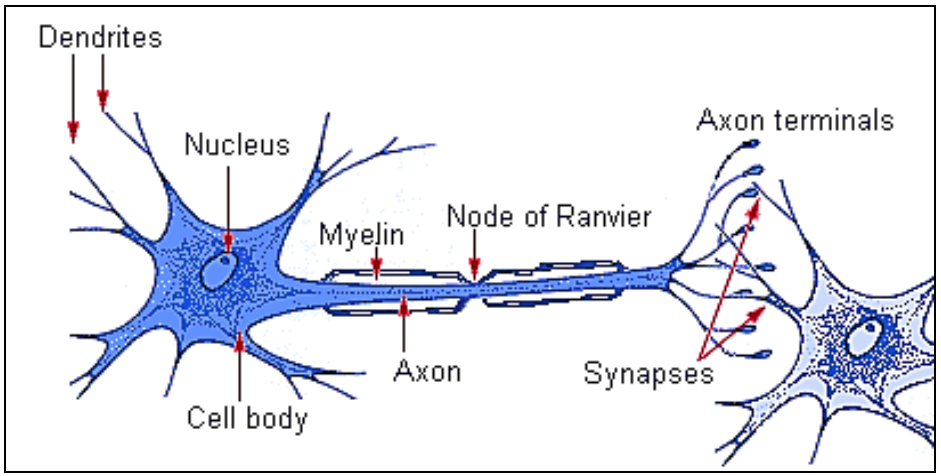


Peripheral nervous system

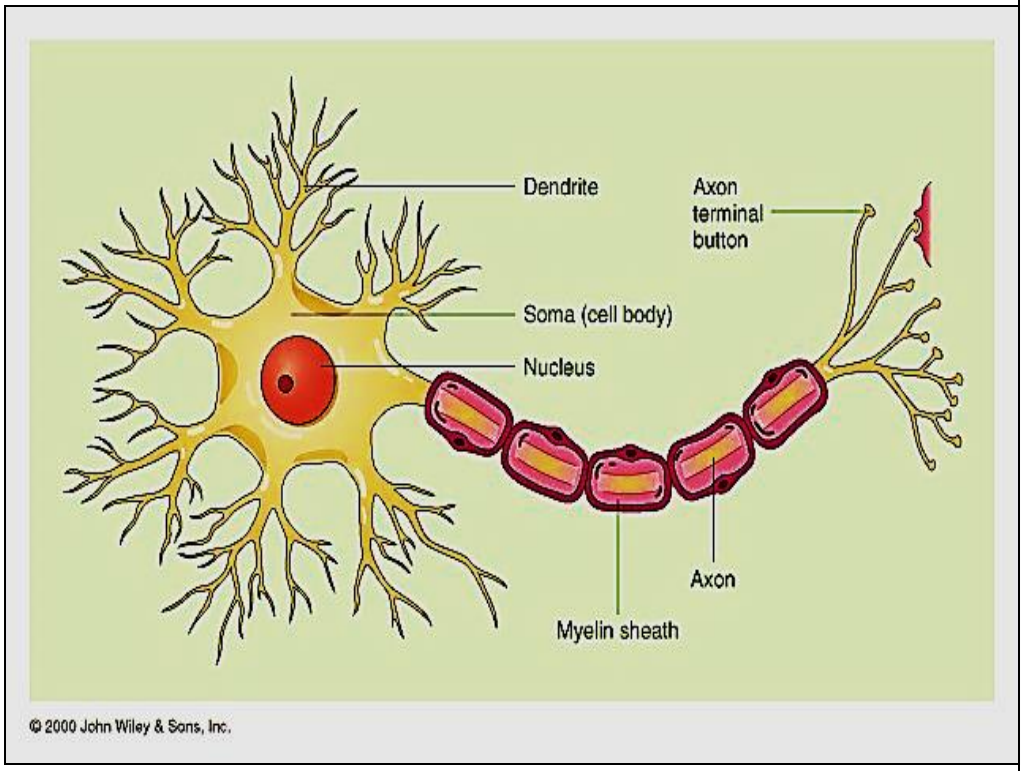
Prof. Dr. Hala Fouad El-mazar

Structure of the neuron (nerve cell)

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

consist of the following main parts:

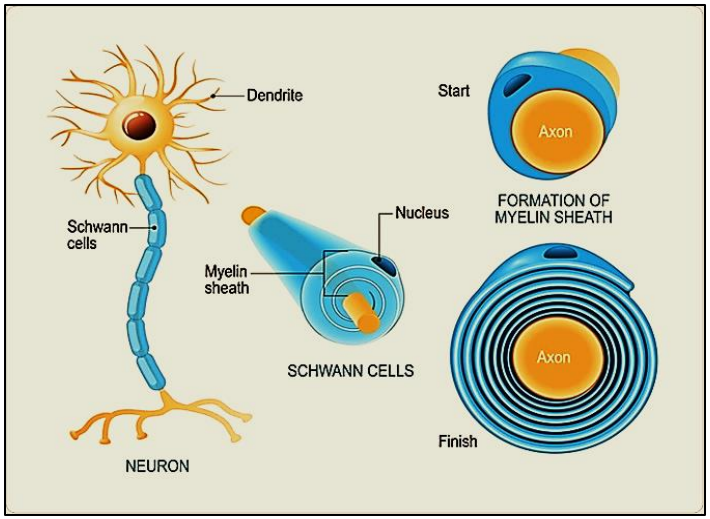
- Cell body (perikaryon)
- Dendrites
- Axon hillock
- Axon
- Axonal terminals
- Knobs
- Synapse



* Axon are enveloped by sheath of Schwann cells

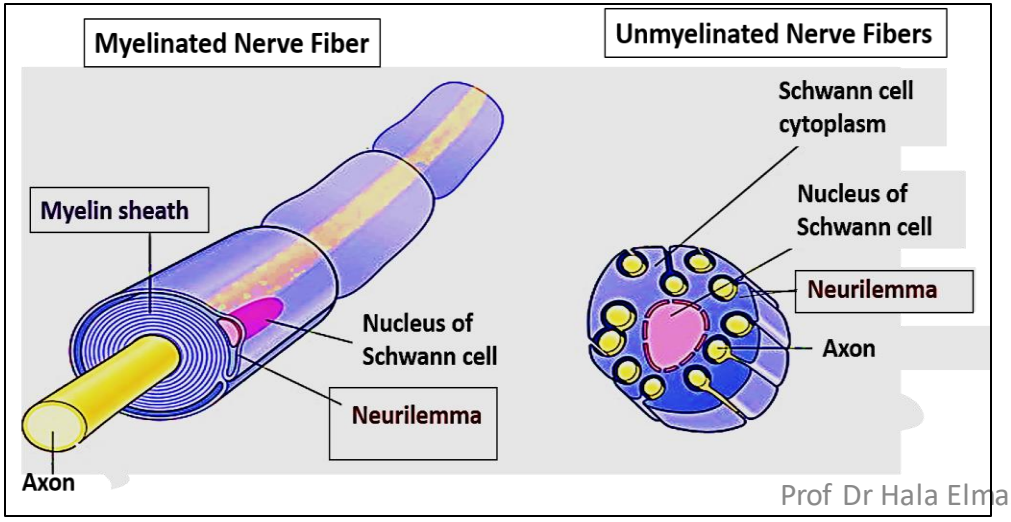
* The cells **may** or **may not** form myelin around the axon thus

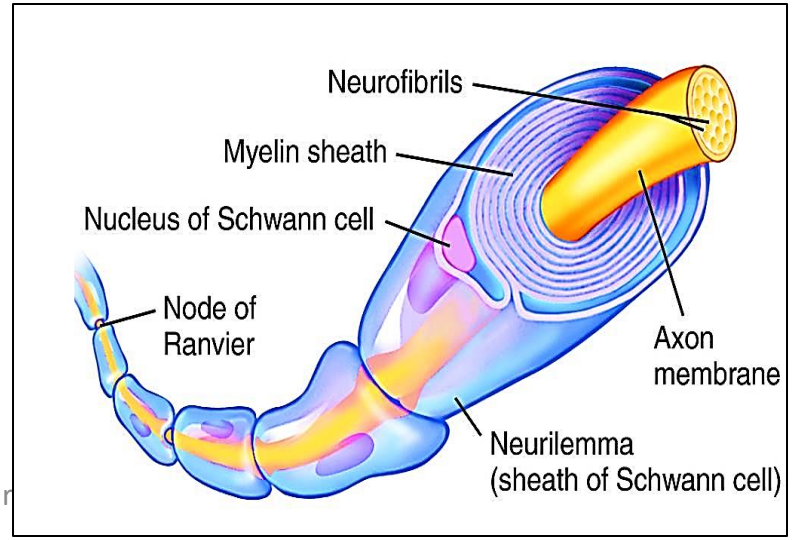
*myelinated or unmyelinated nerves



* **Axolemma**: plasma membrane covering the entire axon

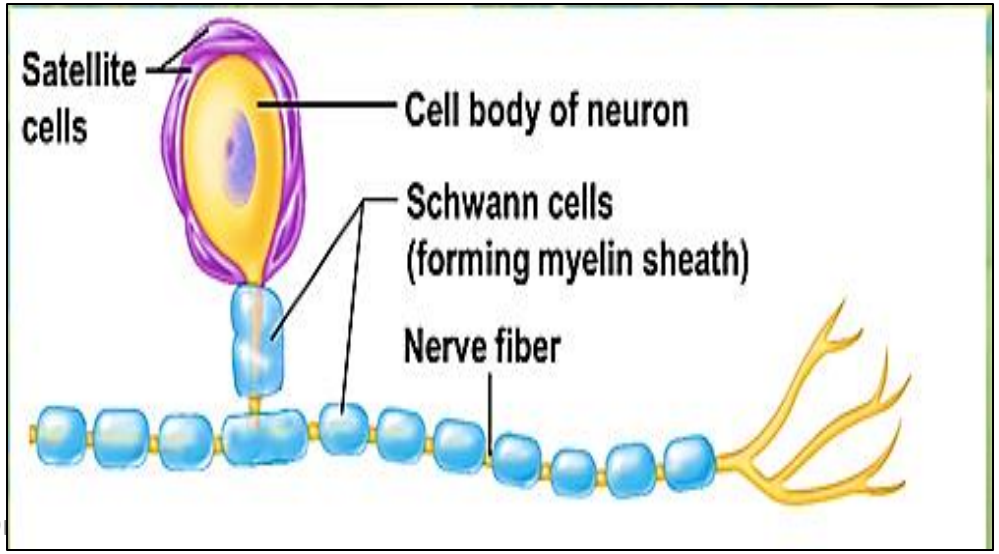
* **Neurilemma** : Outermost part of Schwan cells that contain the nucleus & cytoplasm, surrounds the axon of the neuron





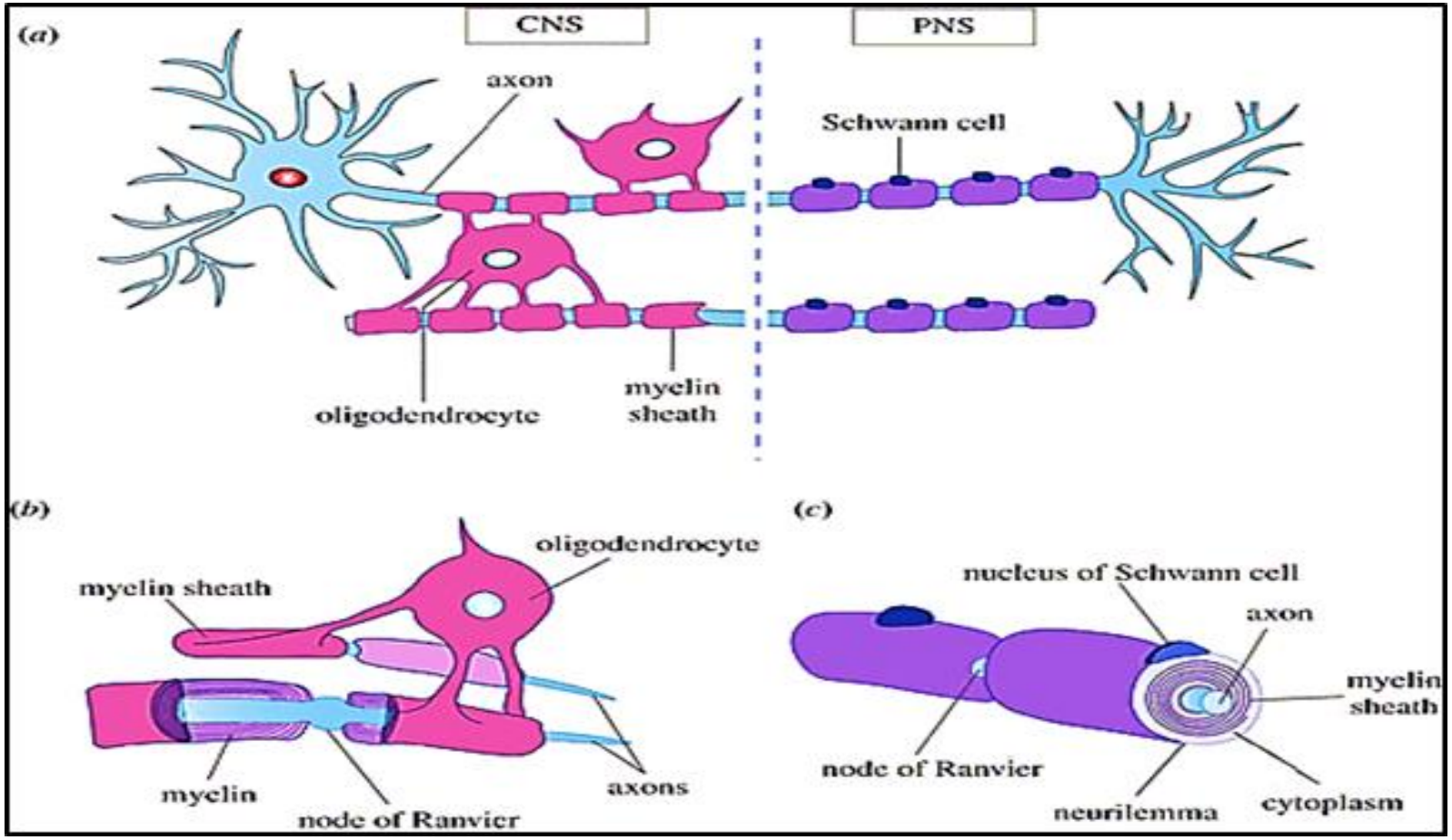
- Along the **Axolemma** the signals are transmitted
- **Neurilemma** serves a protective function for peripheral nerve fibers(damaged n.f . may regenerate if the cell body of Schwan cell is not damaged

- **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



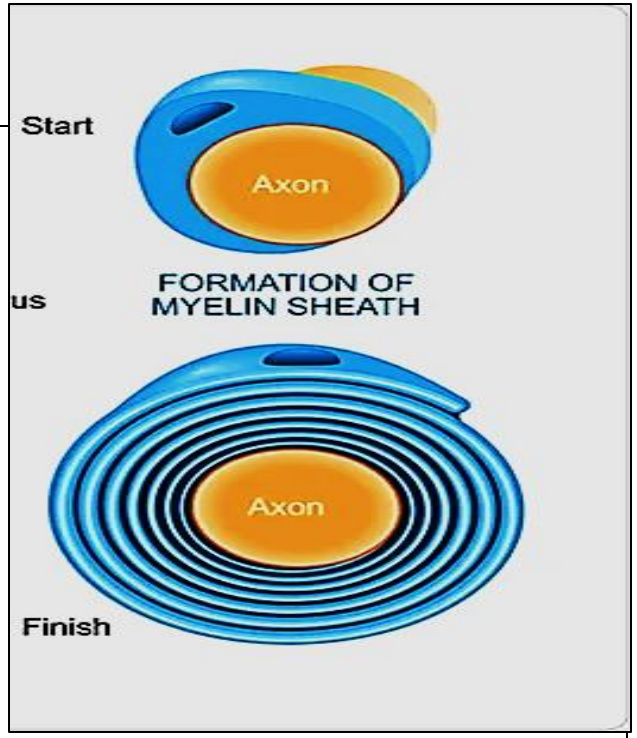
Q: Myelin of CNS is formed by _____?

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



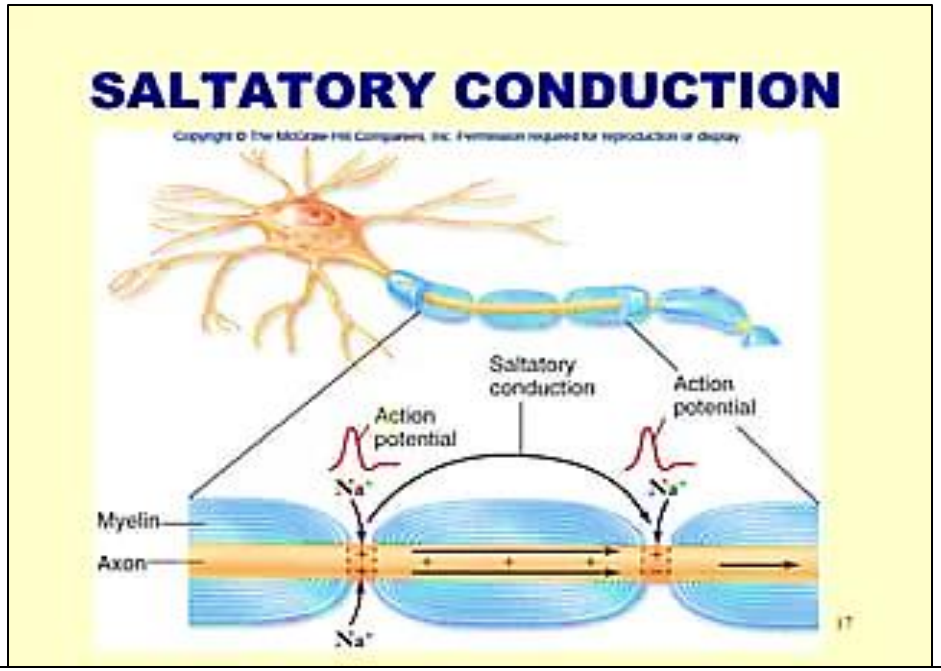
Myelin

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



- consists of many layers of the modified cell membranes of Schwan cells which have high lipid content. The plasma membrane wraps around the axon. Then the layers of the membranes unit and form myelin

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



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

action potentials "jump" between Nodes of Ranvier→

<u>Saltatory conduction:</u>

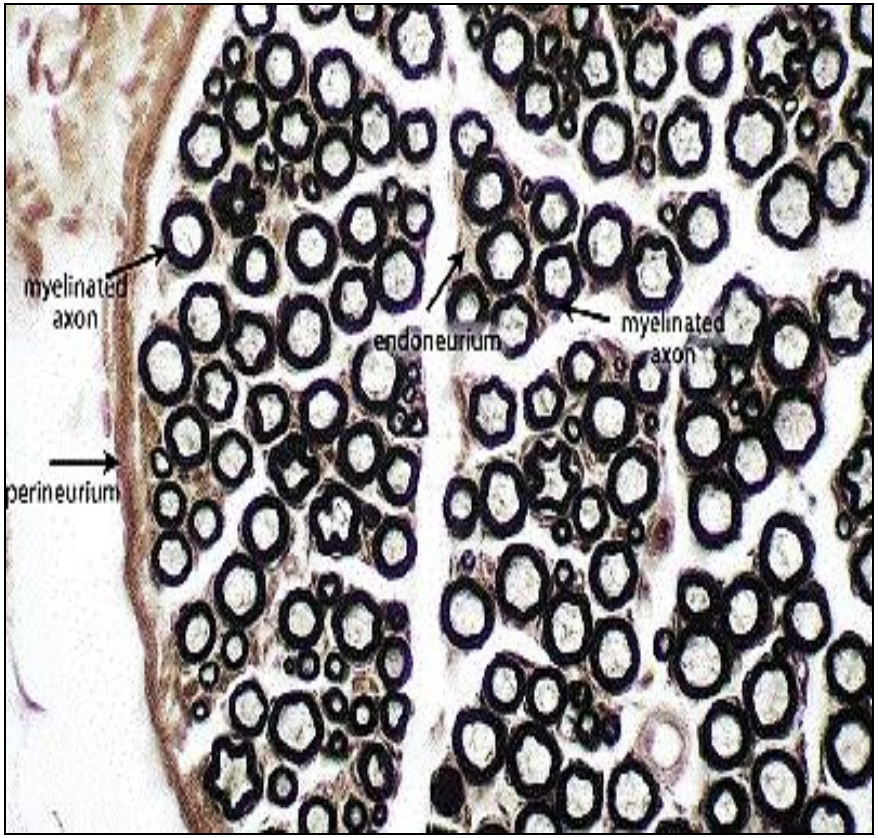
Cuz depolarization can not occur at the cells making up the myelin sheath, the wave of depolarization can only occur at the Nodes of Ranvier. Thus, action potentials appear to jump from node to node when travelling down an axon

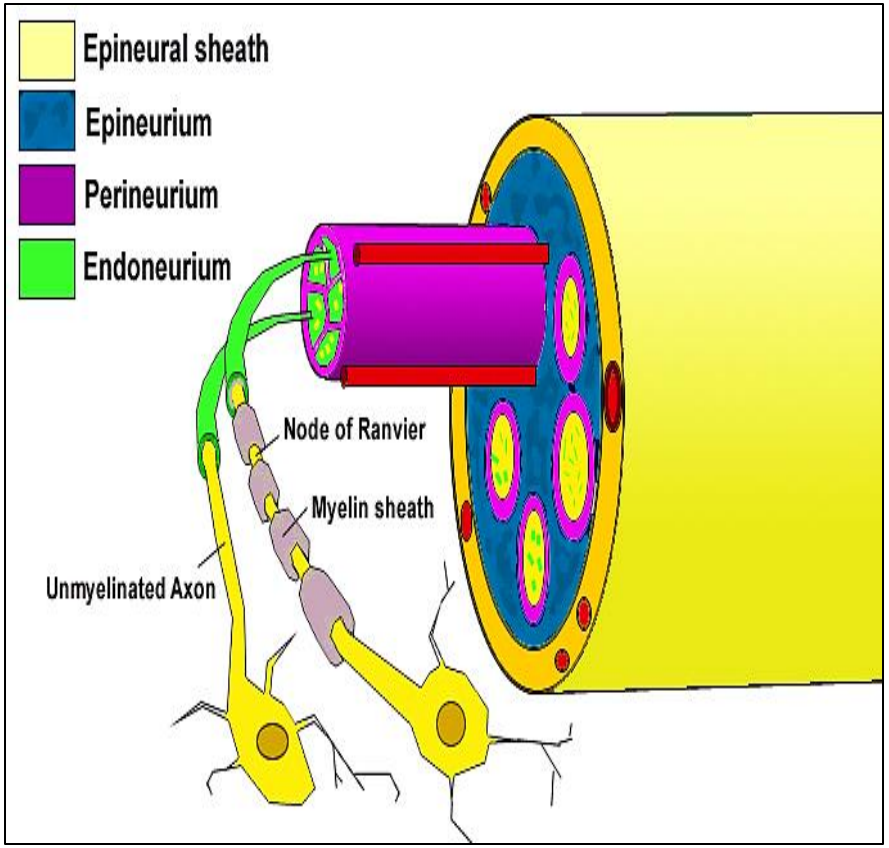
Myelinated vs Unmyelinated nerve fibers

Myelinated nerve fibers	Unmyelinated nerve fibers
contain a myelin sheath around the nerve fiber	do not contain a myelin sheath
White in color	Grey in color
Consist of nodes of Ranvier	Do not consist of nodes of Ranvier
Since transmission occurs only through nodes of Ranvier, the speed of transmission of nerve impulses is high	The speed of the transmission of the nerve impulses is low since these do not contain myelin sheaths
Include most peripheral nerves	Include small-axon neurons in the central nervous system and postsympathetic nerve fibers in the peripheral nervous system
Long axon nerve fibers are myelinated	Short axon nerve fibers are unmyelinated
Myelin sheath prevents the loss of the impulse during conduction	Can lose the nerve impulse during conduction

Visit www.pediaa.com

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





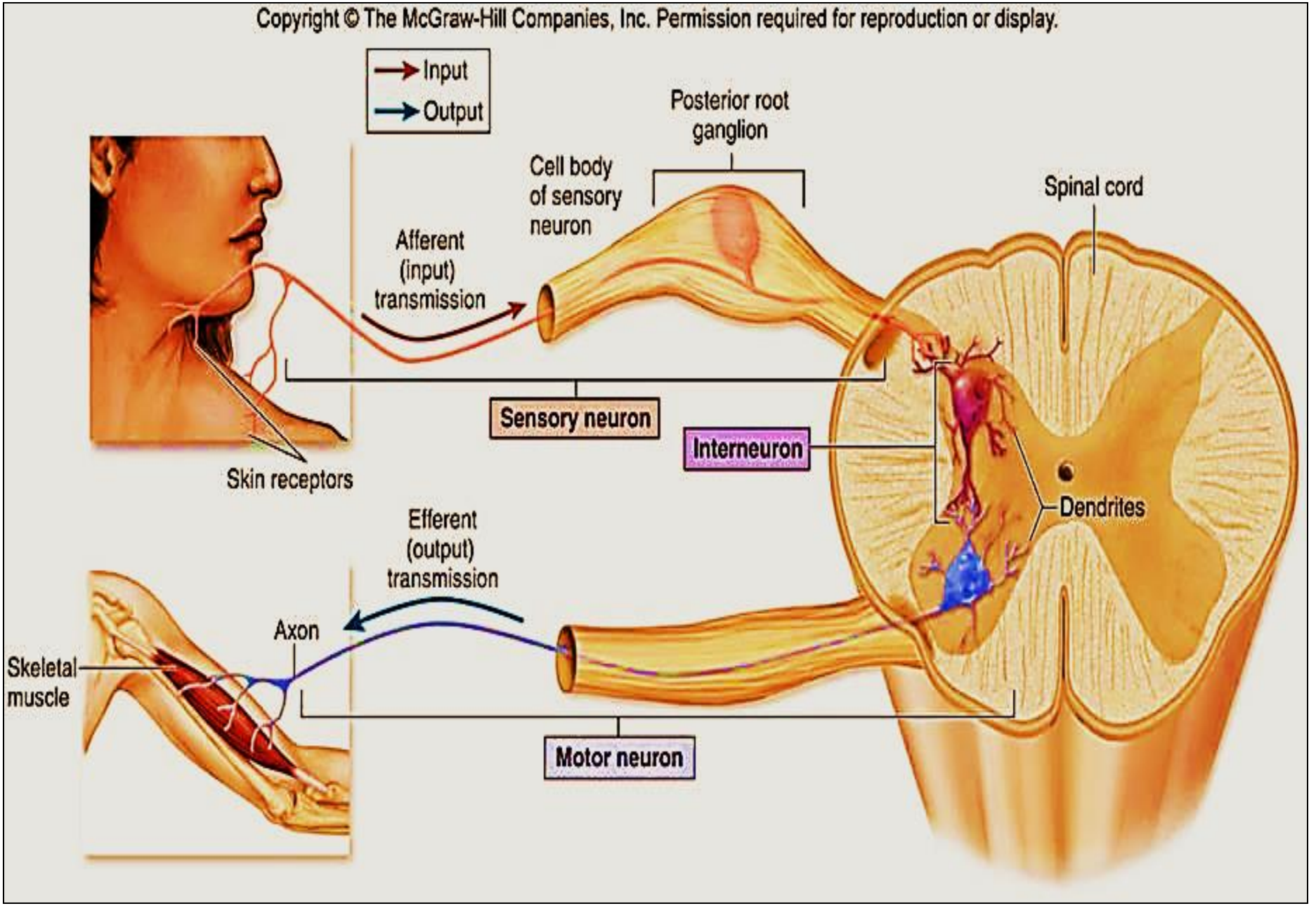
Functional classification of neuron

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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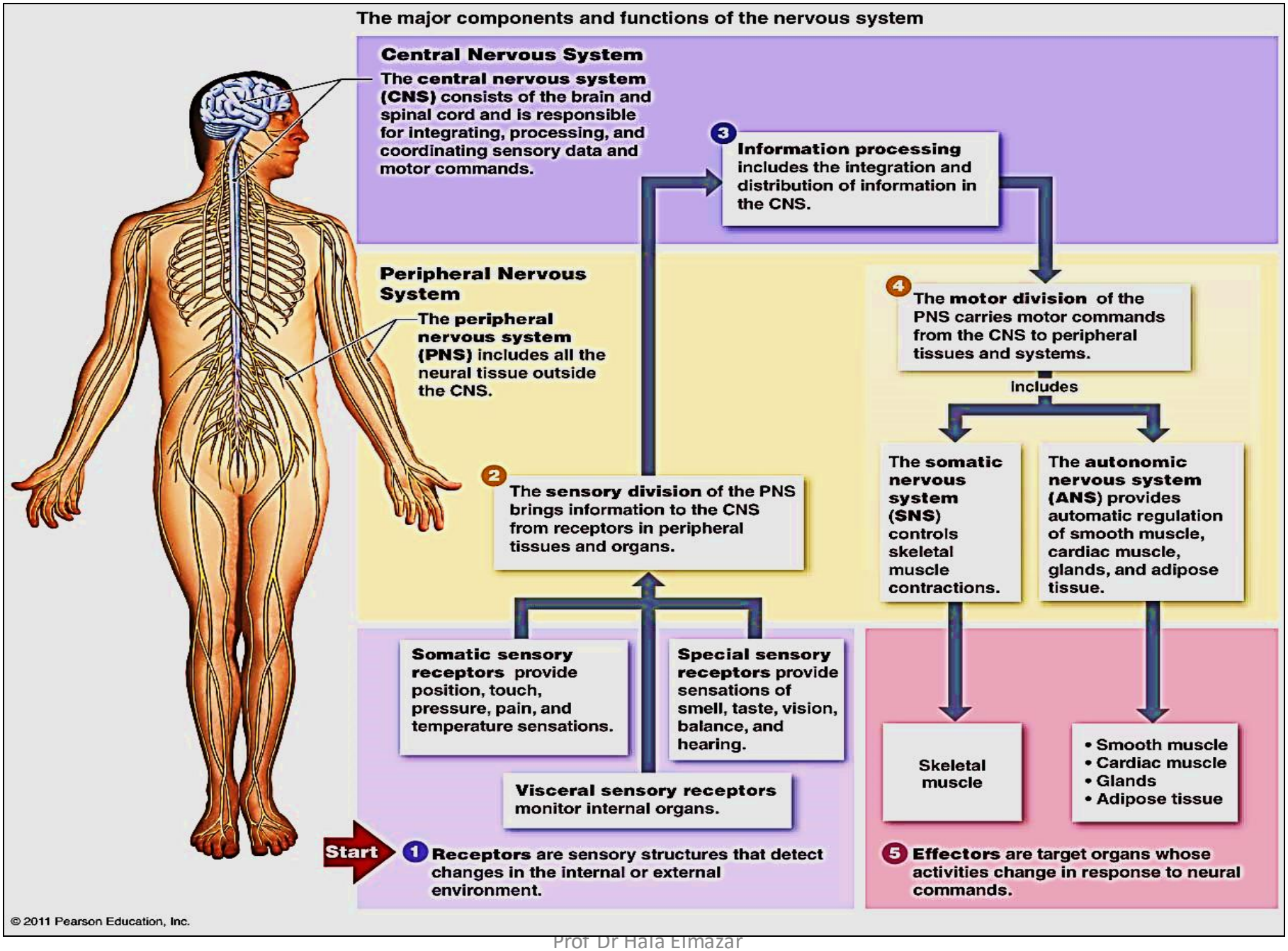
Input
Output
Posterior root ganglion
Cell body of sensory neuron
Spinal cord
Afferent (input) transmission
Sensory neuron
Interneuron
Skin receptors
Dendrites
Efferent (output) transmission
Axon
Skeletal muscle
Motor neuron


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.
2 The sensory division of the PNS brings information to the CNS from receptors in peripheral tissues and organs.
Somatic sensory receptors provide position, touch, pressure, pain, and temperature sensations.
Special sensory receptors provide sensations of smell, taste, vision, balance, and hearing.
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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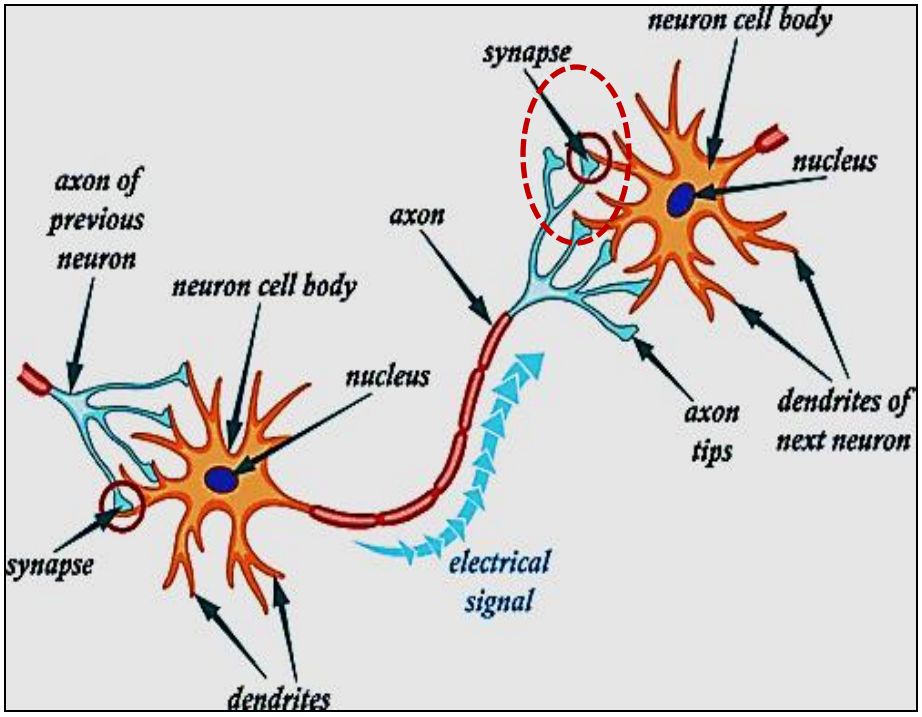
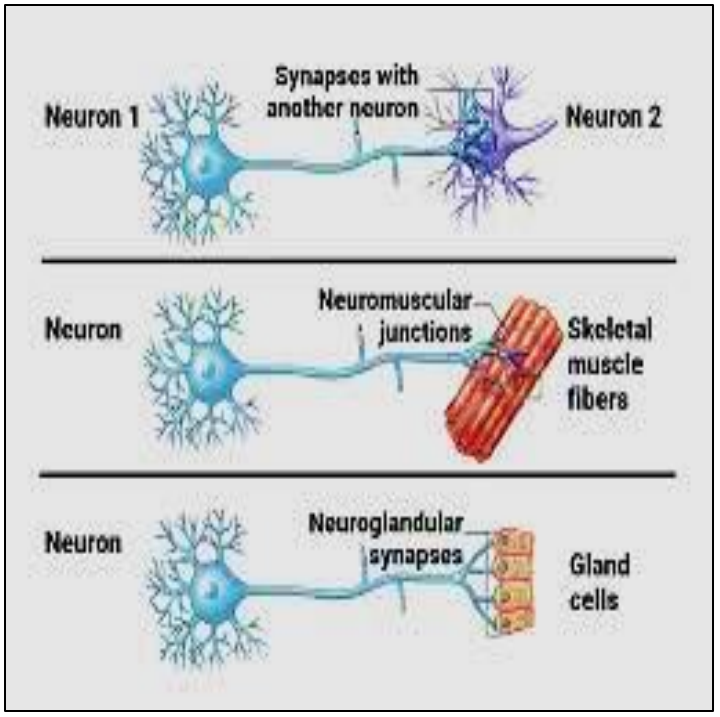
Synapse

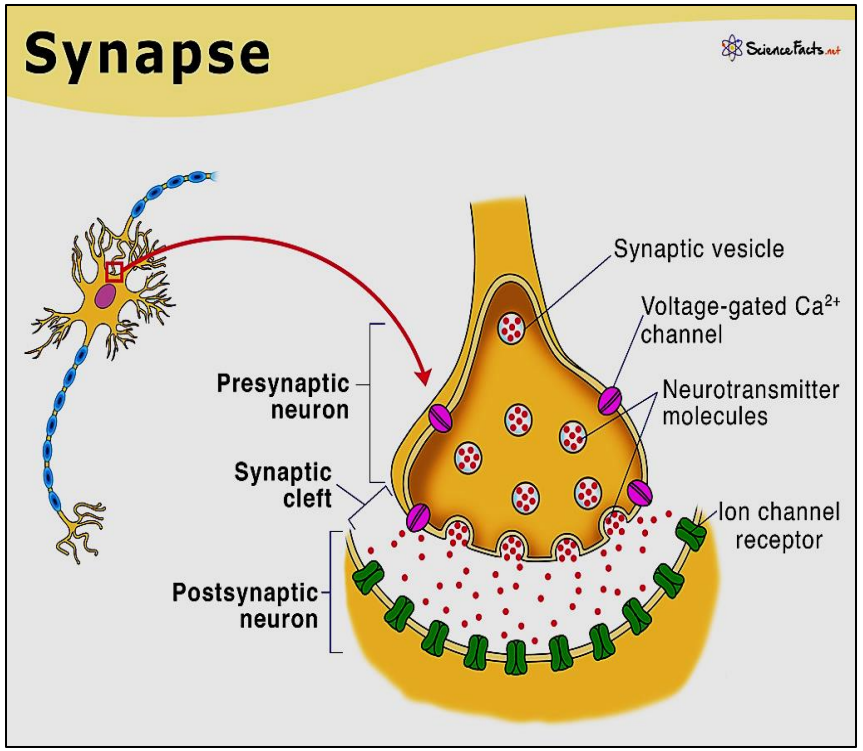
- Sites of **functional contact** between neurons or between neurons & target effector cell e.g. muscle cell or gland cell
- At Synapse unidirectional transmission of nerve impulses occurs.





Structure of synapse

1- Presynaptic axon terminal (terminal knob): which has vesicles that contain Neurotransmitters, ↑ mitochondria



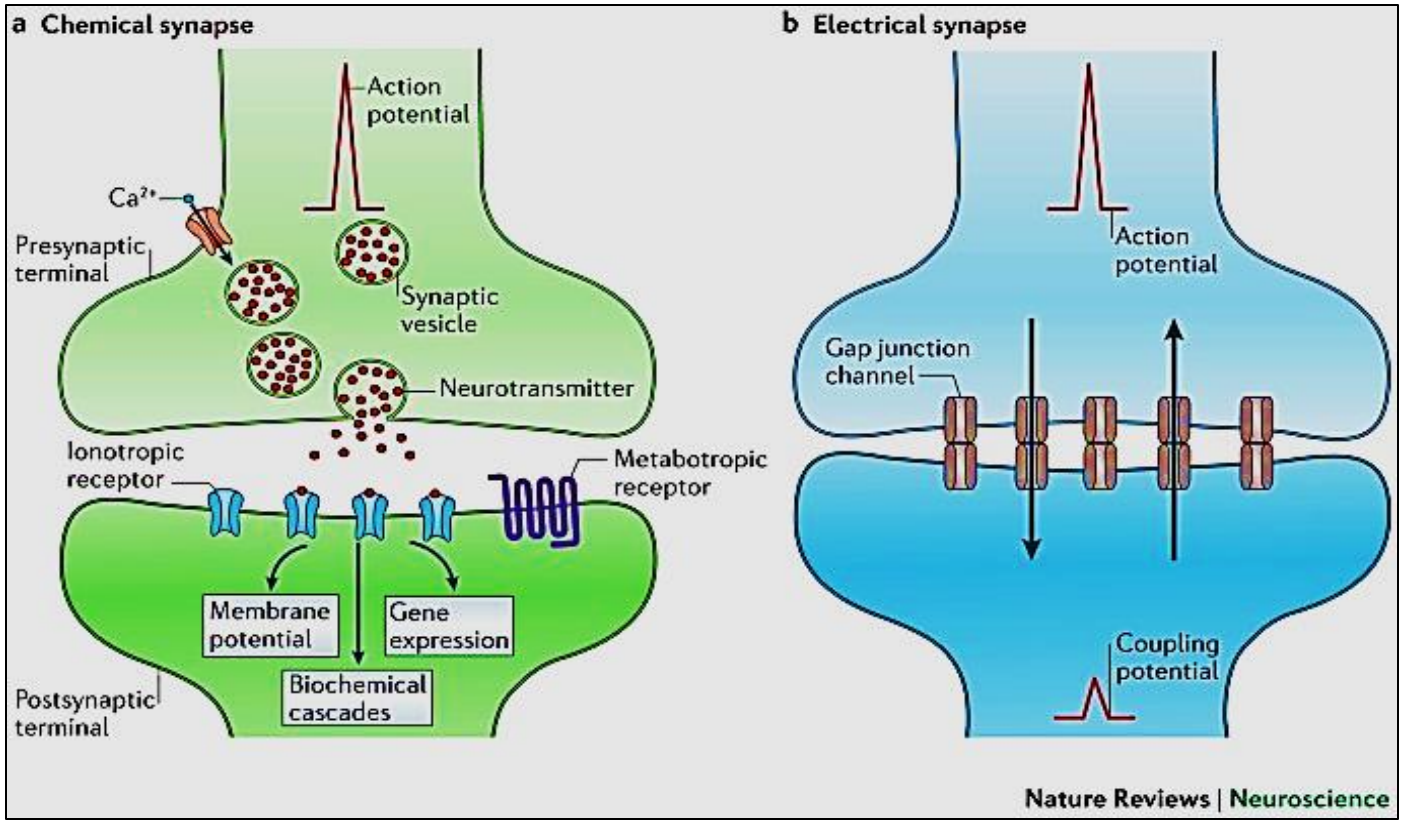
2- Synaptic cleft: narrow space between presynaptic & postsynaptic membranes

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

- Methods of signal transmission:

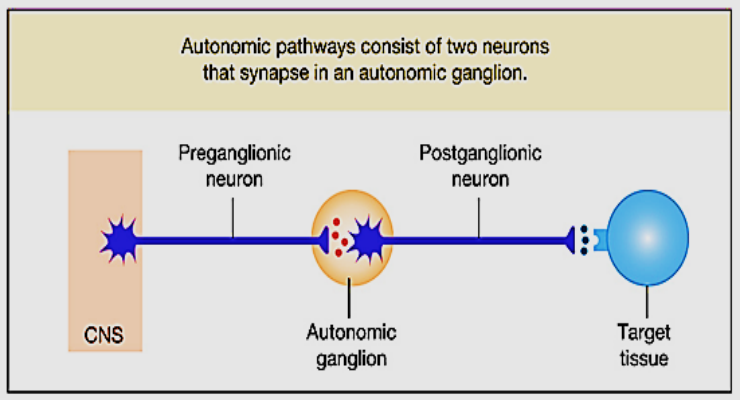
1- Chemical synapses: neurotransmitters e.g motor end plate

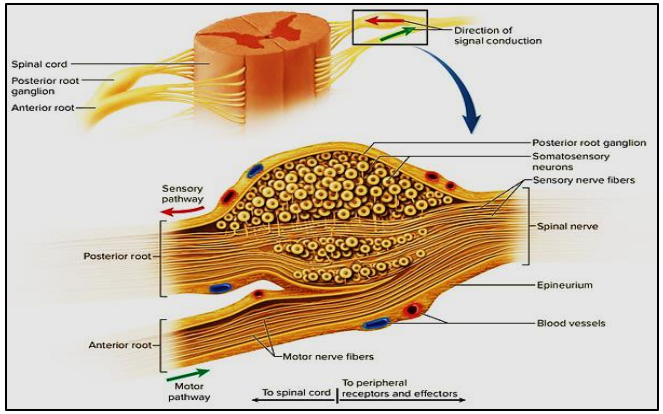
2- Electrical synapses: gap junction (ionic signals) e.g. cardiac muscles



Ganglia

- Ovoid structures contain aggregations of nerve cell bodies & satellite cells supported by CT.
- **Ganglia located outside the CNS (**i.e. collection of nerve cell bodies in PNS)
- They serve as **relay station** to transmit nerve impulse, one nerve enters & another exit from each ganglia



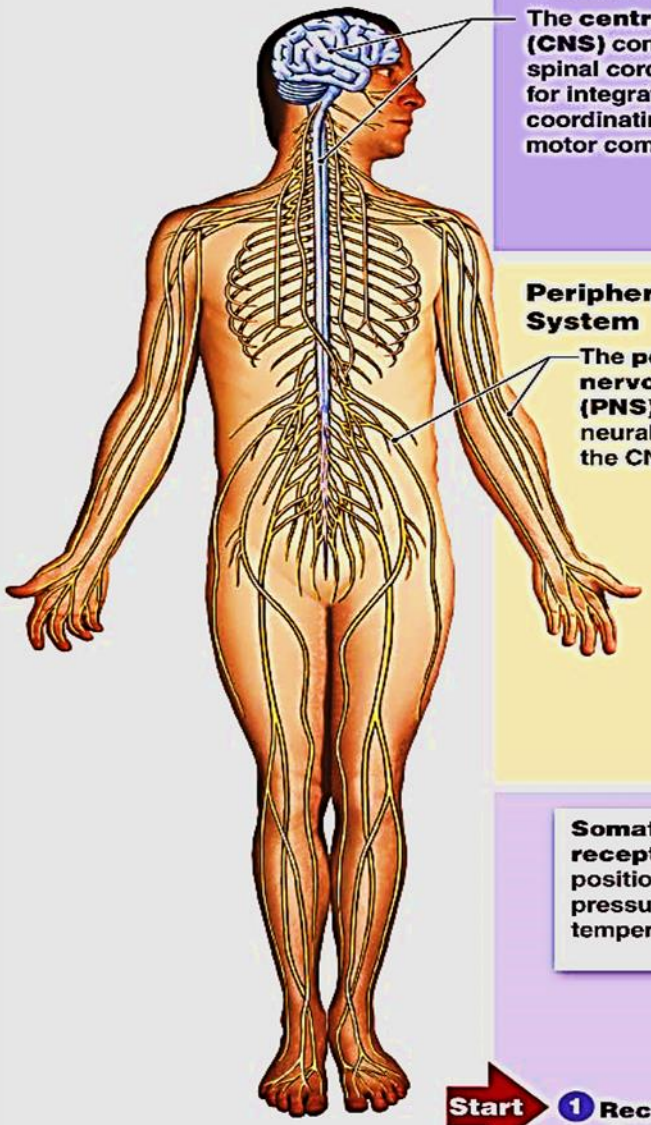


- They are two types: up to the direction of n. impulses

➢ Sensory ganglia (sensory) : spinal & cranial ganglia

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

The major components and functions of the nervous system



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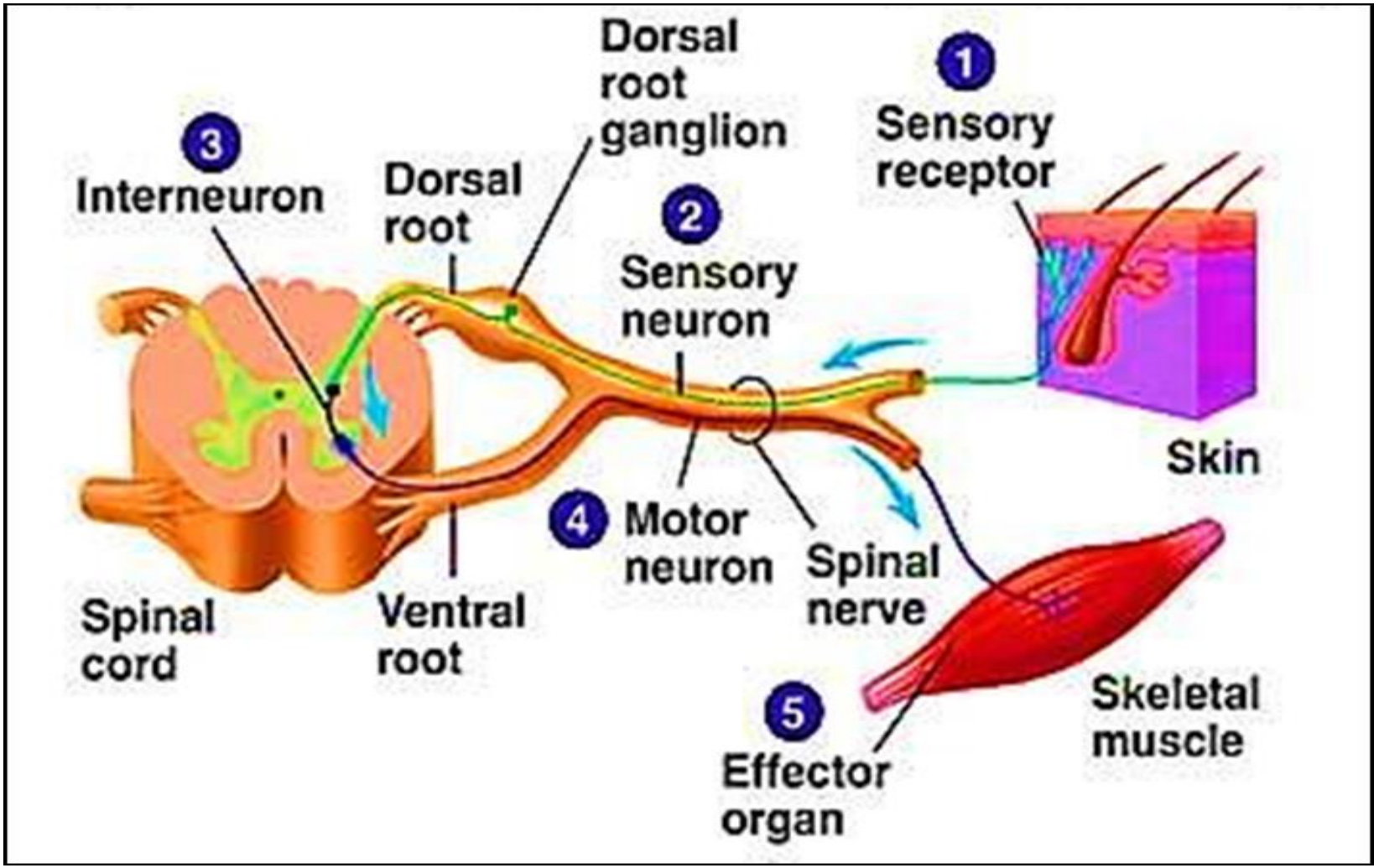
- Smooth muscle
- Cardiac muscle
- Glands
- Adipose tissue

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.

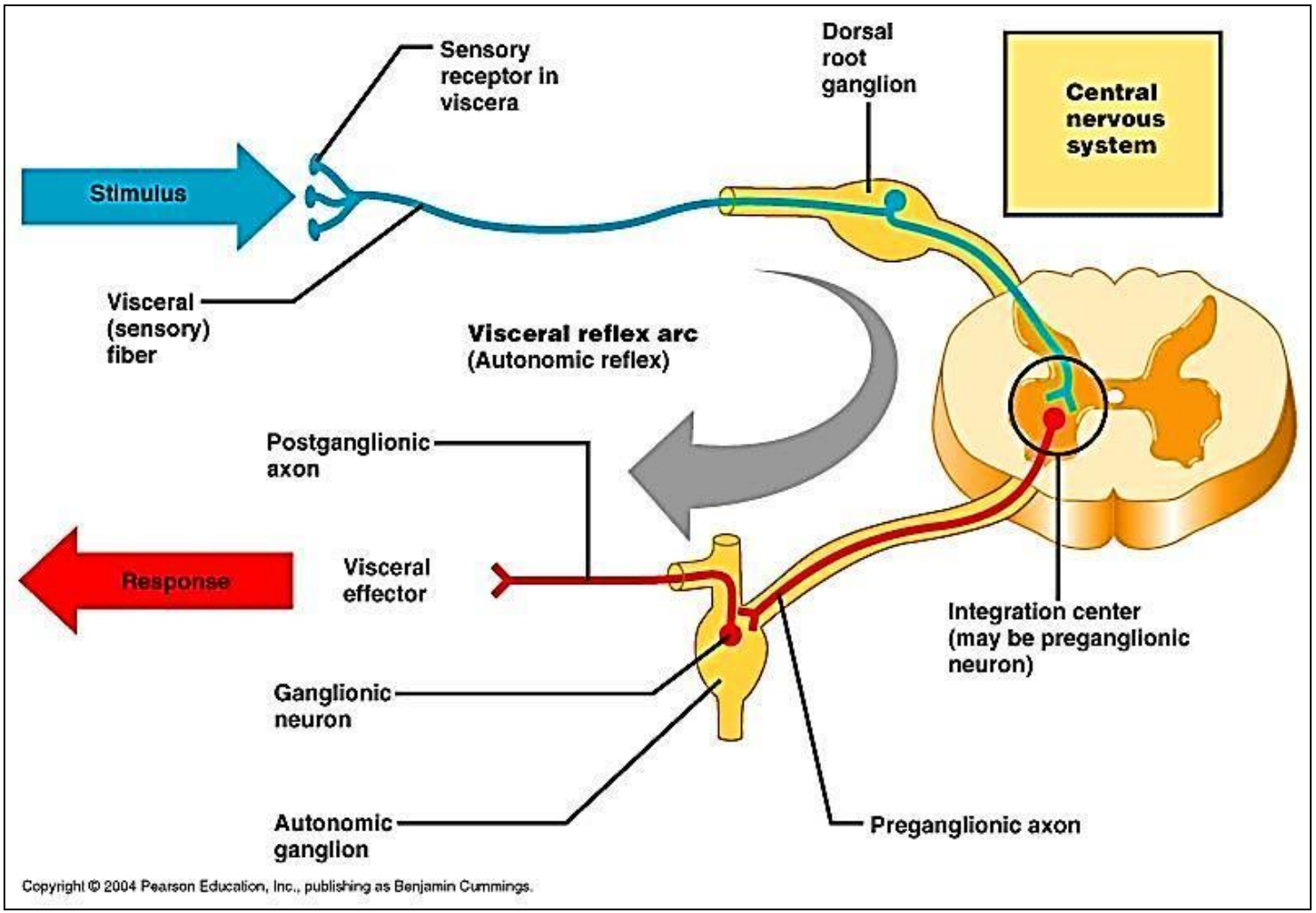
Sensory ganglion



Sensory ganglia: 1- Cranial G

2- Spinal G (Dorsal root ganglia)

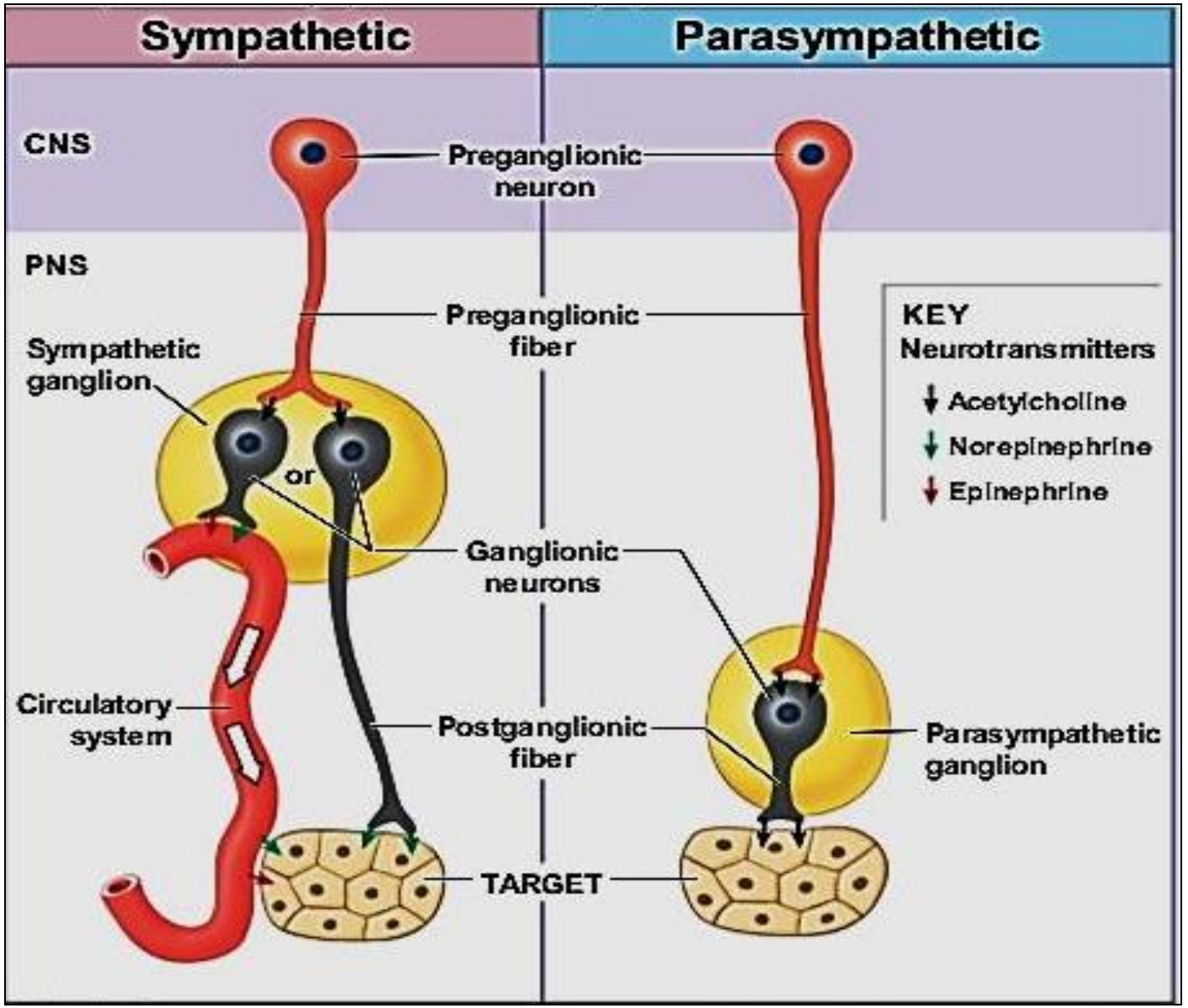
Autonomic ganglion (motor)

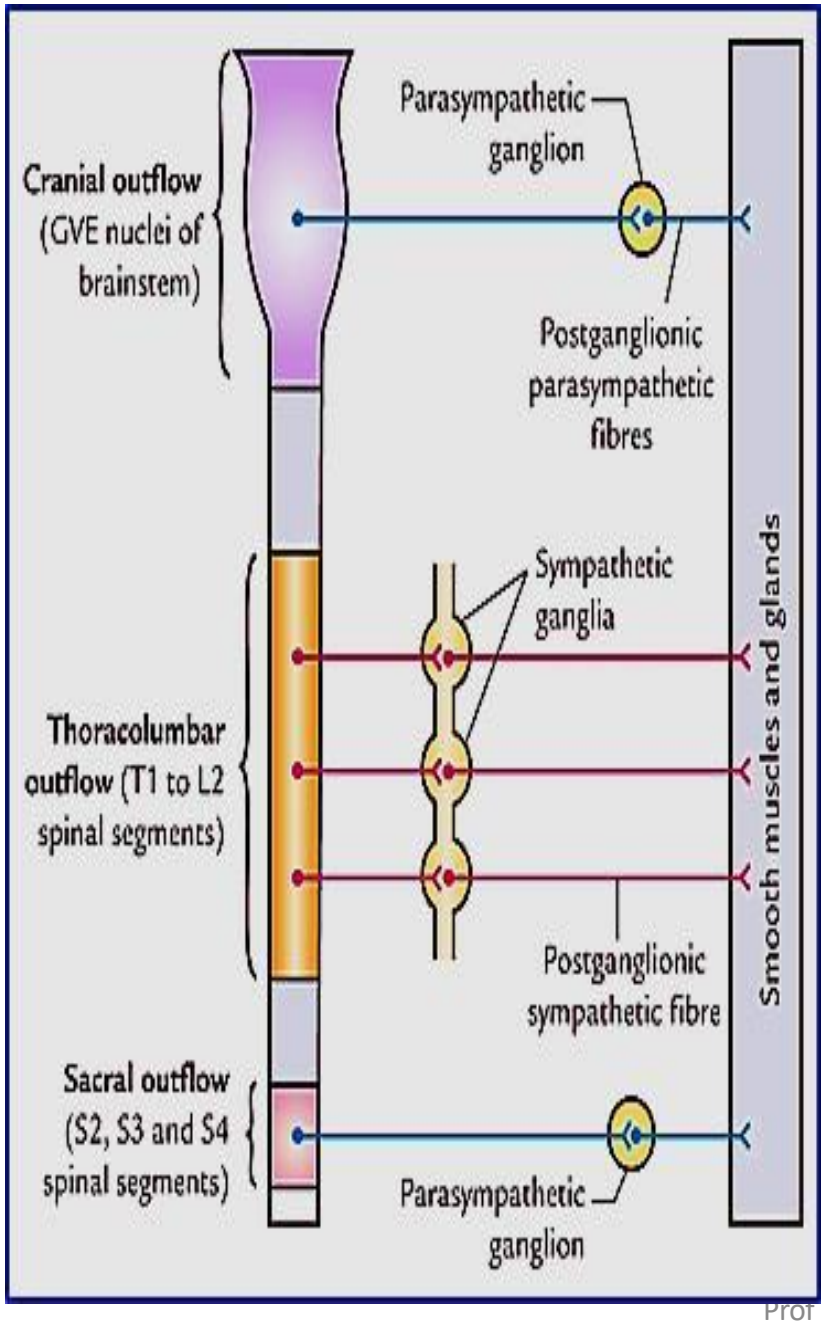


Autonomic ganglia : 1- Sympathetic G

2- Parasympathetic G

Sympathetic vs Parasympathetic ganglion





Sympathetic is thoraco-lumber outflow:

- **Thoraco: (# 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:

- **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**

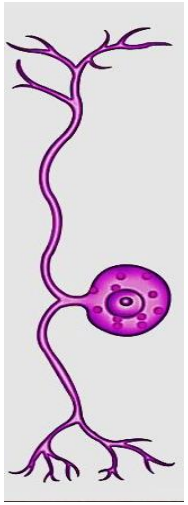
Sensory ganglia

Sensory ganglia (31 pairs)

carry **afferent** impulses to CNS

Example:

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



Nerve cell bodies are:

Unipolar (rounded shape)

Covered with thick capsule

Large , few in numbers

Central nuclei

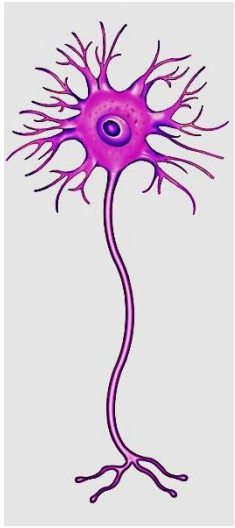
Arranged in groups between the fibers

Autonomic ganglia

Motor ganglia (21-23 pairs)

Carry **efferent** impulses from CNS

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



Nerve cell bodies are:

Multipolar

Thin capsule

Small , numerous

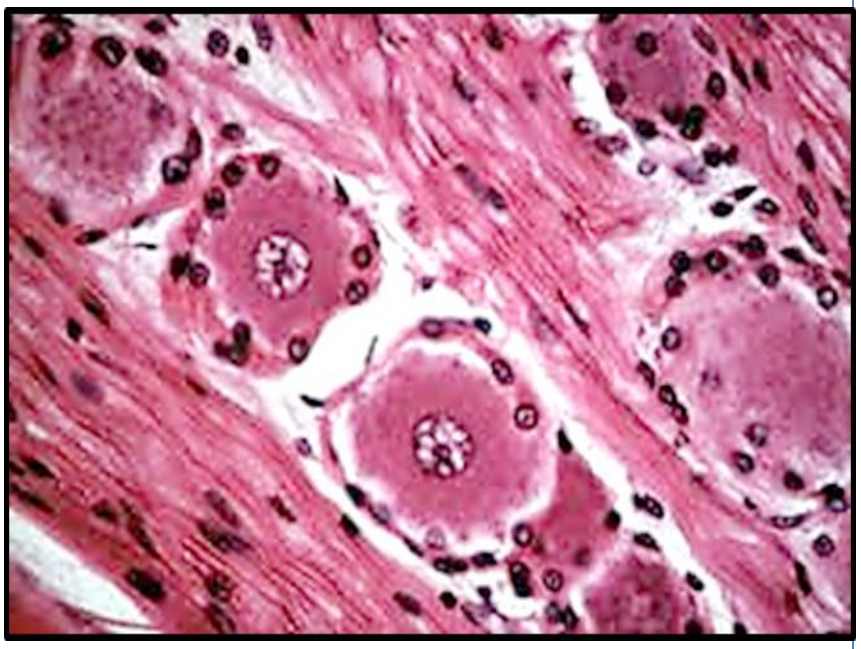
Eccentric nuclei

Scattered , no groups

Spinal ganglia

The groups of cells are separated with myelinated nerve fibers

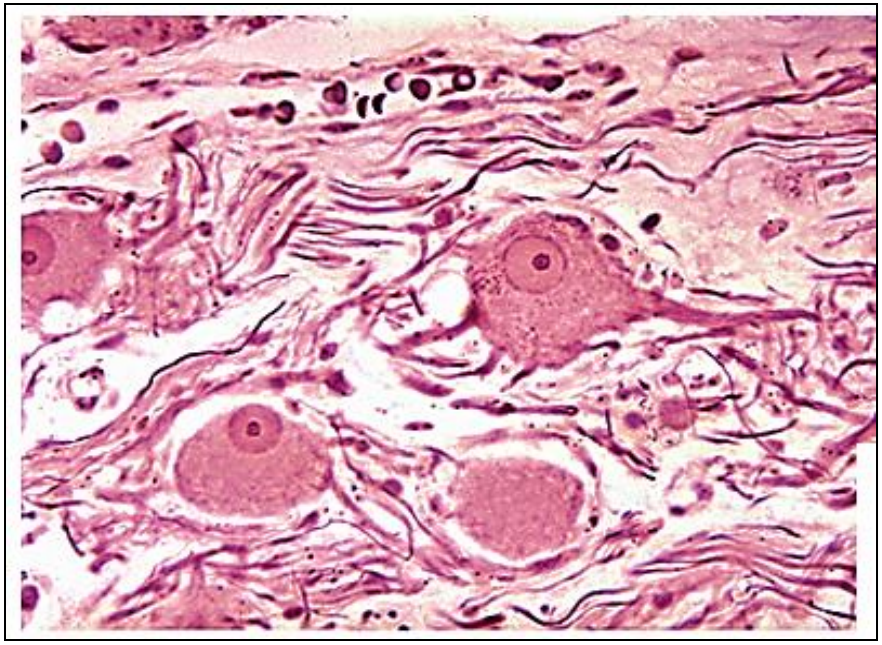
satellite cells are more around each nerve cell body



Sympathetic ganglia

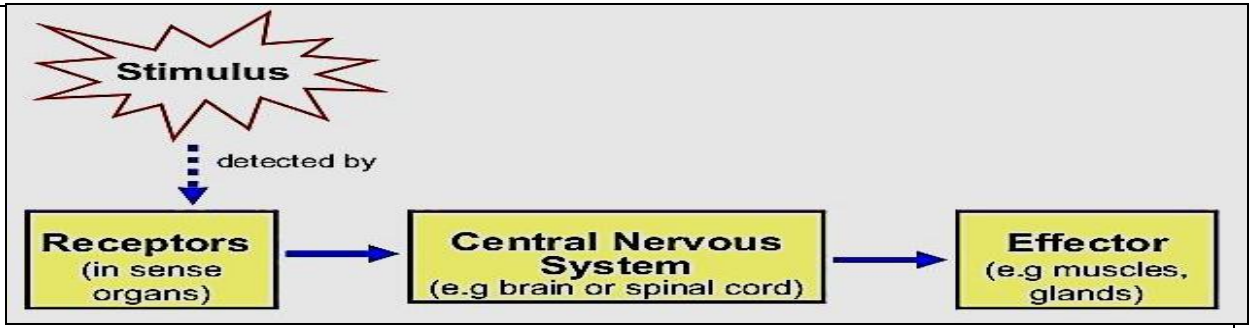
The cells are separated with non/ little mylinated nerve fibers

satellite cells are less



Nerve endings

They are either:



A- At Receptors: receive external or internal stimuli & convert them to nerve impulses → CNS

They are classified into:

- Exteroceptors: external stimuli- epithelium
- Proprioceptors: stimuli from muscles & tendons
- 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:

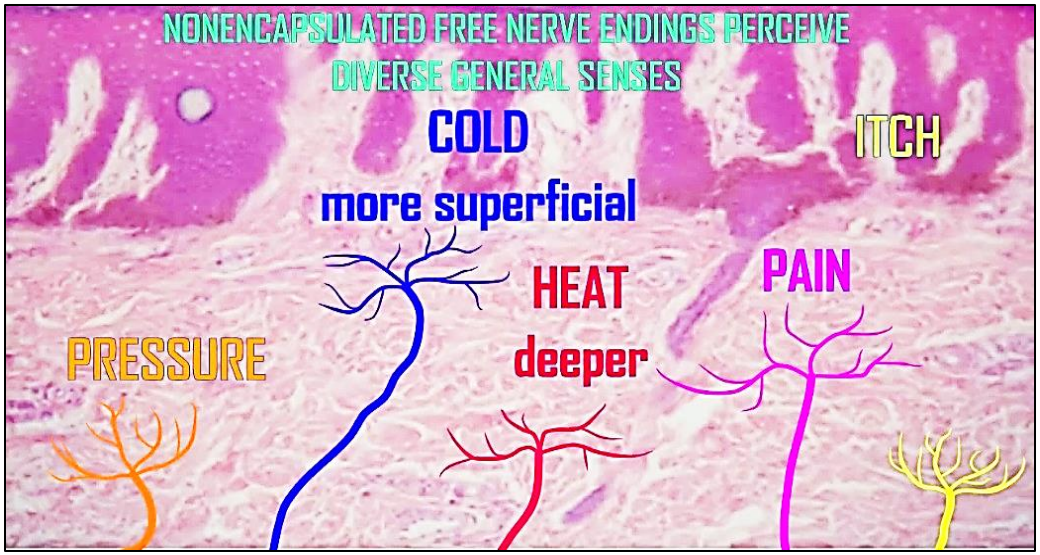
Free nerve endings
Meissner corpuscle
Krause end bulb
Pacinian copuscle
Ruffini's end organ
Golgi tendon organ (tendon spindle

Receptors in muscular tissue:

Muscle spindle

1- Free nerve endings

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

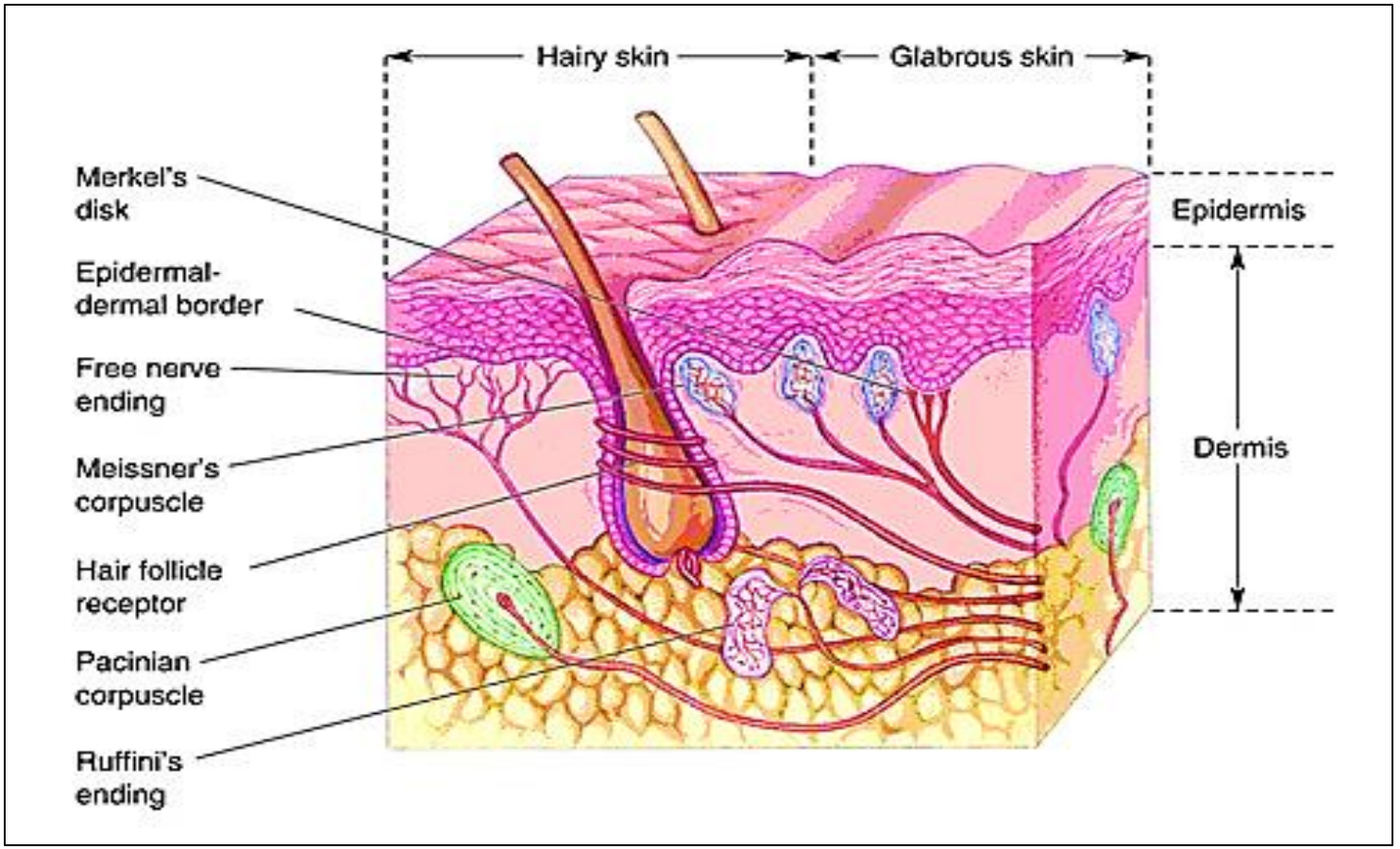


- Are unmyelinated sensory nerve fibers which penetrate the basement membrane of an epithelium to end freely in-between epithelial cells

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

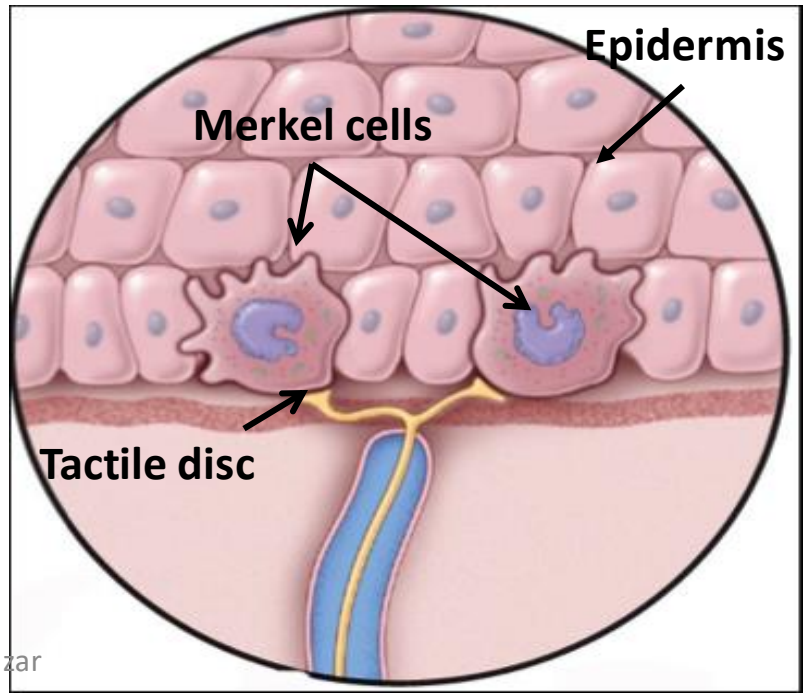
2- Root hair plexus

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



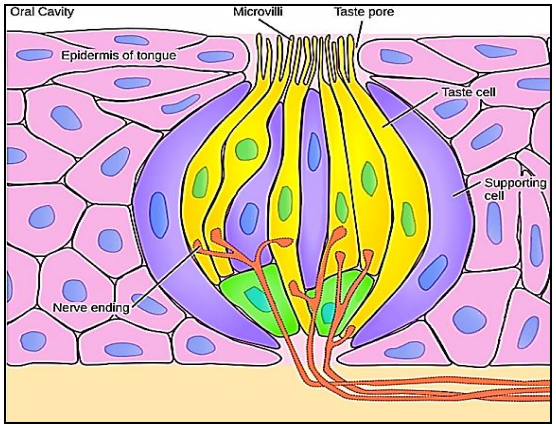
3- Merkel Tactile disc

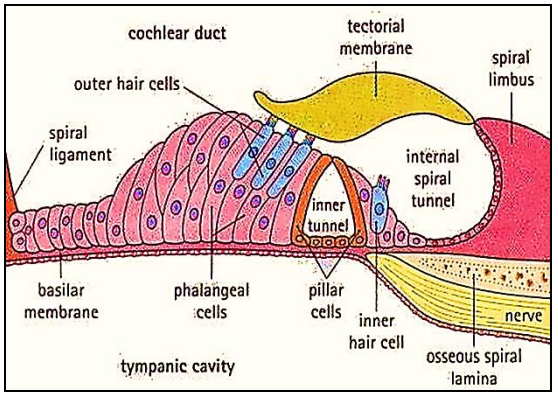
- They are **mechanoreceptors** detect **touch & pressure**
- Present in **epidermis (superficial)** of the skin of soles & palms(fingers .. Tactile discrimination, sophisticated sensory tasks)
- In association with **Merkel cells (**modified epithelial cells**)** of the epidermis
- The Afferent nerve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

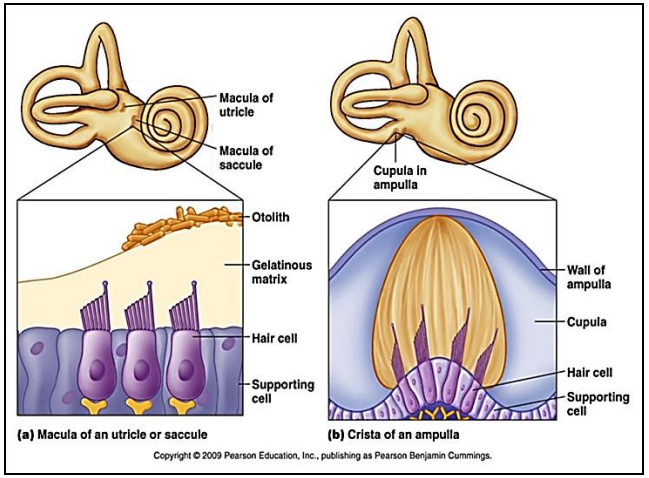


4- Neuroepithelium endings

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



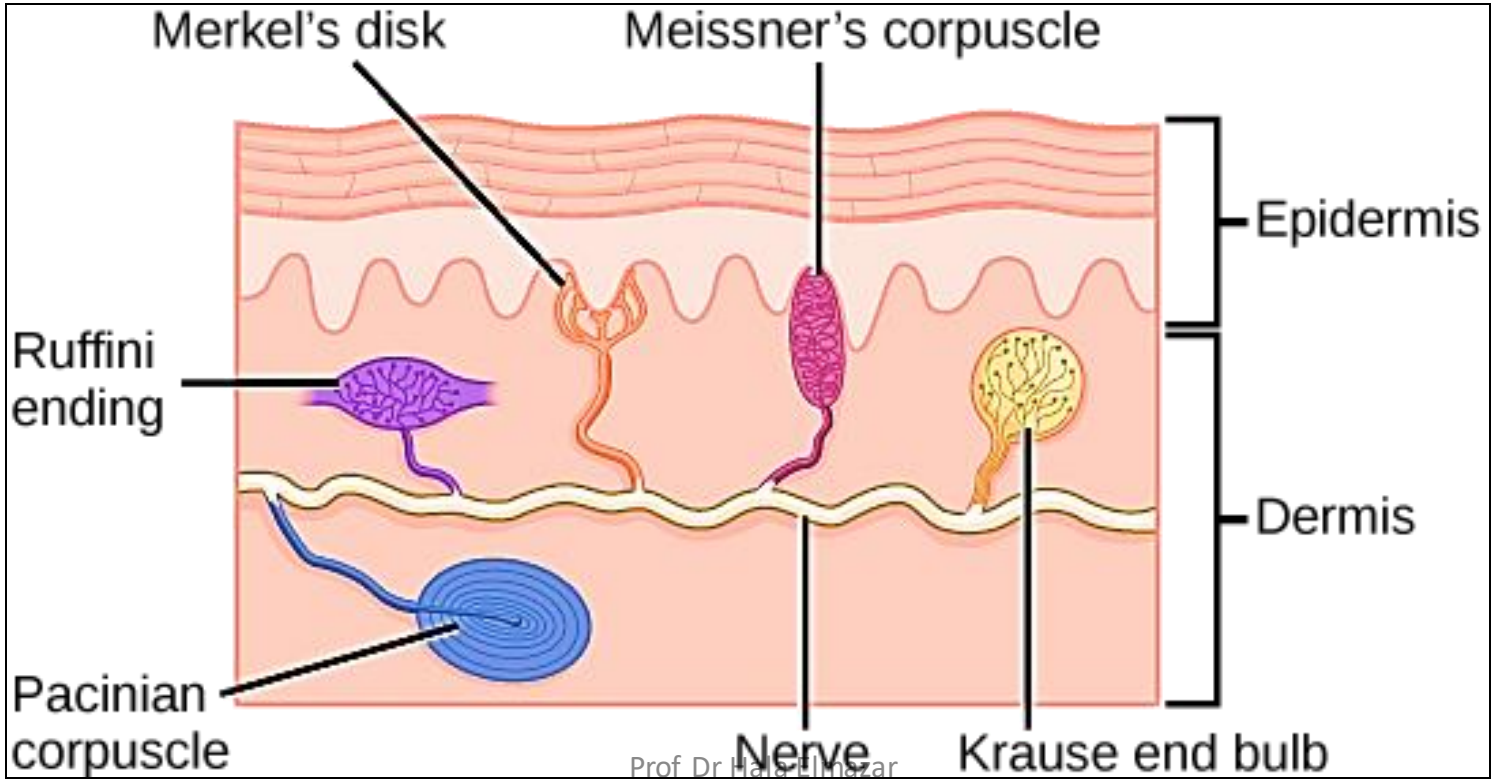




Nerve endings in connective tissue

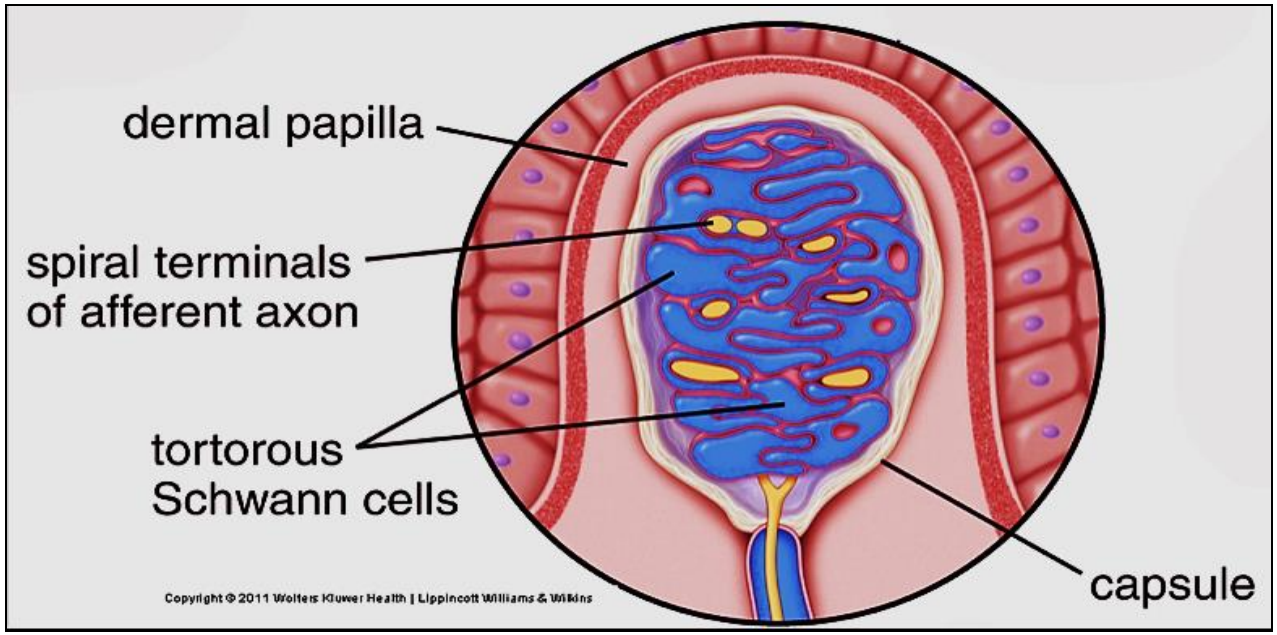
1- Meissner's corpuscles

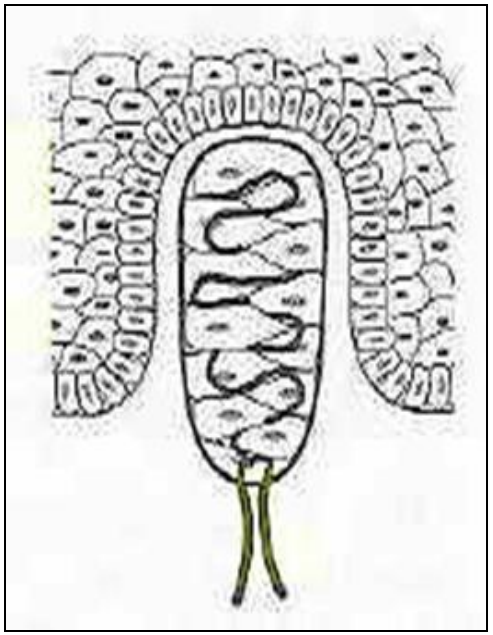
- Oval shape, encapsulated structures present in the dermal papillae **(deep)** of skin that is especially sensitive as tips of fingers (Hairless skin)
- They detect **light touch** (mechanoreceptors)



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

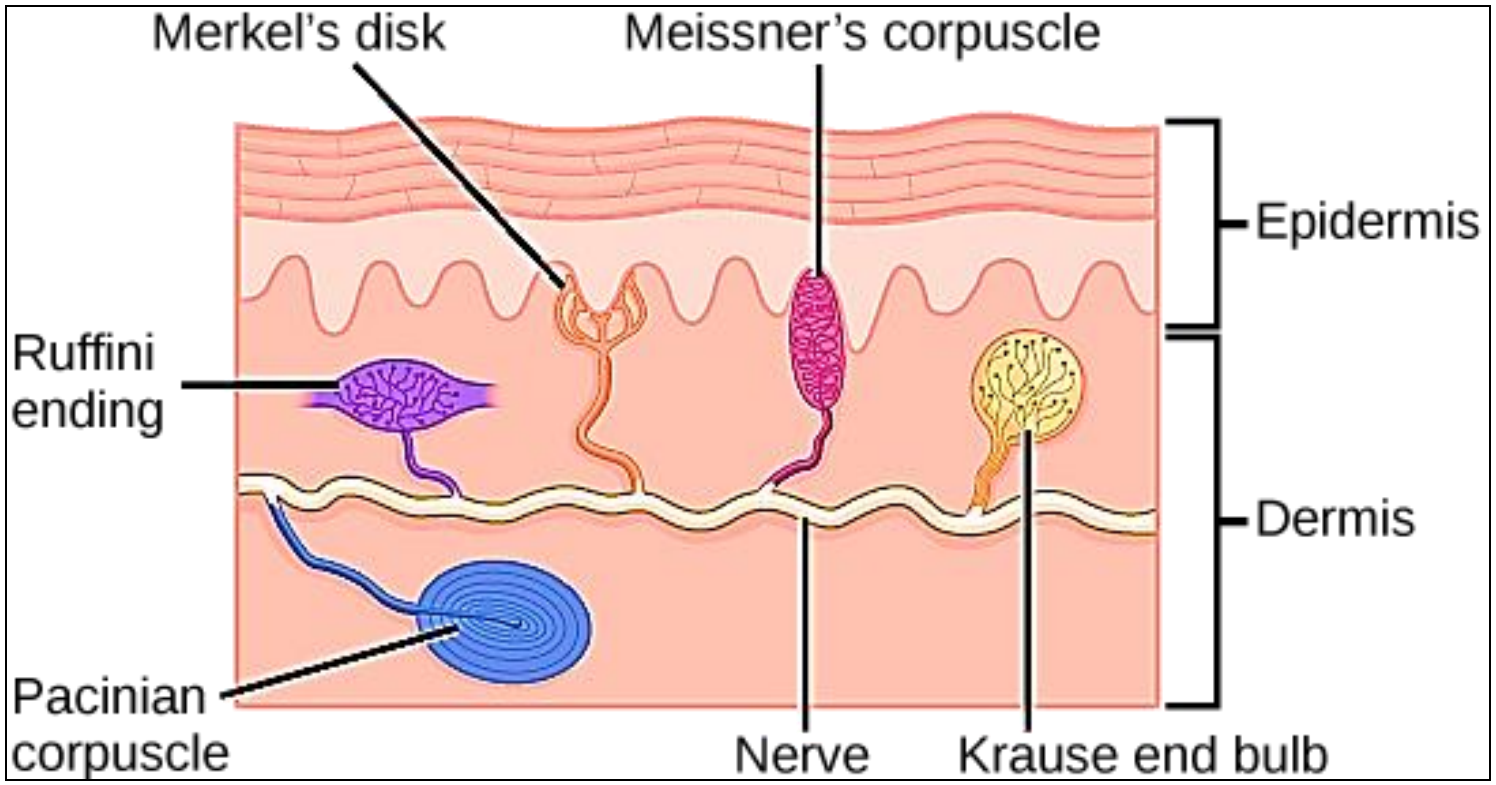
- The aff axon enter the corpuscle after losing its myelin & spiral up between the cells until it ends at upper end of the corpuscle



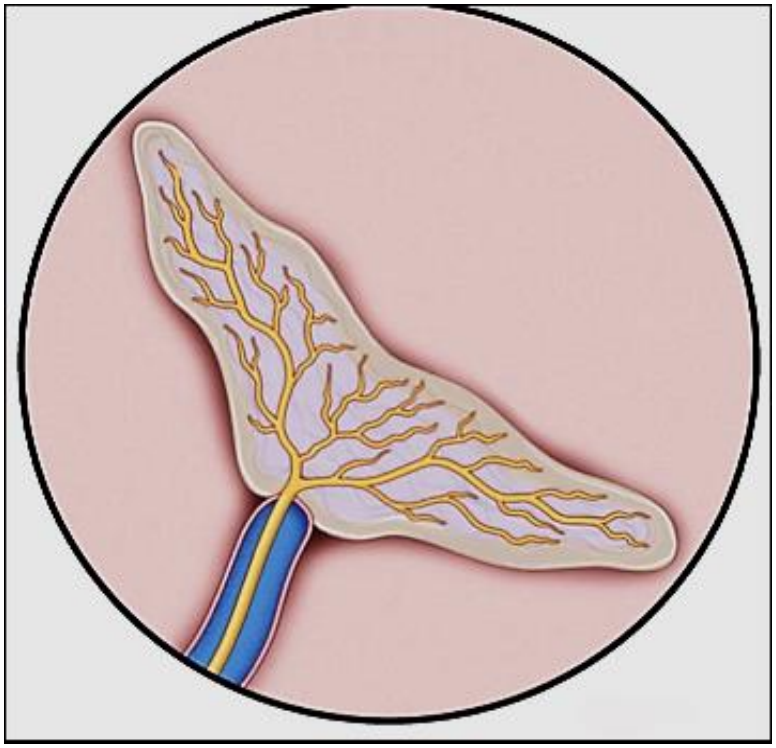


2- Ruffini Corpuscles

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



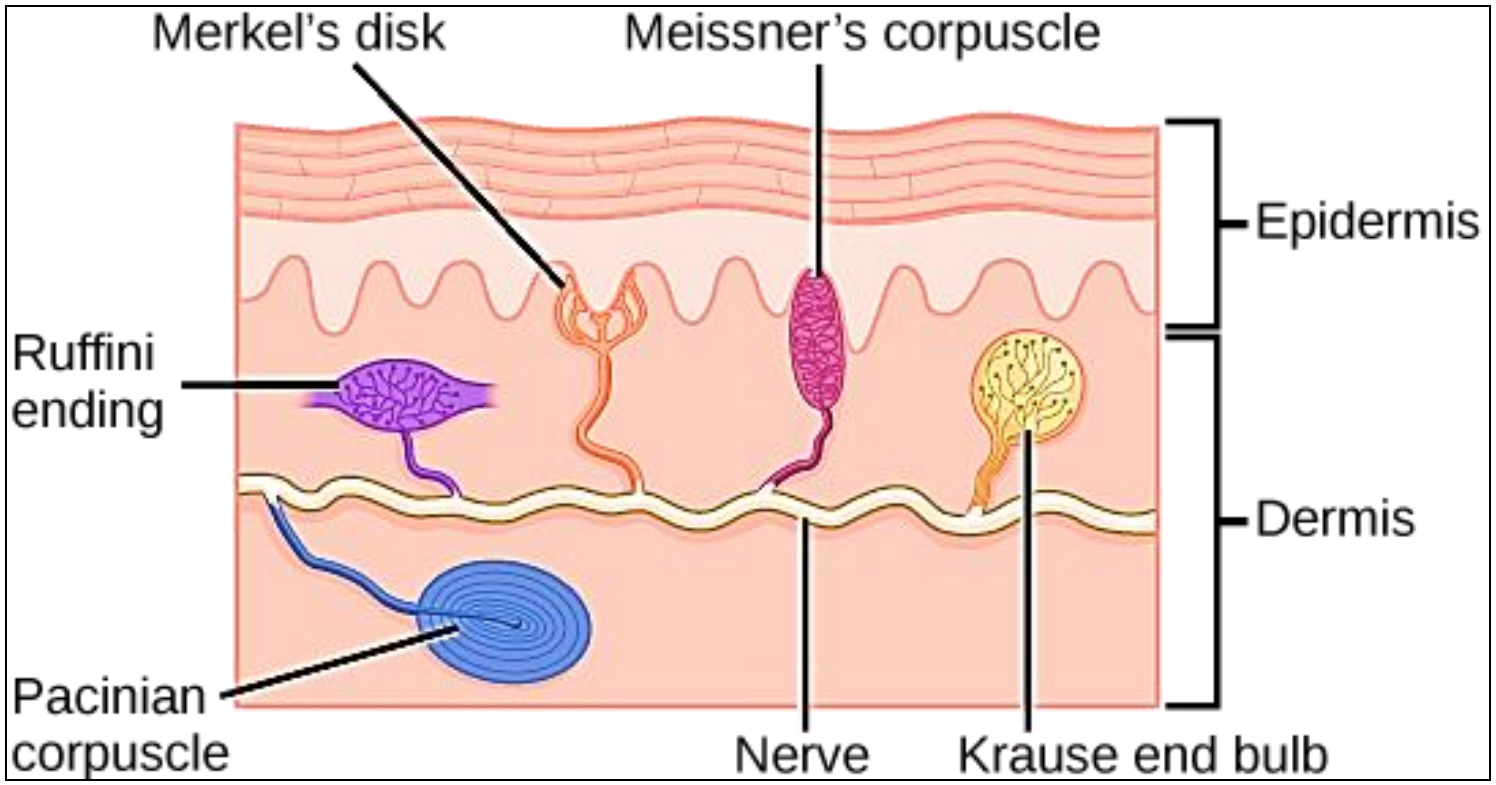
- Inside the capsule there is a **fluid** & collagenous fibers
- The aff nerve fiber lose its myelin penetrates the side of the corpuscle & breaks up into fine branches



Ruffini's corpuscle

3- Krause end bulbs

- Rounded structures, encapsulated
- Found **deep in the dermis** of the skin
- Detect touch/ cold (mechano/ thermo receptors)

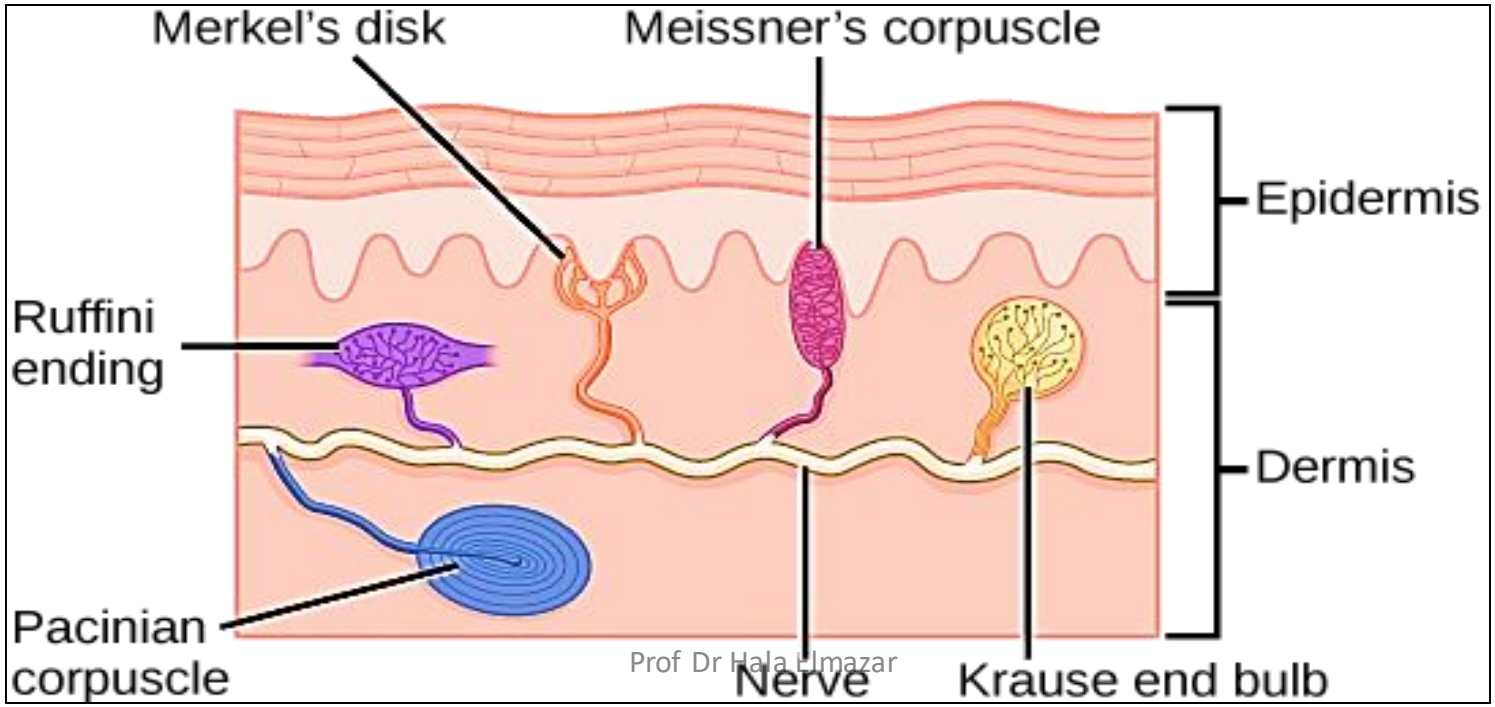


- The aff. nerve fiber penetrate the corpuscles after losing its myelin and breaks up into fine branches terminate with **coiled ends**

Krause's end bulb

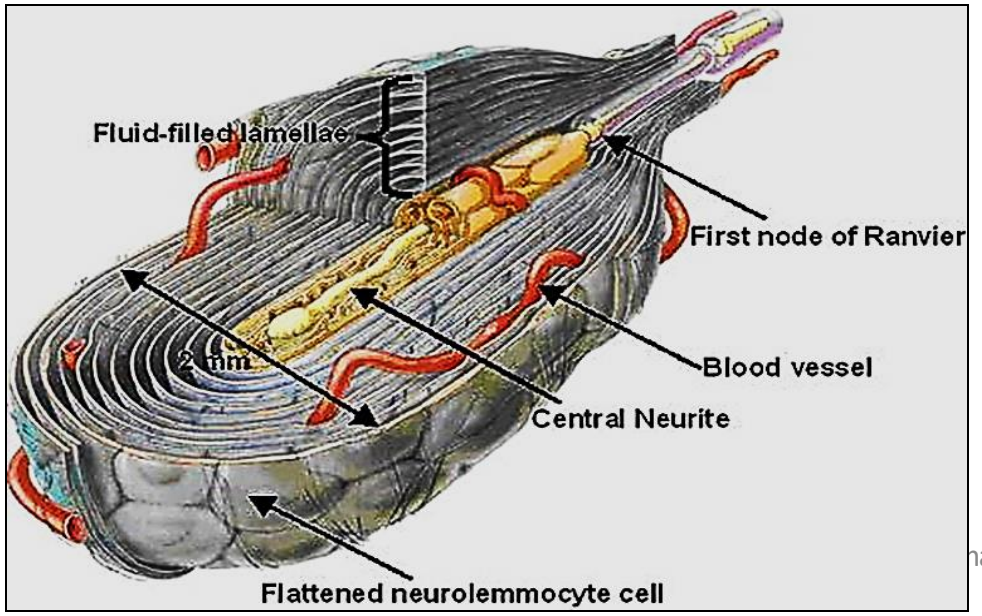
4- Pacinian corpuscles

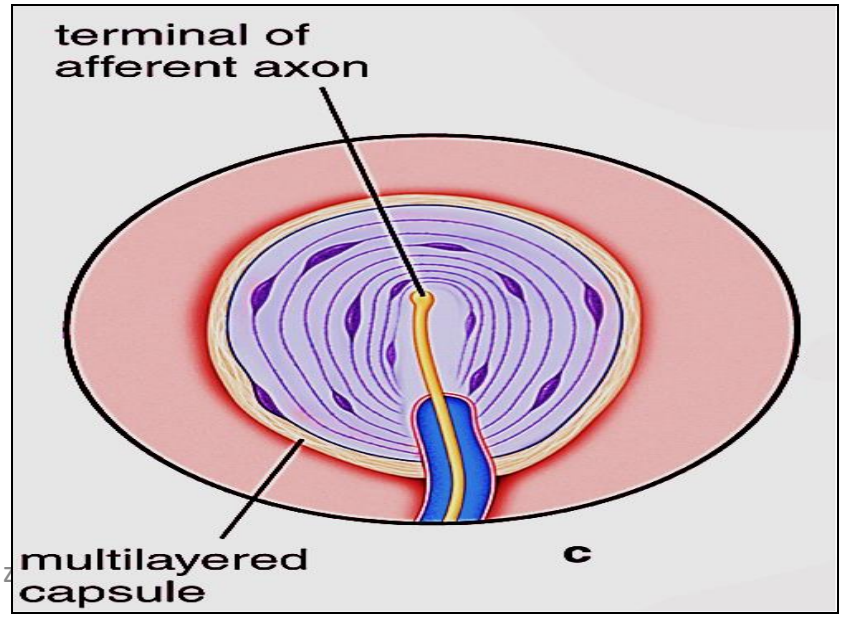
- Large oval encapsulated structures
- Found **deep in dermis**
- Detect **deep touch** (mechanoreceptors), high frequency vibration, pressure
- It is one of the proprioceptors

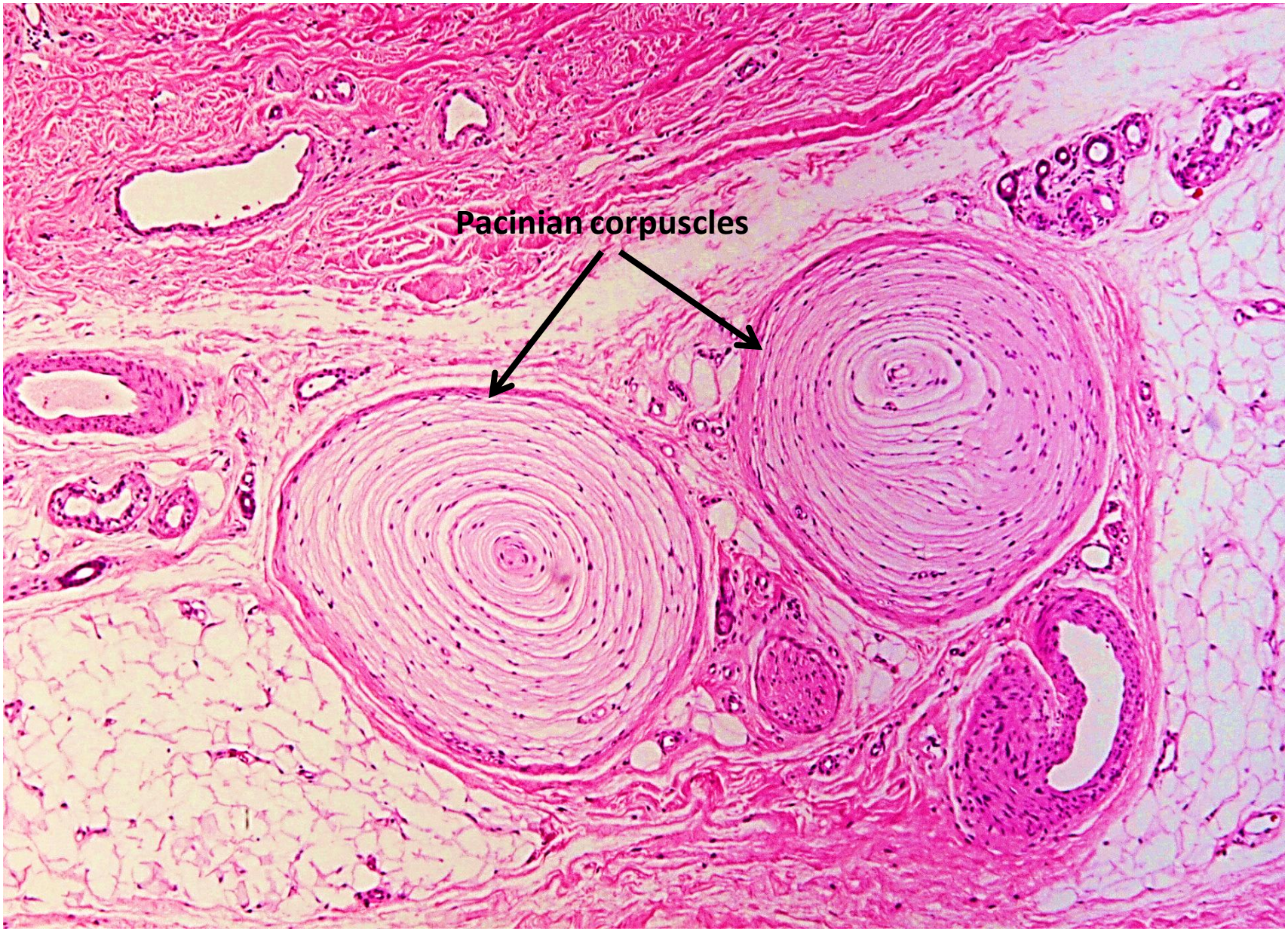


- It is formed of 20-50 thin, concentric lamellae of flat Schwan –like cells separated by narrow spaces filled e gel – like material

- The aff. 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



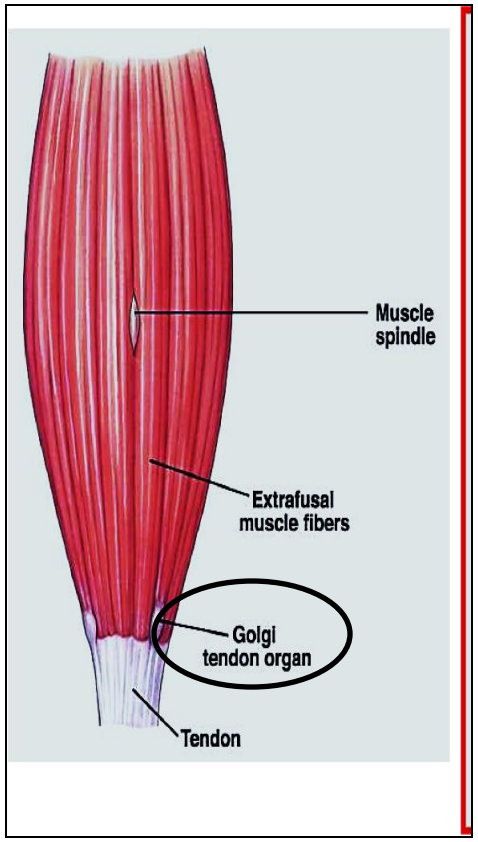


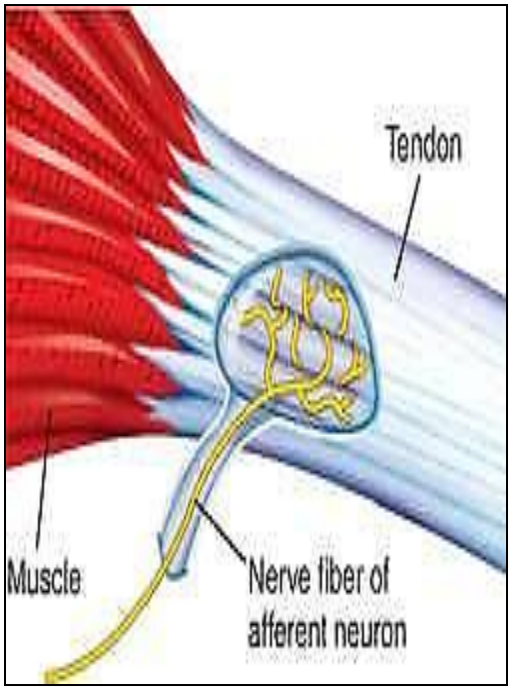

Pacinian corpuscles

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)

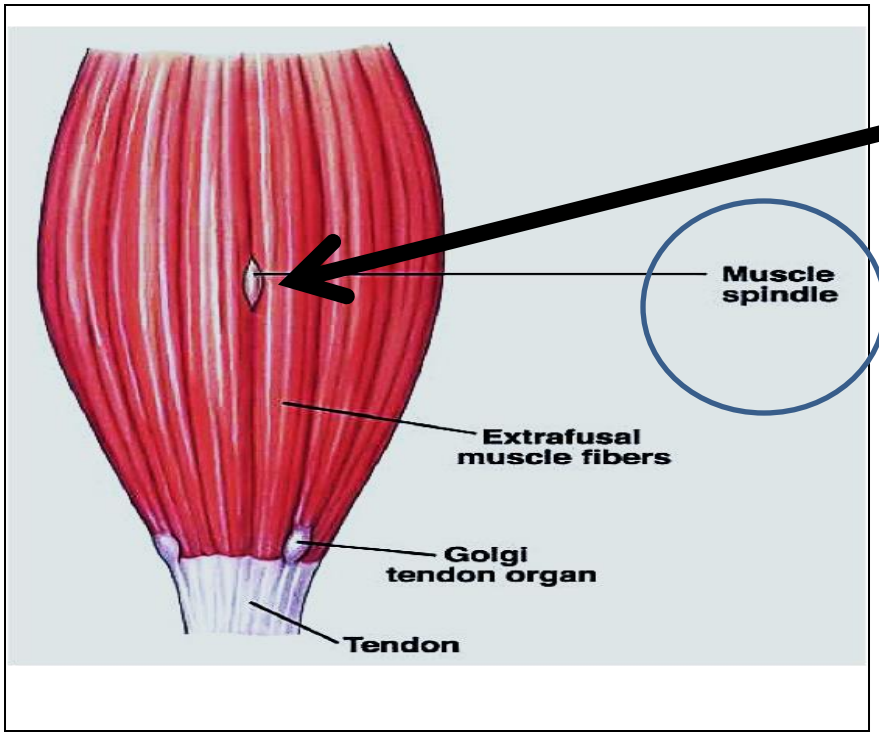
- Sensory nerve penetrates the capsule of the tendon spindle to end around the collagen bundles to detect tension of tendons



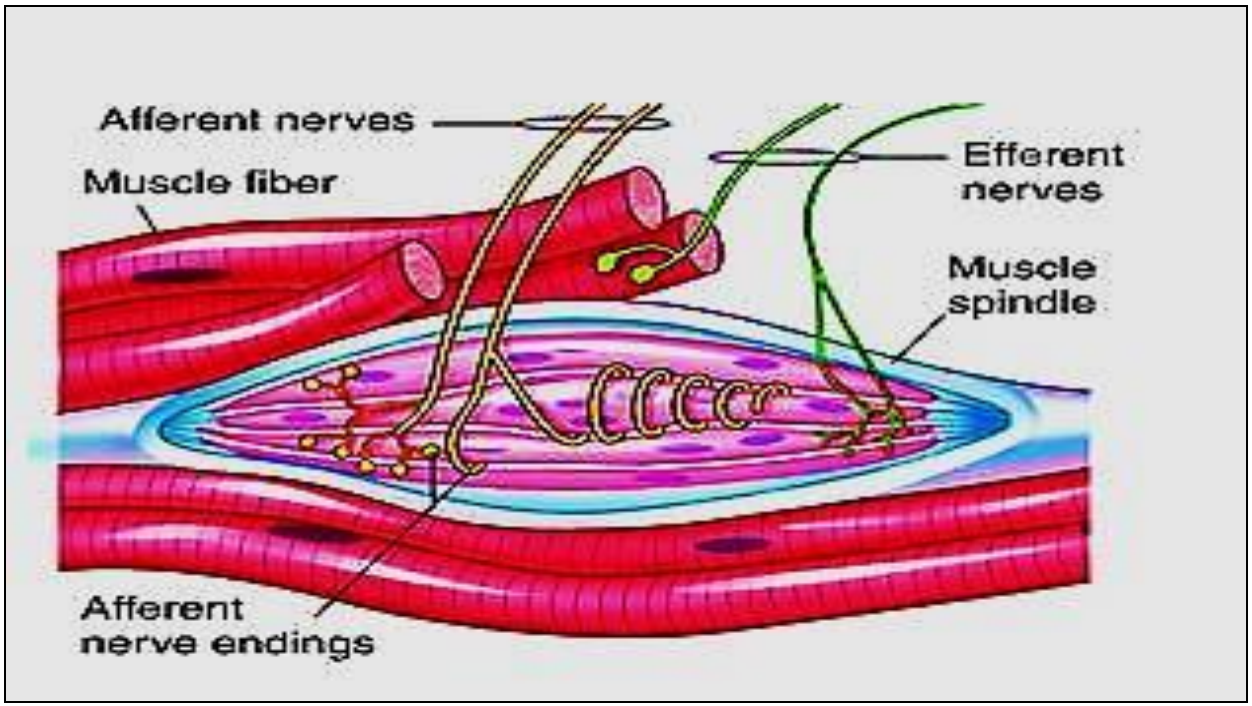


Muscle spindles

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



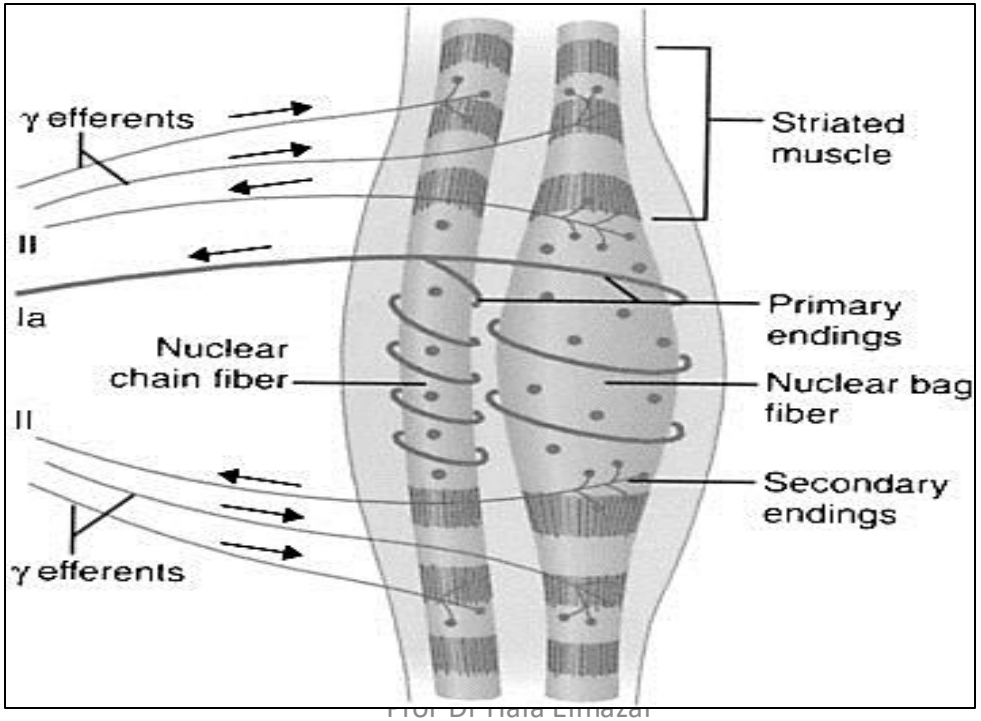
- Fusiform structures enclosed by stretchable CT capsule containing fluid filled space
- The space contains a few (2-12) thin skeletal ms. fibers **intrafusal fibers**
- Several sensory nerve fibers penetrate each ms spindle & wrap around individual intrafusal fibers



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

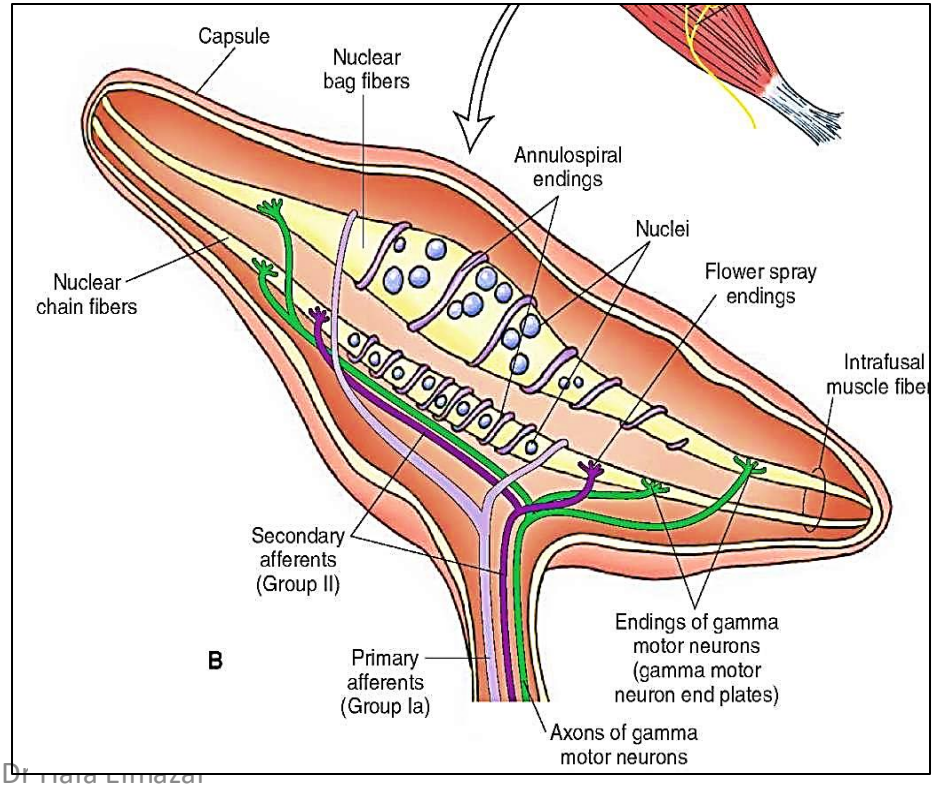
- **The nuclear bag fiber is supplied with a sensory nerve fiber which end around its center and called 1ry sensory fiber (annulospiral)**
- **The nuclear chain fiber is supplied by 1ry sensory (annulospiral) at its center and two 2ry sensory (flower spray) one at each end**

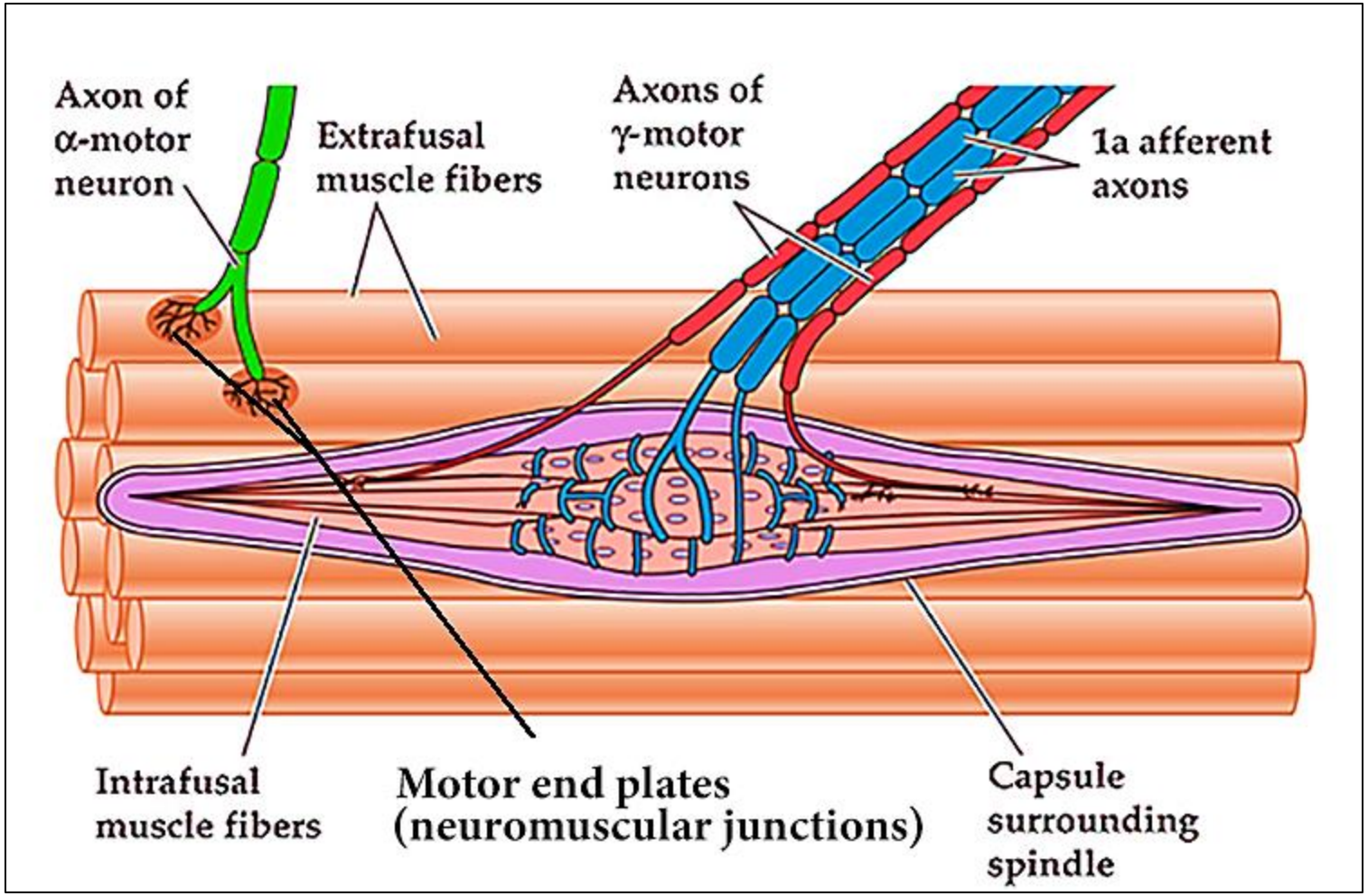
(Total 3 sensory fibers)

The motor (efferent) fibers:

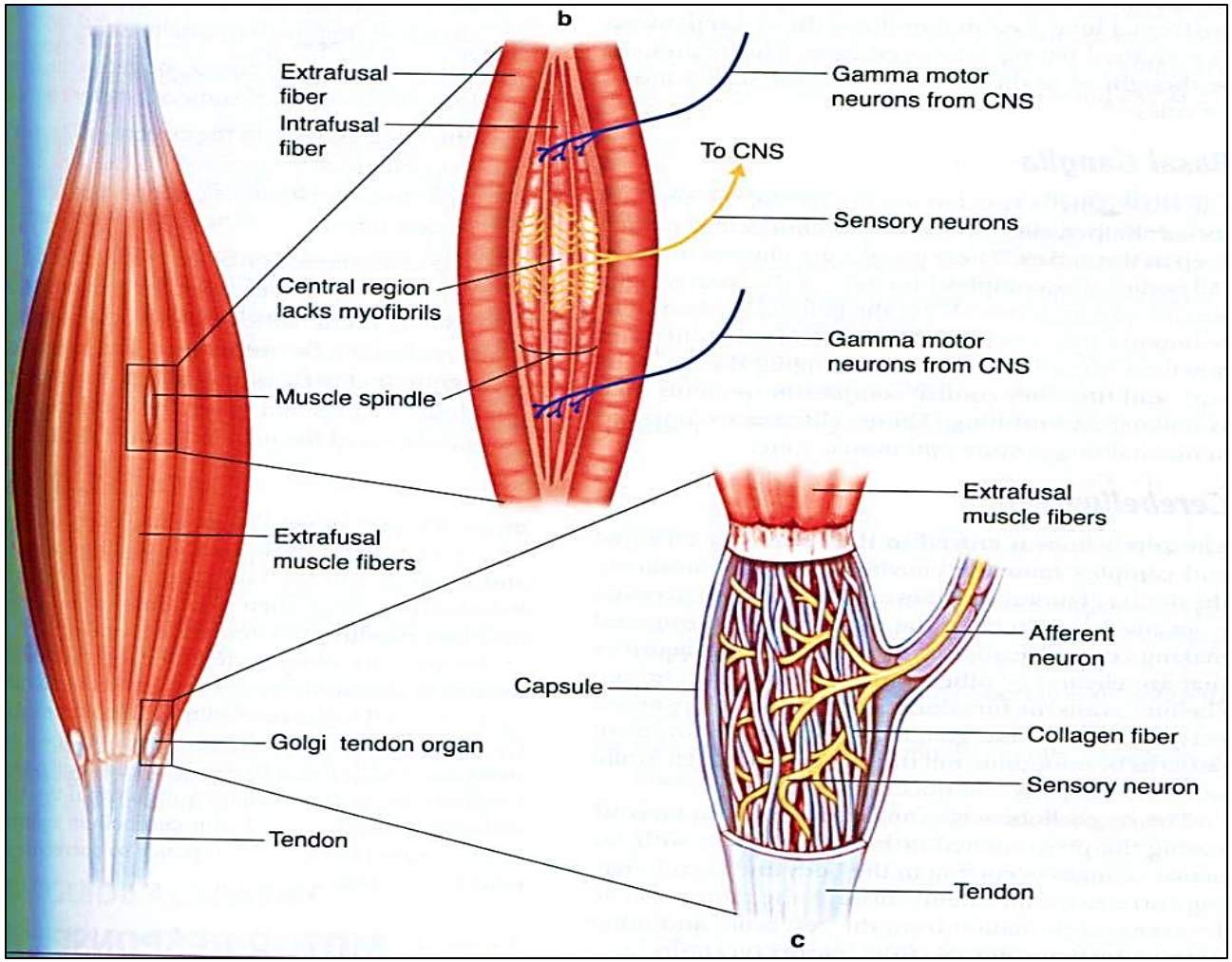
- **Enter the capsule to supply the contractile ends of the intrafusal fibers**

(gamma motor fibers)





Muscle spindle and Motor end plate



Muscle spindle and Golgi tendon

Thank you