses from CNS to effector organs) e.g. *ventral horn cells*.
3. **Interneuron**—connects sensory and motor neurons

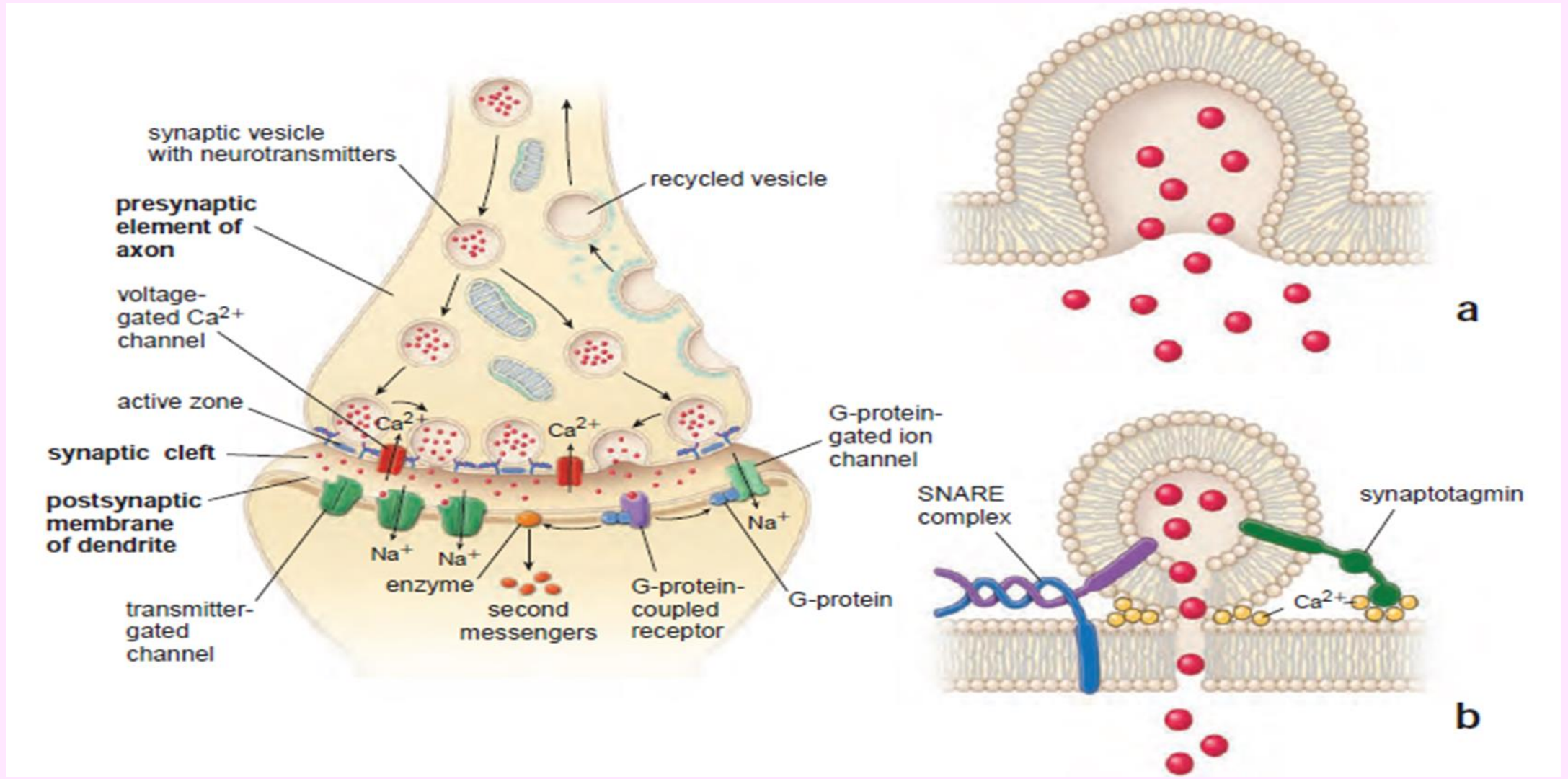


## **Synaptic Communication:**

- **The synapse (transmission of nerve impulses from neuron to another ,transmission is unidirectional).**
- **function of synapse (convert an electrical signal (impulse) into a chemical signal).**
- **synapses transmit information by releasing neurotransmitters.**

*A synapse has the following structure:*

- Presynaptic axon
- Postsynaptic cell membrane.
- 20-30 nm wide intercellular space called the *synaptic cleft*
- The synapses are *excitatory* or *inhibitory synapses*.



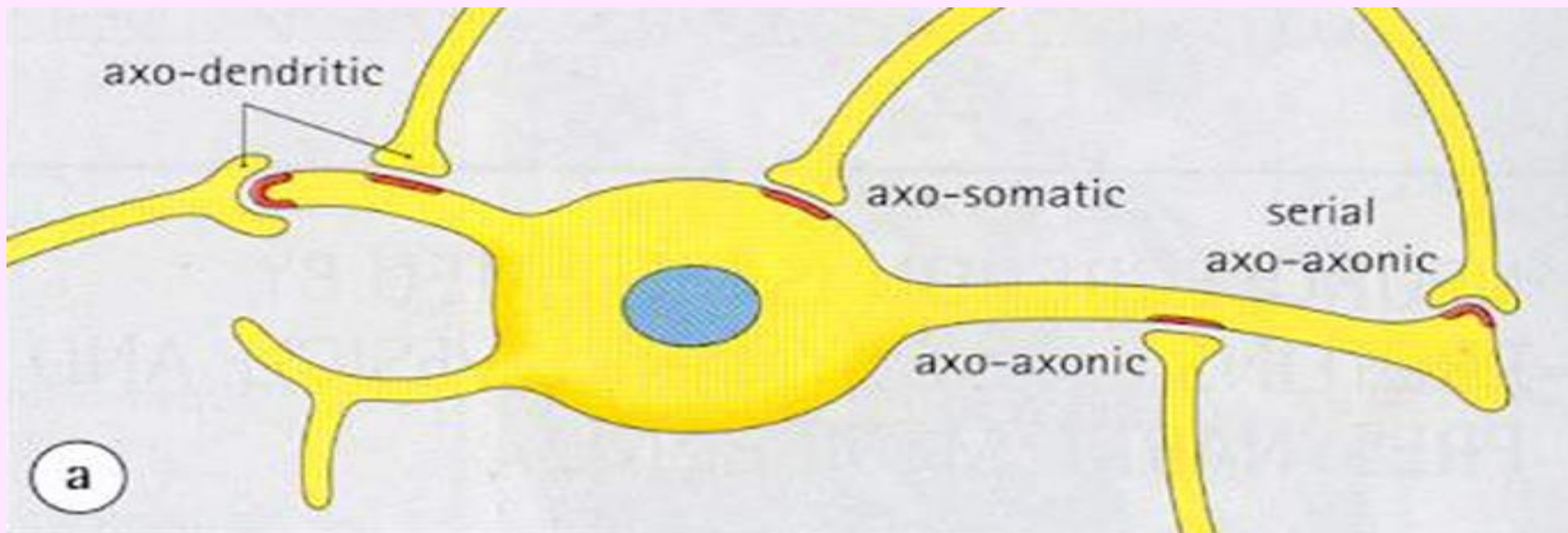
*Diagram of a chemical axodendritic synapse.*

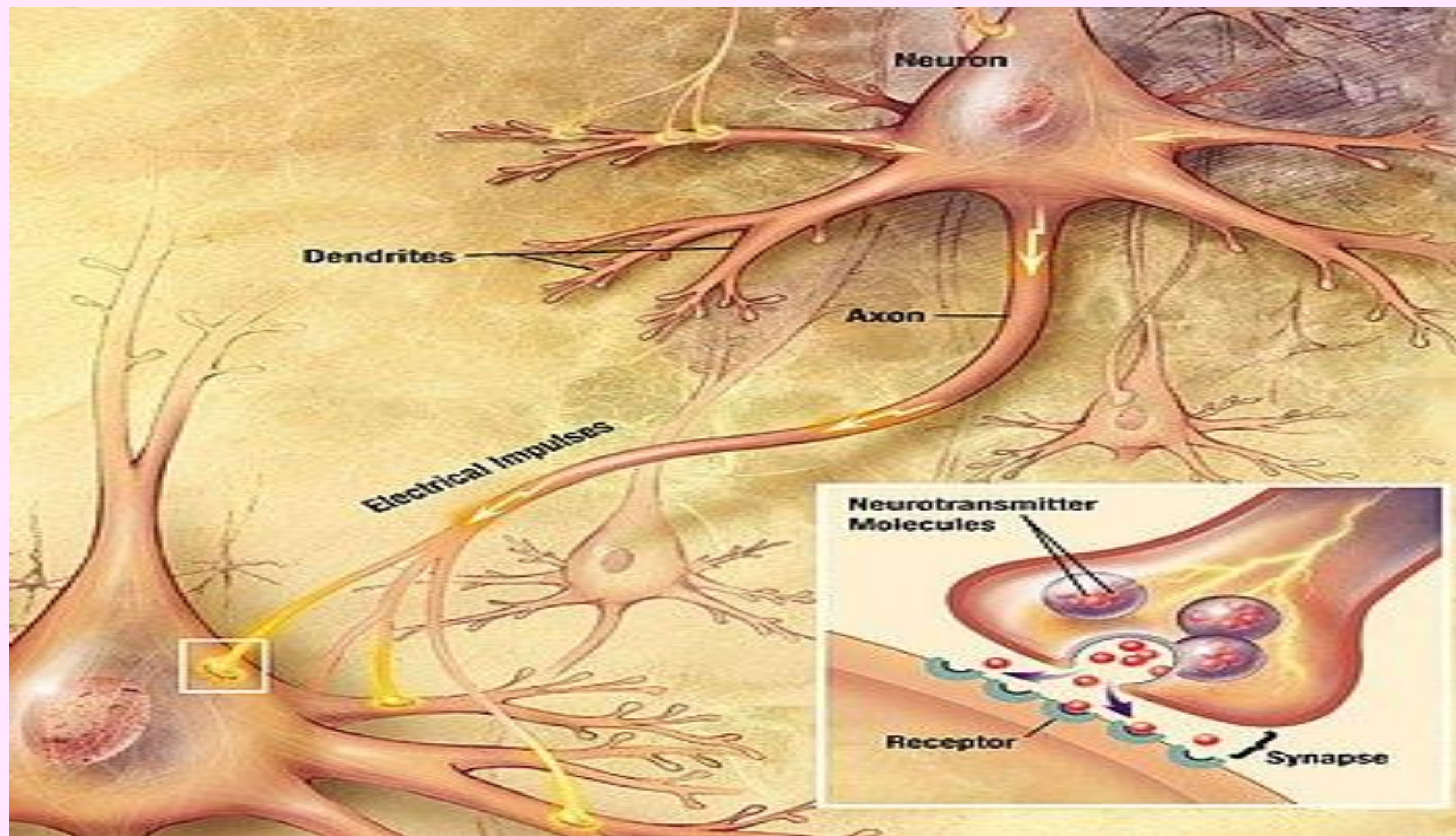
➤ **Neurons can synapse with:**

**Neurons , Muscles , or Glands.**

➤ **Synapses between neurons may be classified morphologically as:**

- **axodendritic**, occurring between axons and dendrites; (*fig.(7a)*).
- **axosomatic**, occurring between axons and the cell body(*fig.(7b)*).; or
- **axoaxonic**, occurring between axons and axons (*fig.(7c)*).

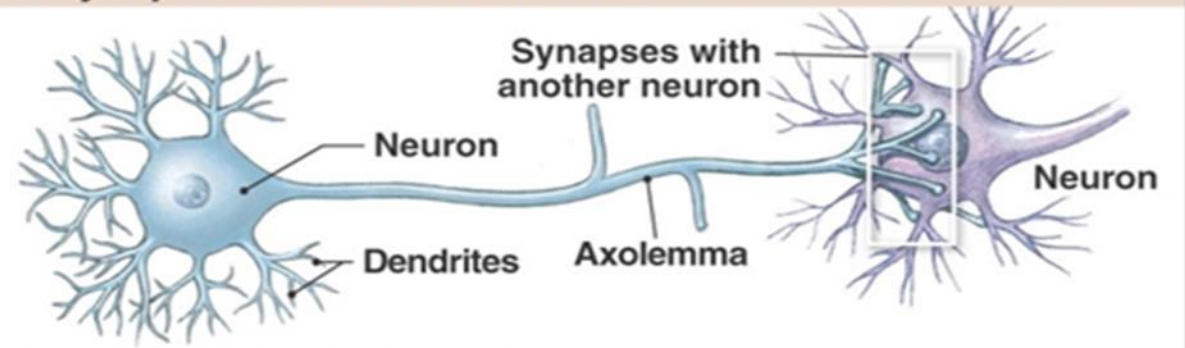




1-Neurons



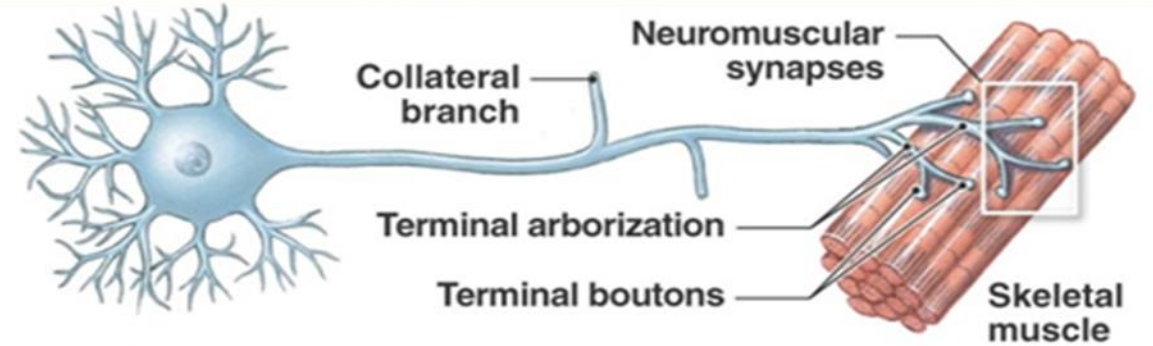
### 1. Synapses with another neuron



2-Muscle



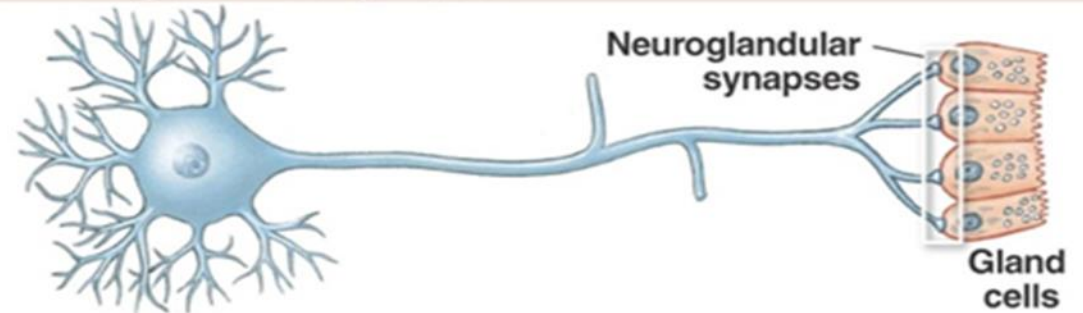
### 2. Neuromuscular synapses



3-Glands



### 3. Neuroglandular synapses



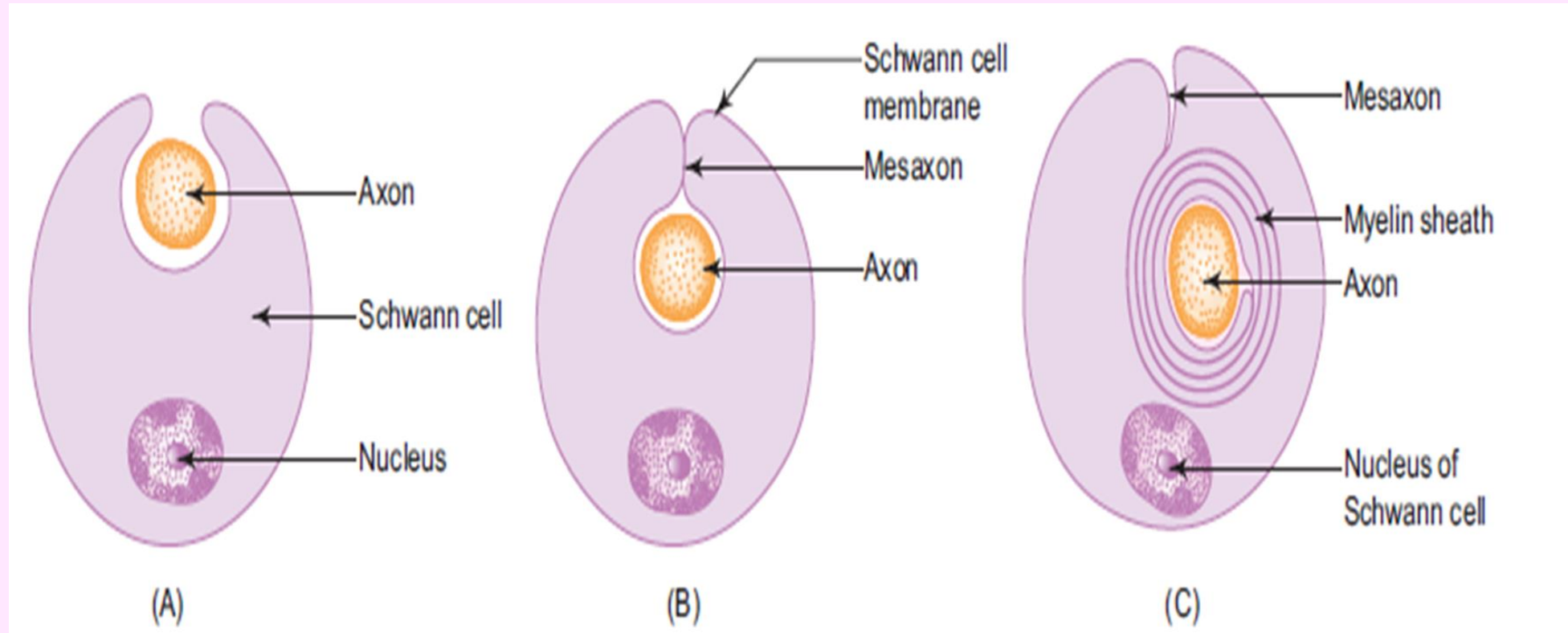
➤ **Some examples of neurotransmitters are :**

- **Acetylcholine .**
- Dopamine , endorphins
- Serotonin ,and
- **Norepinephrine .**

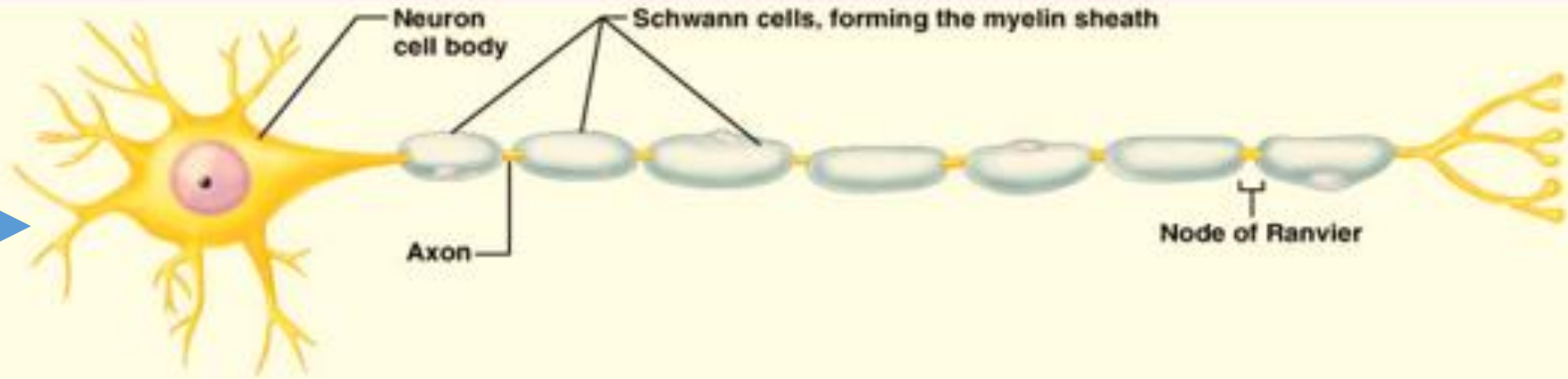


## Myelination:

- Myelination begins with the invagination of the axon into the Schwann cell. The invaginated axon is suspended from the periphery of the cell by a fold of fused plasma membrane called *mesaxon*

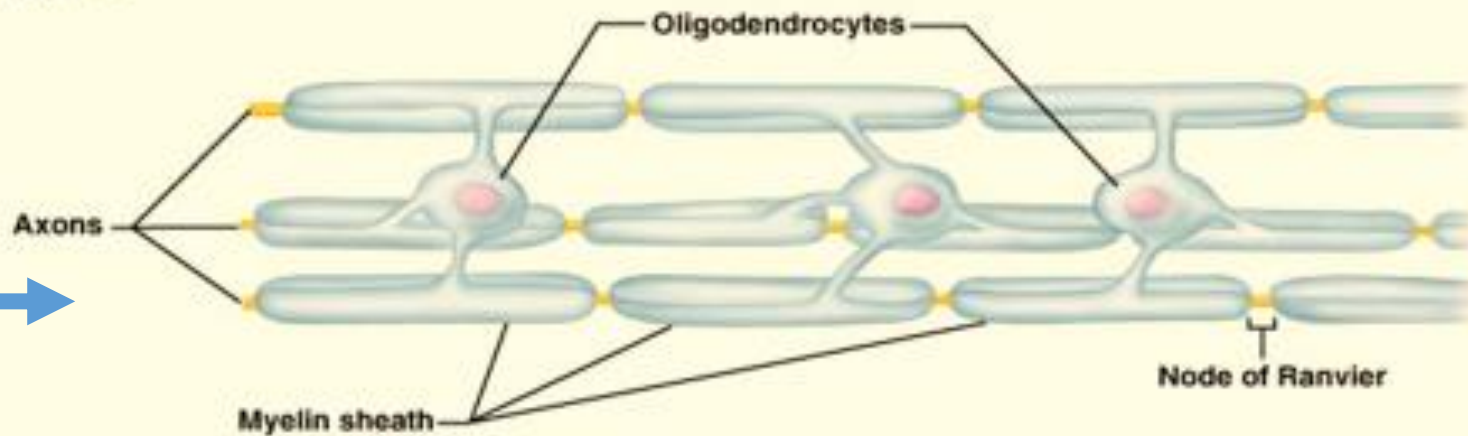
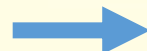


**PNS:**  
*schwan cells*  
*myelin sheet*



**(a) PNS**

**CNS:**  
*oligodendrocyte*  
*myelin sheet*



**(b) CNS**

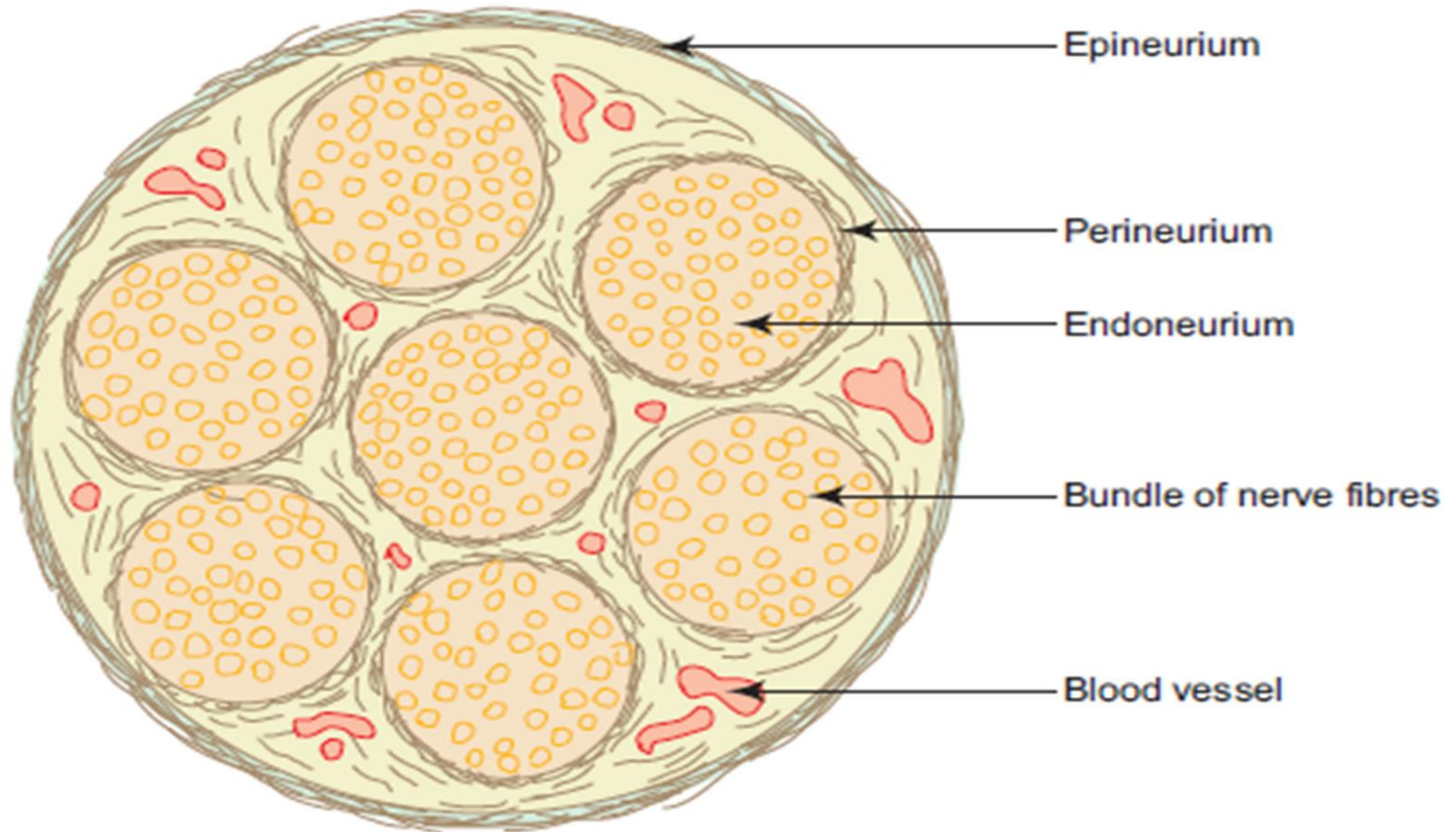
*myelin sheet*

- Each peripheral nerve (**spinal or cranial**) is made of bundles (**fascicles**) of nerve fibres (axons) which may be **myelinated** and/or **unmyelinated**.
- The bundles are held together by connective tissue which provides structural support as well as nutritional support by carrying blood vessels to nerve fibres.

➤ *The connective tissue framework is well appreciated in cross section of a nerve :*

- *Epineurium:* (Dense connective tissue sheath)
- *Perineurium:* A sleeve of flattened specialized epithelial cells surrounding the bundles of nerve fibres.
- *Endoneurium:* Loose connective tissue composed of reticular fibers supporting individual nerve fibers.

❖ *In the case of optic nerve, it is surrounded by meninges of brain*



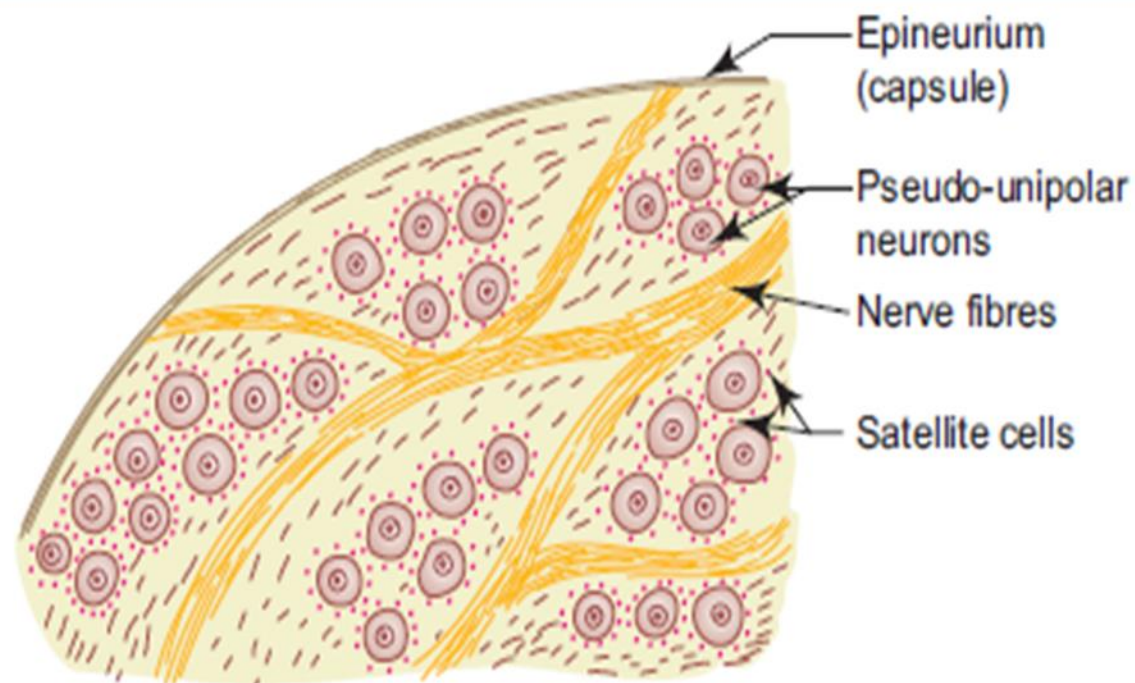
***Peripheral nerve***



## Ganglia:

- **Ganglia are oval bodies**
- **(aggregation of cell bodies of neurons outside the CNS).**
- **relay centres in the neuronal pathway.**
- **covered by a dense connective tissue capsule (**epineurium**).**

**Sensory ganglion (somatic),  
e.g. spinal ganglion**

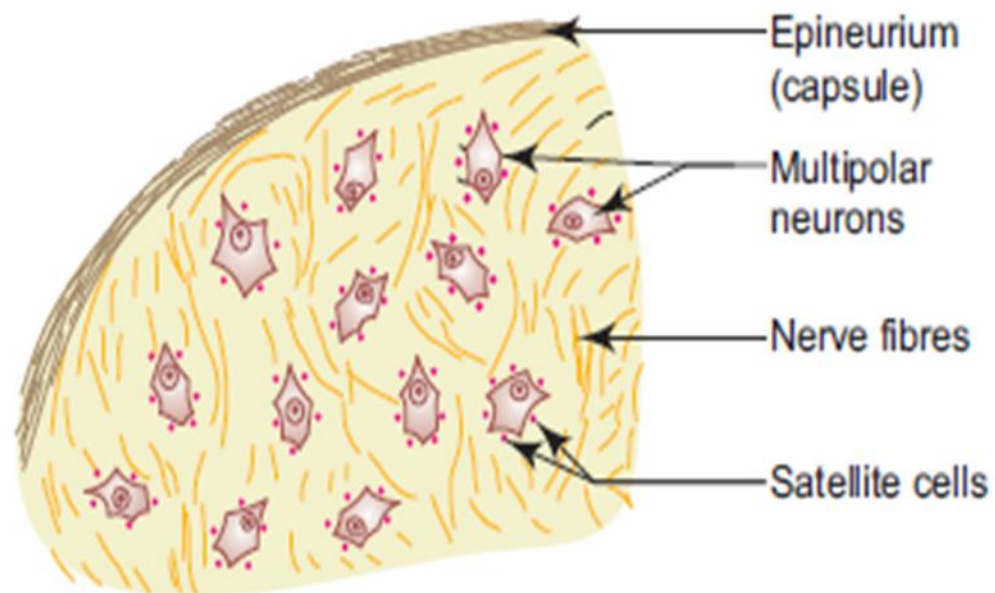


**1. Pseudo-unipolar neurons**

- Large, rounded and of varying size (in section)
- Nucleus centrally placed
- Found in groups

**2. Well-defined satellite cells**

**Motor ganglion (autonomic),  
e.g. sympathetic ganglion**



**1. Multipolar neurons**

- Small, angular and of uniform size (in section)
- Nucleus eccentrically placed
- Found scattered

**2. Poorly defined satellite cells**

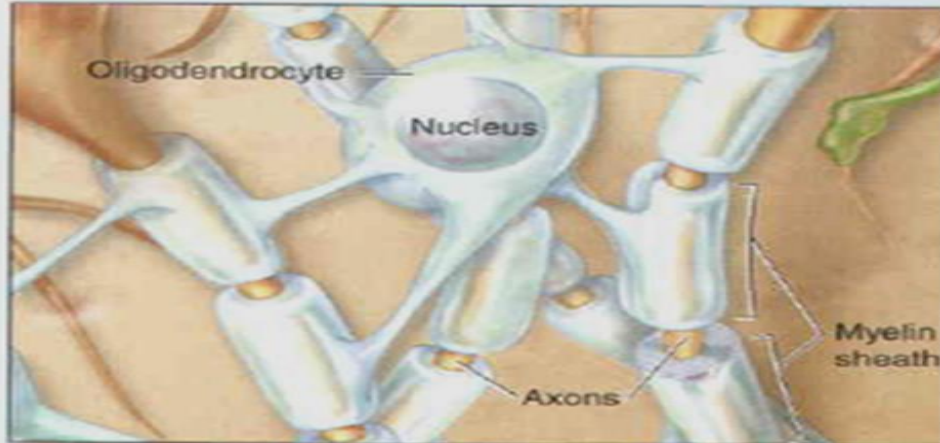
## **Neuroglia**

<b>Glial Cell Type</b>	<b>Location</b>	<b>Main Functions</b>
<b>Oligodendrocyte</b>	<b>Central nervous system</b>	<b>Myelin production, electric insulation.</b>
<b>Neurolemmocyte</b>	<b>Peripheral nerves</b>	<b>Myelin production, electric insulation.</b>
<b>Astrocyte</b>	<b>Central nervous system</b>	<b>Blood-brain barrier, metabolic exchanges.</b>
<b>Ependymal cells</b>	<b>Central nervous system</b>	<b>Lining cavities of central nervous system.</b>
<b>Microglia</b>	<b>Central nervous system</b>	<b>Immune-related activity</b>
<b>Satellite Cells</b>	<b>Peripheral nerves</b>	<b>Supportive role.</b>

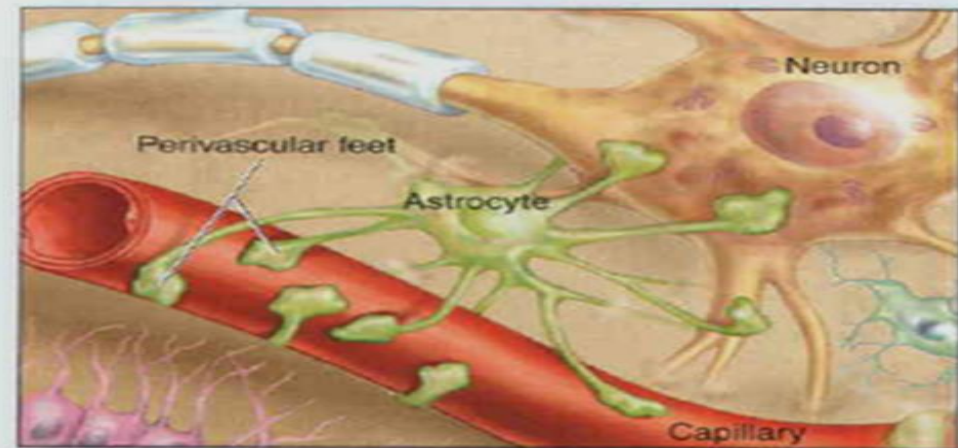
## Neuroglia (in CNS):

- There are four principal types of neuroglia in the CNS; namely *astrocytes*, *oligodendrocytes*, *microglia* and *ependymal cells*.

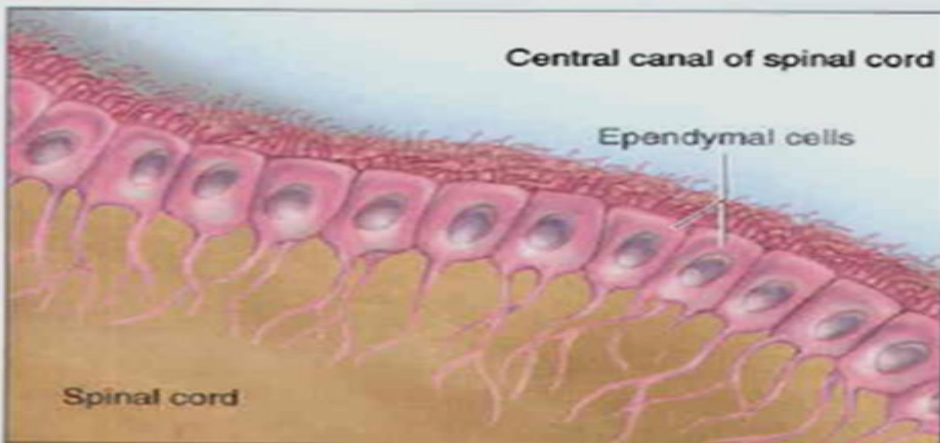
CNS Glial Cells



a Oligodendrocyte



b Astrocyte



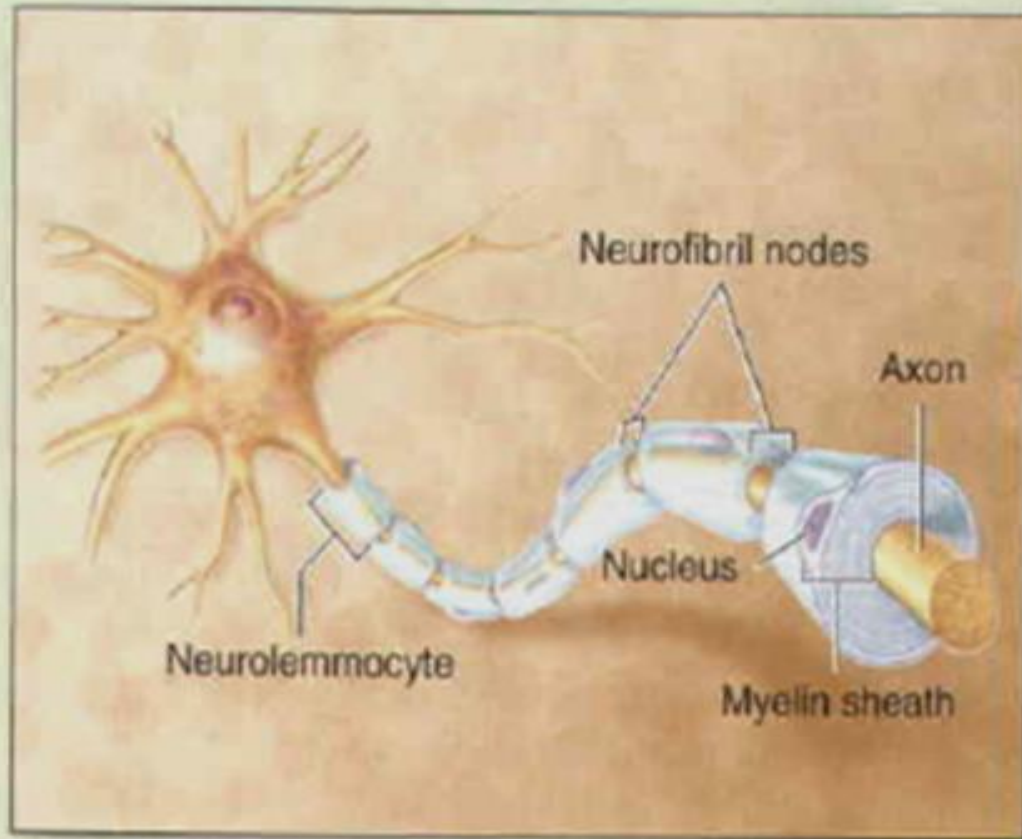
c Ependymal cells



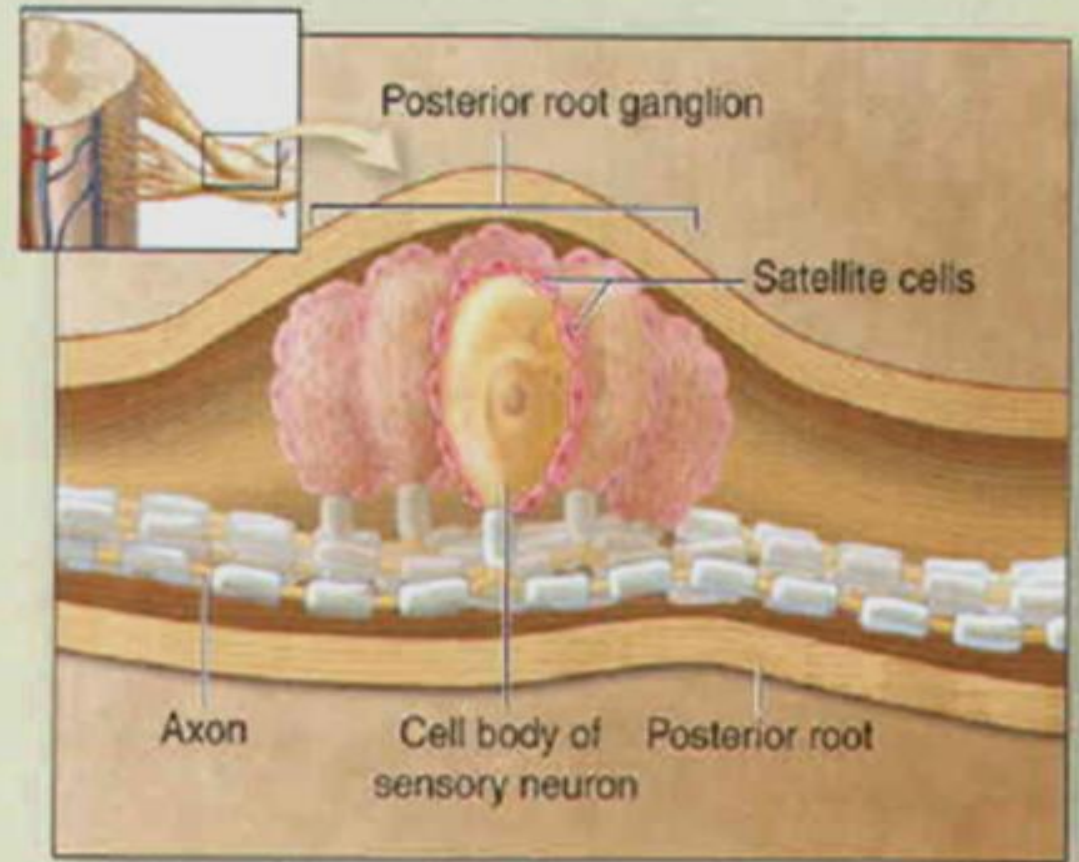
d Microglial cell

## Neuroglia (in PNS):

### PNS Glial Cells



e Neurolemmocytes



f Satellite cells

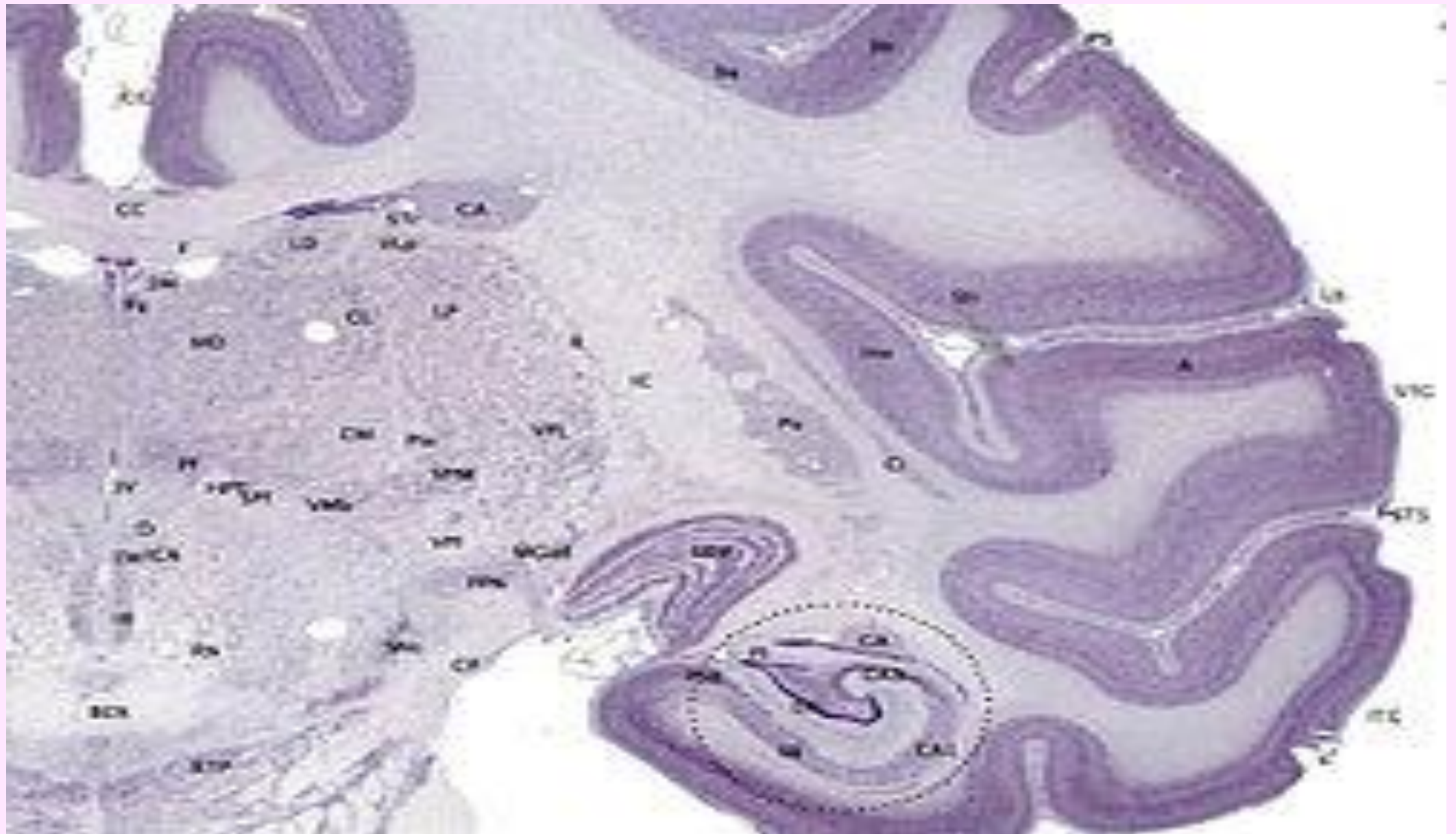


**Note:** Glial cells are capable of reproduction, and when control over this capacity is lost ,primary brain tumors result. Astrocytomas and glioblastomas are amongst the most deadly or malignant forms of cancer.

## Central Nervous System:

- The principal structures :CNS (cerebrum, cerebellum, and spinal cord).
- It has ***virtually no*** connective tissue and is ***therefore*** a relatively soft, gel-like organ.
- When sectioned ,the cerebrum ,cerebellum, and spinal cord show regions of white (***white matter***) and gray (***gray matter***).

- **Gray matter contains** abundant neuronal cell bodies, dendrites, the initial unmyelinated portions of axons , astrocytes ,and microglial cells.
- **Gray matter** is prevalent at the cortex of the cerebrum and cerebellum, **whereas** white matter is present in more central regions.

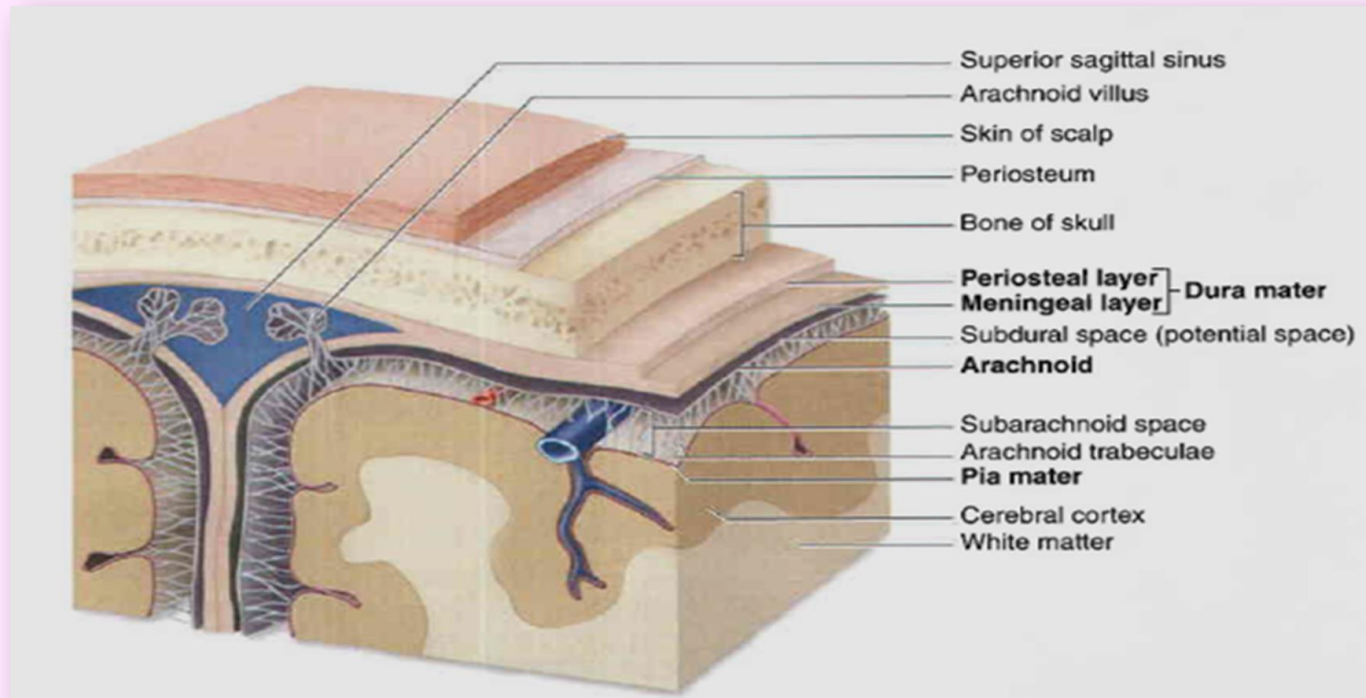


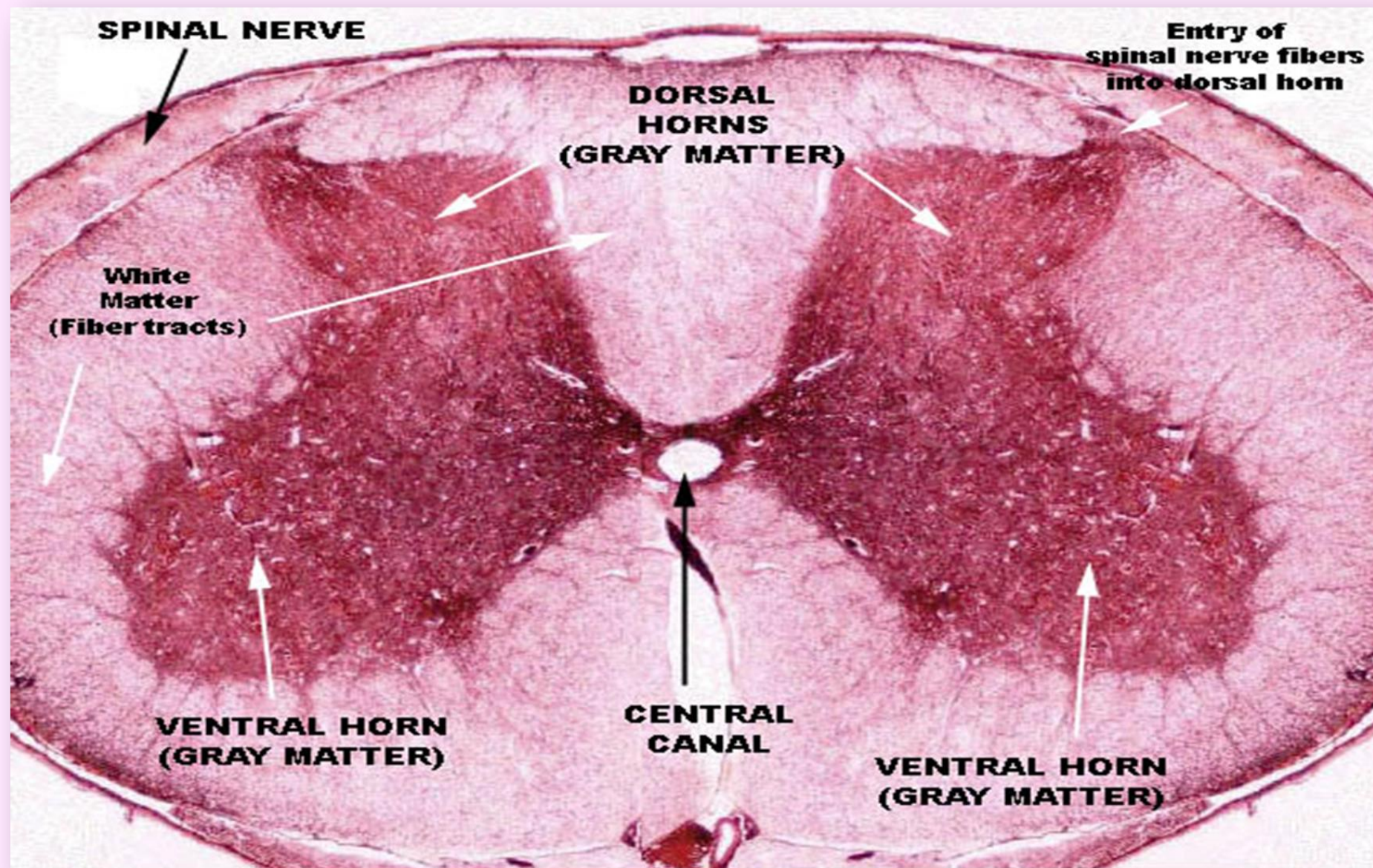
**Brain:cerebral cortex**

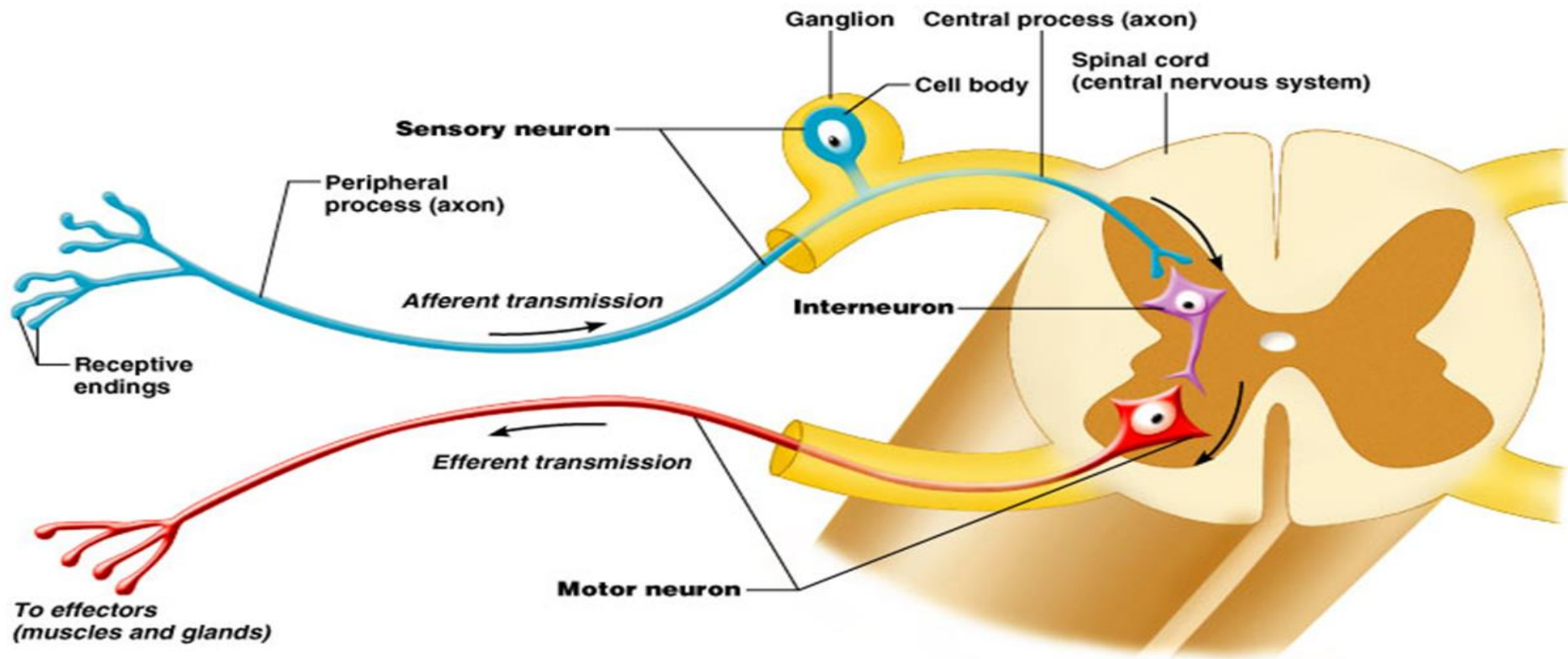


**Meninges:** *Three meningeal layers are distinguished:*

- ✓ **Dura Mater:** The dura mater is the thick external layer (dense, fibroelastic connective tissue )
- ✓ **Arachnoid:** ( connective tissue of the arachnoid avascular *Pia Mater*)
- ✓ **Pia mater:** *loose connective tissue*







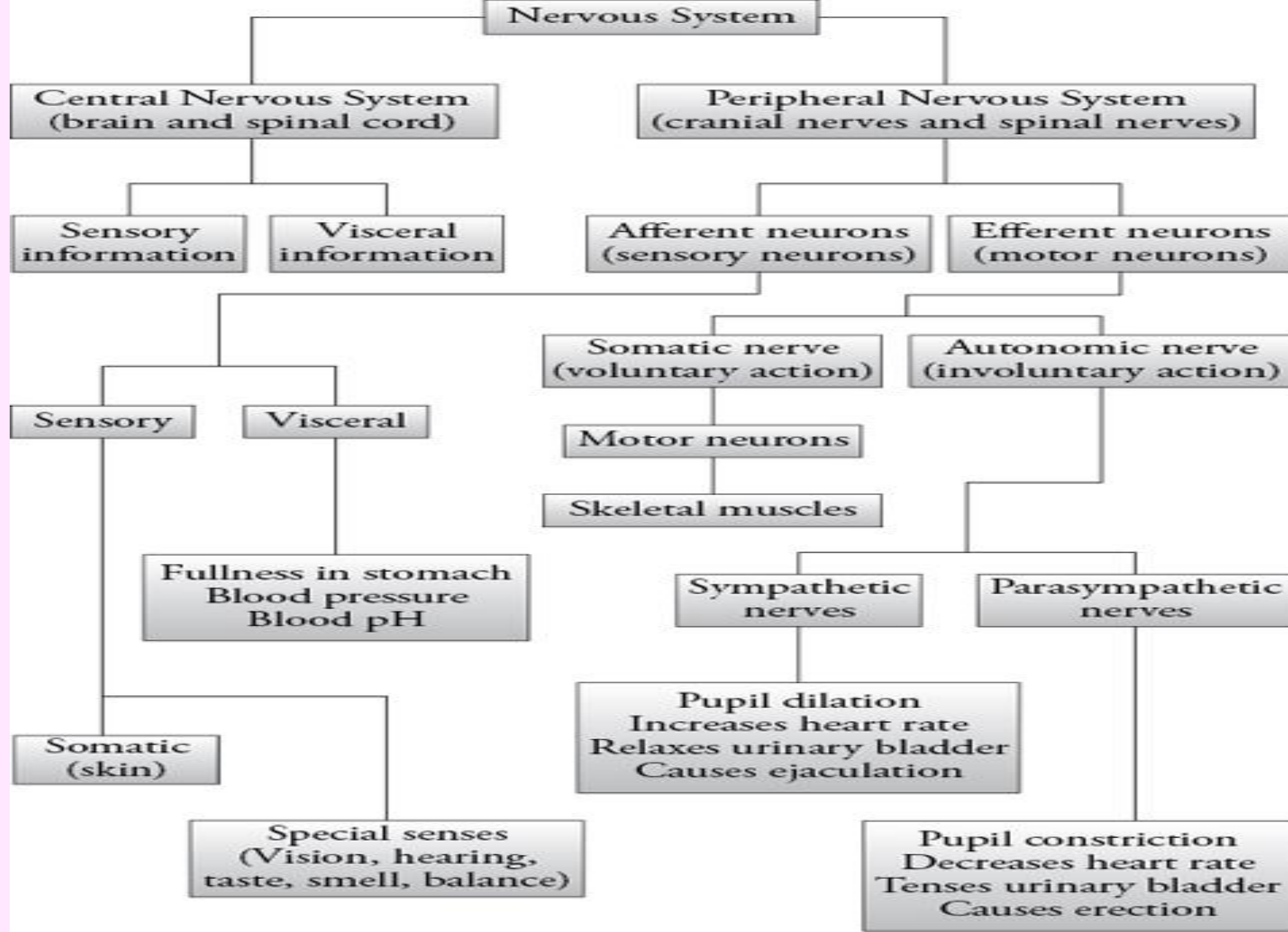
# *Fundamentals of the Autonomic Nervous System*

## *Lecture 2*

## Objectives

*Having revised this lecture you should be able to:*

- *give an outline of the anatomy of the autonomic nervous system (ANS) and its division into the sympathetic and parasympathetic parts.*
- *describe the different pathways via which these two divisions distribute their fibres to and from target organs.*
- *describe the difference in the overall functional roles of these two divisions.*
- *outline the functional control which the two divisions exert on all their target organs.*
- *describe in detail the transmitters involved at the synapses and end organs of both divisions.*
- *briefly account for the importance of these transmitters in the therapeutic domain.*



• *The autonomic nervous system (ANS) is related to the :*

- ✓ control of smooth muscle
- ✓ secretion of some glands
- ✓ modulation of cardiac rhythm.

• *Its function :* is to make adjustments in certain activities of the body to maintain a constant internal environment (*homeostasis*).

Anatomically:

*composed of collections of:*

- ✓ ***nerve cells*** located in the CNS.
- ✓ ***fibers*** that leave CNS (cranial or spinal nerves).
- ✓ ***nerve ganglia*** situated in the paths of these fibers.

*The autonomic nervous system is a **two-neuron network**:*

- ✓ *The first neuron (in the CNS): Its axon called **preganglionic fiber**, forms a synapse with the:*
- ✓ *second multipolar neuron (located in a ganglion of PNS), it is axon called **postganglionic fiber***

❖ The chemical mediator present in the synaptic vesicles of all preganglionic endings and at *anatomically* parasympathetic postganglionic ending is *acetylcholine*

□ *The autonomic nervous system :*  
*composed of :*

1. *sympathetic system SNS*
2. *parasympathetic system PSNS.*

*Nerve fibers that release **acetylcholine** are called **cholinergic** [**preganglionic** autonomic fibers (sympathetic & parasympathetic) & postganglionic parasympathetic fibers to smooth muscles , heart, and exocrine glands ].*

# *Sympathetic System :*

- The nuclei of **SNS** are located in the thoracic and lumbar segments of the **spinal cord**.*
- sympathetic system is also called **thoracolumbar division** of the **ANS**.*
- The axons of these neurons—preganglionic fibers—leave the CNS by way of the **ventral roots** and white communicating rami of the thoracic and lumbar nerves.*

- The chemical mediator of the postganglionic fibers of sympathetic system is **norepinephrine**.
- Nerve fibers that release norepinephrine are called **adrenergic** .
- Adrenergic fibers innervate **sweat glands** and **blood vessels** of skeletal muscle.

## Parasympathetic System

- ✓ The nuclei in the medulla and midbrain and in the sacral portion of the spinal cord .
- ✓ The preganglionic fibers of these neurons leave through 4 of the cranial nerves and also through the **2nd , 3d and 4th** sacral spinal nerves.
- ✓ **parasympathetic System** is therefore also called the **craniosacral division** of the autonomic system.

# Parasympathetic System

*Its messages flow from the Brain (via Cranial Nerves) and Spinal cord*

## Cranial Nerves:

Oculomotor (III)

Facial (VII)

Glossopharyngeal (IX)

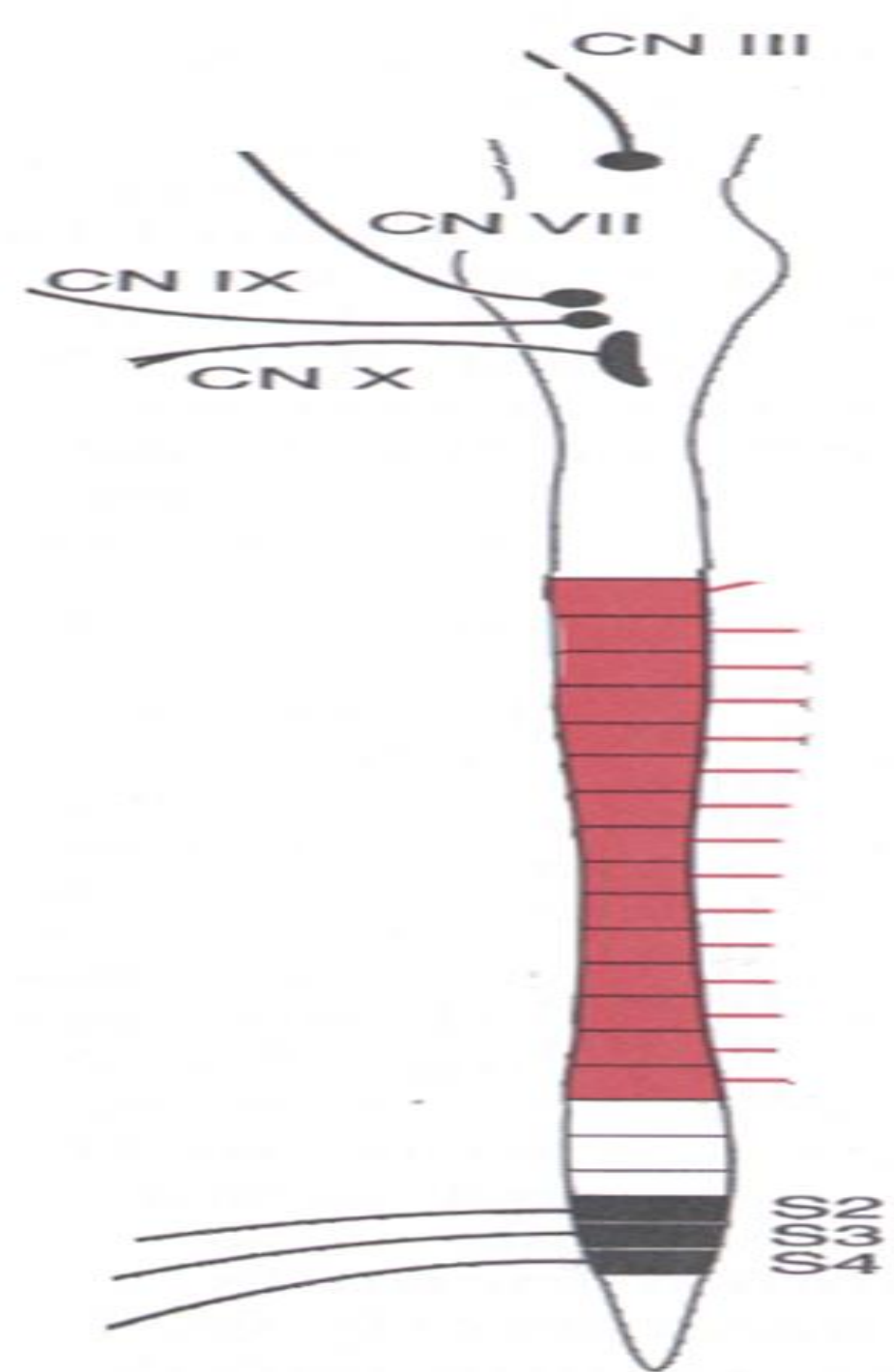
Vagus (X)

## Sacral Spinal Cord Levels:

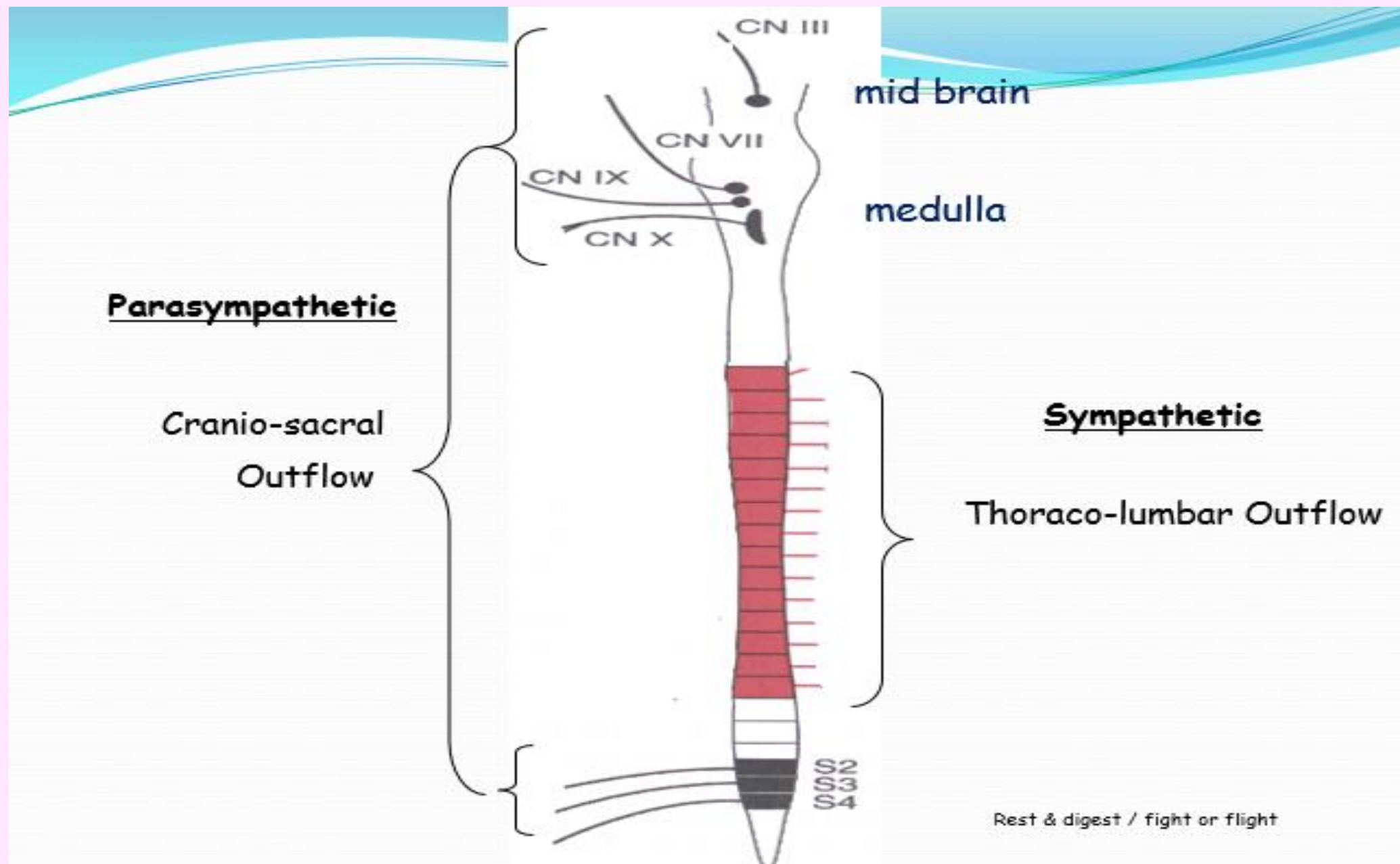
**S2, S3, S4**

*Hence it is also known as the*

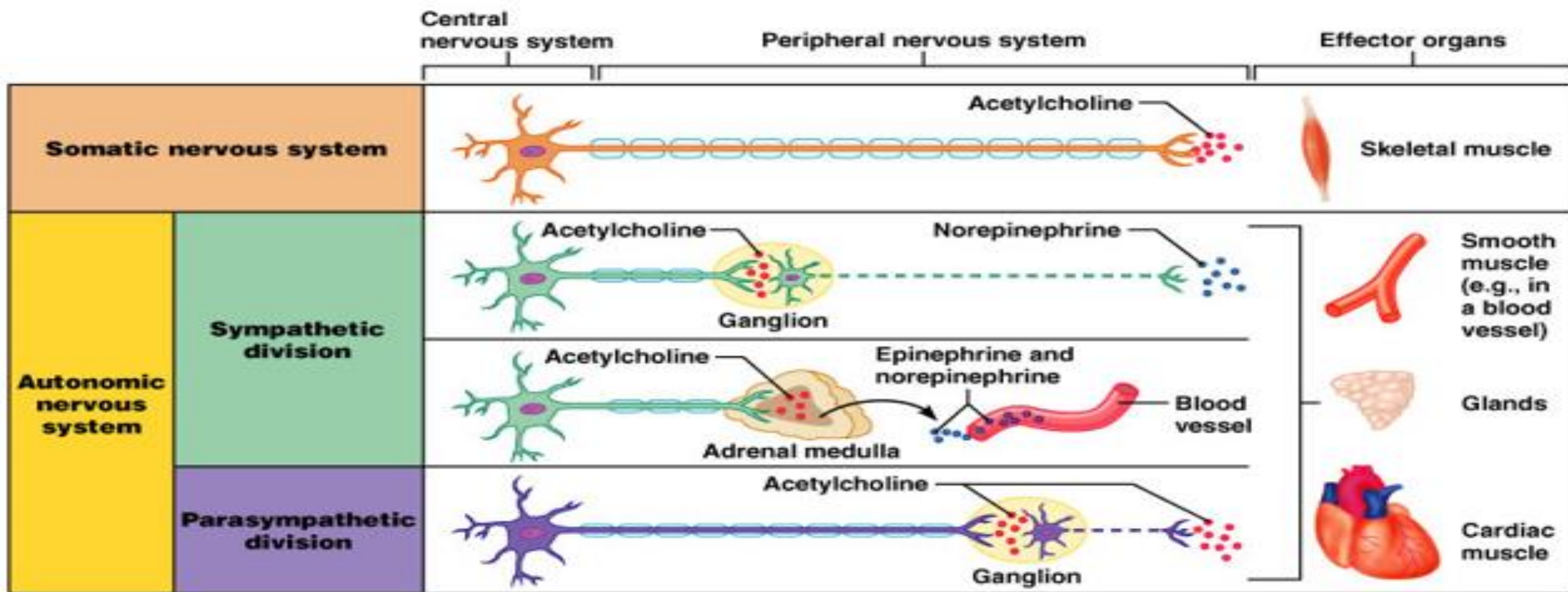
**Cranio-Sacral Division of ANS**



- ✓ The second neuron **PSNS** is found in ganglia smaller than those of the **SNS**; (near or within the effector organs).
- ✓ located in the walls of of organs (eg. Stomach, intestine) in which case the preganglionic fibers enter the organs and form a synapse with the **second neuron** in the chain.
- ✓ The chemical mediator released by the **pre**-and **postganglionic PSNS** nerve endings : **acetylcholine**.



# Comparison of Somatic & Autonomic Nervous System



**Key:**

= Preganglionic axons (sympathetic)    
 = Postganglionic axons (sympathetic)    
 = Myelination    
 = Preganglionic axons (parasympathetic)    
 = Postganglionic axons (parasympathetic)

