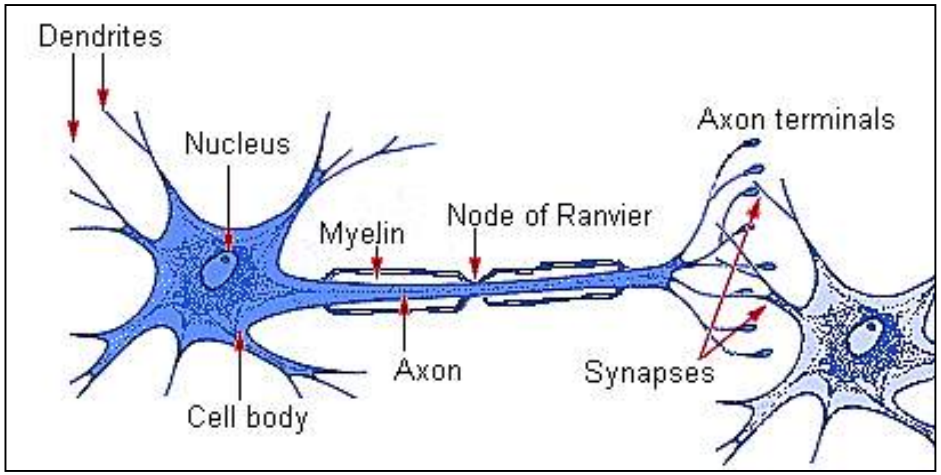


Peripheral nervous system

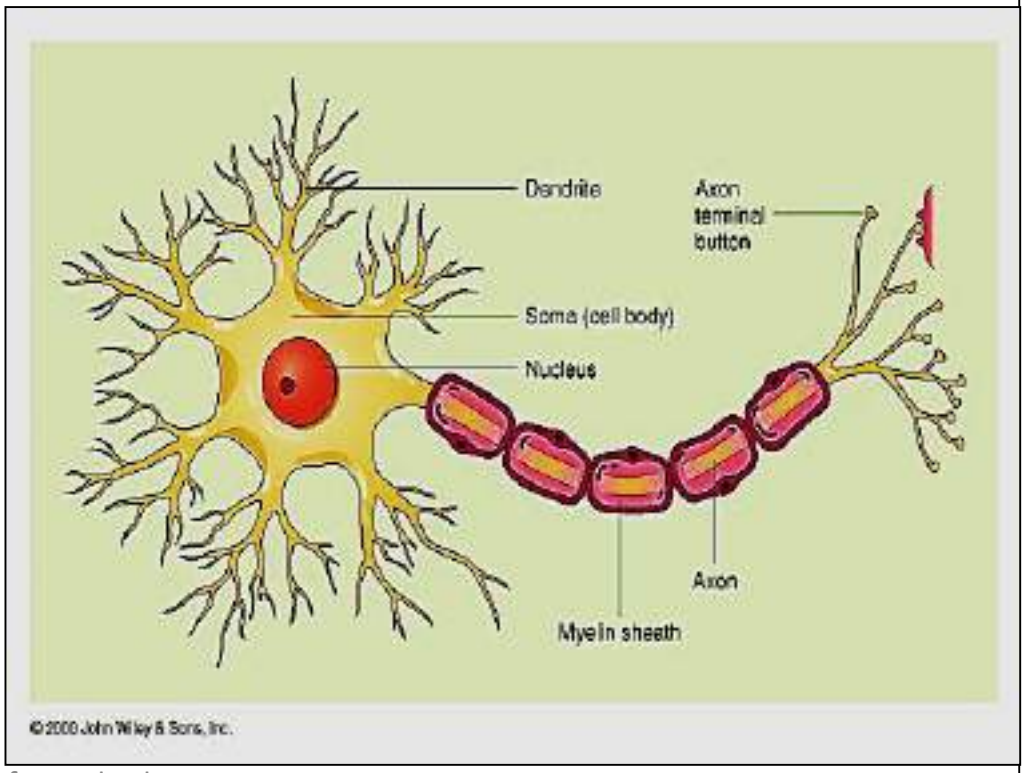
Prof. Dr. Hala Fouad El-mazar

Structure of the neuron (nerve cell)

PNS: consists of all nervous tissue outside the brain & spinal cord. Includes, nerves, Ganglia & receptors as they found in various parts of the body

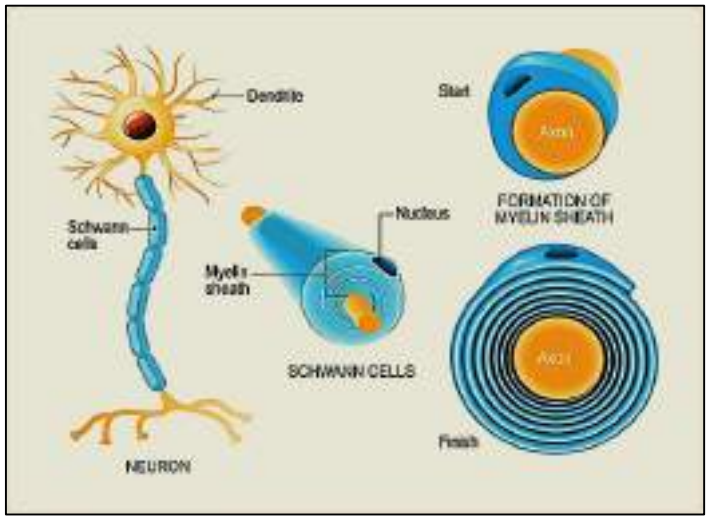
Nerve cell consists of the following main parts:

- Cell body (perikaryon)
- Dendrites
- Axon hillock
- Axon
- Axonal terminals
- Knobs
- Synapse

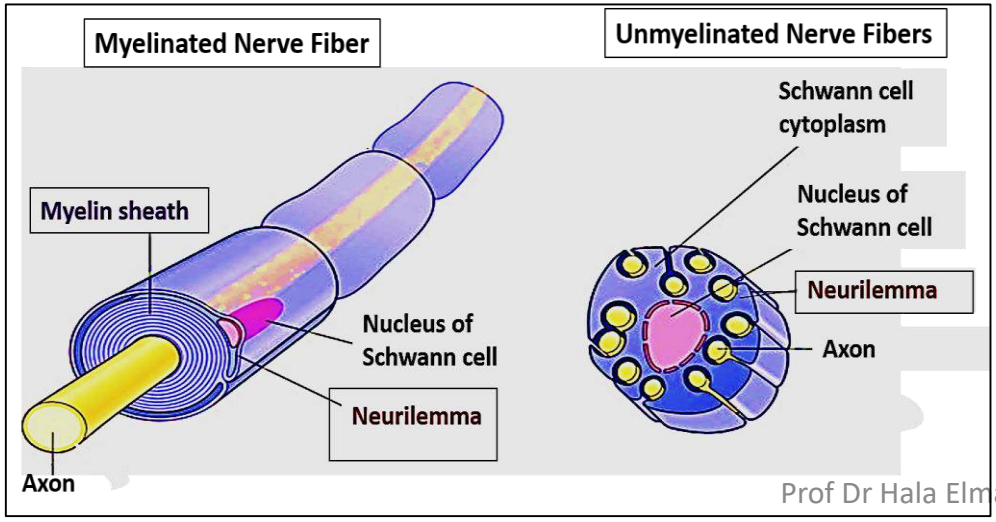


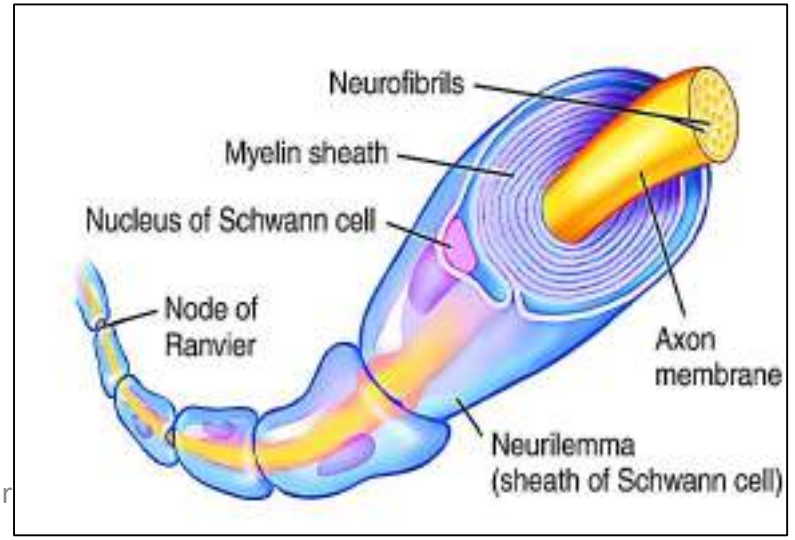
* Axon are enveloped by sheath of Schwann cells

* The cells **may** or **may not** form myelin around the axon thus myelinated or unmyelinated nerves



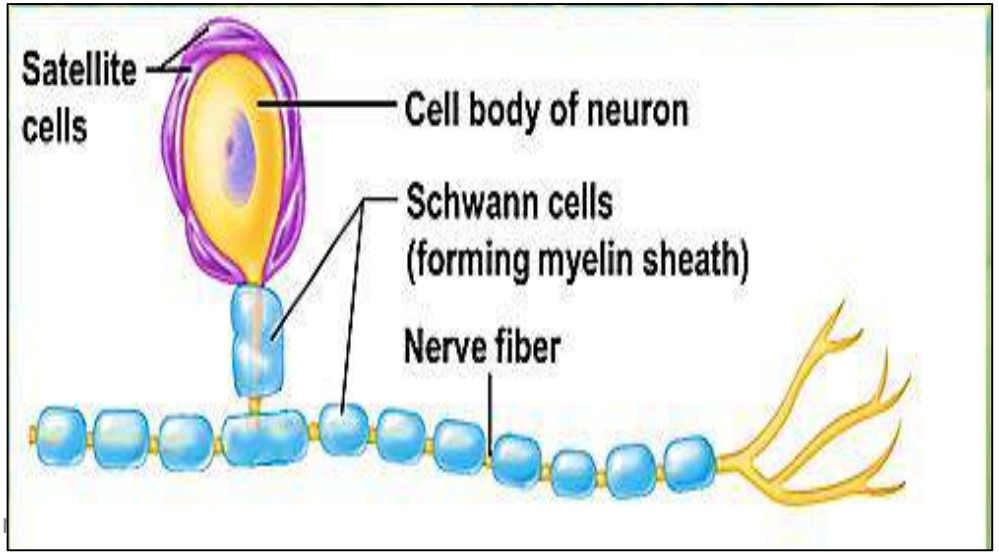
- **Axolemma**: plasma membrane covering the entire axon
- **Neurilemma** : Schwan cell sheath, outermost layer surround the axon & myelin sheath





- Along the **Axolemma** the signals are transmitted
- **Neurilemma** supportive function for peripheral nerve fibers & imp for nerve regeneration (damaged n.f . may regenerate if the cell body of Schwan cell is not damaged)

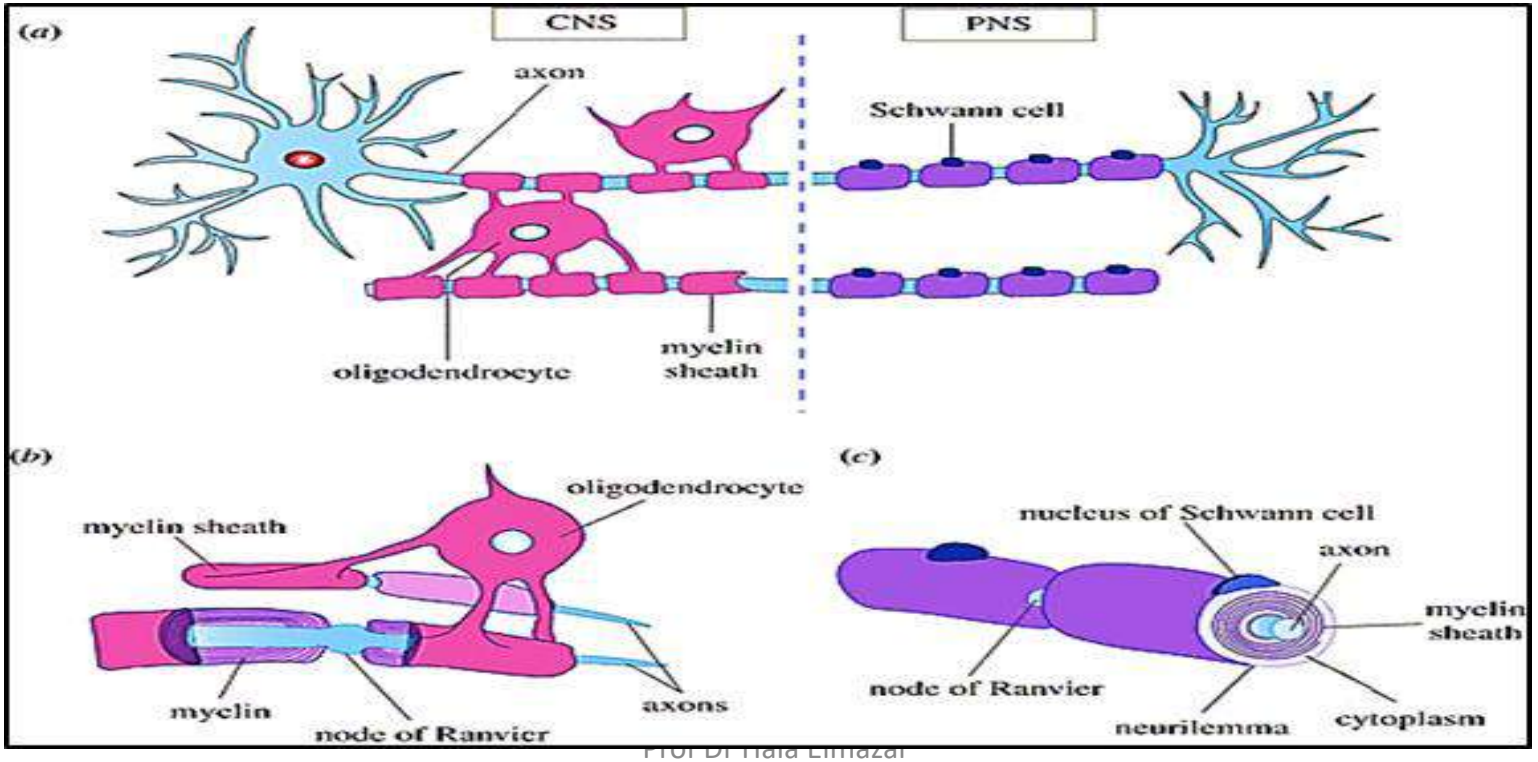
- **Glial cells** found in PNS are 2 types: **Schwan cells** & **Satellite cells**.
- Schwan found in close contact with axons of PNS
- Satellite are found within ganglia in close association with the nerve cell bodies



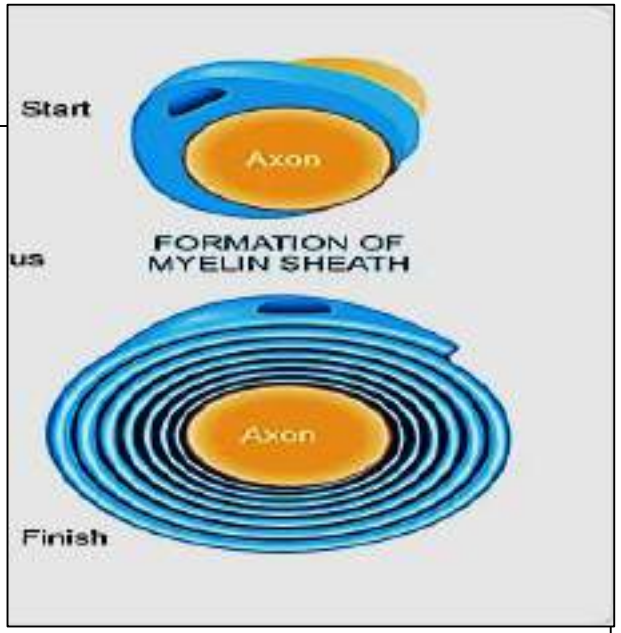
Q: Myelin of CNS is formed by _____?

The myelin sheath of oligodendrocytes **don't have** neurilemma because excess cytoplasm is directed centrally toward the oligodendrocyte cell body

Nuerilemma Key difference between PNS & CNS in regeneration ability



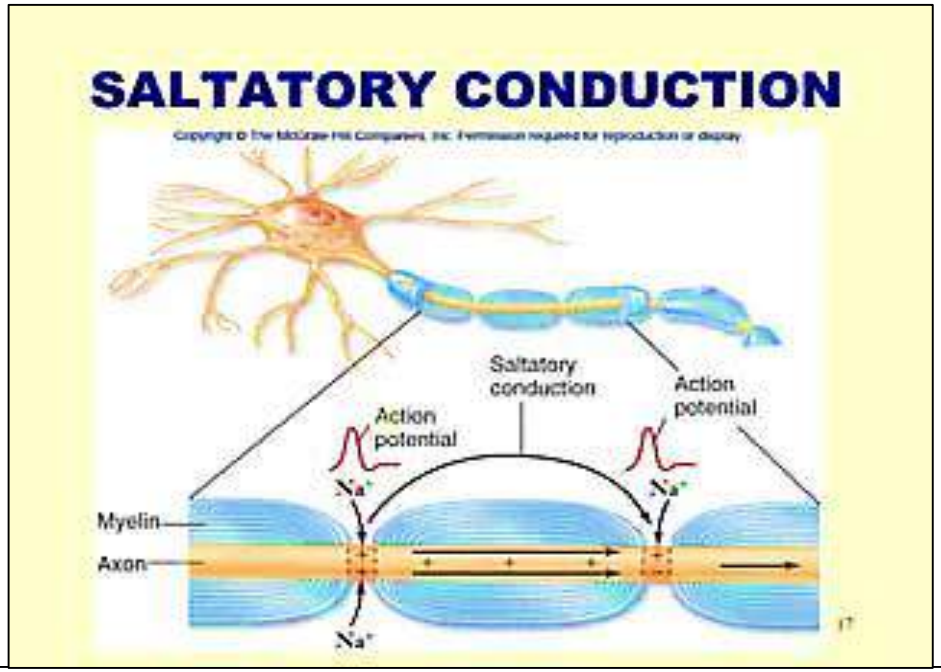
Myelin



- White fatty material
  (80% lipid and 20% protein)
  covers the axons in PNS & is Formed by Schwann cells which are glial cells

- Schwan cells spiral & wrap around the axon . Laying down multiple layers of its own membrane.
  The lipid – rich membrane forms the myelin sheath

- **Myelin protects** and **insulates** the axon and **increase the transmission rate** of nerve impulses



Node of Ranvier (NOR) increases conduction velocity of the action potential (= rate of transmission of impulse).

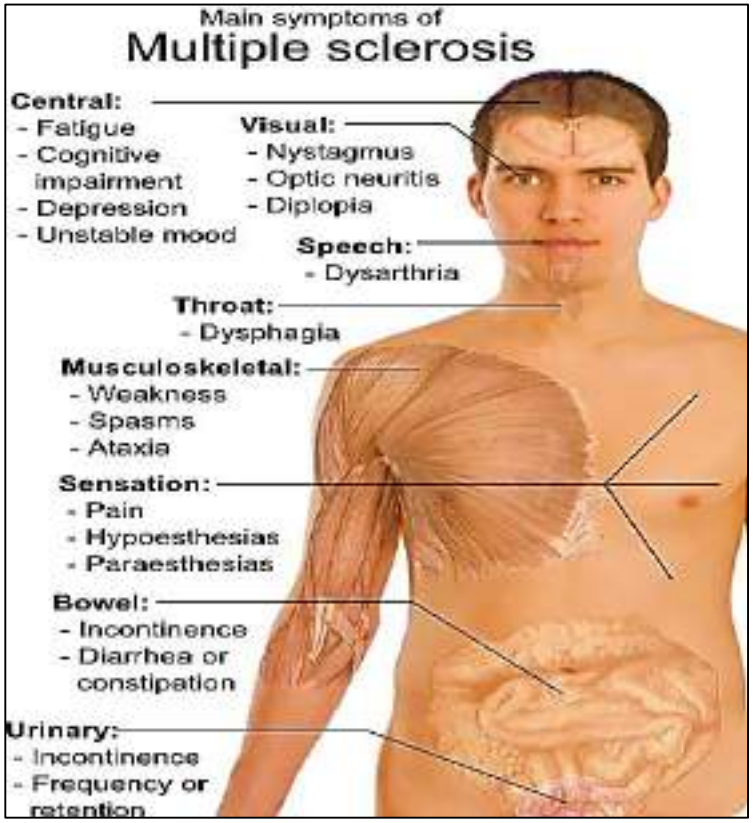
action potentials "jump" between Nodes of Ranvier→

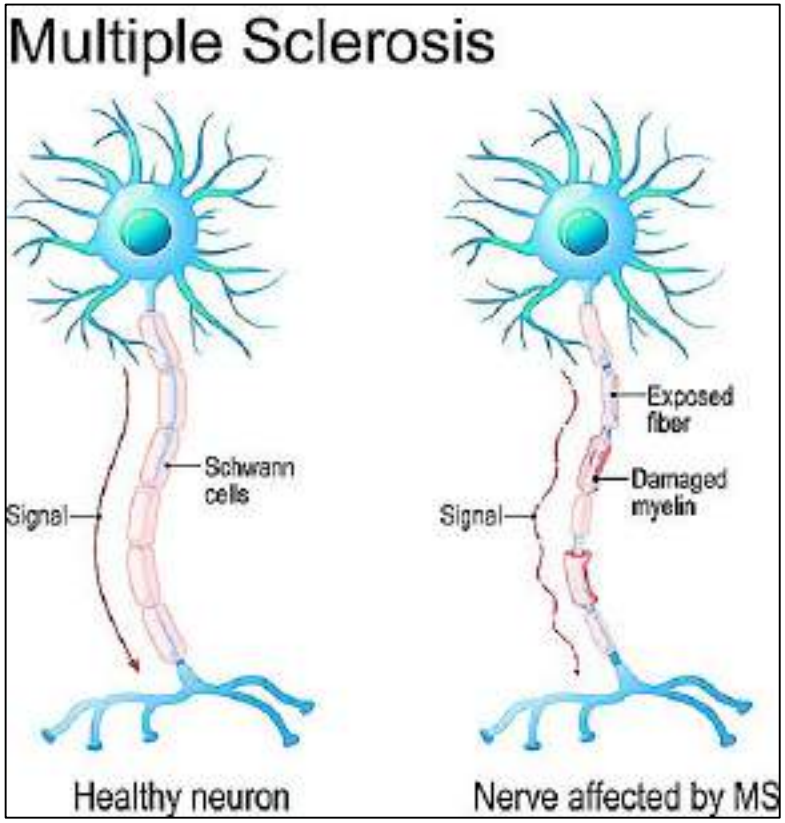
<u>Saltatory conduction:</u>

Cuz depolarization cannot occur at the cells making up the myelin sheath, the wave of depolarization can only occur at the Nodes of Ranvier. Thus, action potentials appear to jump from node to node when travelling down an axon

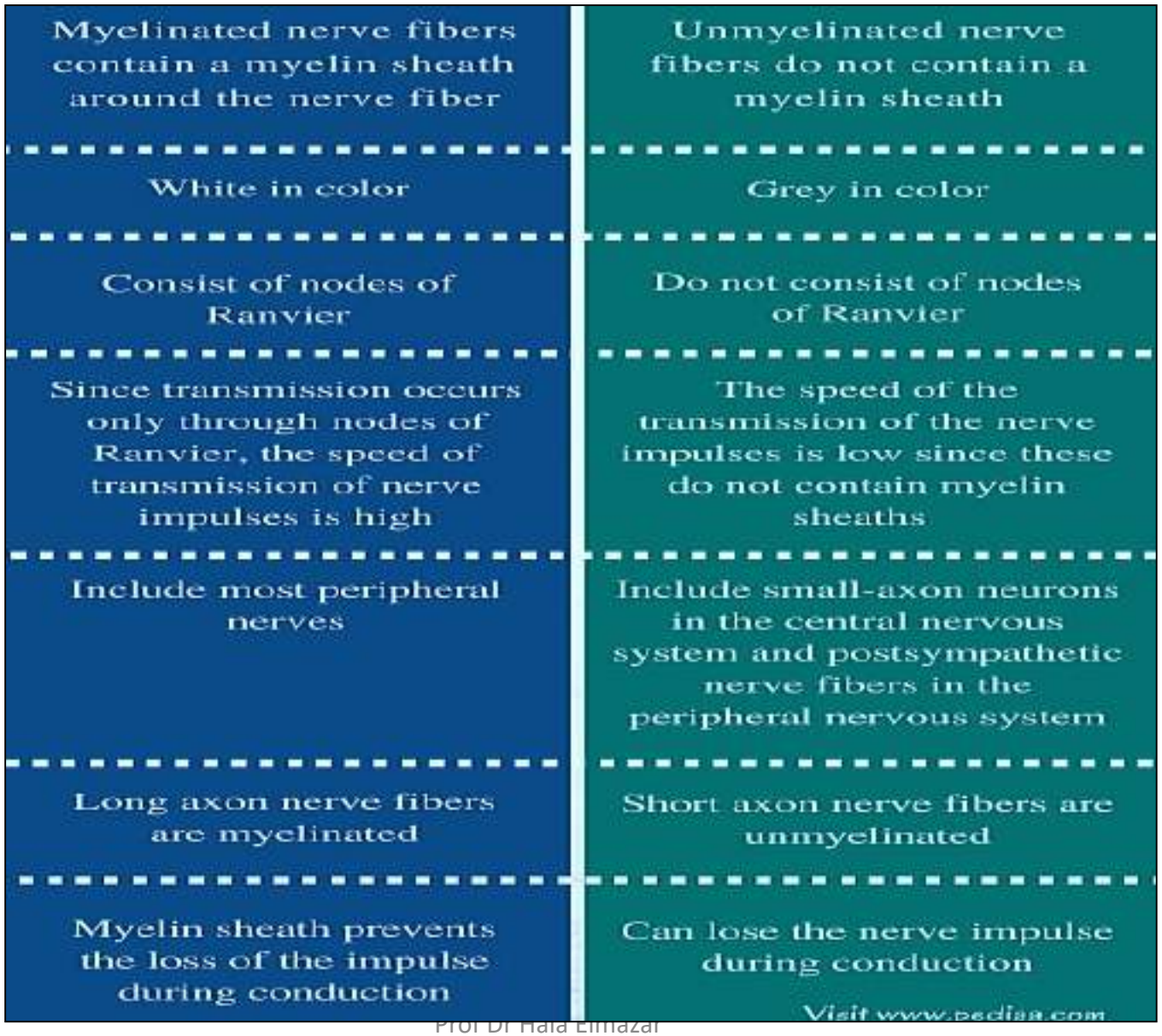
Multiple sclerosis :

In this condition myelin sheath is damaged leading to slower & less efficient nerve signal transmission which will cause multiple neurological symptoms

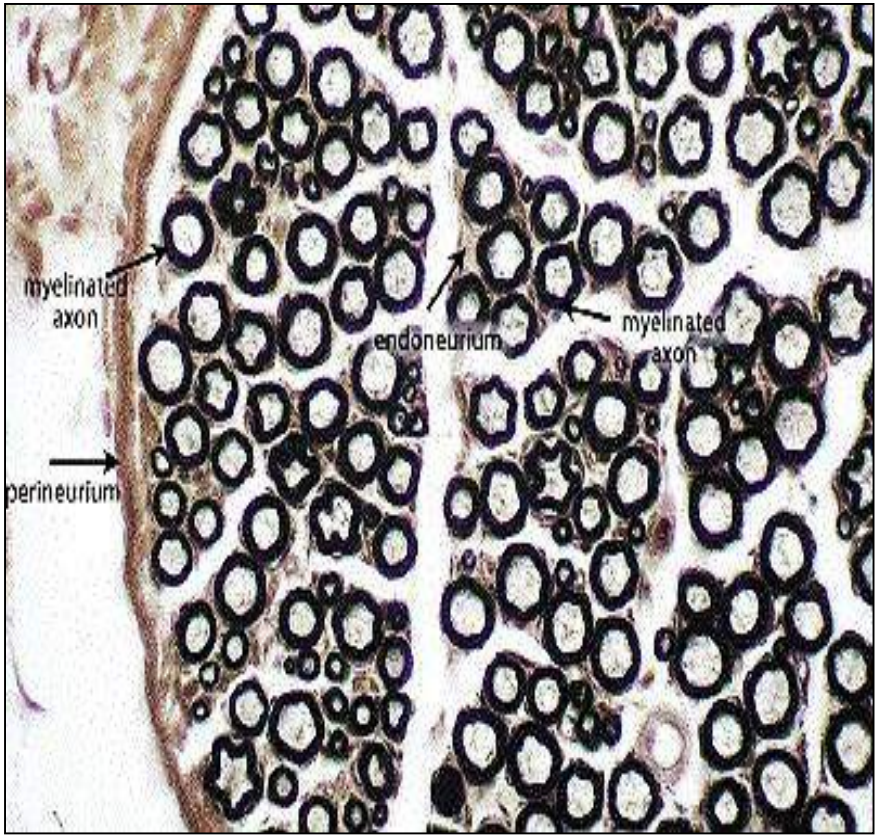


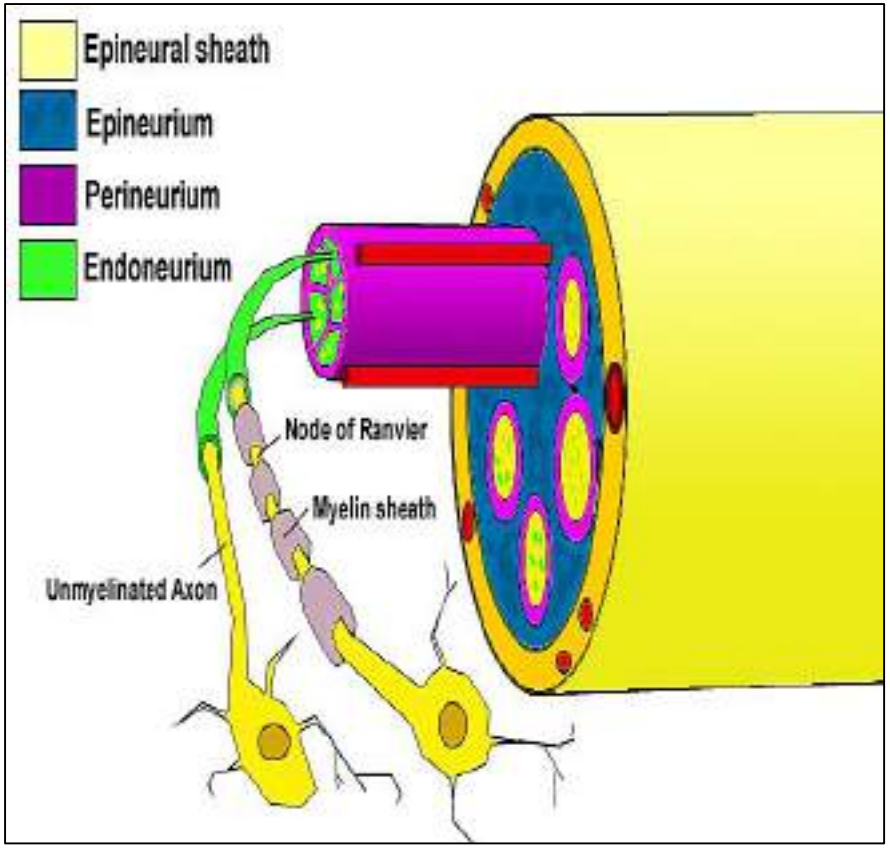


Myelinated vs Unmyelinated nerve fibers



Myelinated axons are visible in this cross-section of a peripheral nerve when stained with Osmic acid (OA stains the myelin)





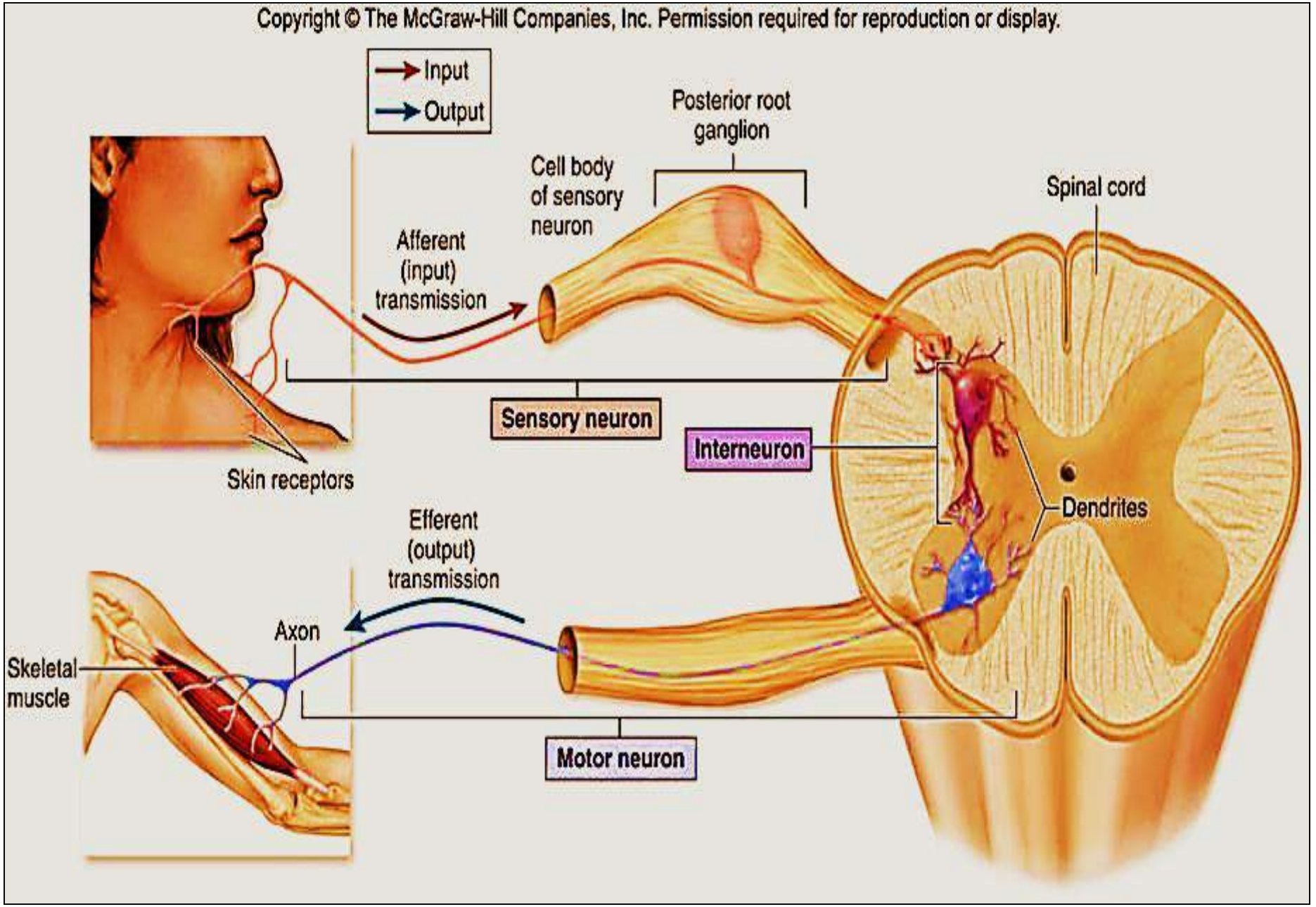
Functional classification of PNS neurons

Based on the direction of **conduction of impulses**

- **Afferent (Sensory) neuron**: conduct impulses (stimuli) toward **CNS**

- **Interneuron (association neurons):** lie entirely in the CNS. Interposed between sensory and motor neurons, perform integrative function

- **Efferent (Motor) neuron**: they transmit the appropriate response from the CNS to an **end organ** (**muscle** & **glands**) to carry out the body's response to stimuli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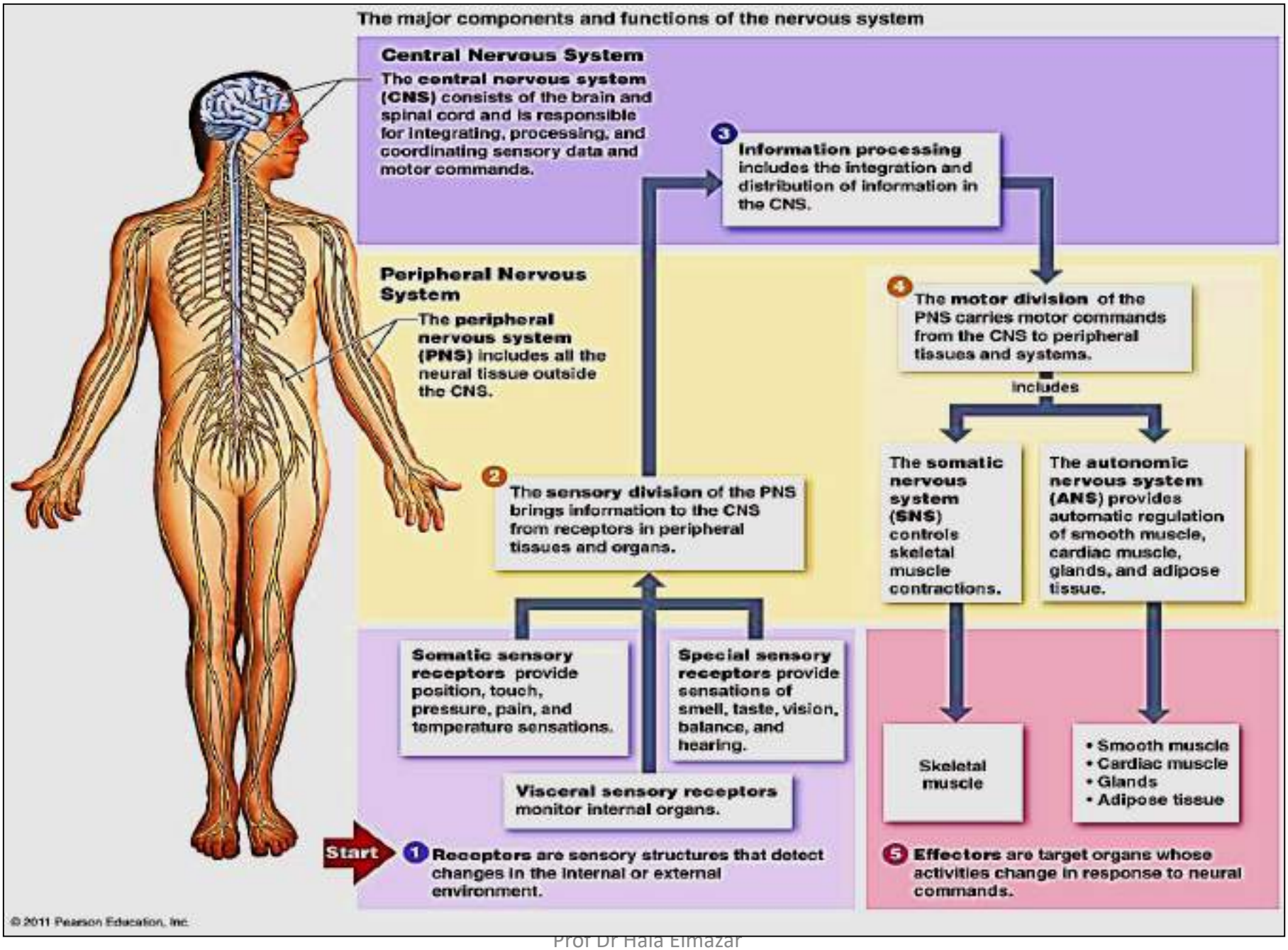
Input
Output
Posterior root ganglion
Cell body of sensory neuron
Spinal cord
Afferent (input) transmission
Sensory neuron
Interneuron
Skin receptors
Dendrites
Efferent (output) transmission
Axon
Skeletal muscle
Motor neuron


The major components and functions of the nervous system
Central Nervous System
The central nervous system (CNS) consists of the brain and spinal cord and is responsible for integrating, processing, and coordinating sensory data and motor commands.
3 Information processing includes the integration and distribution of information in the CNS.
Peripheral Nervous System
The peripheral nervous system (PNS) includes all the neural tissue outside the CNS.
4 The motor division of the PNS carries motor commands from the CNS to peripheral tissues and systems.
Includes
The somatic nervous system (SNS) controls skeletal muscle contractions.
The autonomic nervous system (ANS) provides automatic regulation of smooth muscle, cardiac muscle, glands, and adipose tissue.
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Somatic sensory receptors provide position, touch, pressure, pain, and temperature sensations.
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Visceral sensory receptors monitor internal organs.
Skeletal muscle
• Smooth muscle
• Cardiac muscle
• Glands
• Adipose tissue
Start
1 Receptors are sensory structures that detect changes in the internal or external environment.
5 Effectors are target organs whose activities change in response to neural commands.
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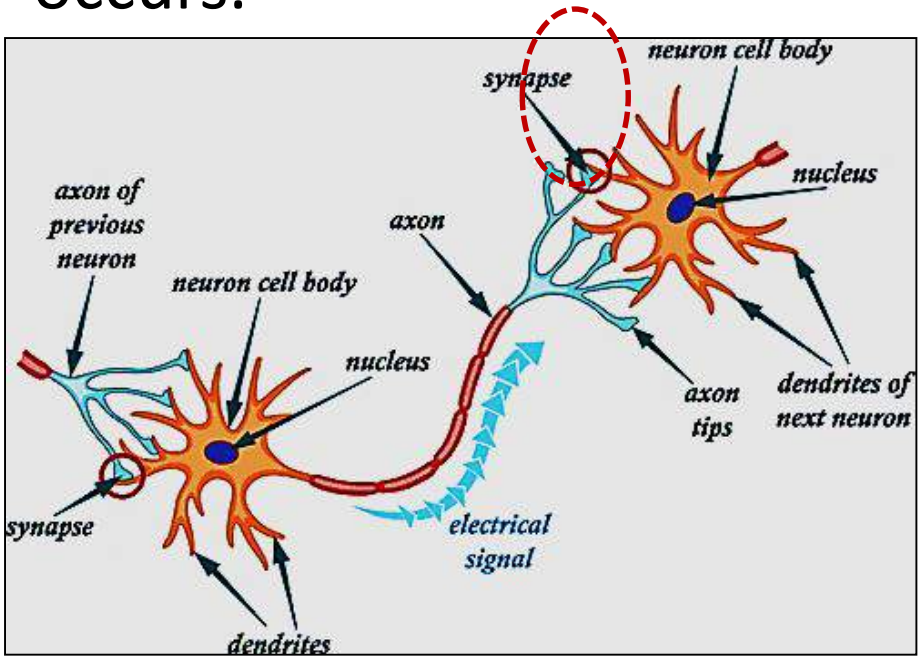
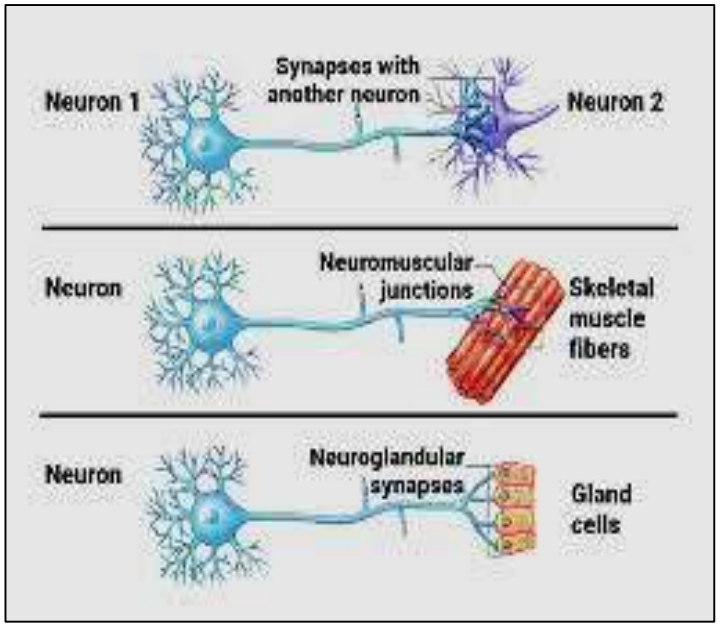
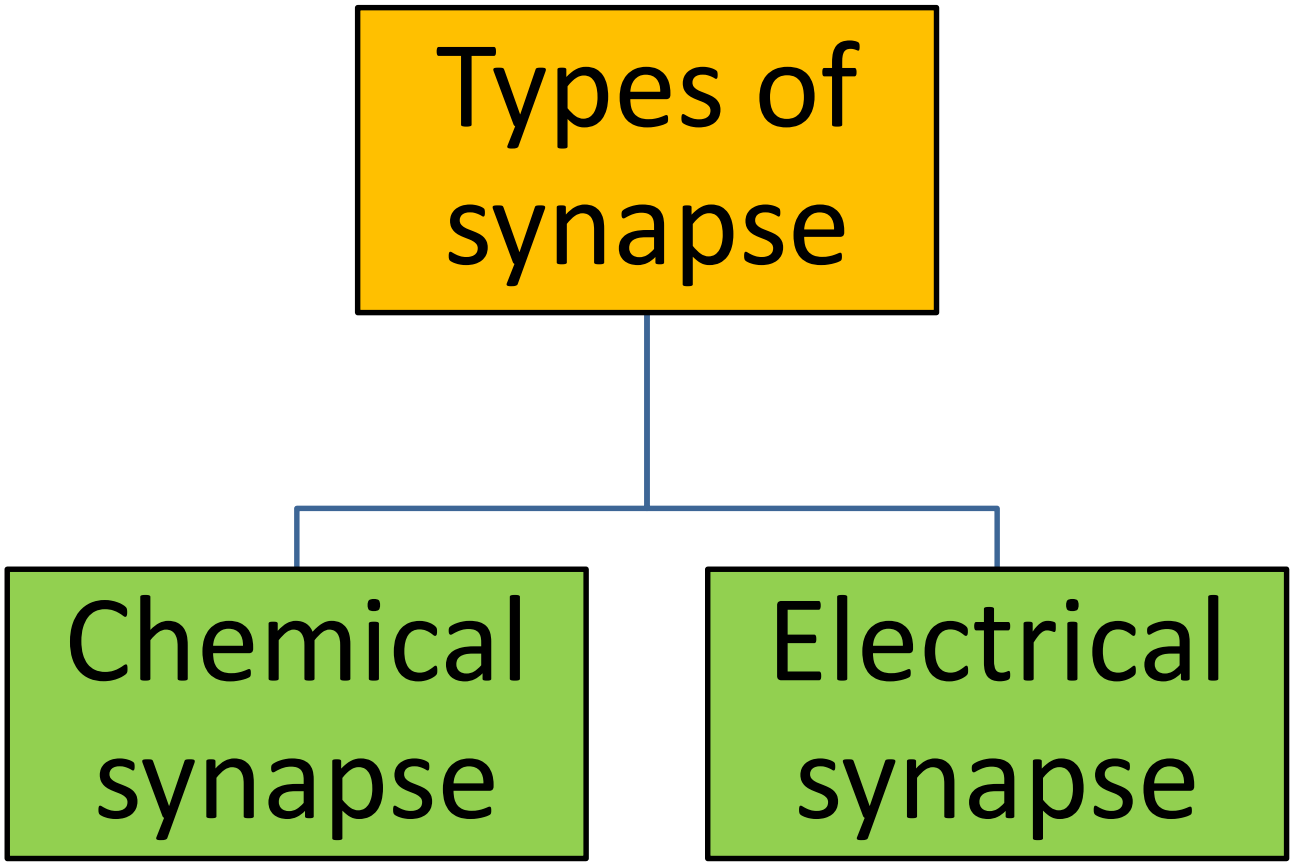
Synapse

- Sites of **connection** between neurons or between neurons & target effector cell e.g. muscle cell or gland cell. Allow the transmission of electrical or chemical signals
- At Synapse unidirectional transmission of nerve impulses occurs.





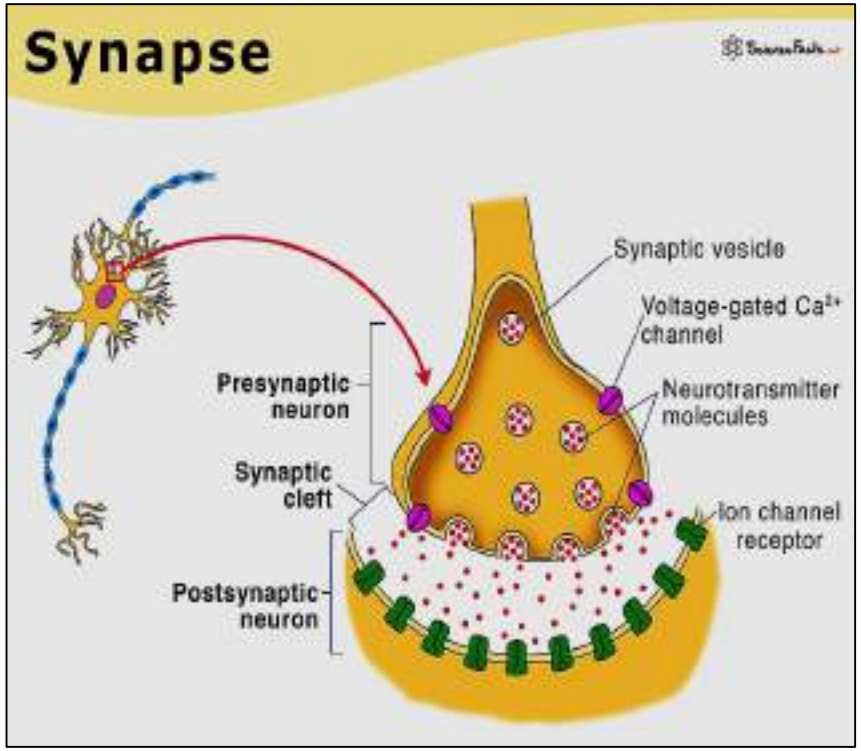

Types of synapse
Chemical synapse
Electrical synapse

Structure of:

Chemical synapse

1- Presynaptic axon terminal (terminal knob):

which has vesicles that contain Neurotransmitters, ↑ mitochondria



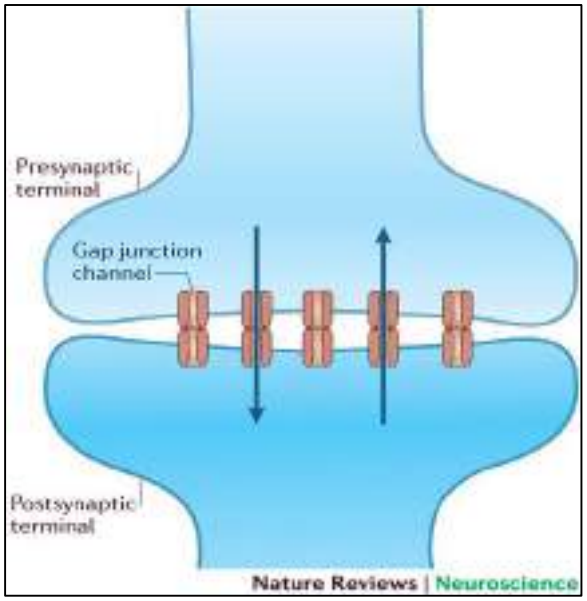
2- Synaptic cleft: narrow space between presynaptic & postsynaptic membranes

3- Postsynaptic cell membrane: which has receptors for the chemical transmitters

Electrical synapse

Involve direct connection between neurons via gap junctions . Which are protein channels that allow ions small molecules to pass directly from one neuron to another

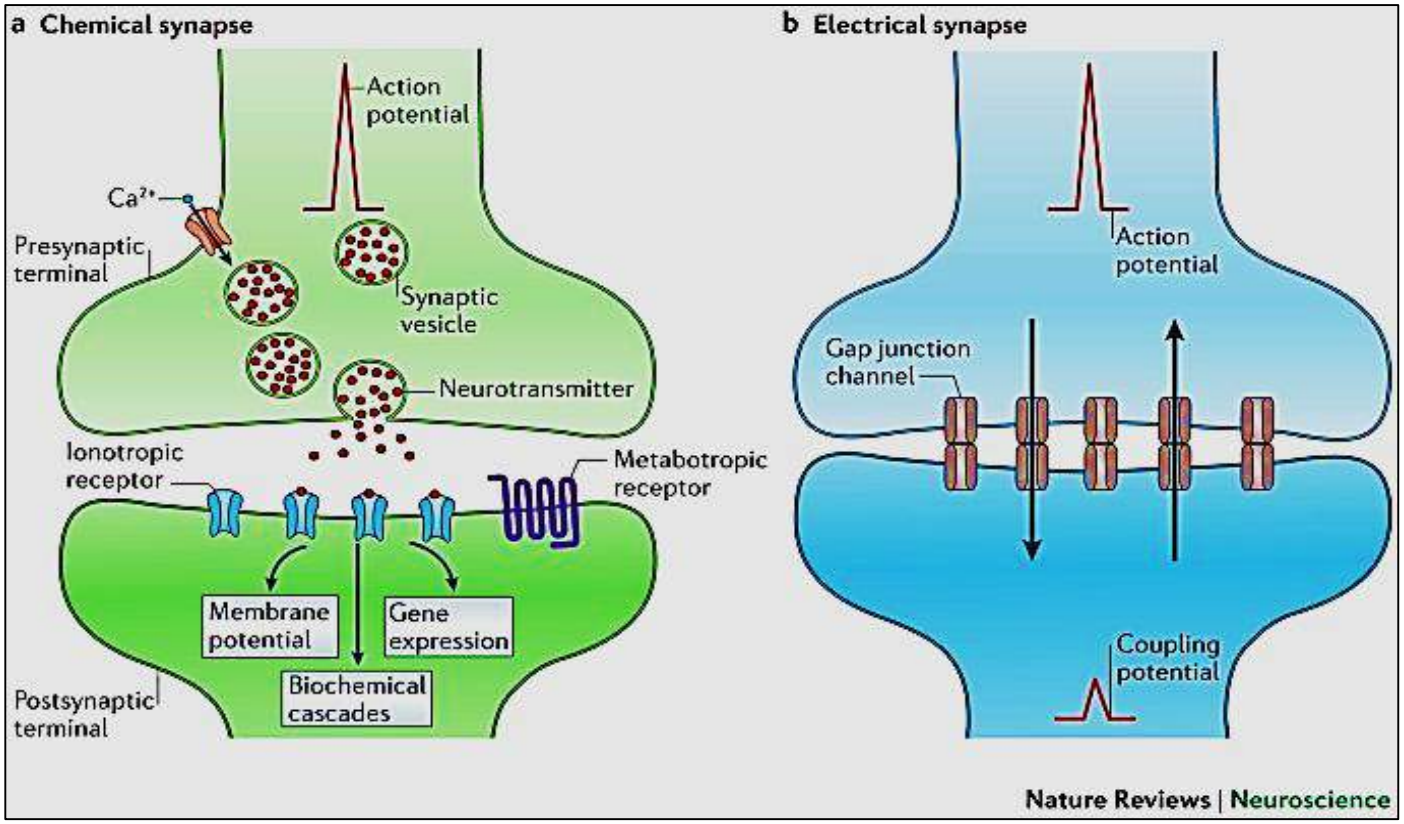
Allow faster transmission of signals compared to chemical synapses



Methods of signal transmission

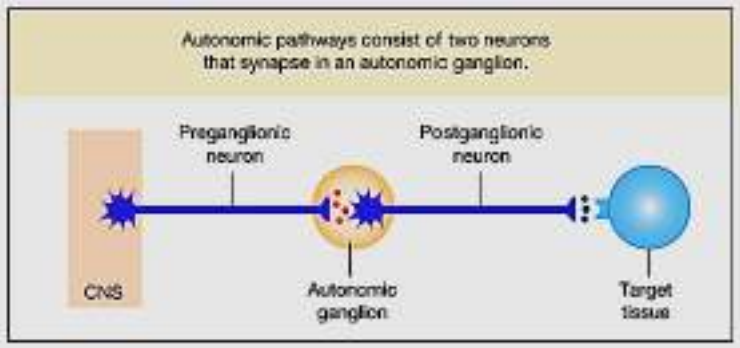
1- Chemical synapses: neurotransmitters e.g motor end plate

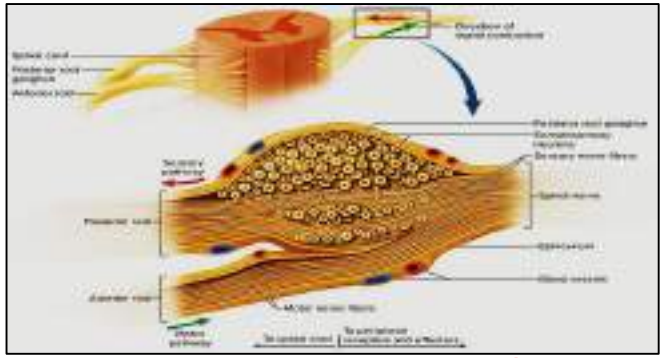
2- Electrical synapses: gap junction (ionic signals) e.g. cardiac muscles



Ganglia

- Ovoid structures contain aggregations of nerve cell bodies & satellite cells supported by CT.
- **Ganglia located outside the CNS (**i.e. clusters of nerve cell bodies outside CNS (in PNS)
- They serve as **relay station for nerve signals** from CNS to peripheral organs or vice versa

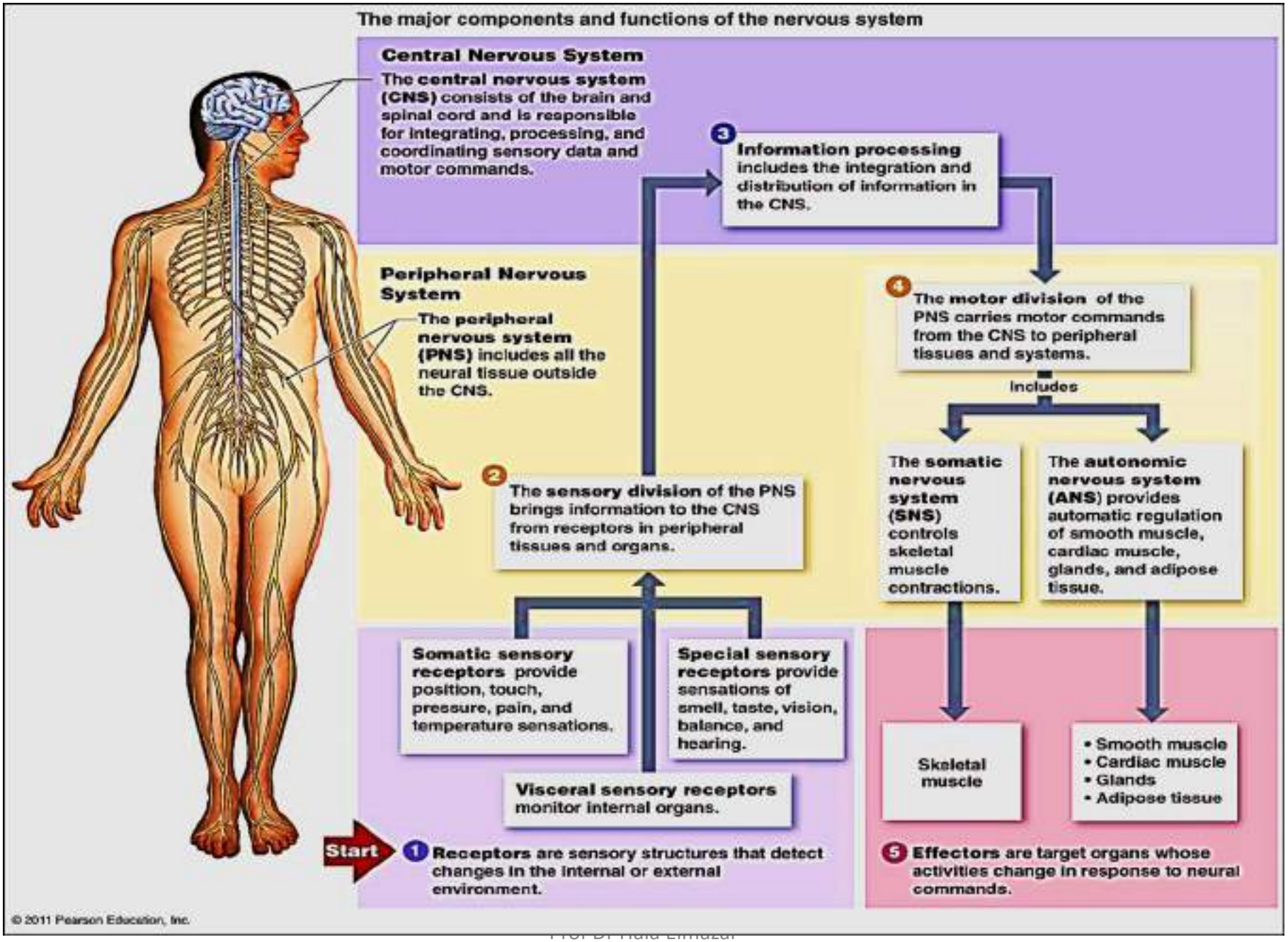




- They are two main types: up to the direction of n. impulses

➢ Sensory ganglia (sensory) : spinal & cranial ganglia

➢ Autonomic ganglia (motor) : sympathetic or parasym. gan.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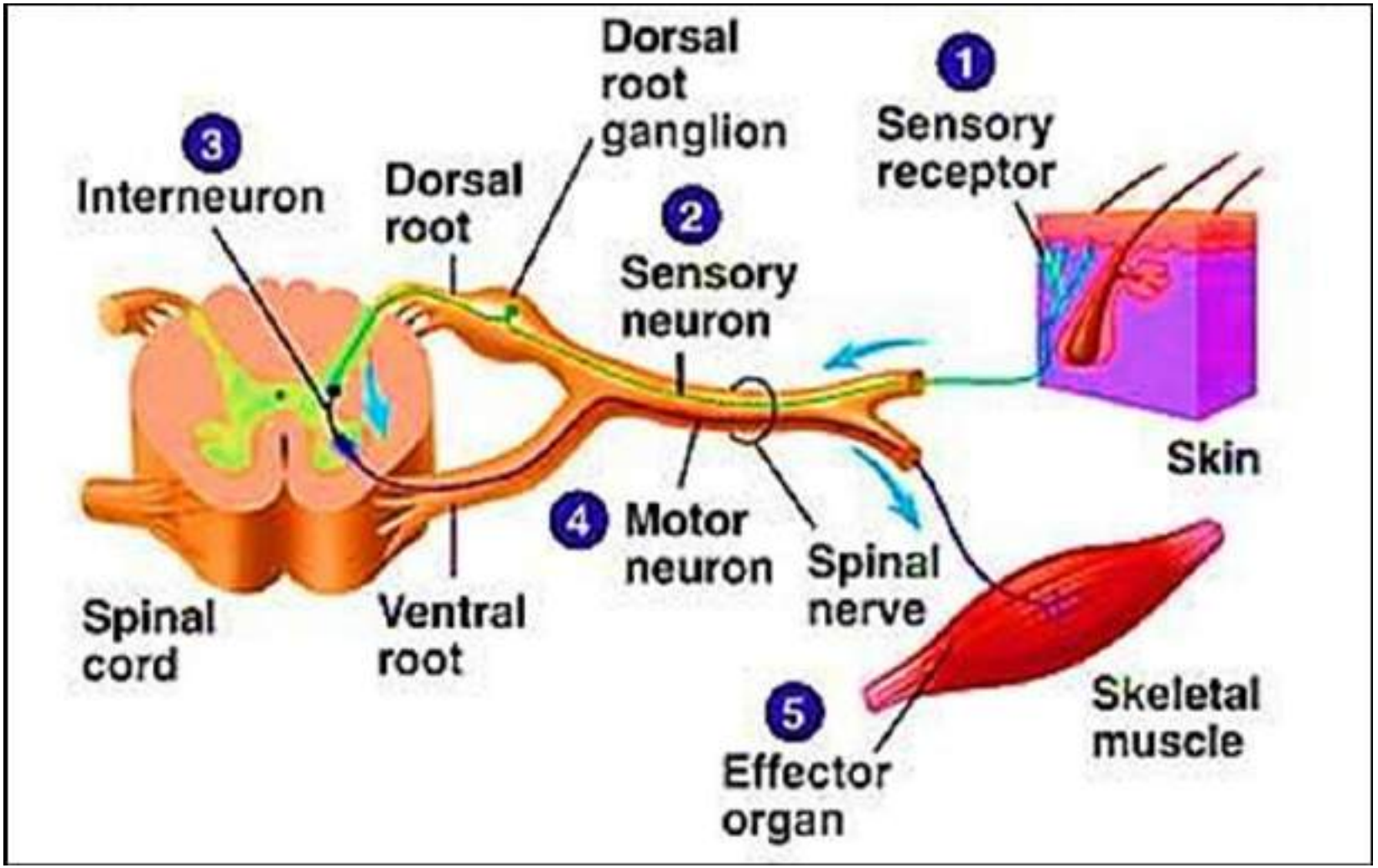
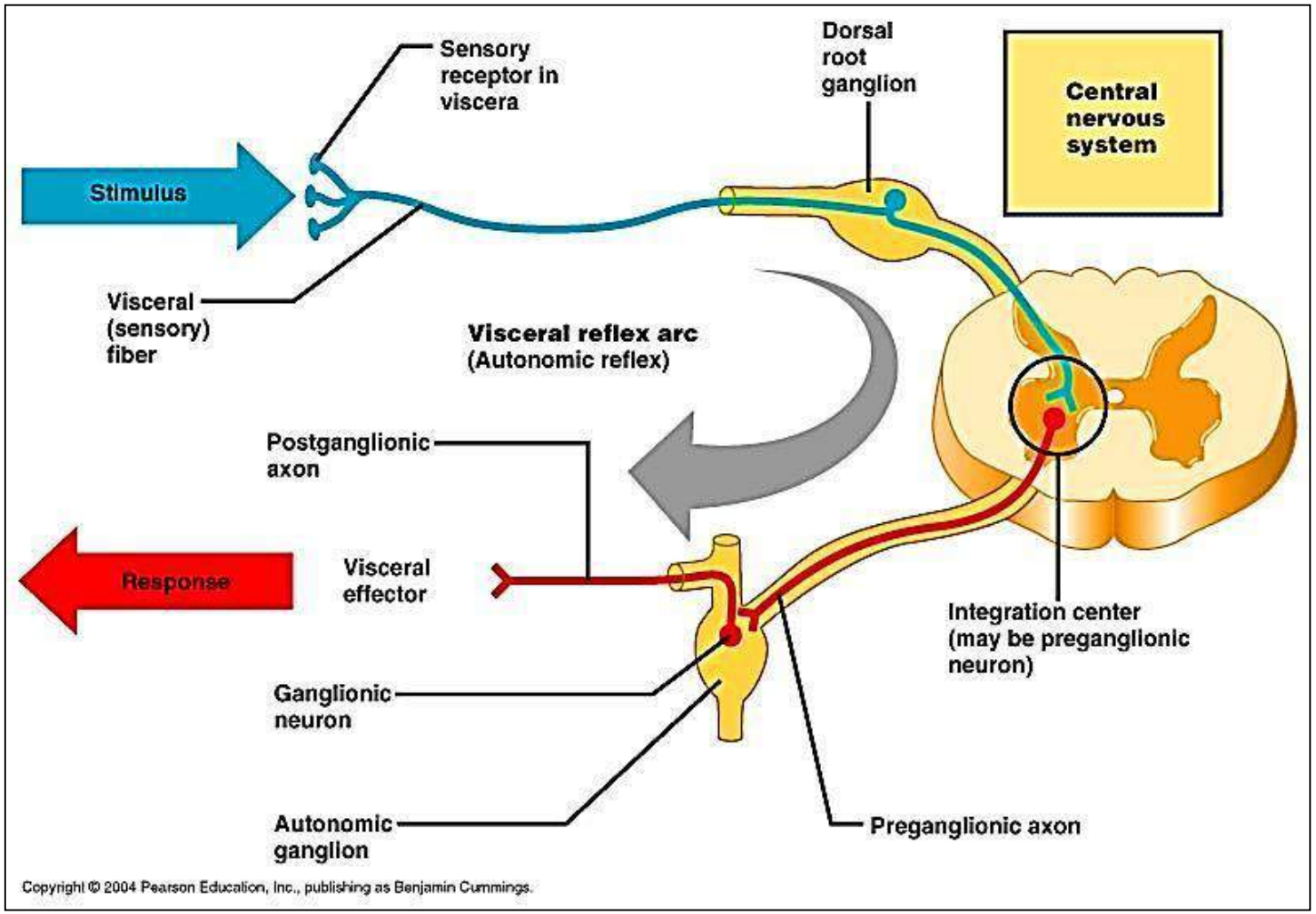
Sensory ganglion



Sensory ganglia: 1- Cranial G

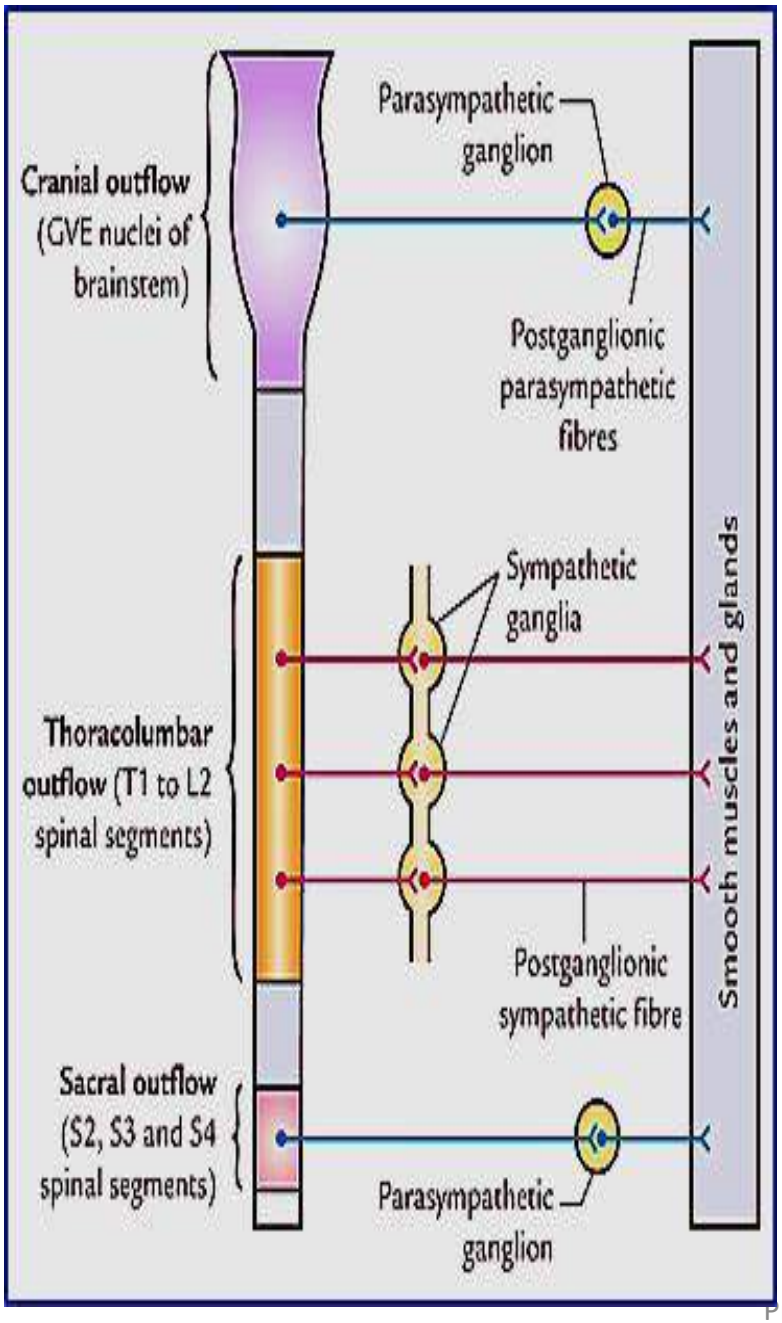
2- Spinal G (Dorsal root ganglia)

Autonomic ganglion (motor)



Autonomic ganglia : 1- Sympathetic G

2- Parasympathetic G



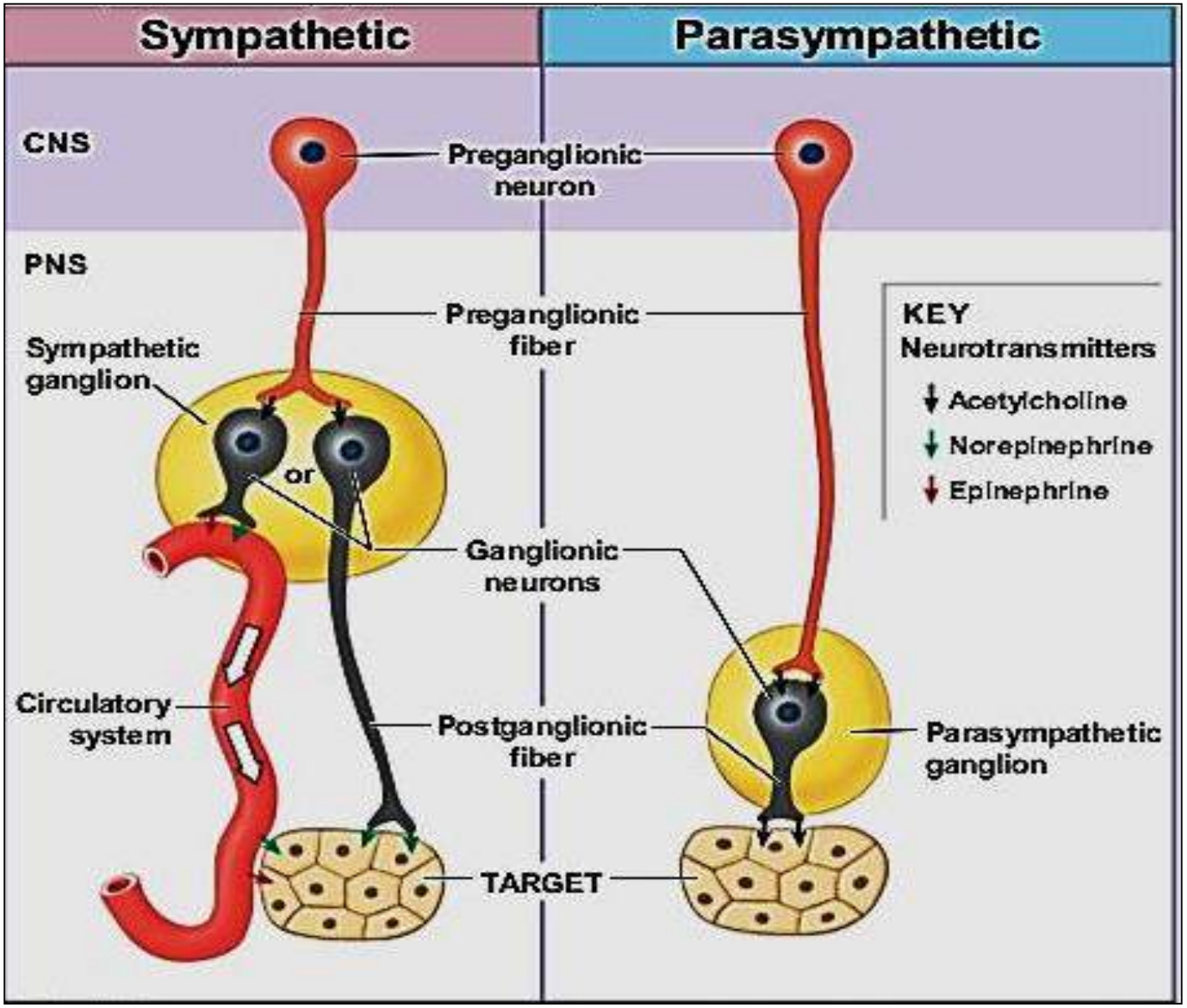
Sympathetic is thoraco-lumber outflow 31:

- **Thoraco: (# 10-12 G) T1 – T12**
- **Lumbar : (# 3 G) L 1- 2, 3**
- **Postganglionic fibers → Epinephrine**
- **Ganglia close to spinal cord → sympathetic chain**
- **Lots of post- ganglionic branching so that multiple organs can be controlled**

Parasympathetic is cranio-sacral out flow 22:

- **Cranial: (# 4 G) 3,7,9, & 10**
- **Sacral: (# 3 G) 2-4**
- **Post- ganglionic fibers → Ach**
- **Ganglia near or within target organs**
- **Very little post- ganglionic branching**

Sympathetic vs Parasympathetic ganglion



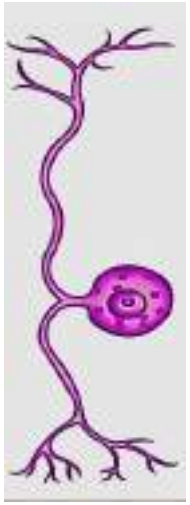
Sensory ganglia

Sensory ganglia (31 + 8 pairs)

carry **afferent** impulses to CNS

Example:

- **Dorsal root g**. e spinal nerves
- **Cranial ganglia** e cranial nerves



Nerve cell bodies are:

Unipolar (rounded shape)

Large , few in numbers

Central nuclei

Arranged in groups between the fibers

Autonomic ganglia

Motor ganglia (21-23 pairs)

Carry **efferent** impulses from CNS

- **Sympathetic** ganglia
- **Parasympathetic** ganglia

Nerve cell bodies are:

Multipolar

Small , numerous

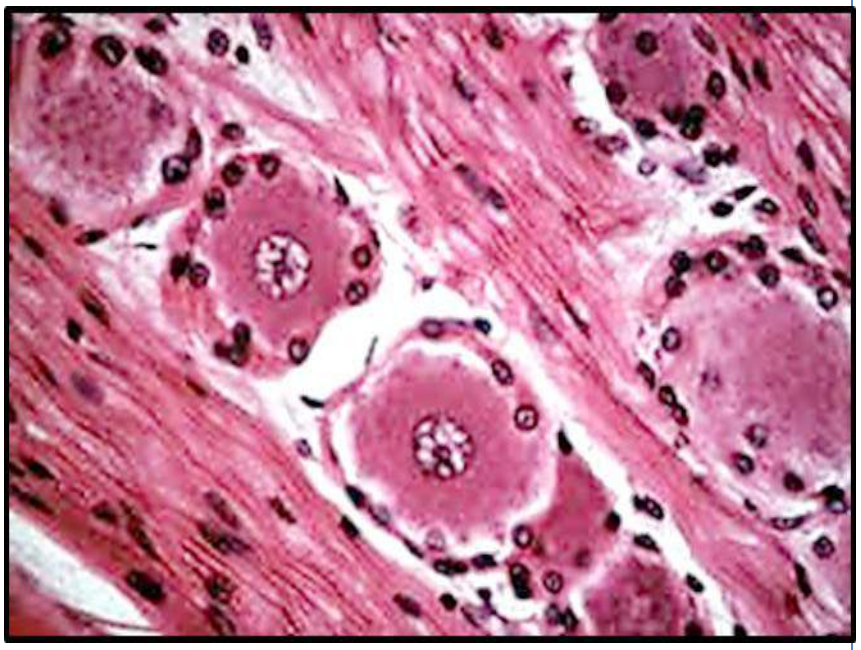
Eccentric nuclei

Scattered , no groups

Spinal ganglia

The groups of cells are separated with myelinated nerve fibers

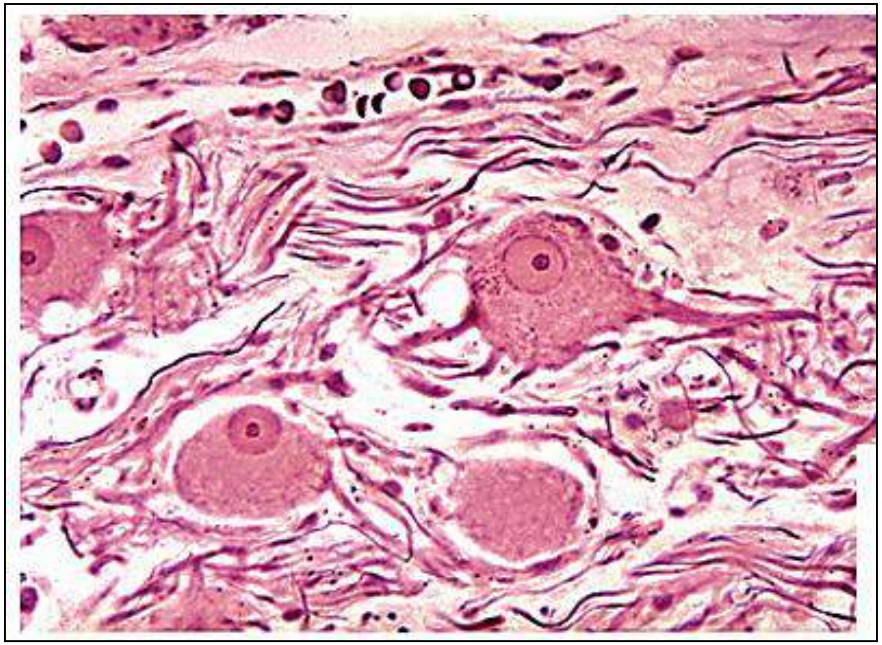
satellite cells are more around each nerve cell body



Sympathetic ganglia

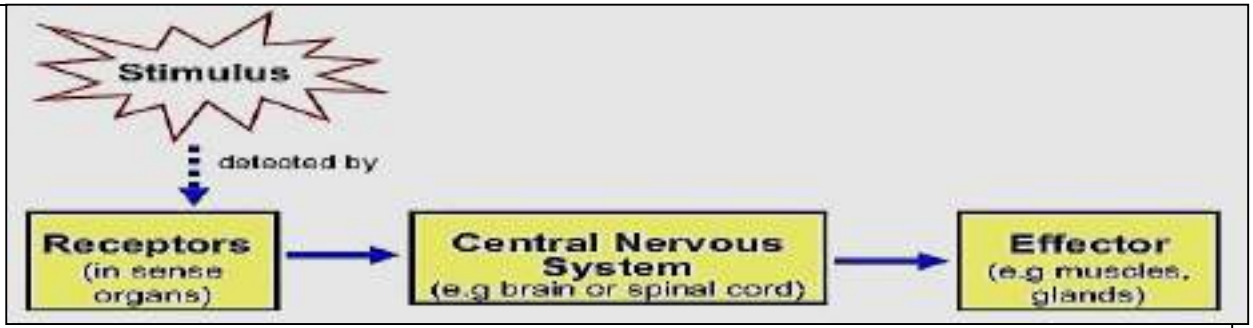
The cells are separated with un/ little mylinated nerve fibers

satellite cells are less



Nerve endings

They are either:



A- At Receptors: receive external or internal stimuli

They are classified into:

- Exteroceptors: external stimuli- epithelium
- Proprioceptors: stimuli from muscles & tendons, joints
- Interoceptors : stimuli from viscera & blood vessels

B- At Effectors: carry orders from CNS to muscles or glands

Classification of receptors

- Location of receptors

Receptors in epithelium:

Free nerve endings
Hair root plexus
Merkle tactile disc
Neuroepithelium endings

Receptors in CT:

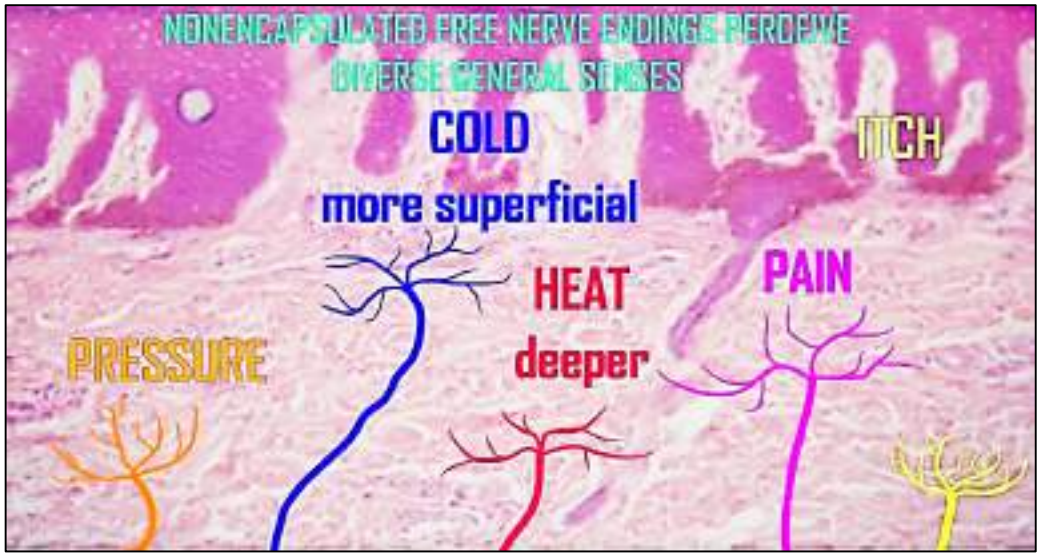
Free nerve endings
Meissner corpuscle
Krause end bulb
Pacinian copuscle
Ruffini's end organ
Golgi tendon organ (tendon spindle

Receptors in muscular tissue:

Muscle spindle

1- Free nerve endings

- They are receptors for pain & temperature
- Simplest receptors & Widely distributed throughout the body

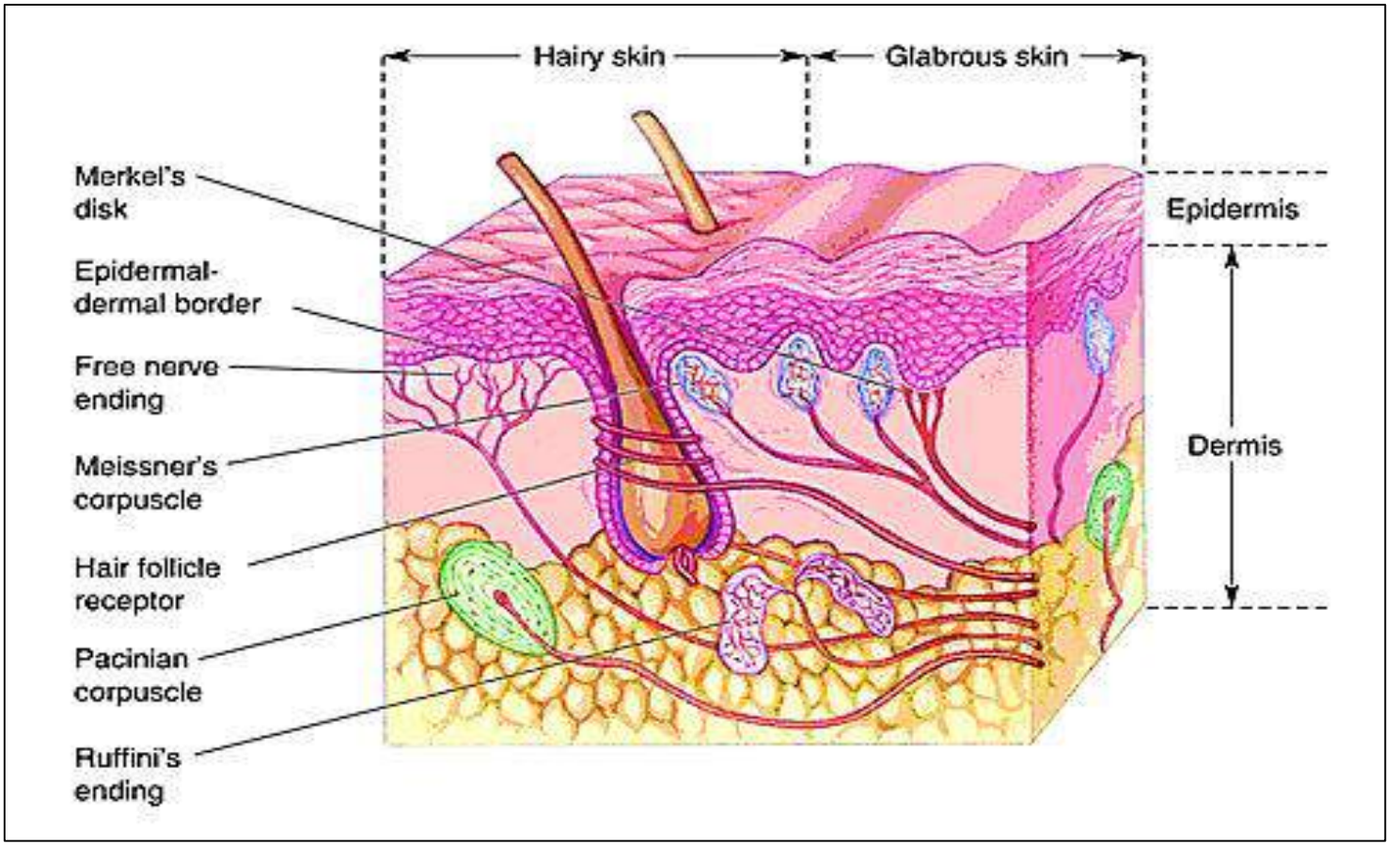


- Are unmyelinated sensory nerve fibers which penetrate the basement membrane of an epithelium to end freely in-between epithelial cells

- Sites: epidermis of skin, corneal ,conjunctiva & oral cavity

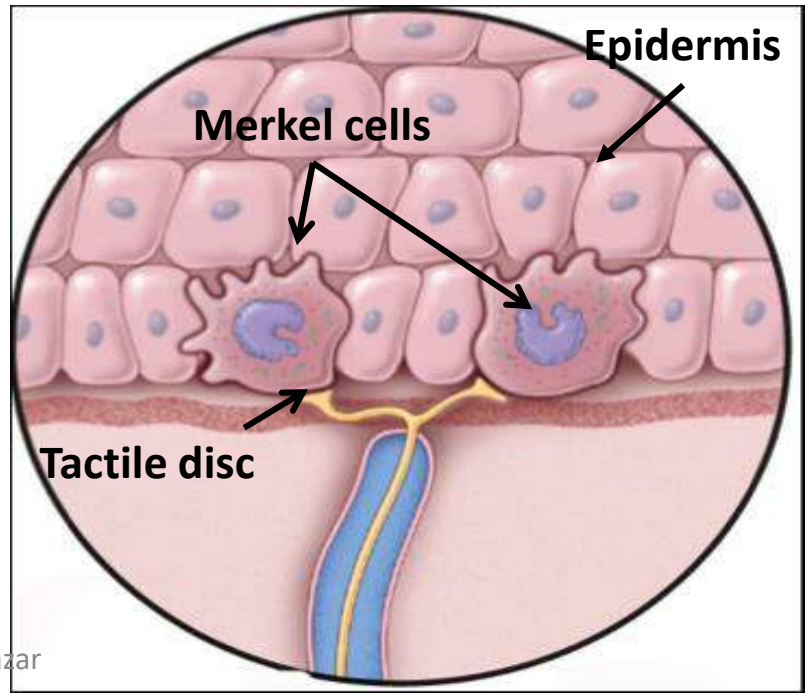
2- Root hair plexus

- **A web of free nerve endings, form basket – like structure around the base of hair follicles (thin skin)**
- **Function: mechanoreceptors for light touch sensation**



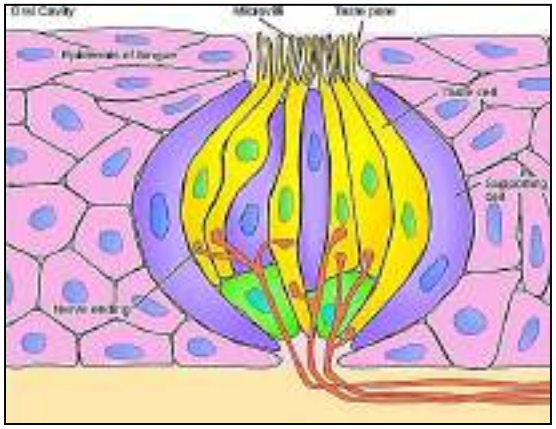
3- Merkel Tactile disc

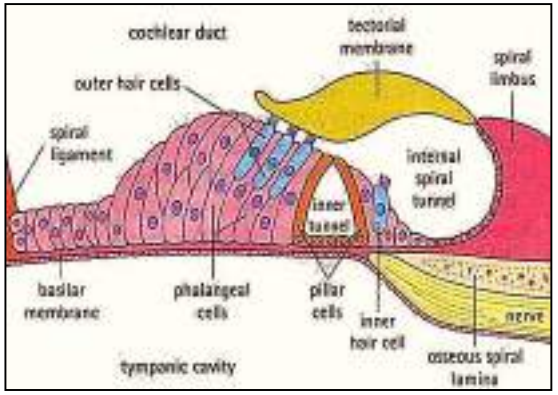
- They are **mechanoreceptors** detect **touch & pressure**
- Present in **basal layer** of **epidermis (superficial)** of the skin of soles & palms(fingers .. Tactile discrimination, sophisticated sensory tasks)
- In association with **Merkel cells (**modified epithelial cells**)** of the epidermis
- The sensory nerve fiber lose its Myelin, penetrates the basement membrane & terminate as a disc (cup)around Merkel cells

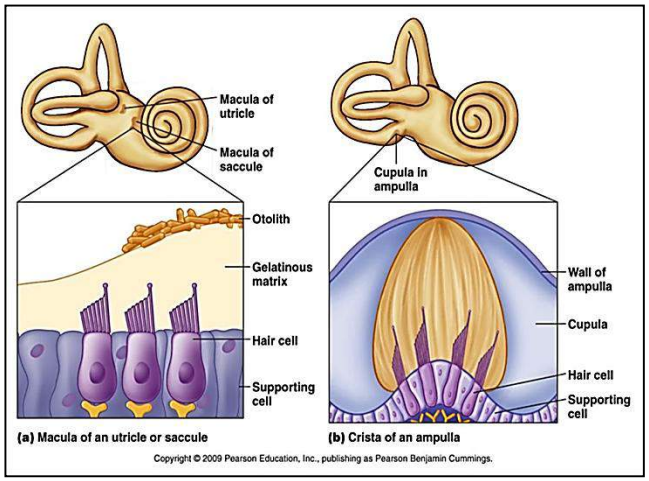


4- Neuroepithelium endings

- Taste buds / tongue
- Olfactory epithelium / nose
- Organ of Corti / ear
- Macula utriculi, macula sacculi & crista ampullaris for equilibrium/ ear
- Photoreceptors / retina



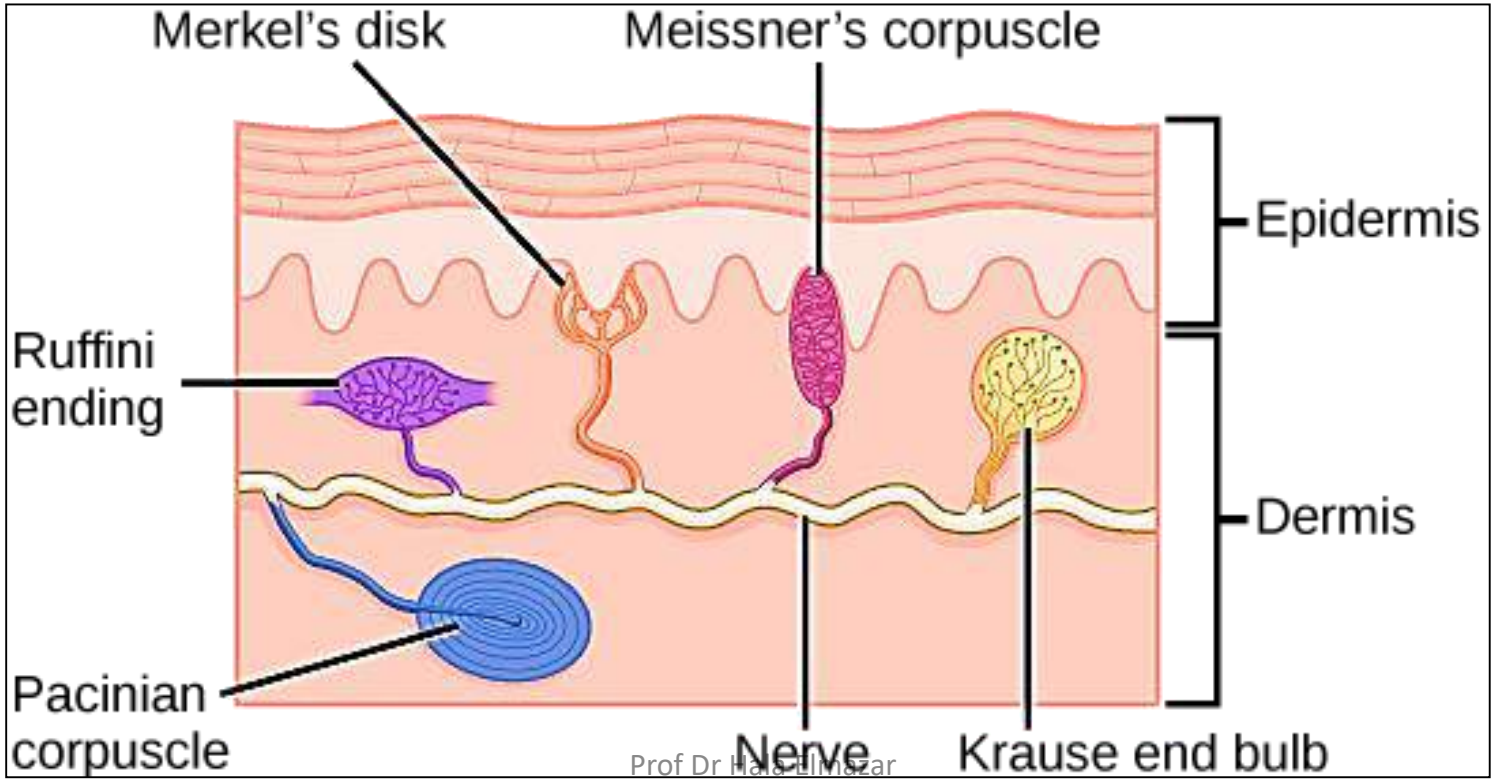




Nerve endings in connective tissue

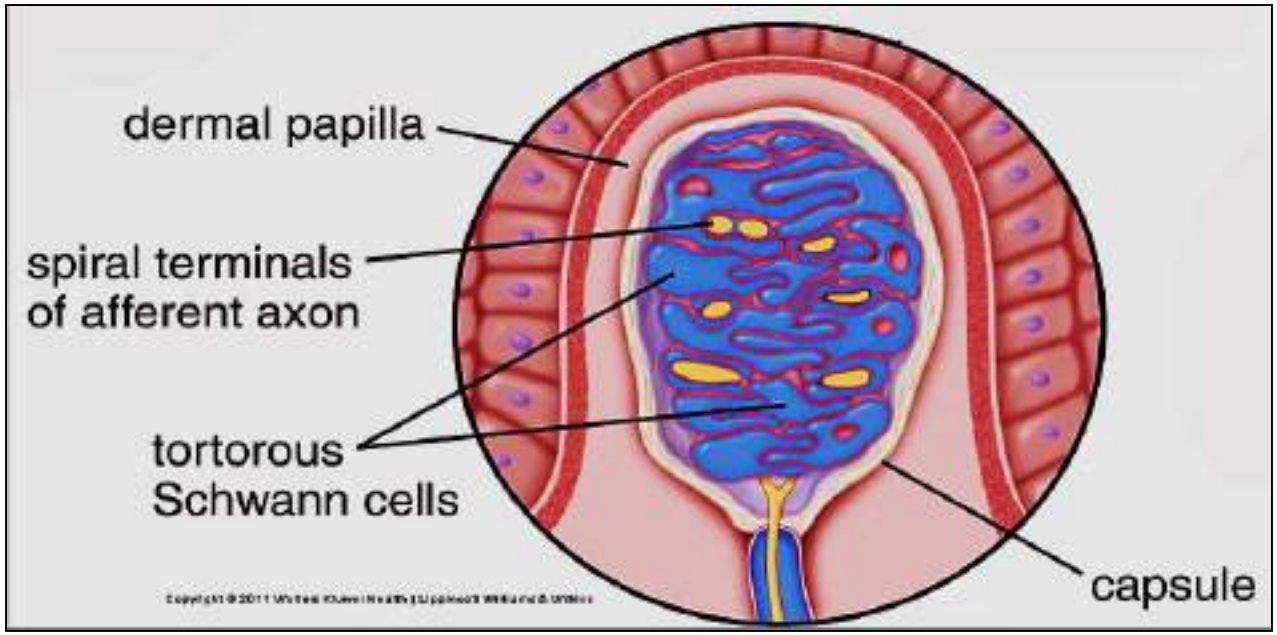
1- Meissner's corpuscles

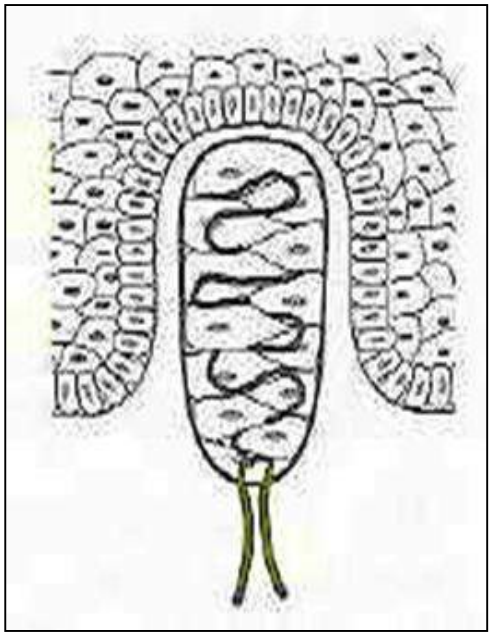
- Oval shape, encapsulated structures present in the dermal papillae **(deep)** of skin that is especially sensitive such as tips of fingers (Hairless skin)
- They detect **light touch** (mechanoreceptors)



- The corpuscle is formed of transversely arranged **modified Schwan cells.** Collagenous fibers anchor the corpuscle to the dermo-epidermal junction

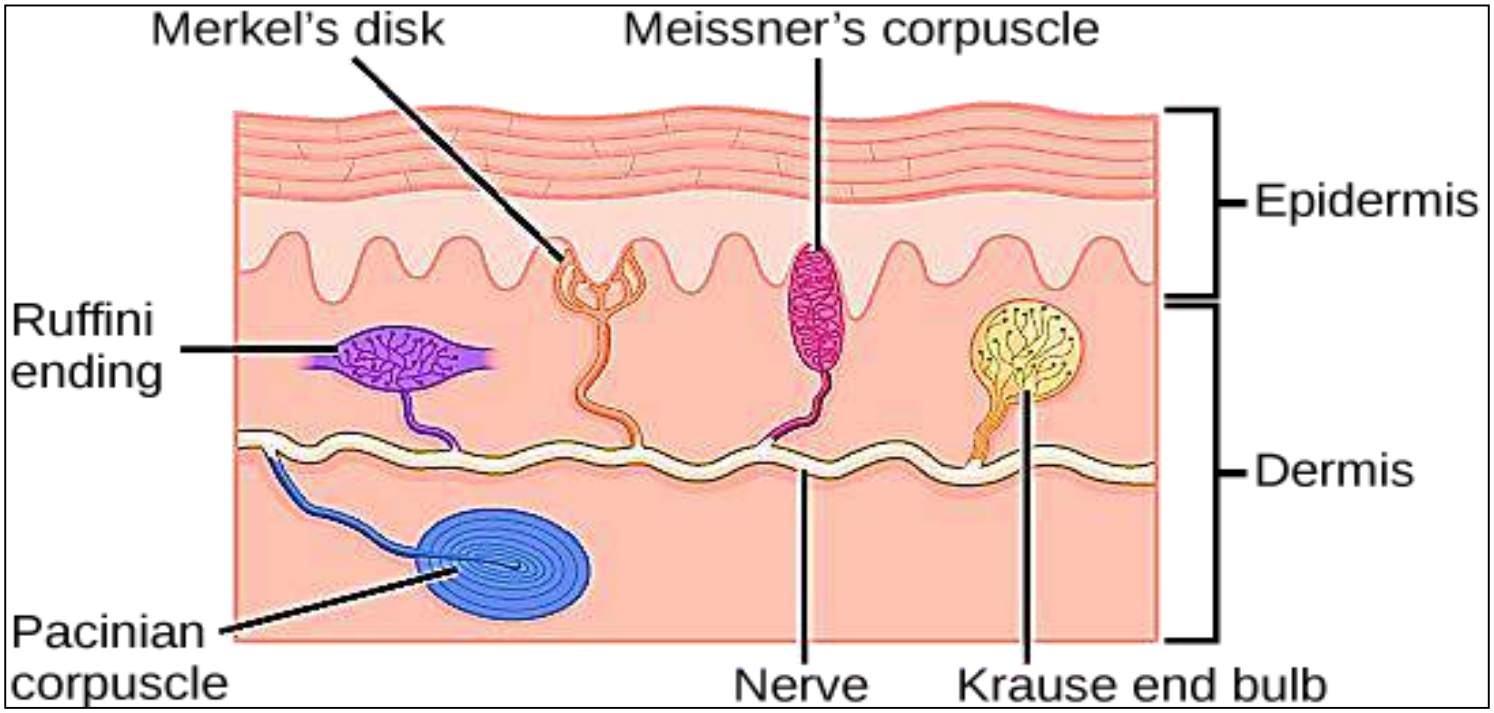
- The **sensory nerve fiber** enter the corpuscle **myelinated** then lose its myelin & spiral up between the cells until it ends at upper end of the corpuscle



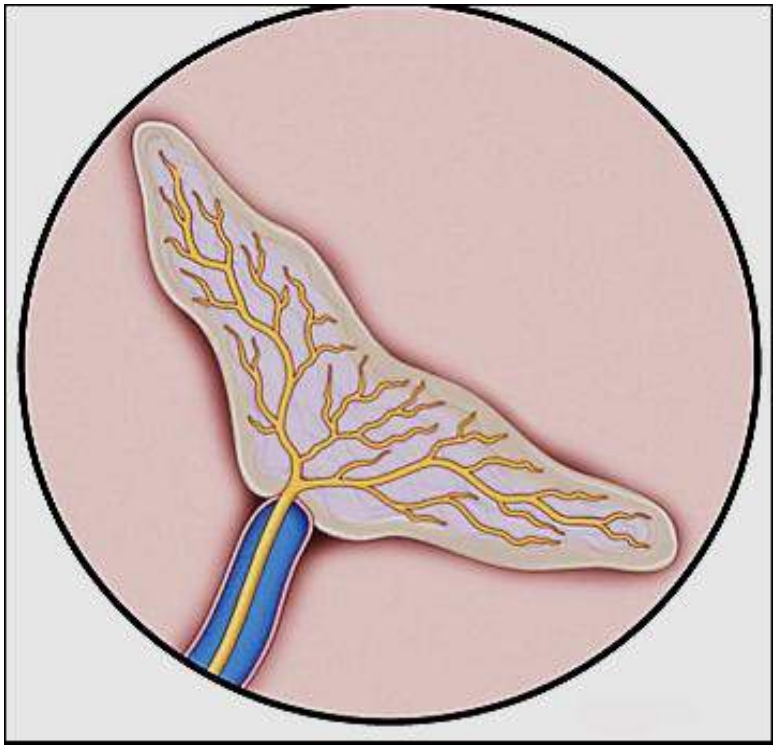


2- Ruffini Corpuscles

- Fusiform encapsulated structures
- Found **the dermis** of skin especially in the **sole**
- Detect **skin stretch & sustained pressure** (mechanoreceptors)



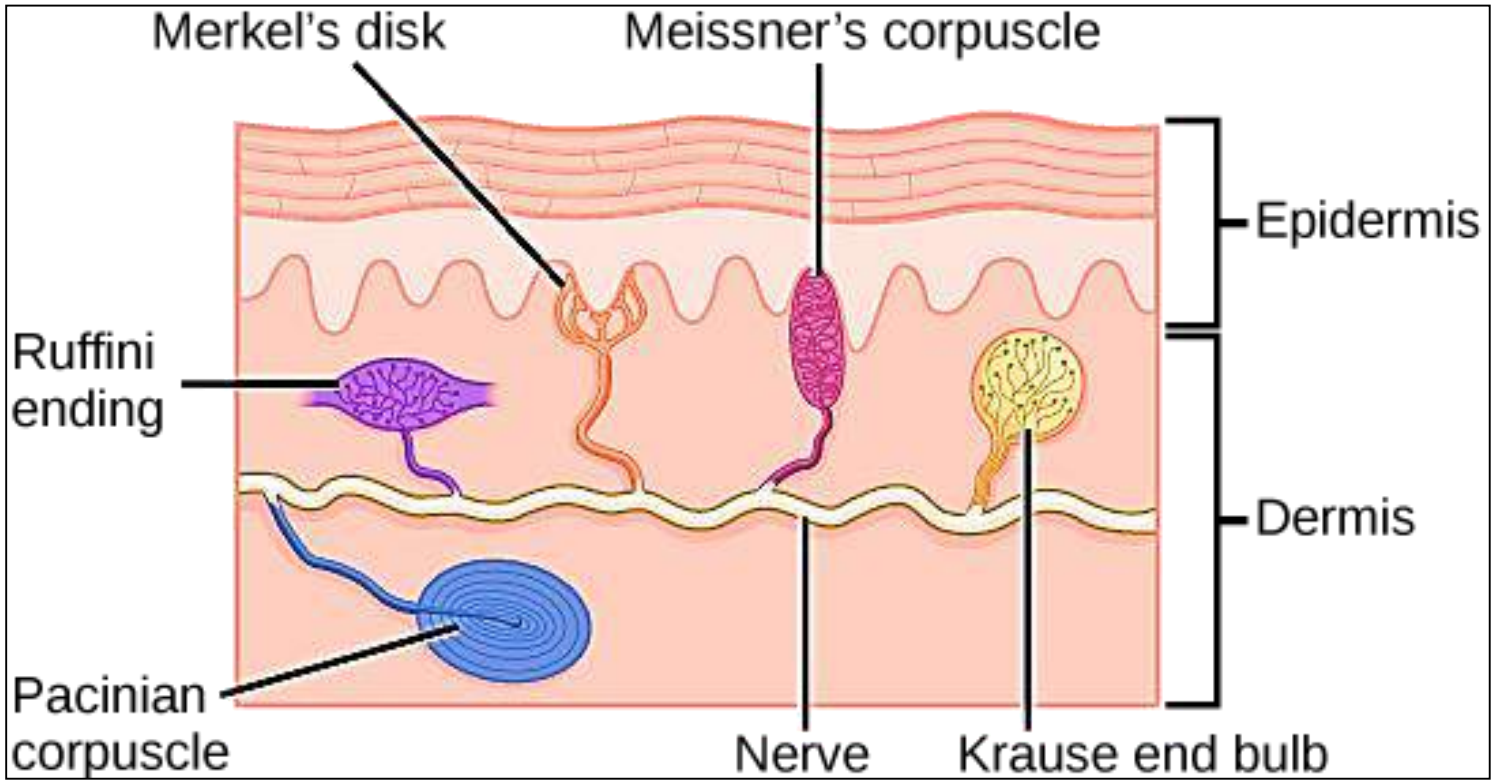
- Inside the capsule there is a **fluid** & collagenous fibers parallel to the skin surface (detect skin stretch)
- The **sensory nerve fiber unmyelinated** penetrates the side of the corpuscle & breaks up into fine branches



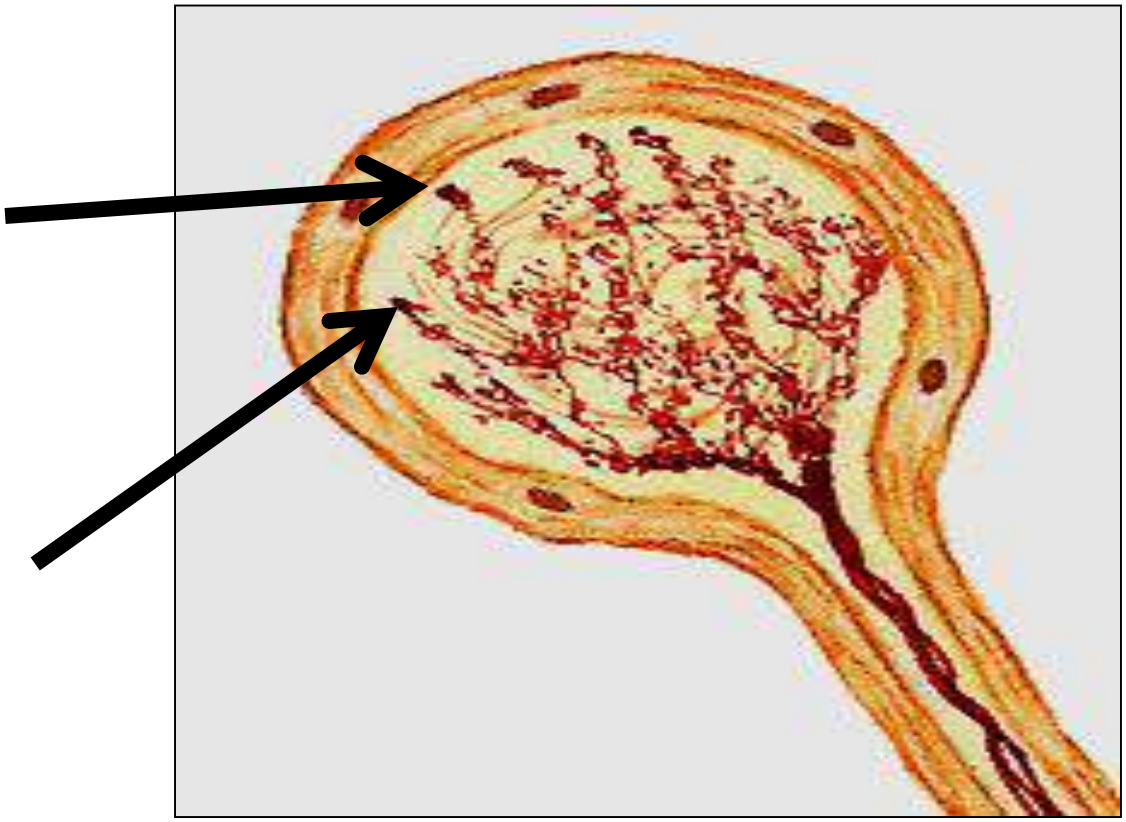
Ruffini's corpuscle

3- Krause end bulbs

- Rounded structures, encapsulated
- Found **the dermis** of the skin in genital areas &in **mucous membrane**
- Detect **cold / touch** (mechano/ thermo receptors)



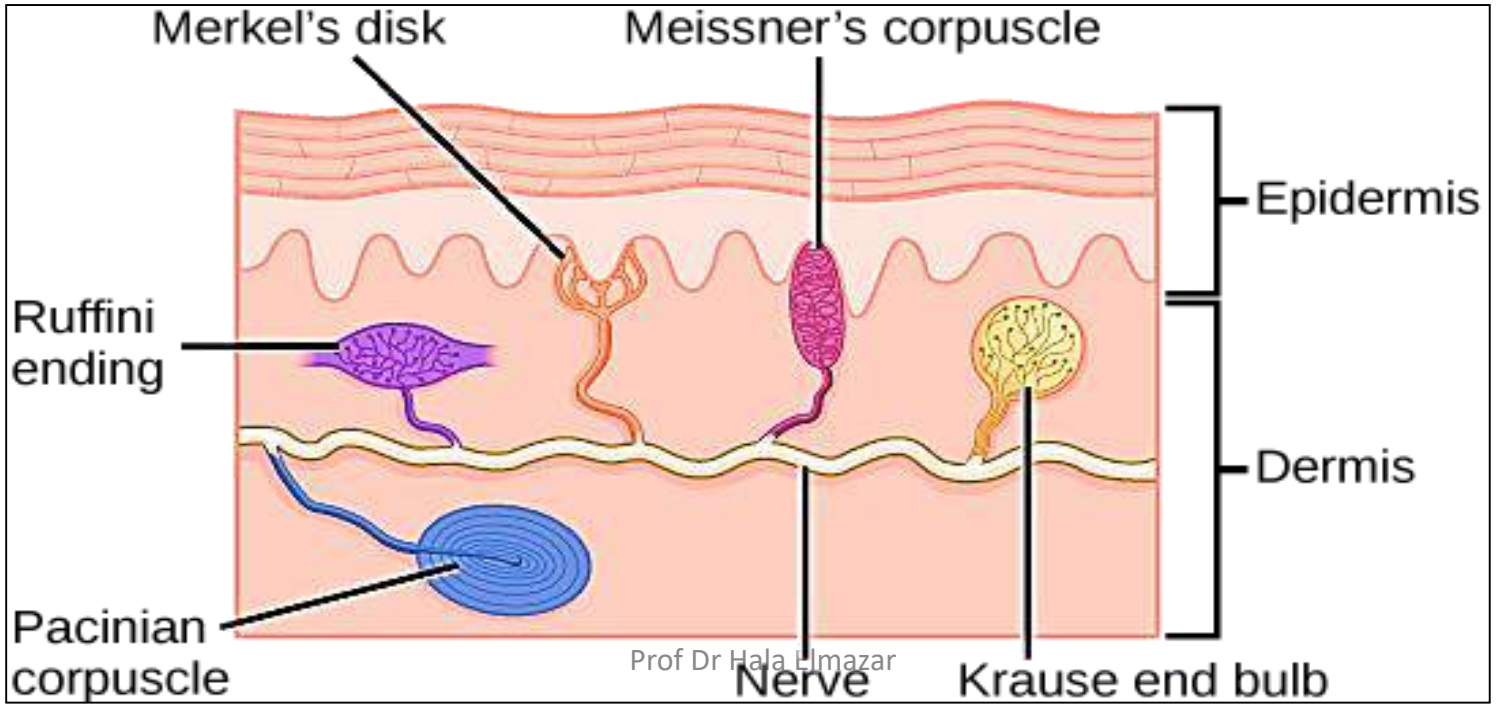
- The sensory nerve fiber penetrate the corpuscles the fibers are **unmyelinated** and breaks up into fine branches terminate with **coiled / bulb ends**



Krause's end bulb

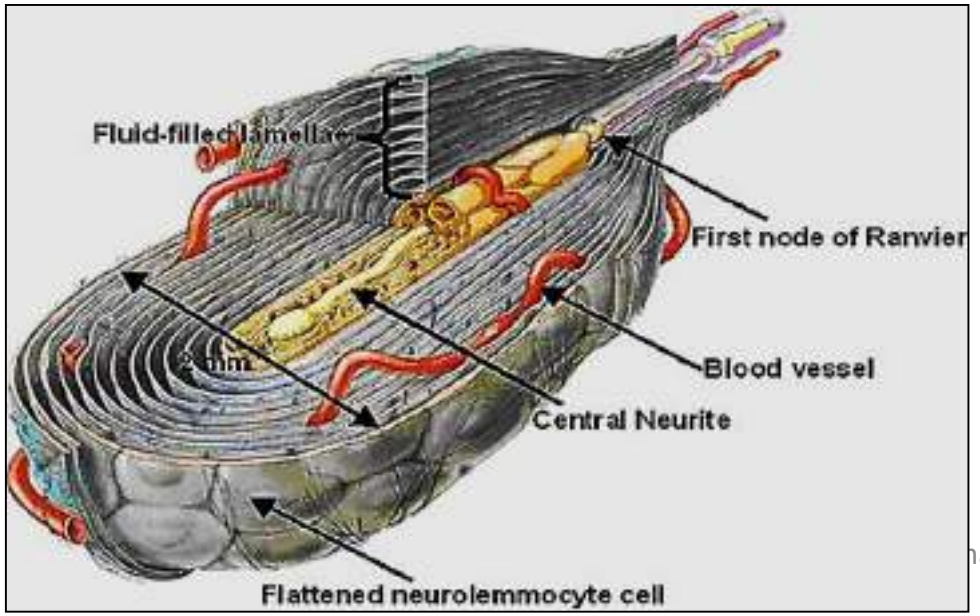
4- Pacinian corpuscles

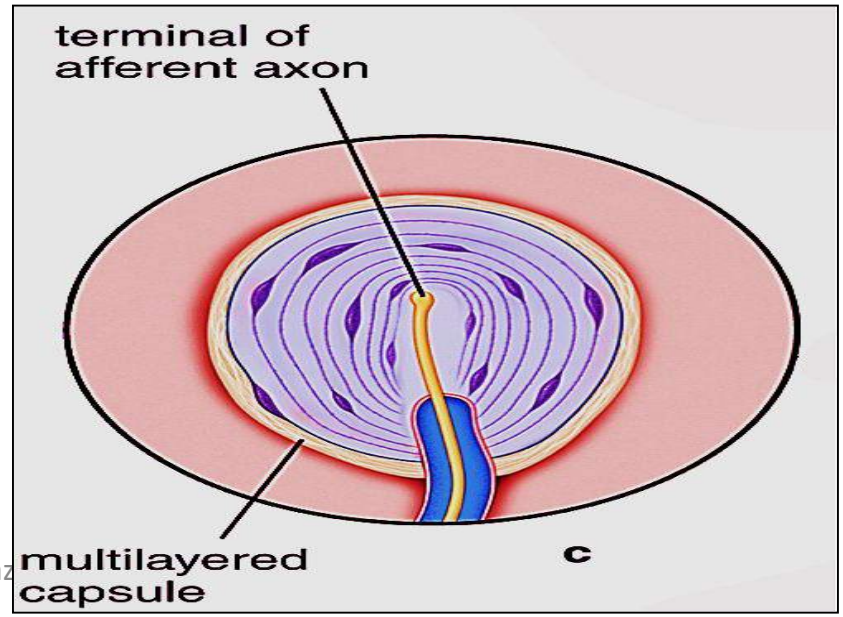
- Large oval encapsulated structures
- Found **deep in dermis**
- Detect **deep touch** (mechanoreceptors), high frequency vibration, pressure
- It is one of the proprioceptors

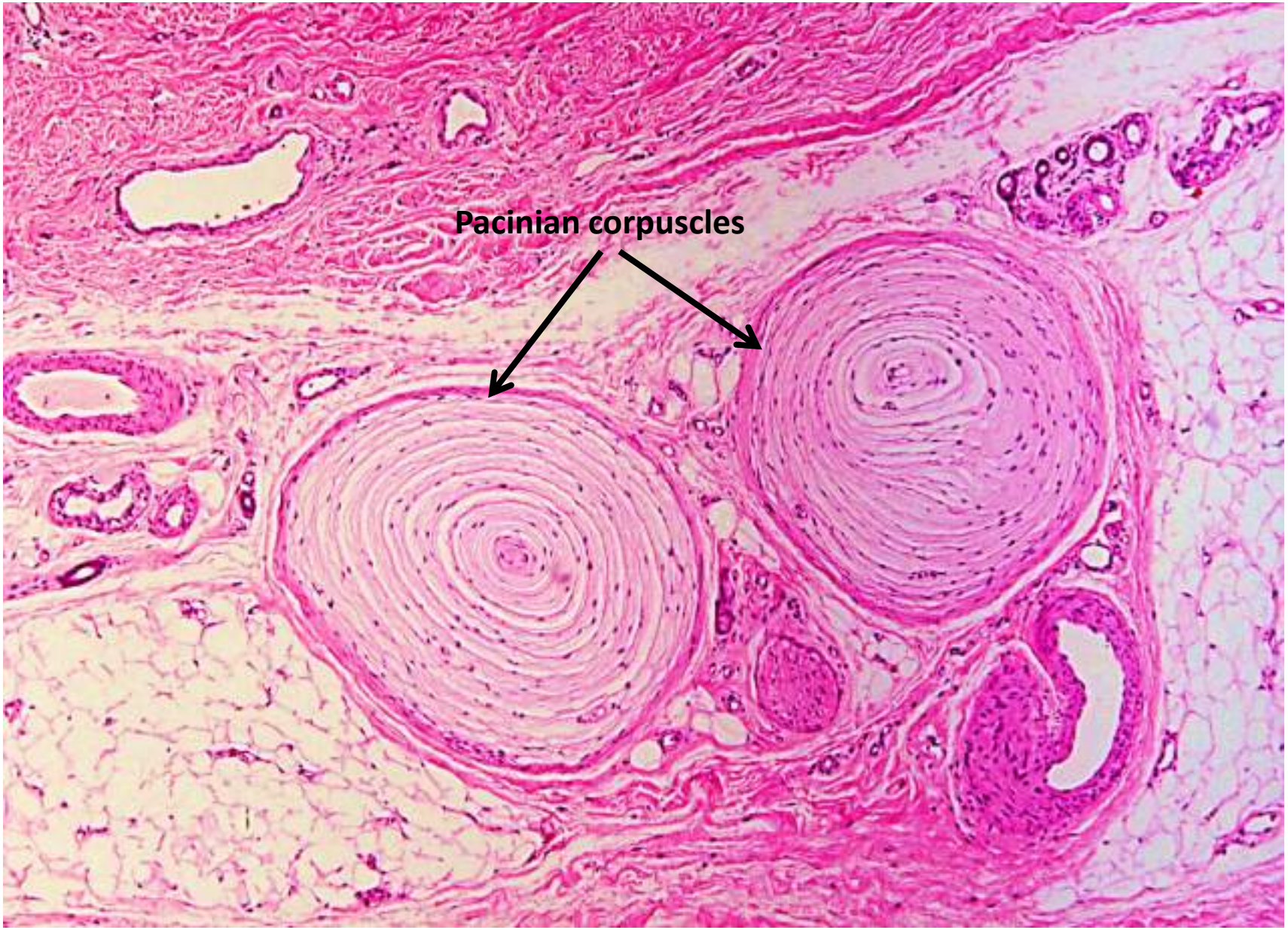


- It is formed of 20-50 thin, concentric lamellae of flat Schwan –like cells separated by narrow spaces filled e gel – like material

- The sensory nerve fiber **lose its myelin**, enter the corpuscle at one pole then runs along its longitudinal axis to end in small expansions
- Corpuscle resemble **sliced onion** in L. section



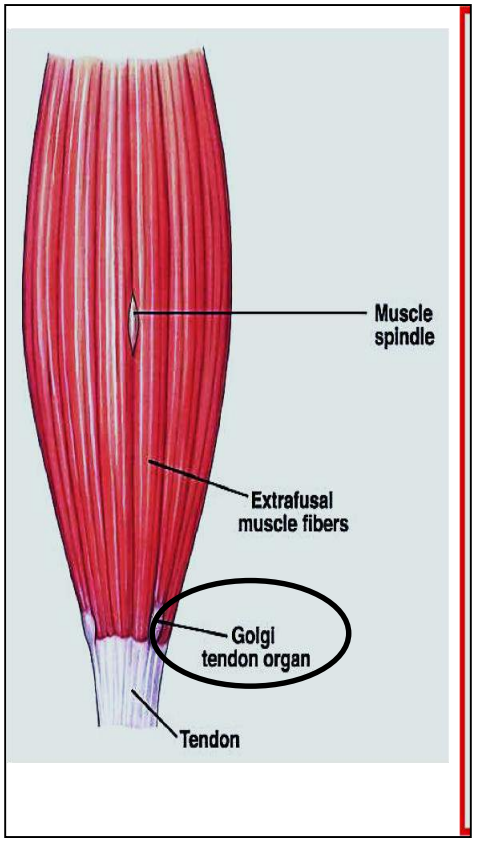


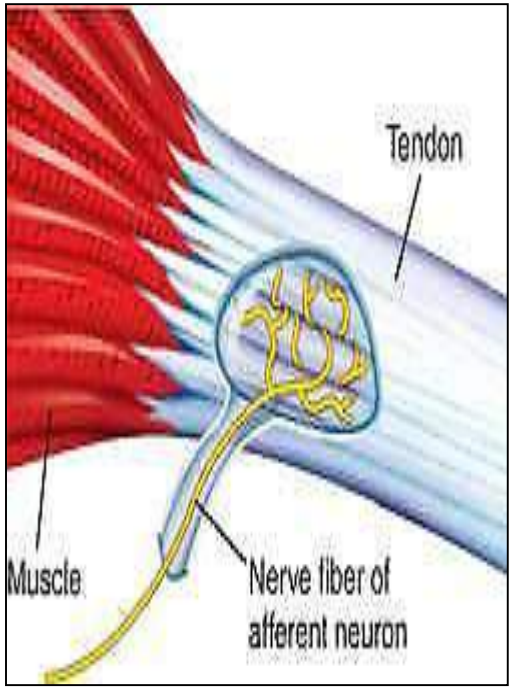

Pacinian corpuscles

5- Golgi Tendon organ (tendon spindle)

- Found in **tendons** near the insertion of the ms fibers
- They detect tensions within tendons When muscle contract (proprioceptors)

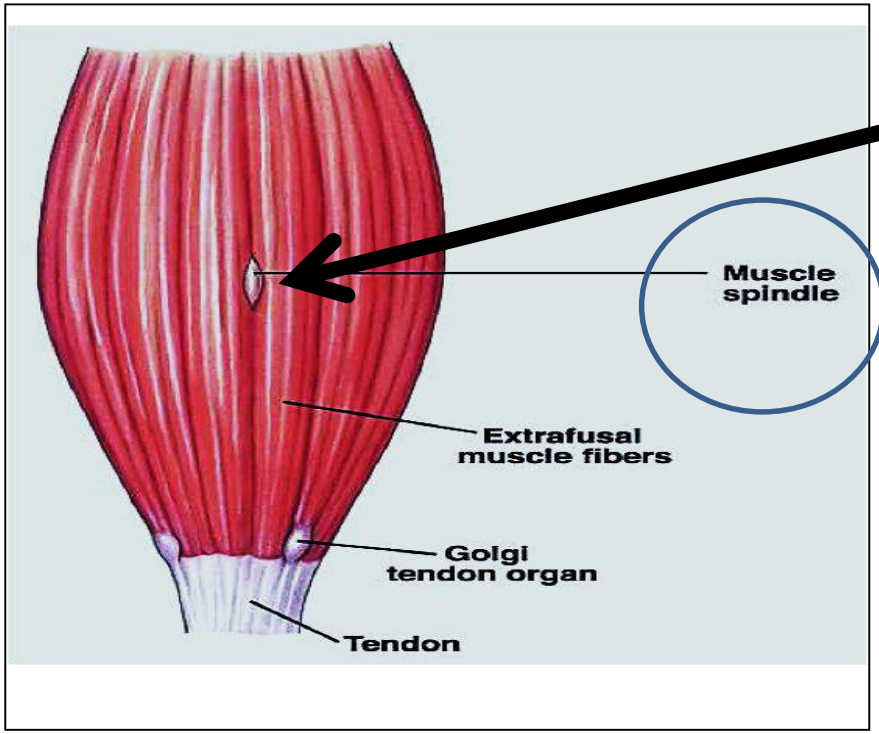
- Sensory nerve penetrates the capsule of the tendon spindle to end around the collagen bundles to detect tension of tendons



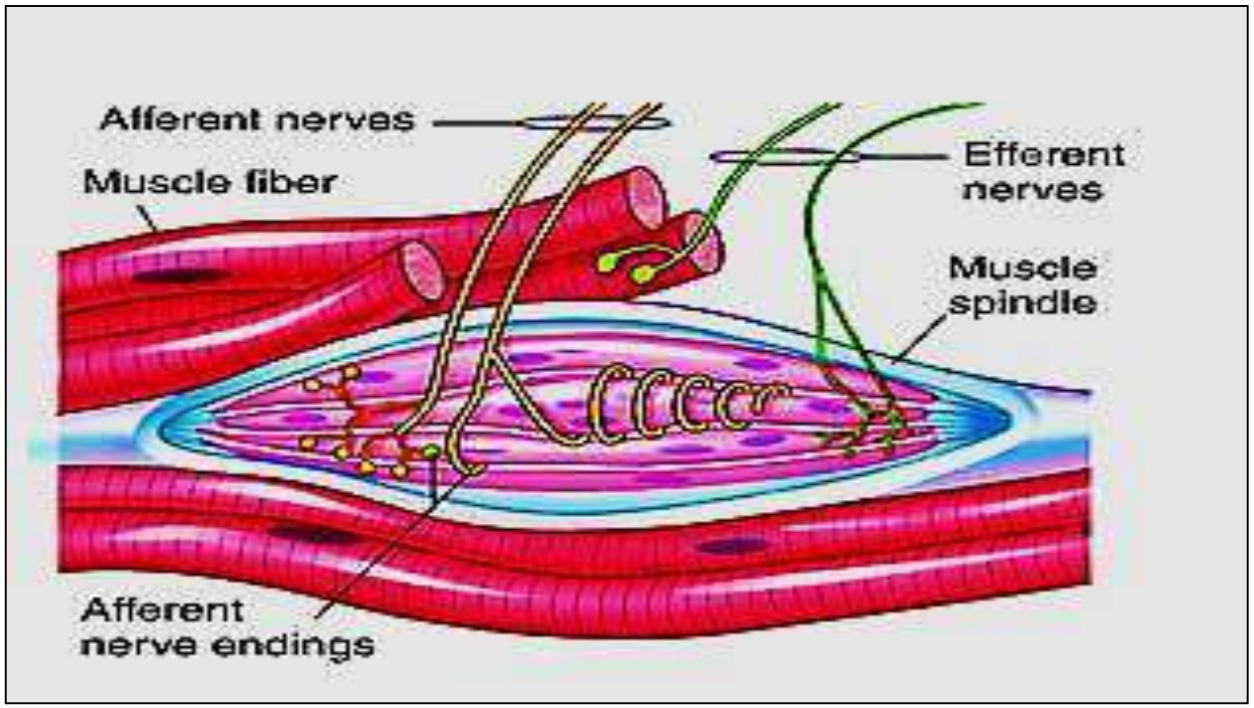


Muscle spindles

- Proprioceptors within the skeletal muscles (lie parallel to the muscle fibers)
- Responsible for regulation of muscle tone, movement, body posture
- More numerous in muscles involved with fine movements



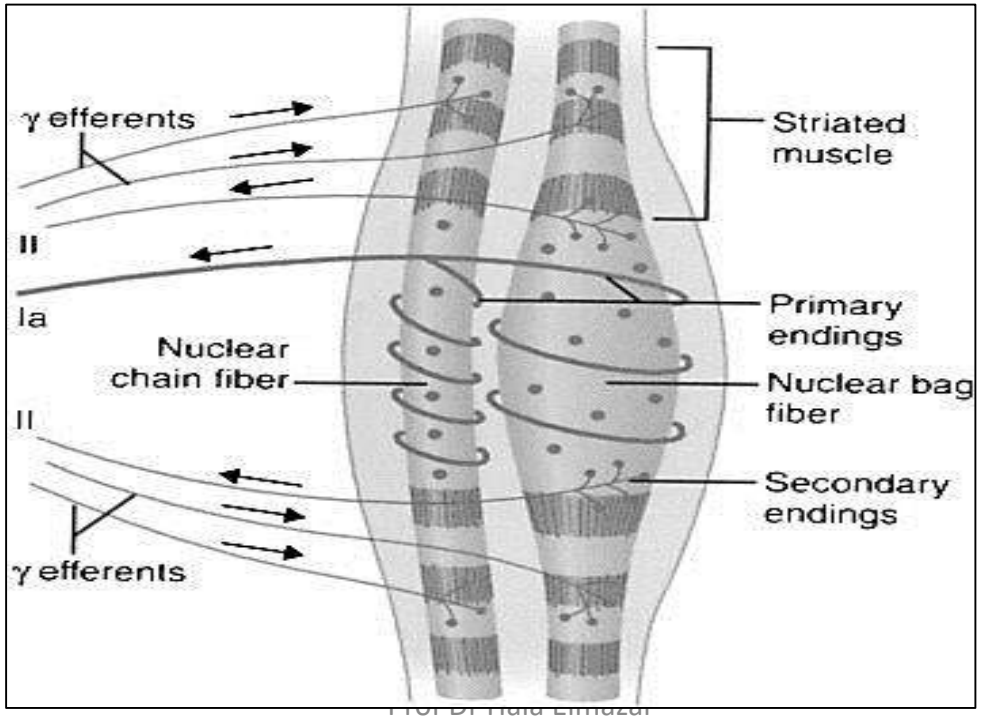
- Fusiform structures enclosed by stretchable CT capsule containing fluid filled space
- The space contains a few (2-12) thin skeletal ms. fibers **intrafusal fibers**
- Several sensory nerve fibers penetrate each ms spindle & wrap around individual intrafusal fibers



The intrafusal fibers are 2 types:

- The nuclear bag fibers: are few in number but thicker & longer. They have distended central nuclear area.

- The nuclear chain fibers: are numerous but thinner & shorter. The nuclei are arranged in row a (like a chain)



intrafusal fibers are supplied with sensory and motor nerve fibers.

The Sensory (afferent) fibers

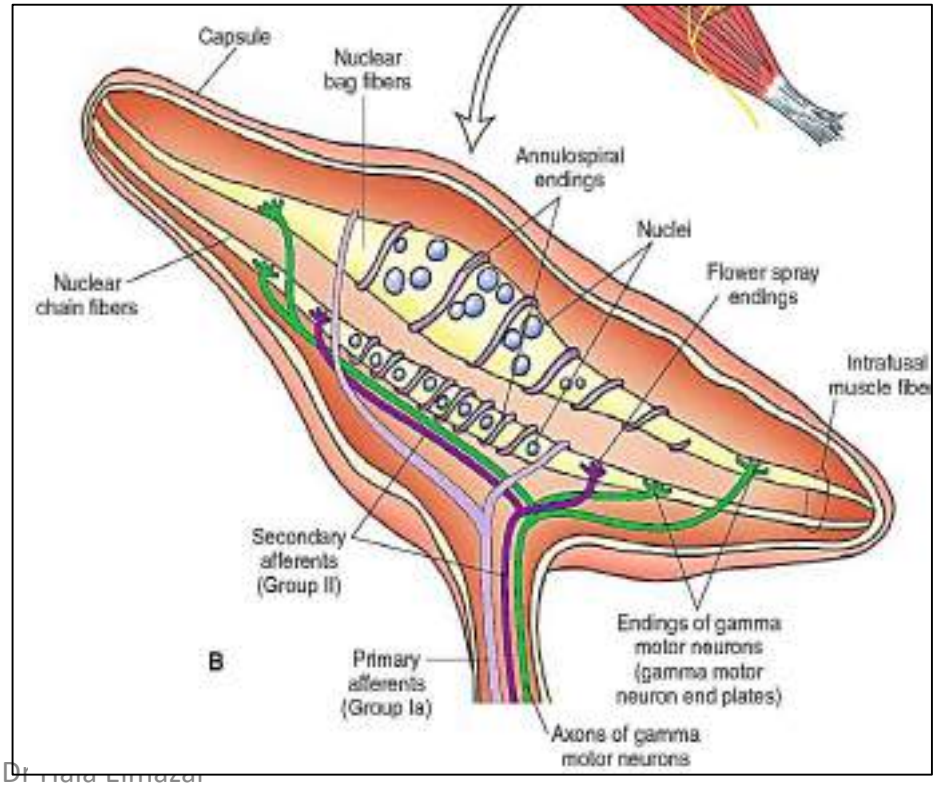
- **The nuclear bag fiber is supplied with a sensory nerve fiber which end around its center and called 1ry sensory fiber (annulospiral)**
- **The nuclear chain fiber is supplied by 1ry sensory (annulospiral) at its center and two 2ry sensory (flower spray) one at each end**

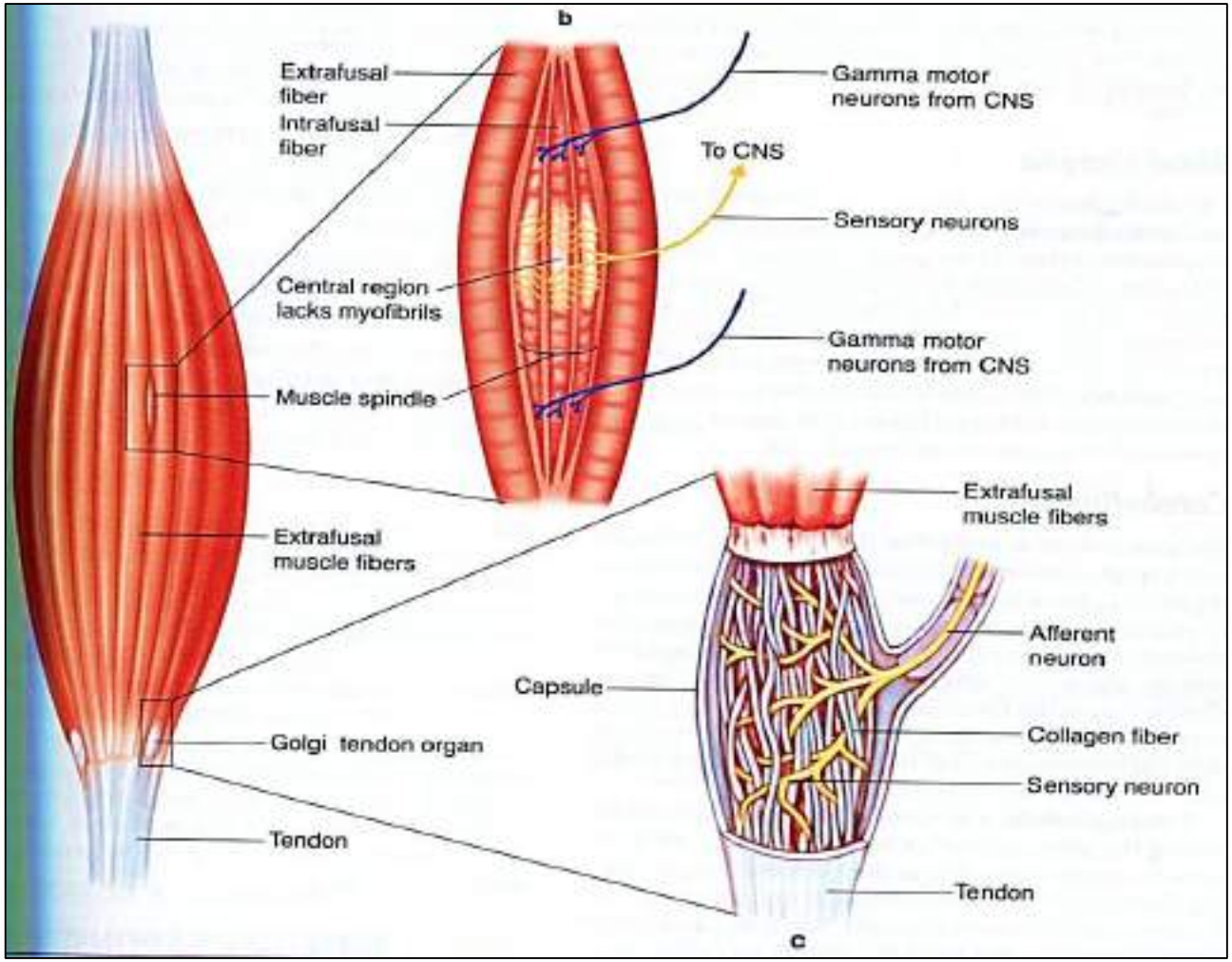
(Total 3 sensory fibers)

The motor (efferent) fibers:

- **Enter the capsule to supply the contractile ends of the intrafusal fibers**

(gamma motor fibers)





Muscle spindle and Golgi tendon

Thank you

Prof Dr Hala Elmazar