



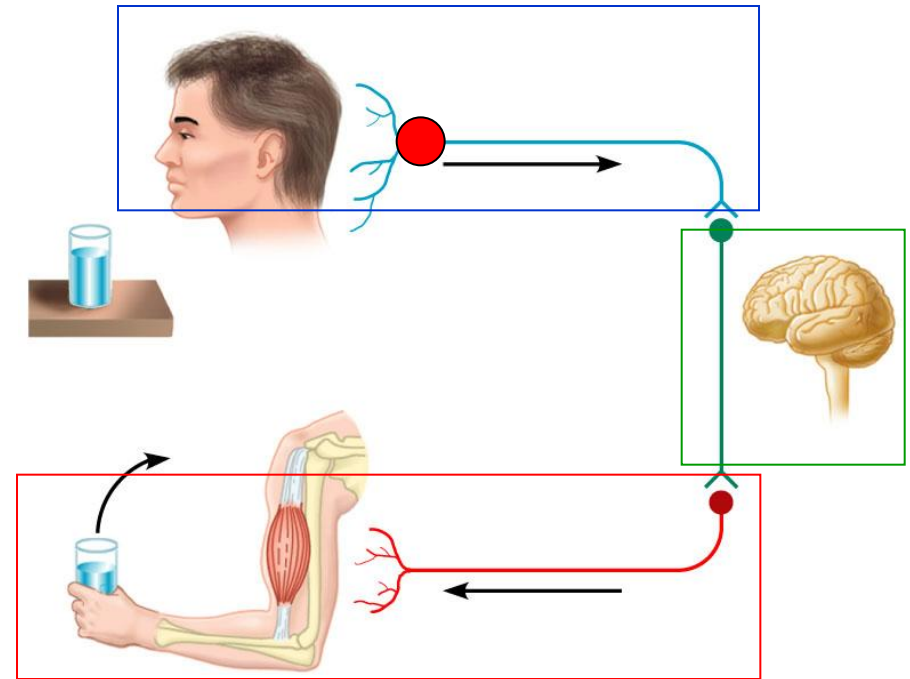
Nervous Tissue

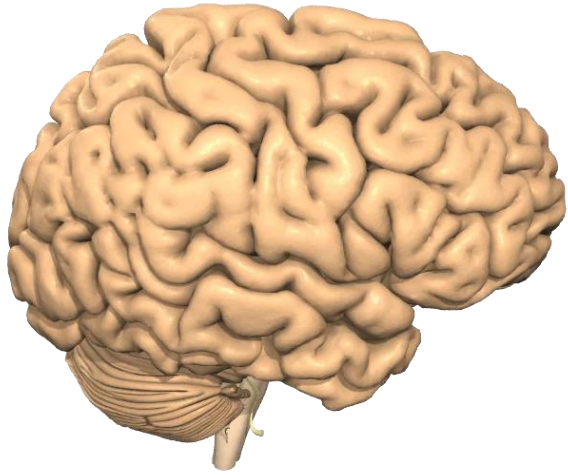


Dr. Heba Kalbouneh
Associate Professor of Anatomy and Histology

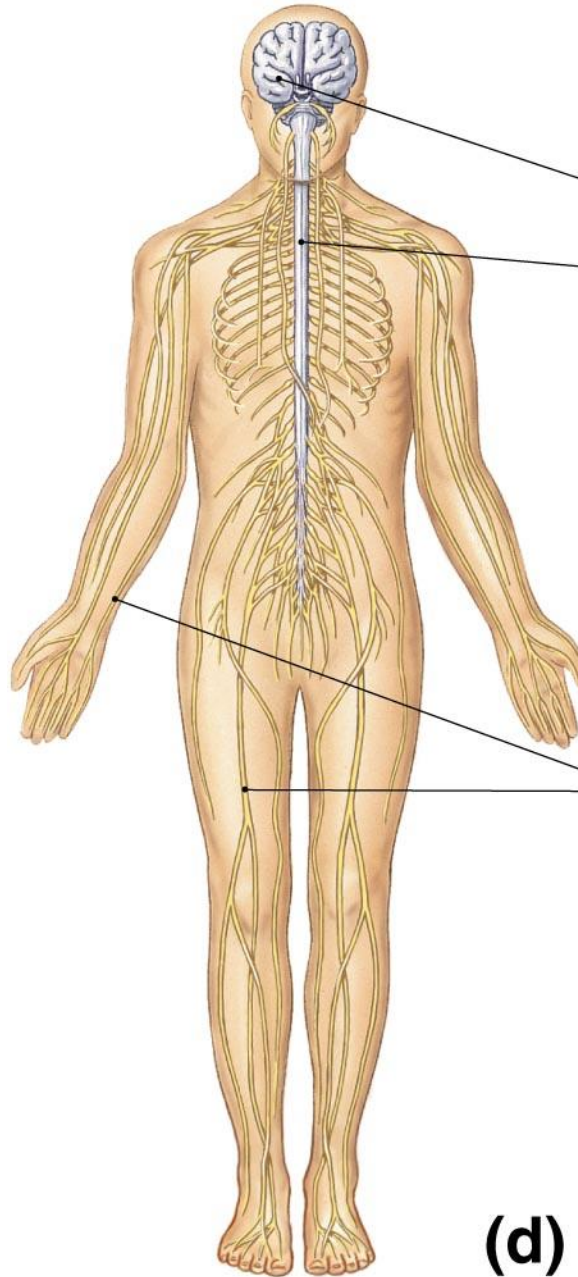
Nervous Tissue

- Controls and integrates all body activities within limits that maintain life
- Three basic functions
 1. sensing changes with **sensory receptors**
 2. **interpreting** and remembering those changes
 3. **reacting** to those changes with effectors (motor function)





PRIMAL PICTURES 



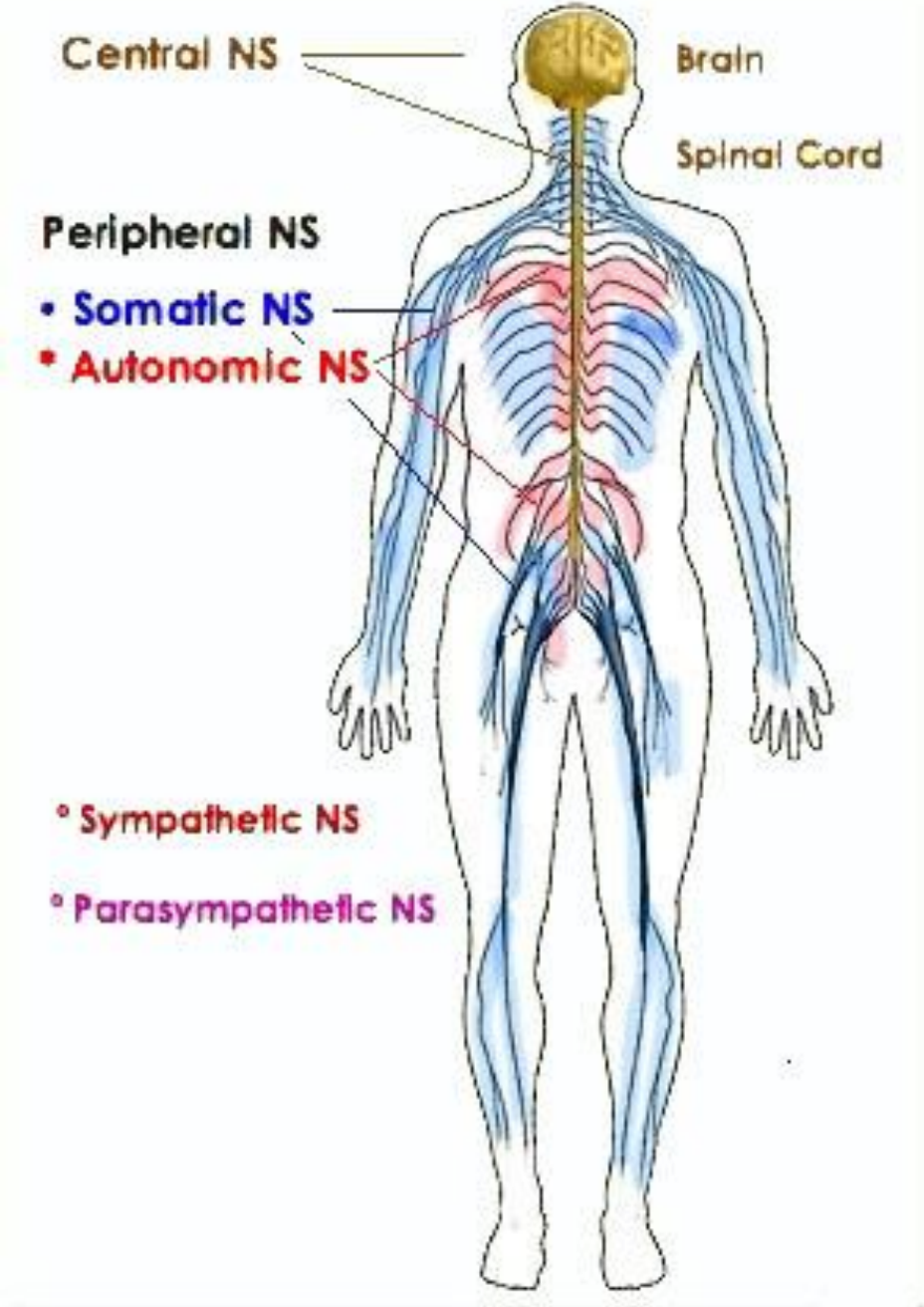
Central nervous system
Brain
Spinal cord

Peripheral nervous system
Peripheral nerves

(d)

The PNS is divided into :

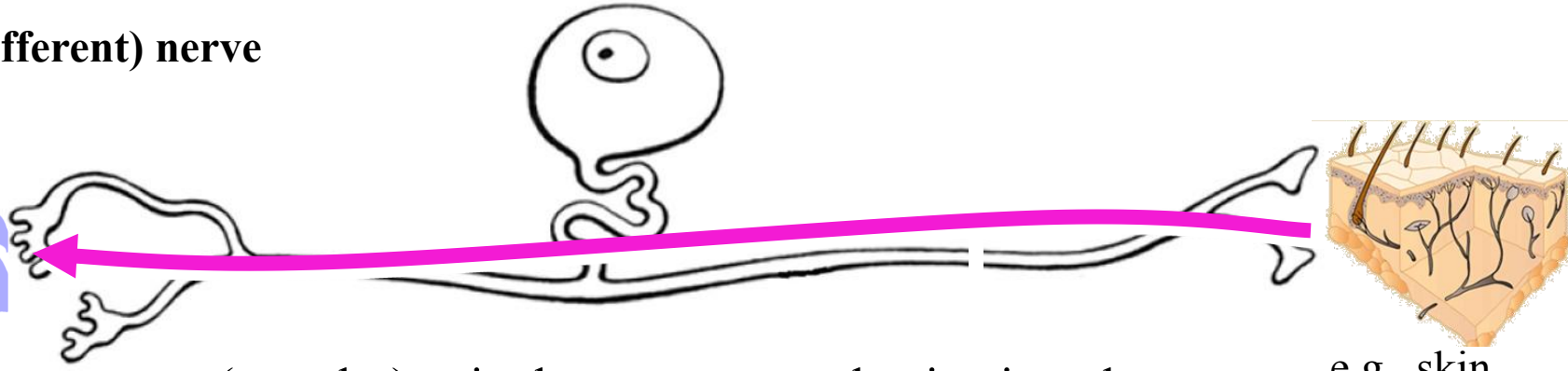
- 1- **Somatic nervous system (SNS)**
- 2- **Autonomic nervous system (ANS)**



Sensory (Afferent) vs. Motor (Efferent)

sensory (afferent) nerve

CNS

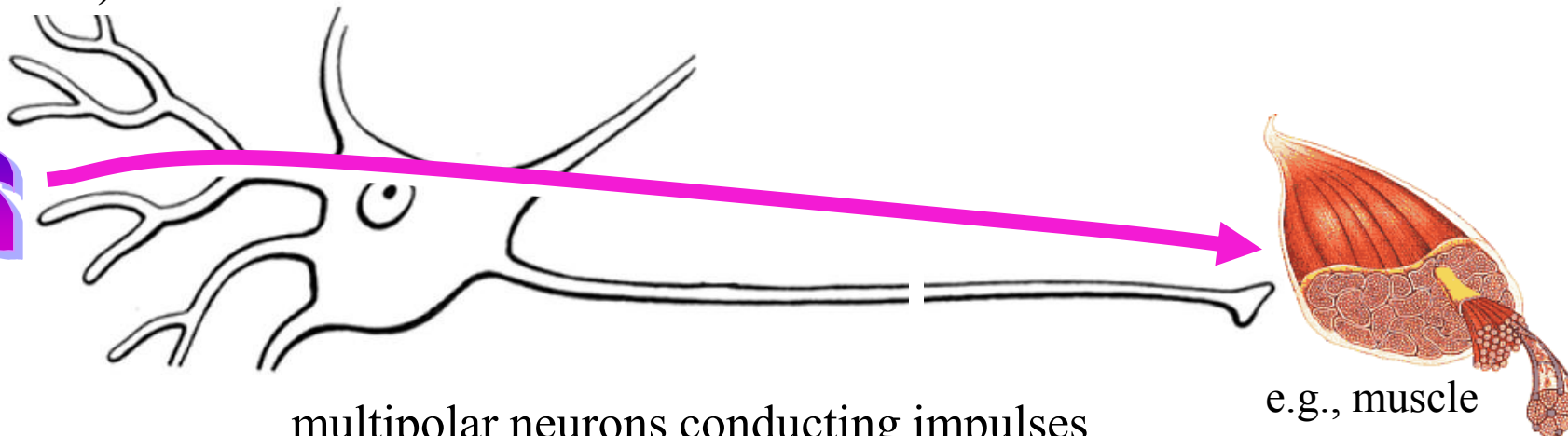


(pseudo-) unipolar neurons conducting impulses from sensory organs to the CNS

e.g., skin

motor (efferent) nerve

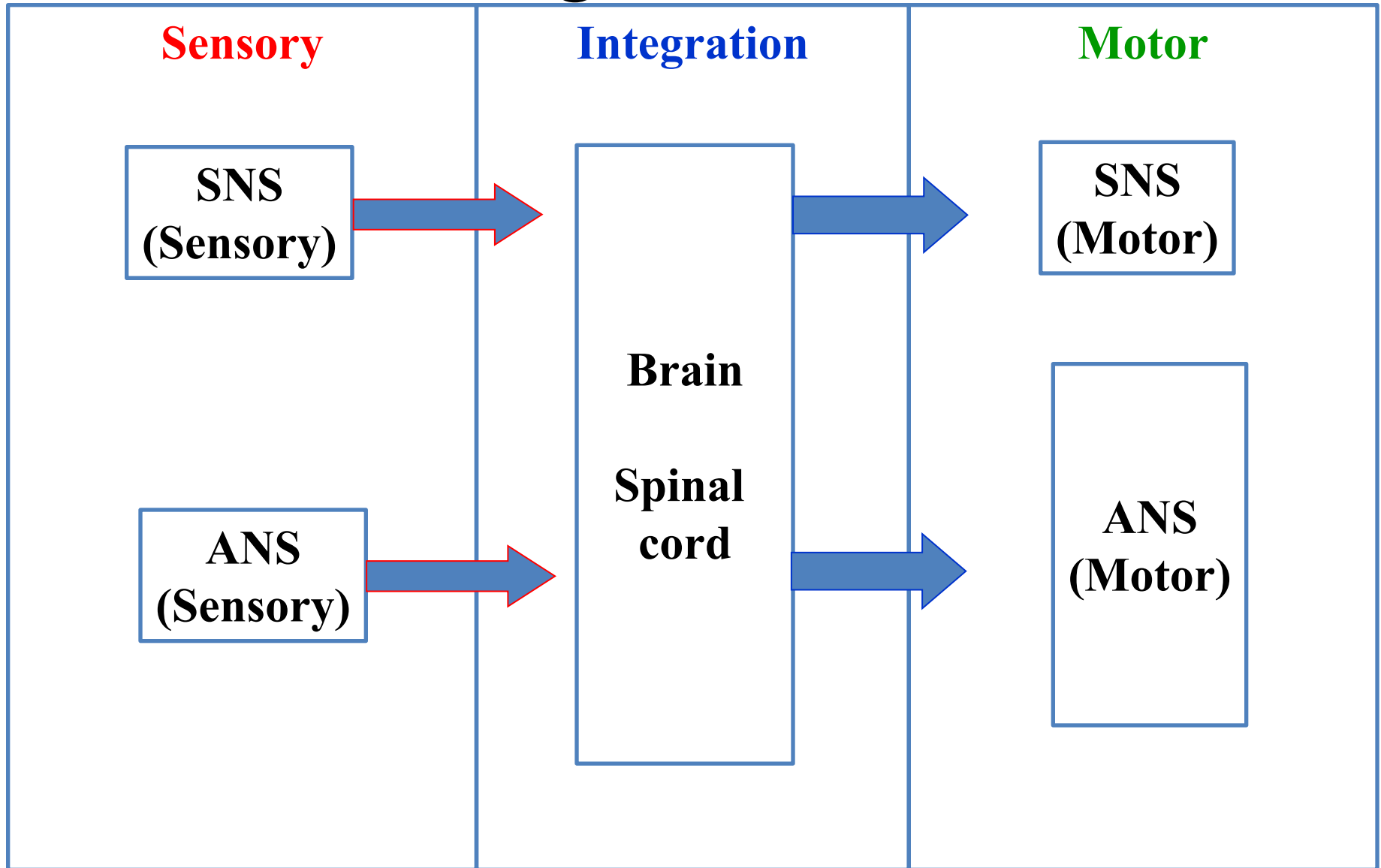
CNS



multipolar neurons conducting impulses from the CNS to effector organs (muscles & glands)

e.g., muscle

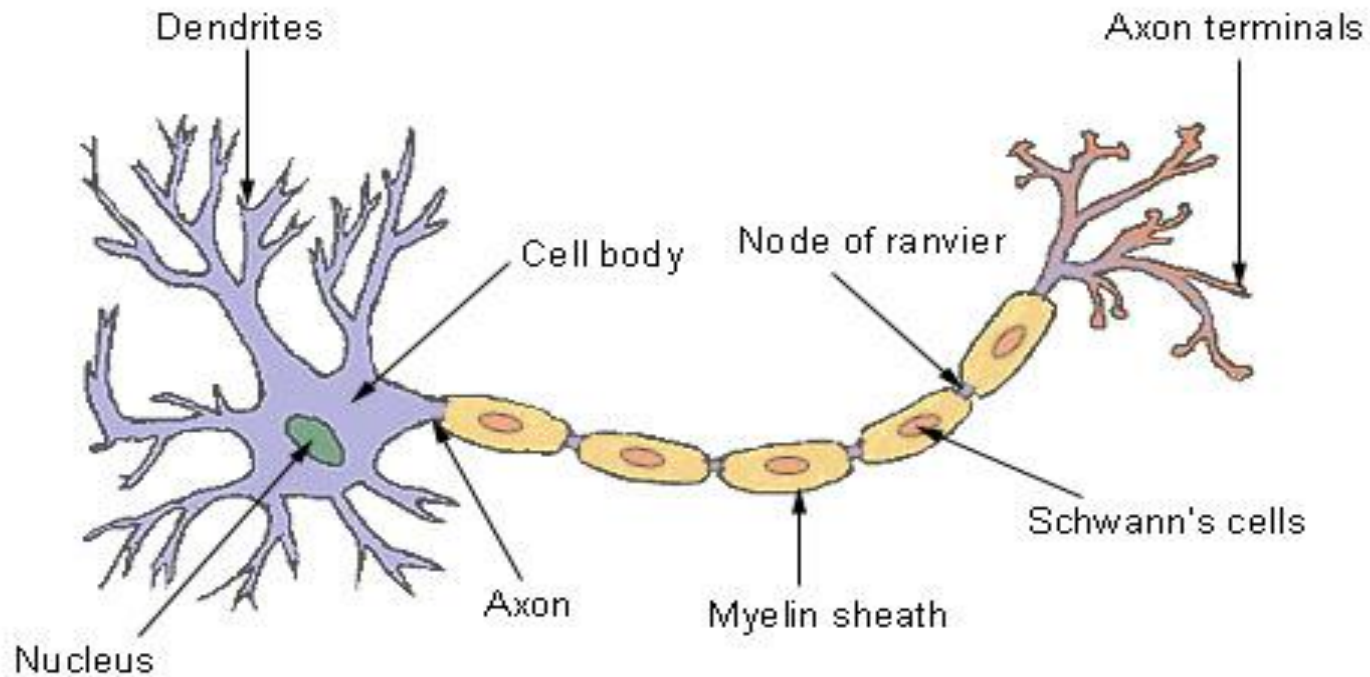
Organization



Neuron has three parts:

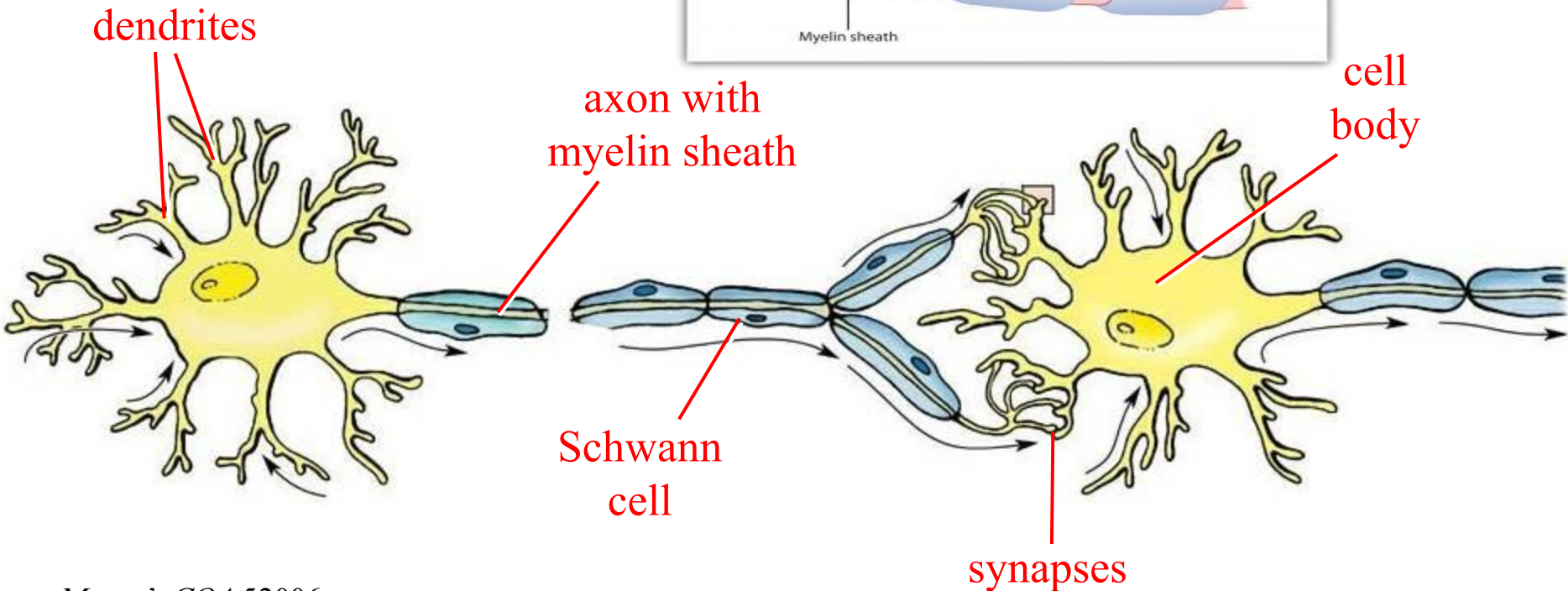
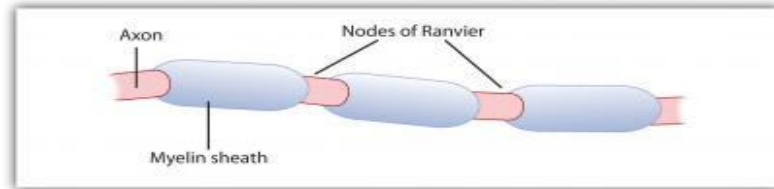
- (1) a cell body: *perikaryon or soma*
- (2) dendrites
- (3) an axon

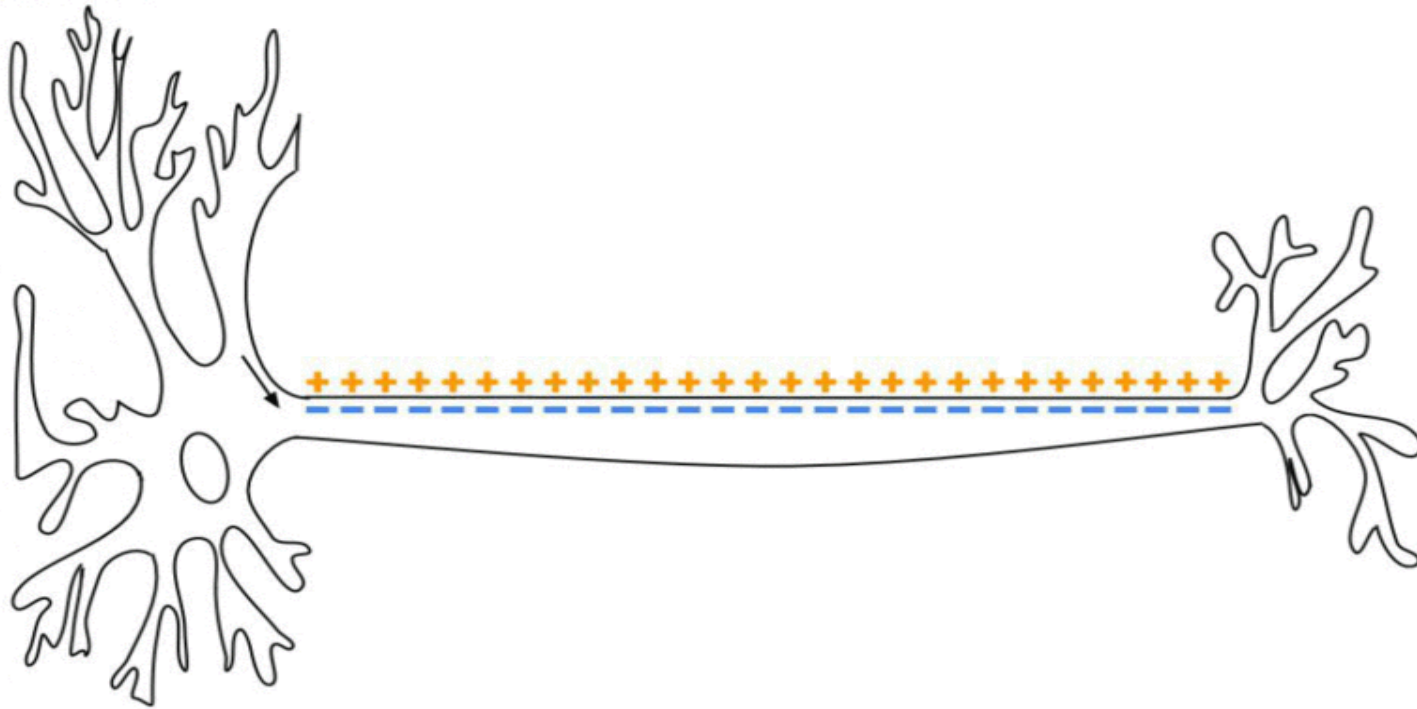
Structure of a Typical Neuron



Neurons

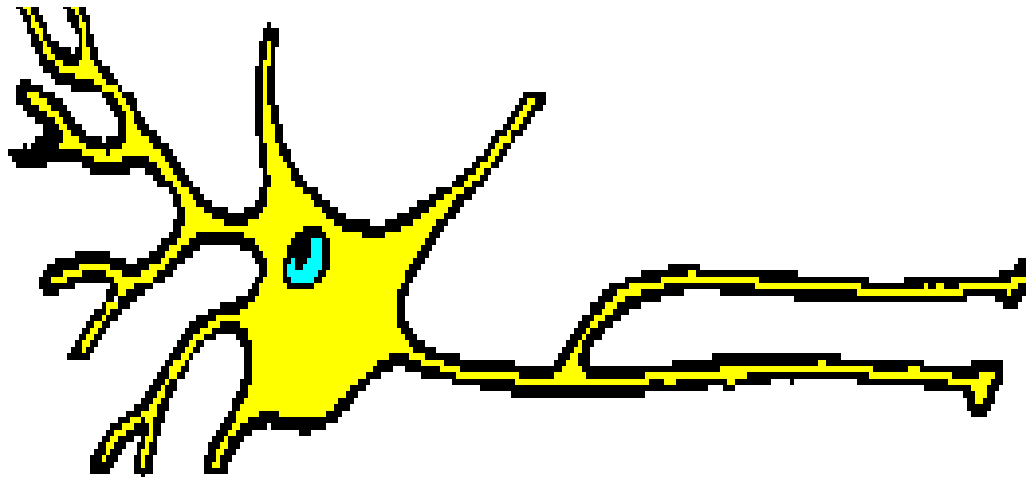
- Dendrites: carry nerve impulses toward cell body
- Axon: carries impulses away from cell body
- Synapses: site of communication between neurons using chemical neurotransmitters
- Myelin & myelin sheath: lipoprotein covering produced by glial cells (e.g., Schwann cells in PNS, oligodendrocytes in the CNS) that increases axonal conduction velocity





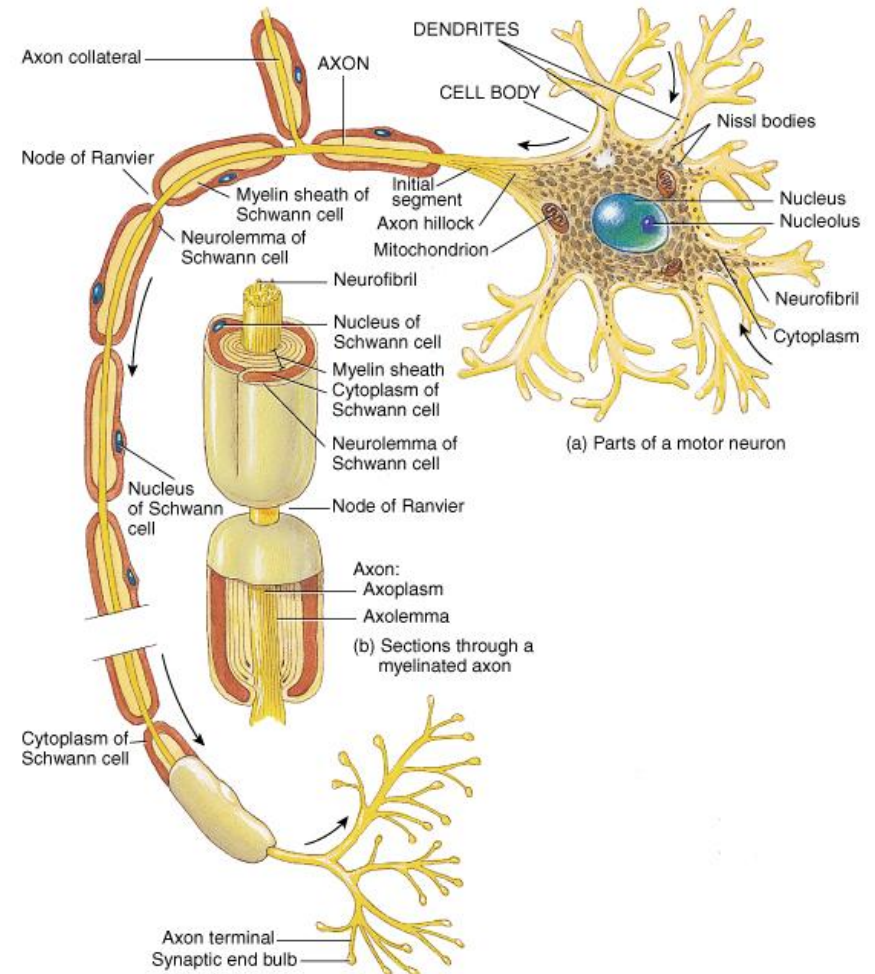
Notice that action potential propagation is unidirectional

MakeAGIF.com



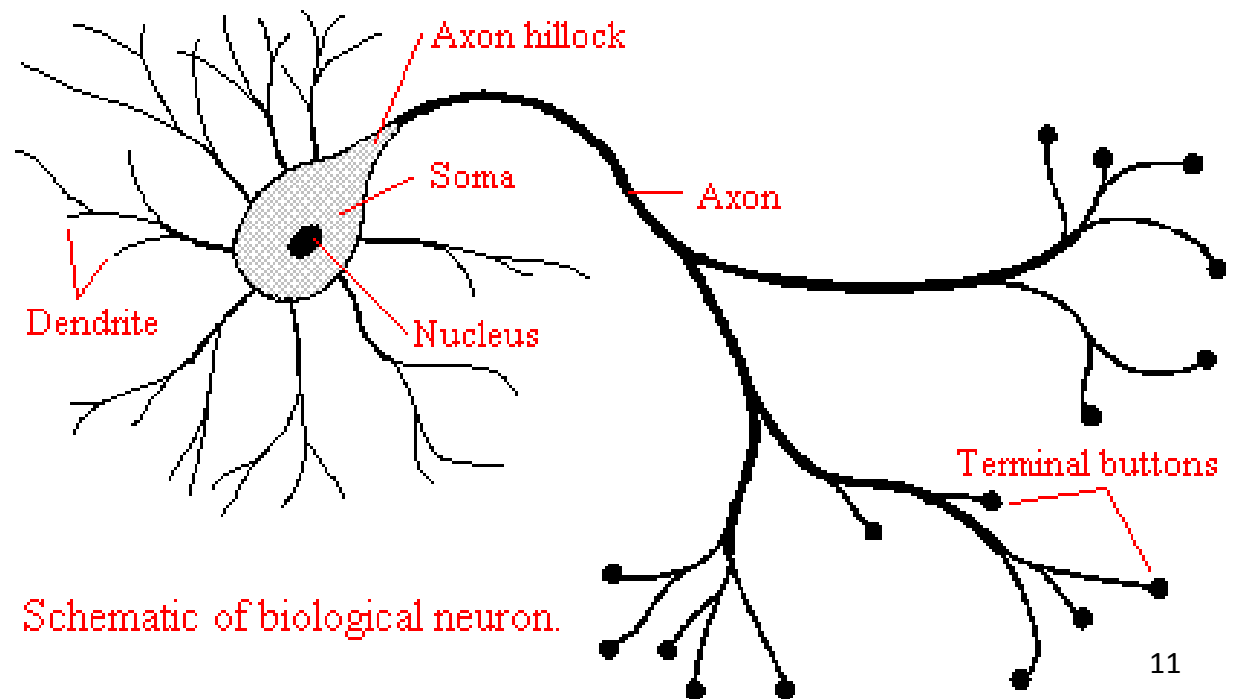
Neurons

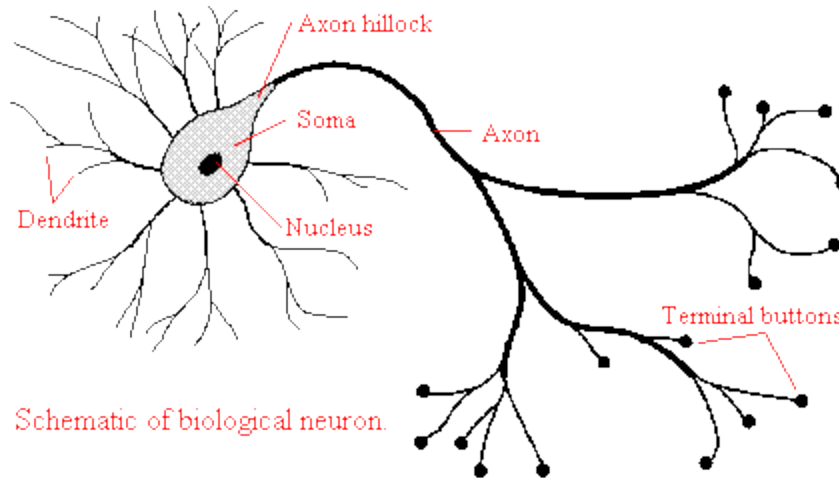
1. Cell body
 - a) Nissl bodies
 - b) Golgi apparatus
 - c) Neurofilaments (IFs)
 - d) Microtubules
 - e) Lipofuscin pigment clumps
2. Cell processes
 - a) Dendrites
 - b) Axons



Structure of neurons

- **Axoplasm:** cytoplasm of axon
- **Axolemma:** cell membrane of axon
- **Axon hillock:** where axon originates from soma
- **Synaptic boutons:** swelling of axon terminal
- **Synapse:** junction axon makes with cell acting upon
- Synaptic vesicles



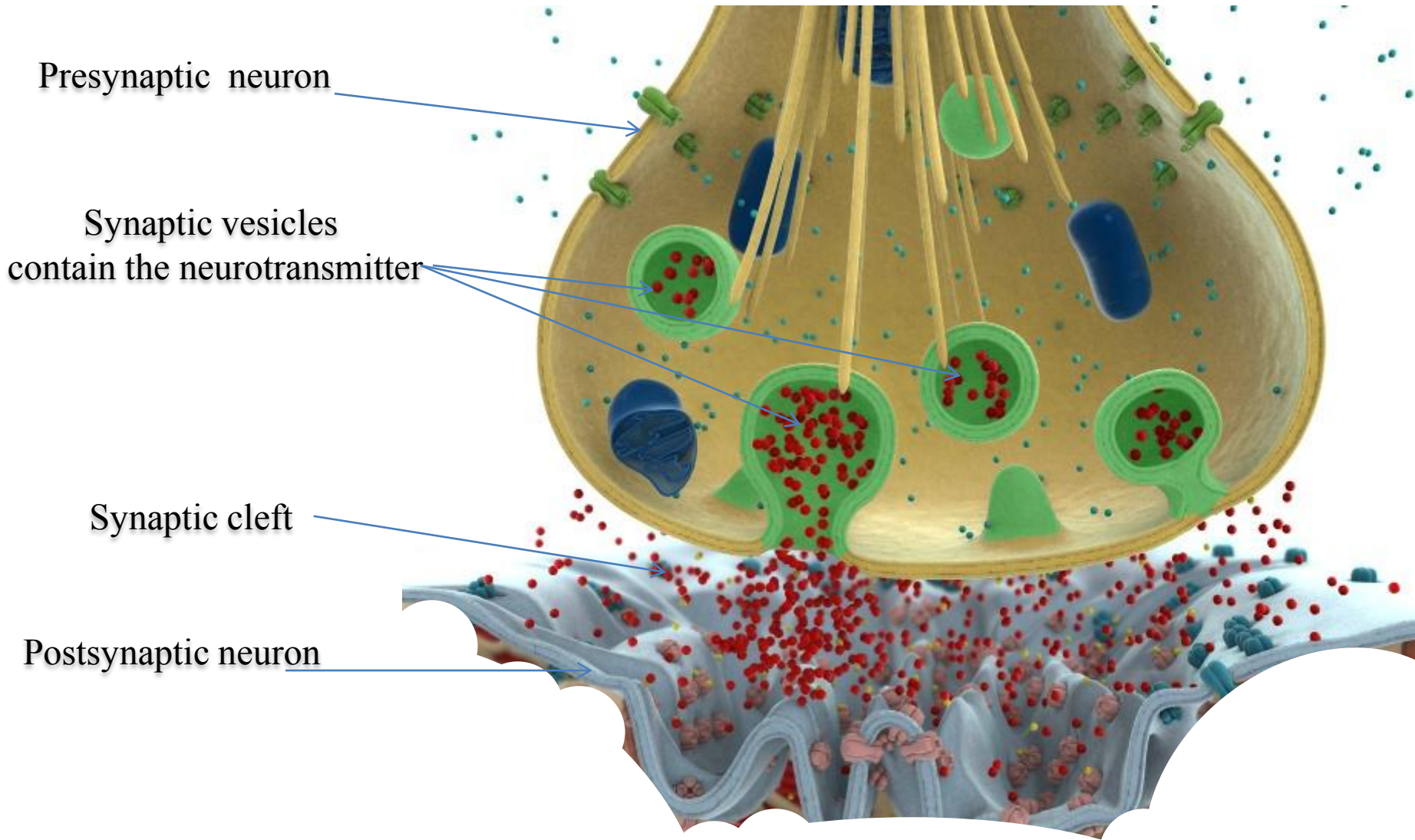


Axon

- Nearly constant diameter
- Much Longer
- Branches less profusely
- Distal end forms terminal arborization and terminal boutons
- Mostly myelinated, could be unmyelinated
- Axoplasm contains mitochondria, microtubules, neurofilaments and SER but not RER and ribosomes
- Bidirectional transport along the axon

Dendrite

- Becomes much thinner (tapering)
- short
- Branches profusely
- The cytoplasm of its base is similar to cell body
- Typically unmyelinated



Presynaptic neuron

Synaptic vesicles
contain the neurotransmitter

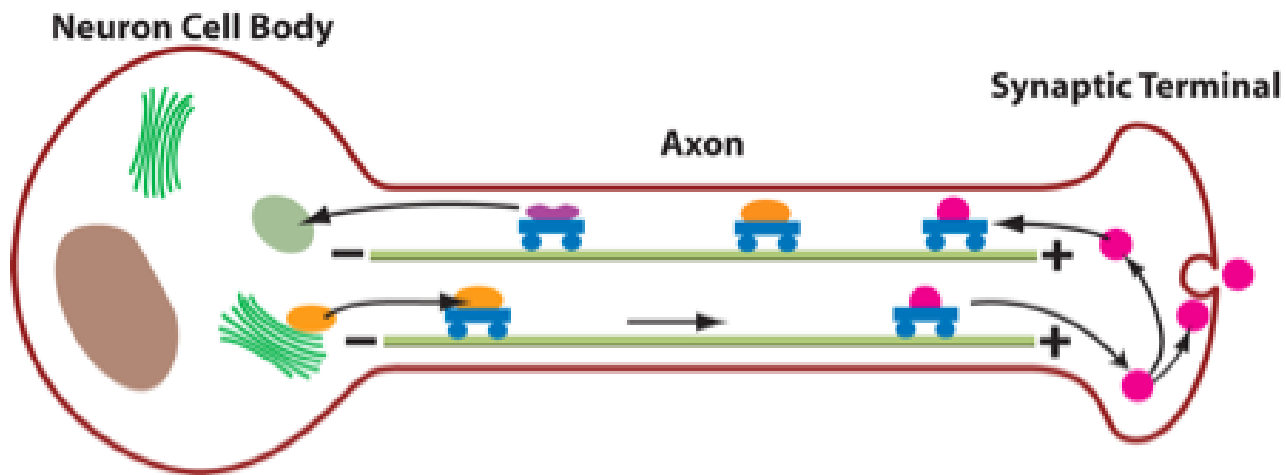
Synaptic cleft

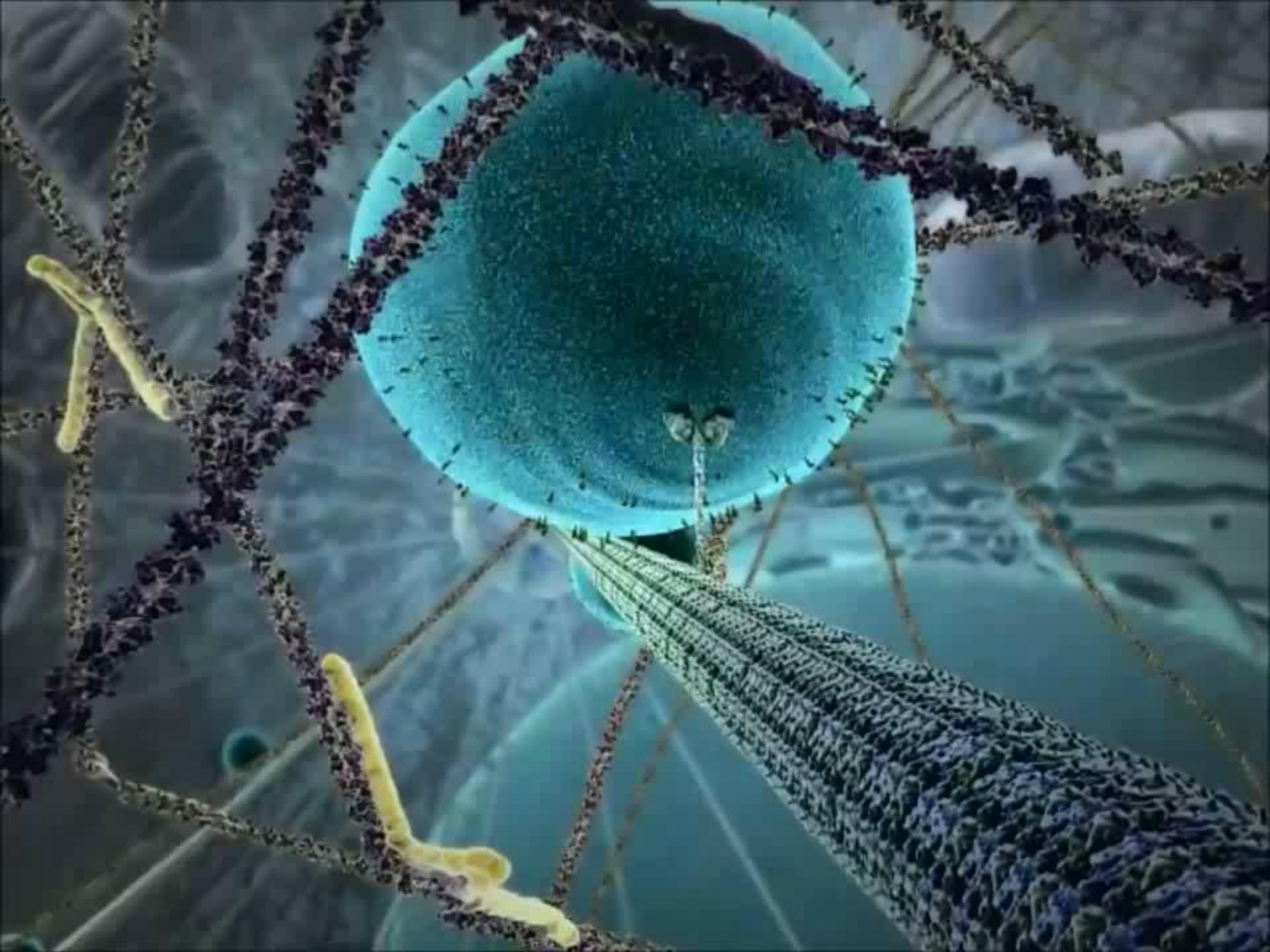
Postsynaptic neuron

Axonal transport

Anterograde: movement away from soma

Retrograde: movement up toward soma





Cells of nervous tissue

Neurons:

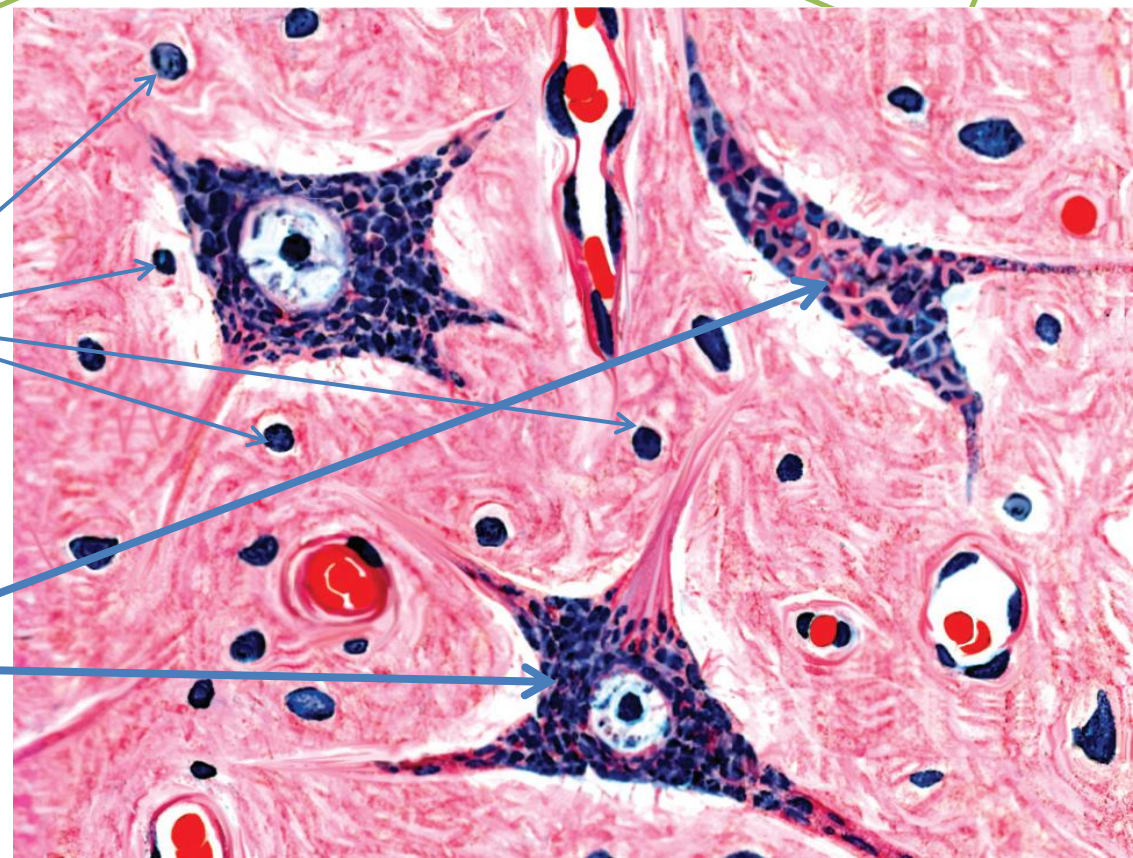
- Sensing, thinking, remembering, controlling muscle activity, and regulating glandular secretions
- Do not divide (no centriols!!!)
- Long lived
- High metabolic activity
- **Electrically excitable**

Neuroglia:

- Support, nourish, and protect neurons
- Divide
- Smaller cells but they greatly outnumber neurons

Neuroglia

Neurons



Structural classification of neurons

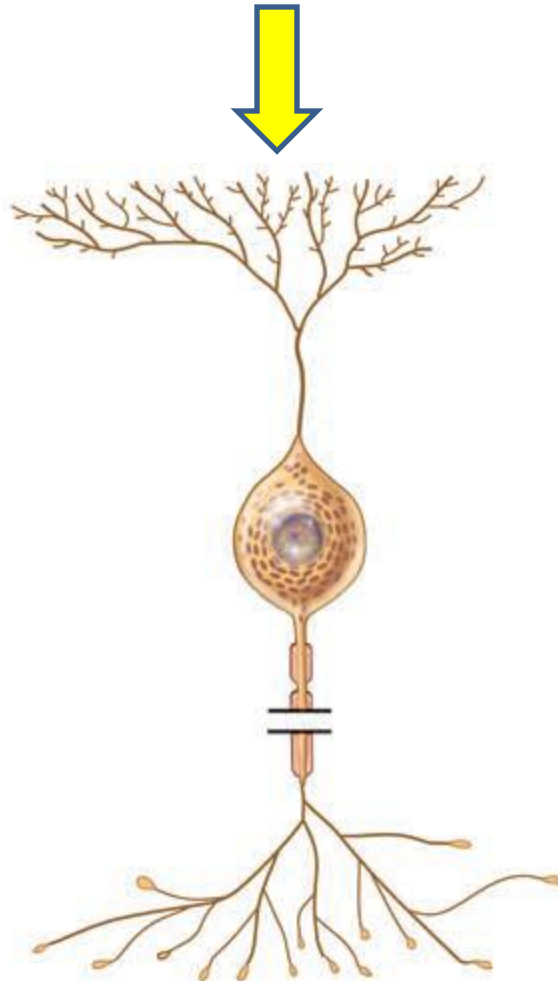
Multipolar neurons

- Usually have several dendrites and one axon
- Motor neurons



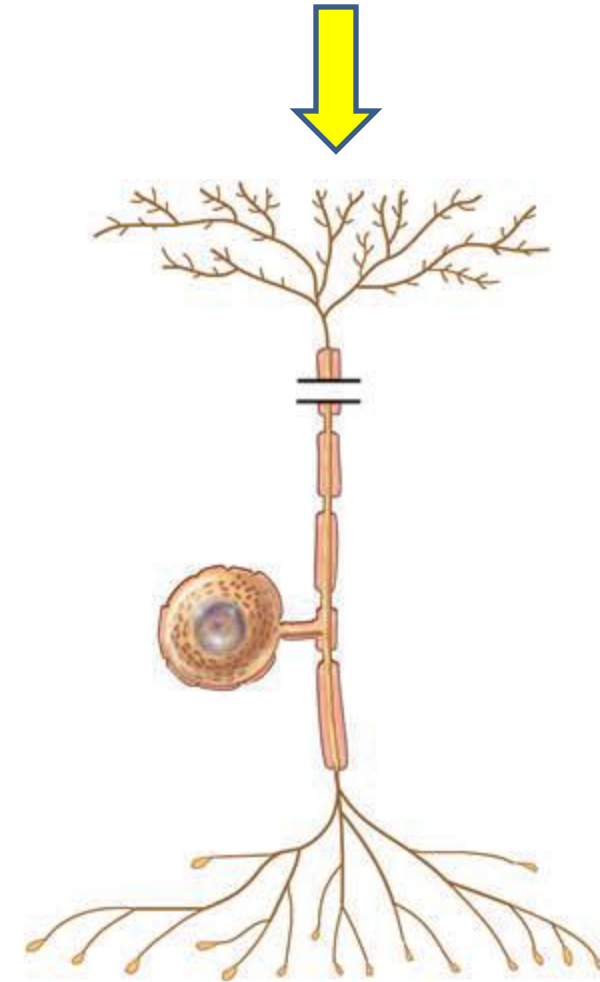
Bipolar neurons

- Have one main dendrite and one axon
- The retina of the eye



Unipolar neurons (pseudounipolar neurons)

- Sensory neurons



Anaxonic neuron:

- CNS
- Lack true axon
- Don't produce action potential
- Regulatory function

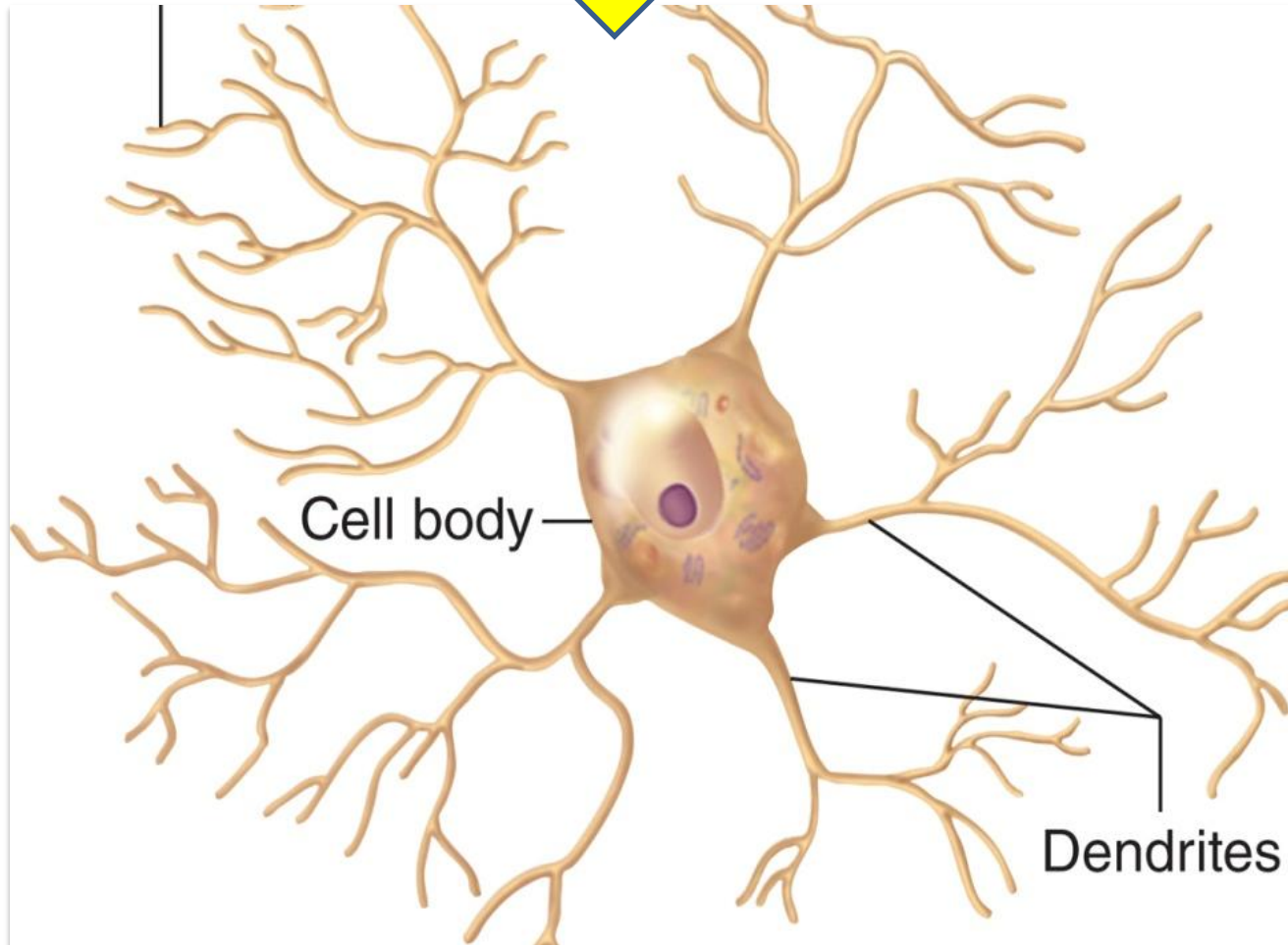
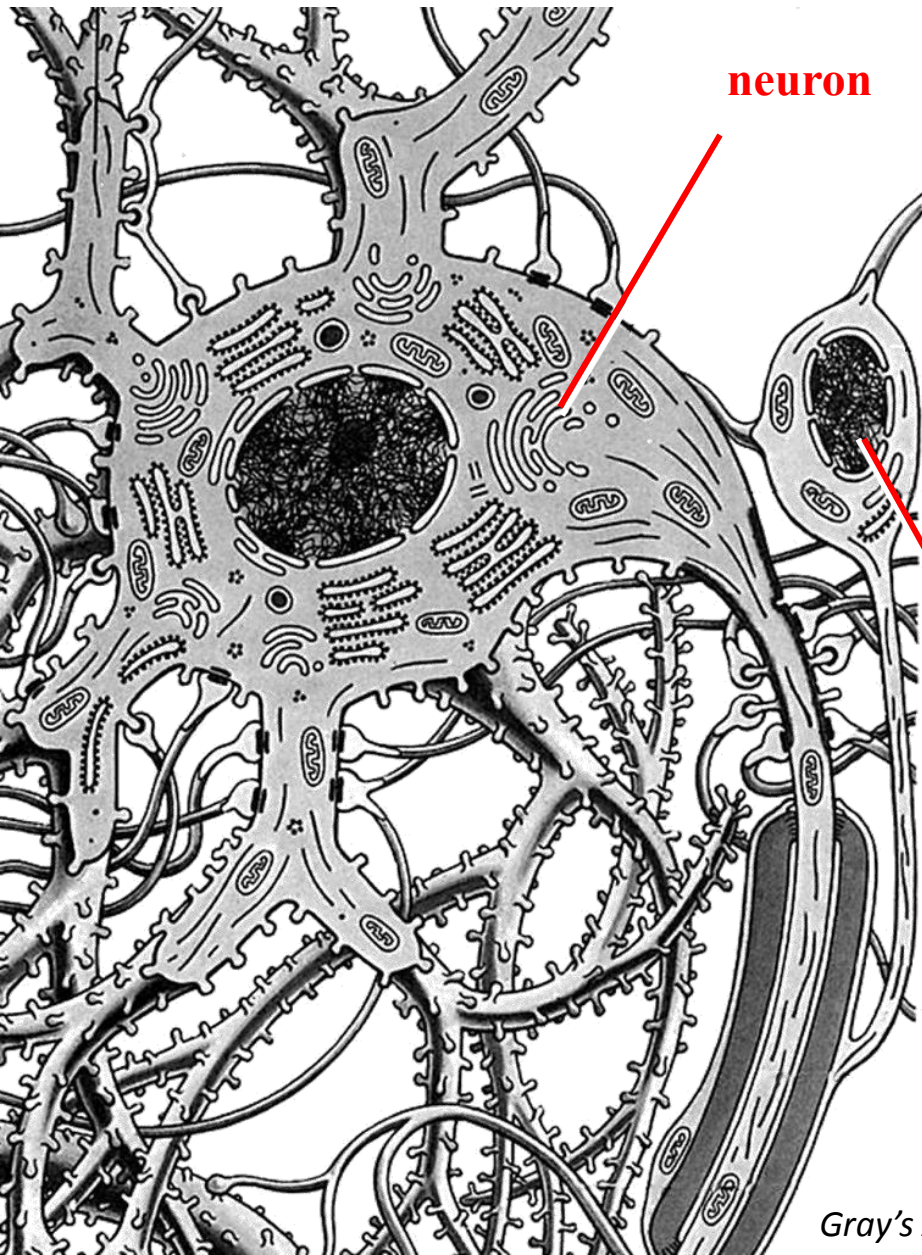


Figure 9-4



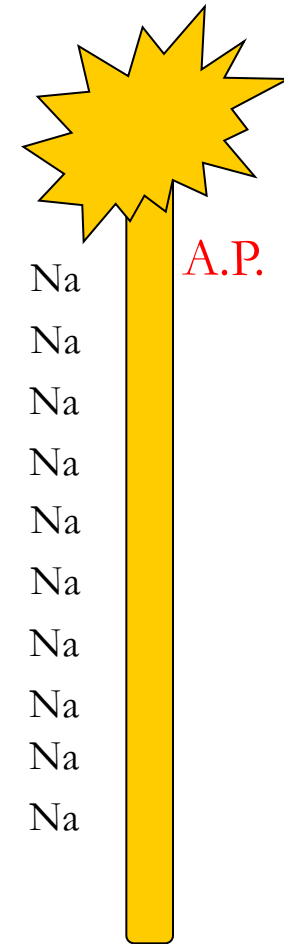
neuron

1. Tissues: neurons vs. glia
2. Position: CNS vs. PNS
3. Function 1: sensory vs. motor
4. Function 2: somatic vs. visceral

glial cell

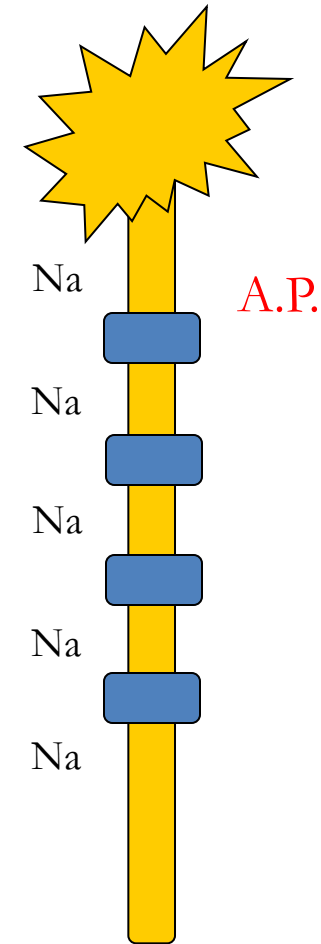
Continuous versus Saltatory Conduction

1. **Continuous conduction**
(unmyelinated fibers)
2. Saltatory conduction
(myelinated fibers)



Saltatory Conduction

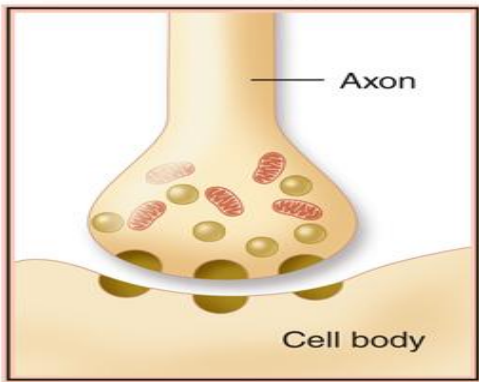
- Nerve impulse conduction in which the impulse **jumps** (**Salta**) from node to node



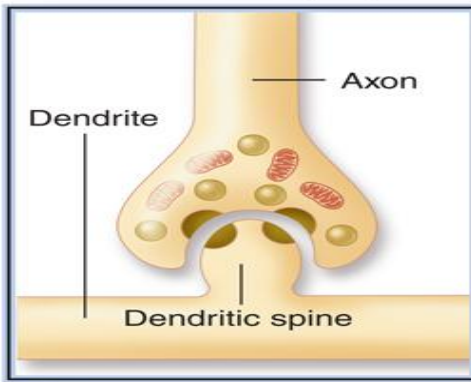
Local anesthetics!!!!!!



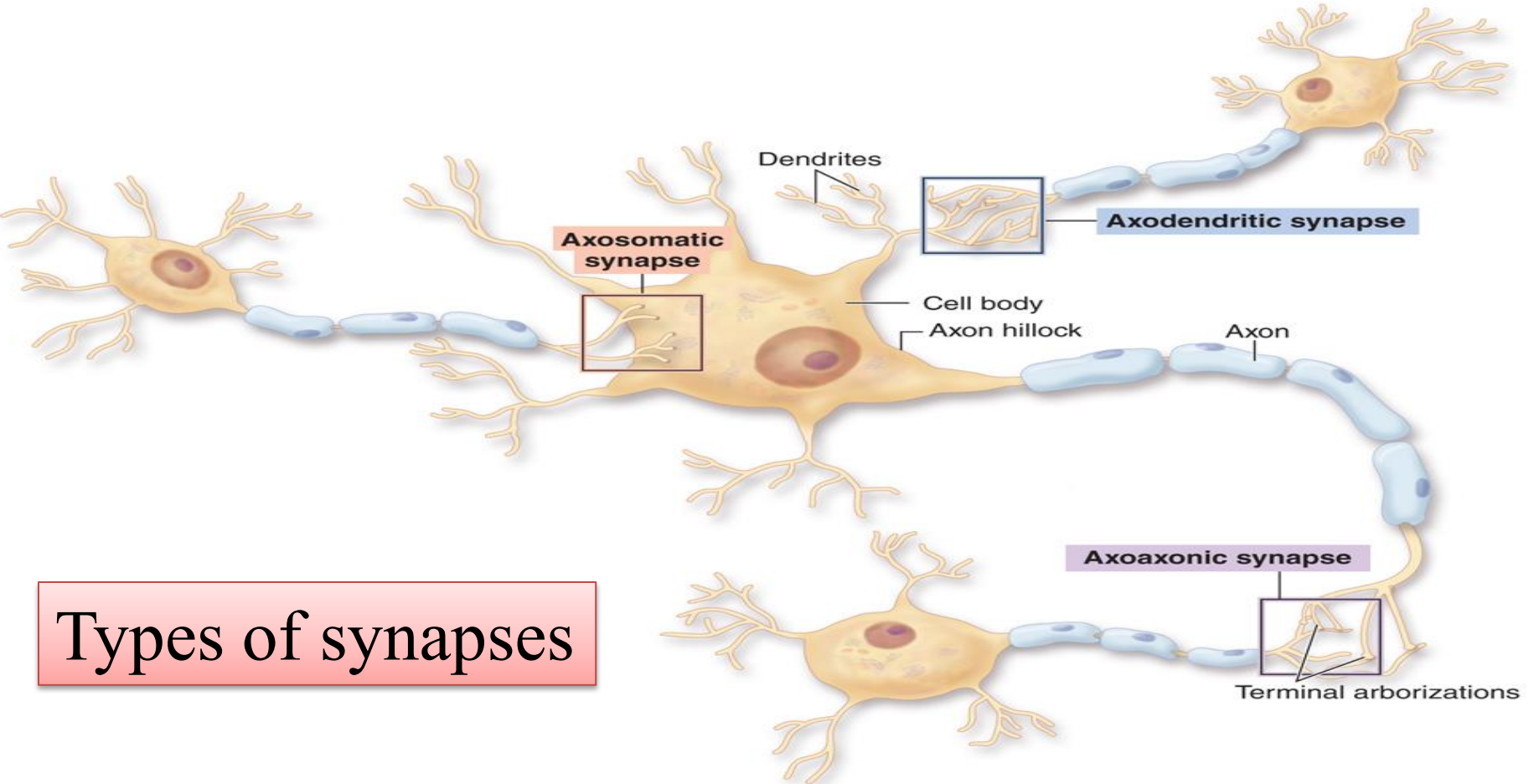
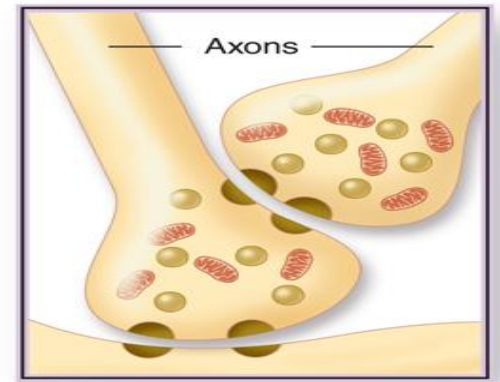
Axosomatic synapse



Axodendritic synapse



Axoaxonic synapse



Types of synapses

**Clusters of
Neuronal
Cell
Bodies**

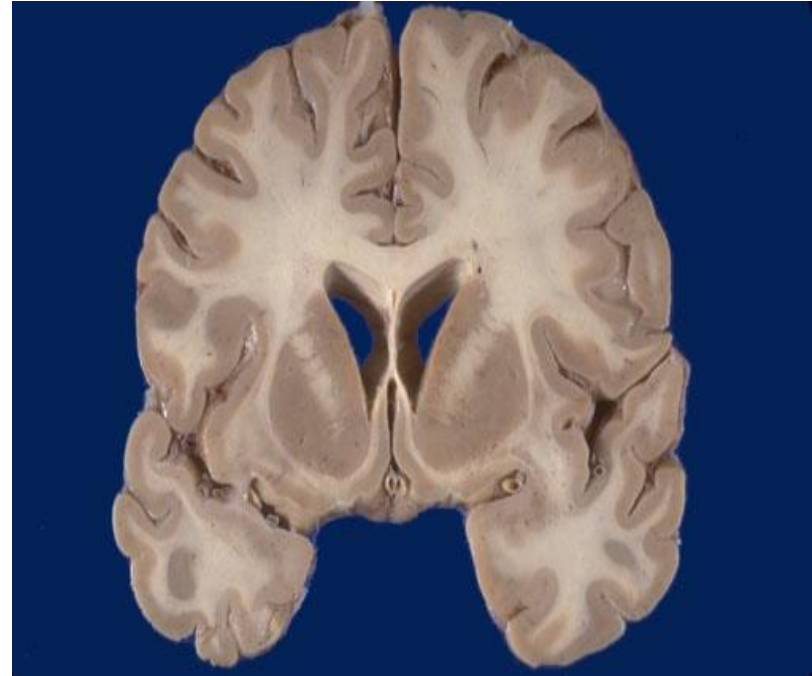


**Bundles
of
Axons**



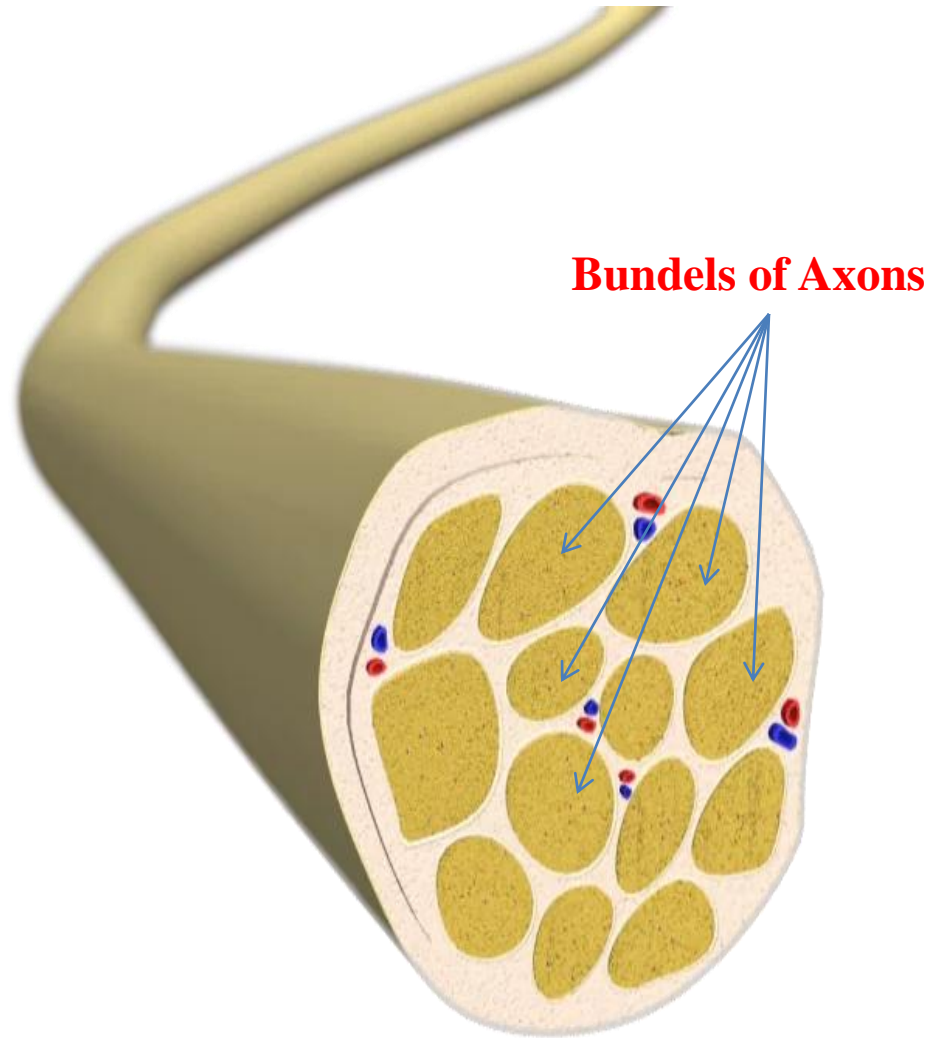
Clusters of Neuronal Cell Bodies

1. A **ganglion** (plural is ganglia) a cluster of neuronal cell bodies located in the PNS.
2. A **nucleus**: a cluster of neuronal cell bodies located in the CNS.



Bundles of Axons

- A **nerve**: is a bundle of axons that is located in the PNS.
 - Cranial nerves connect the brain to the periphery
 - spinal nerves connect the spinal cord to the periphery
- A **tract**: is a bundle of axons located in the CNS.
 - Tracts interconnect neurons in the spinal cord and brain.



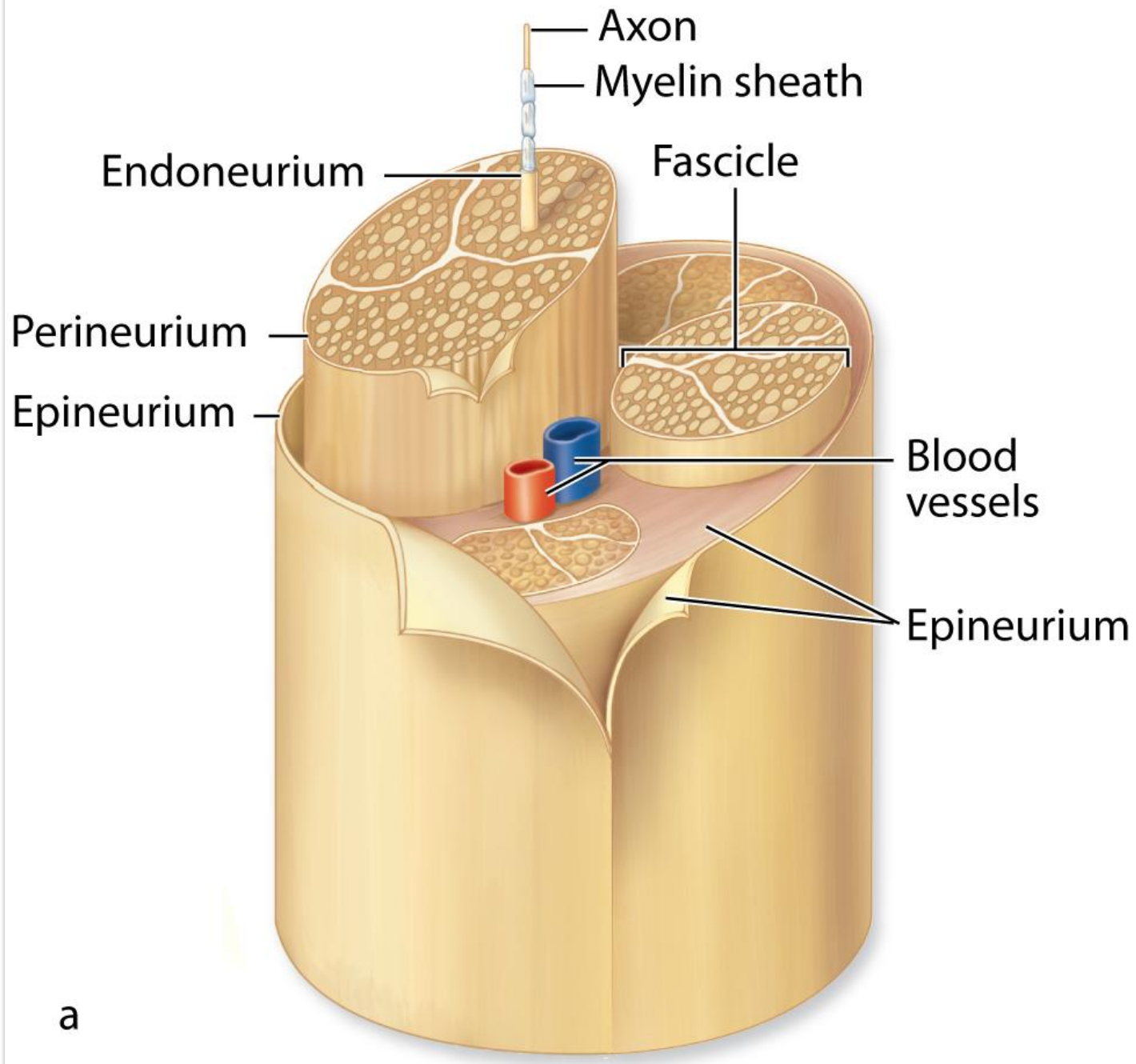
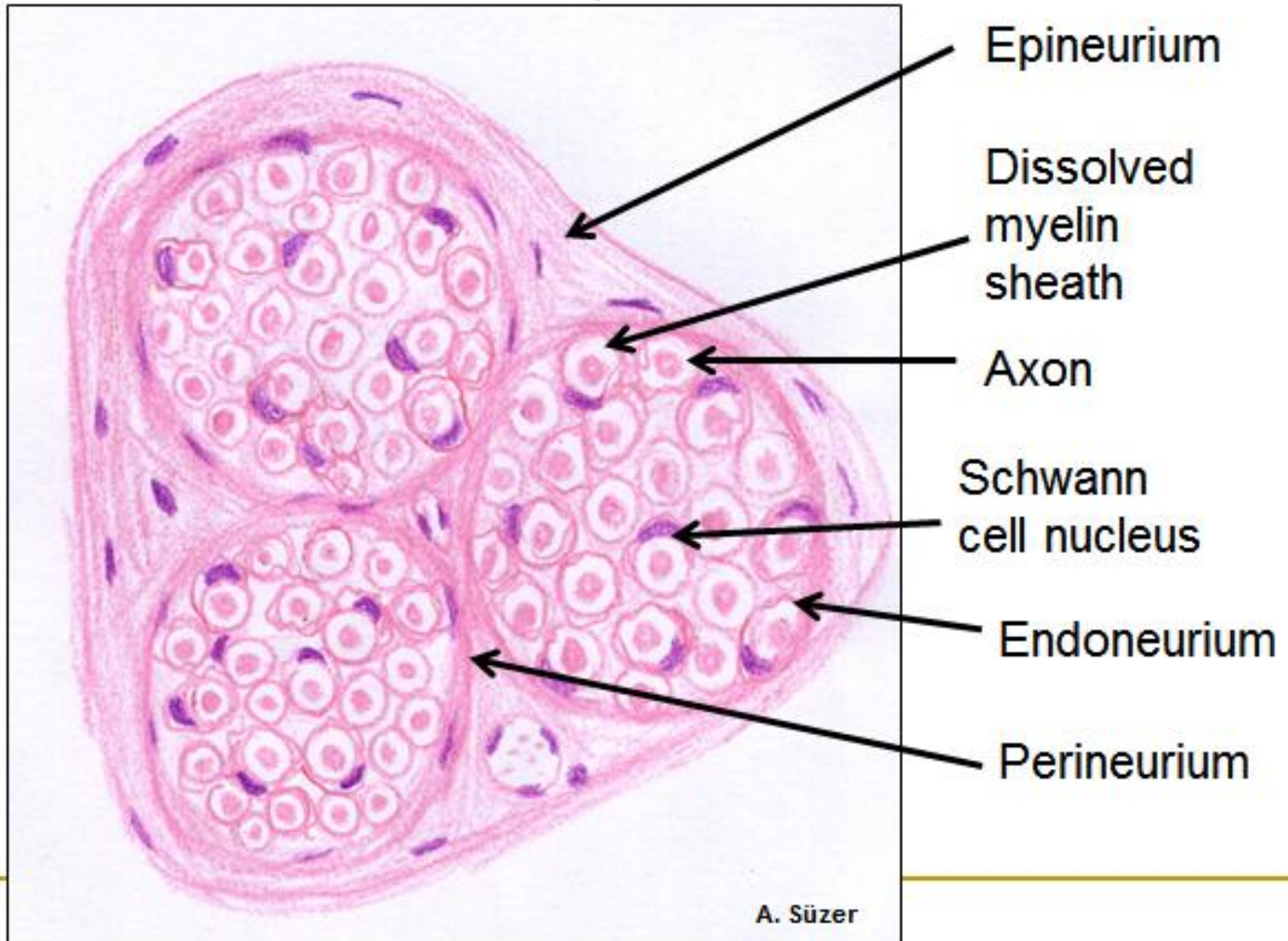


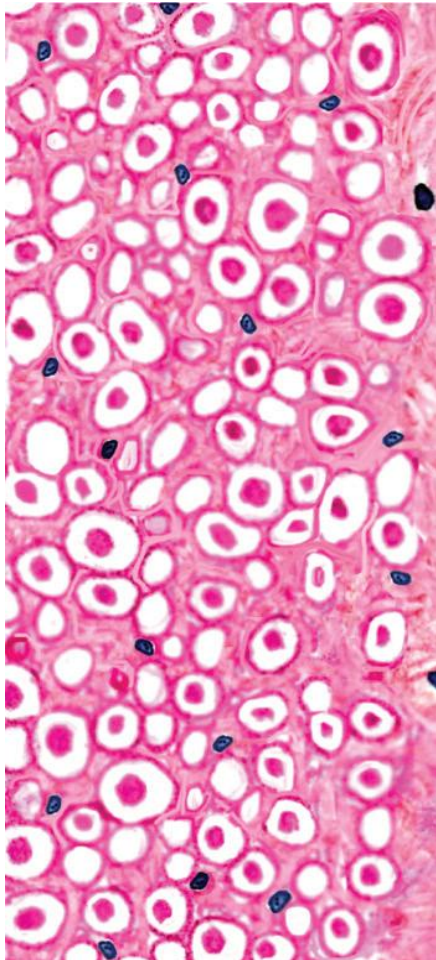
Figure 9-26

Peripheral Nerve

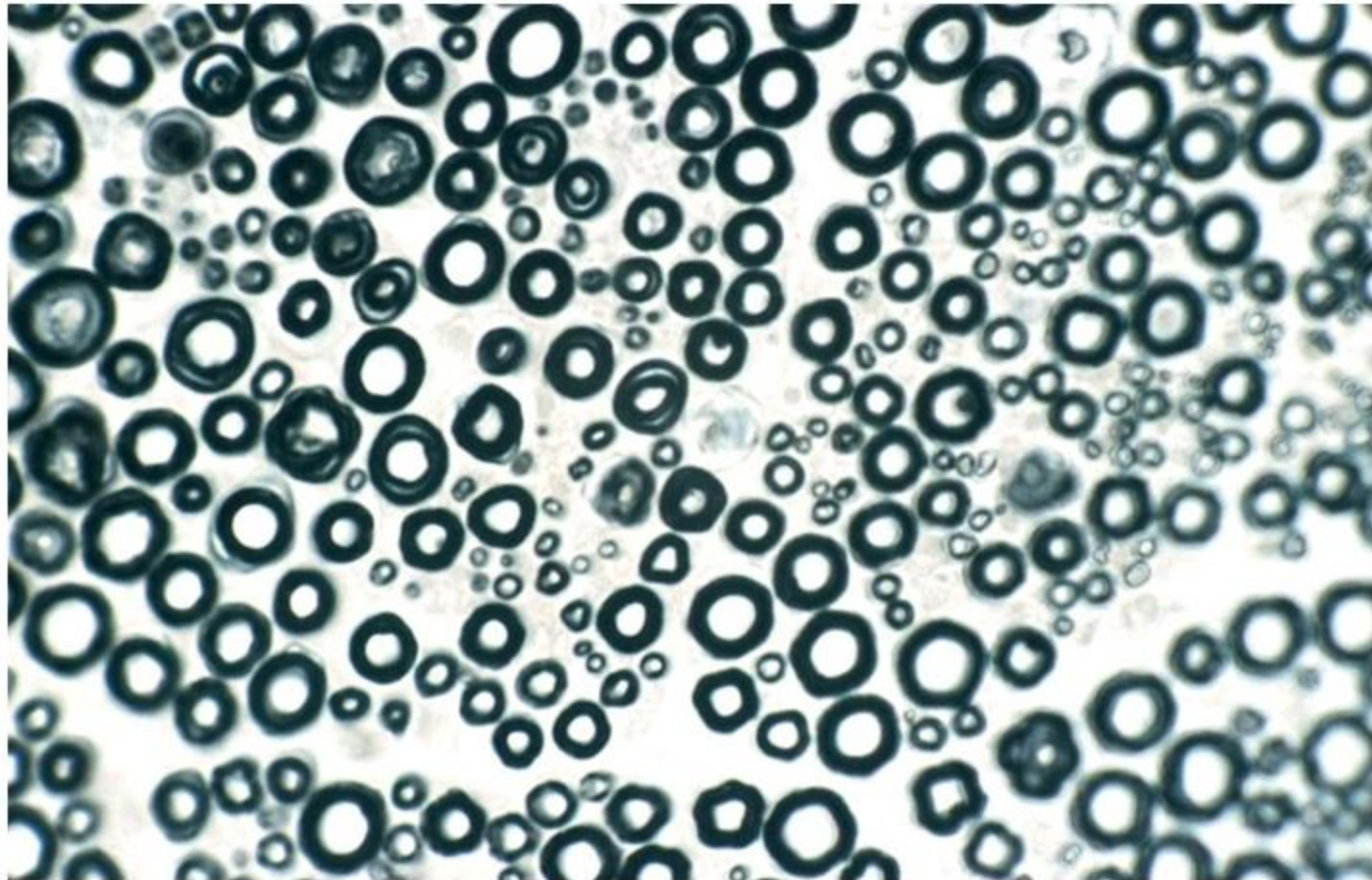


Myelinated Axons

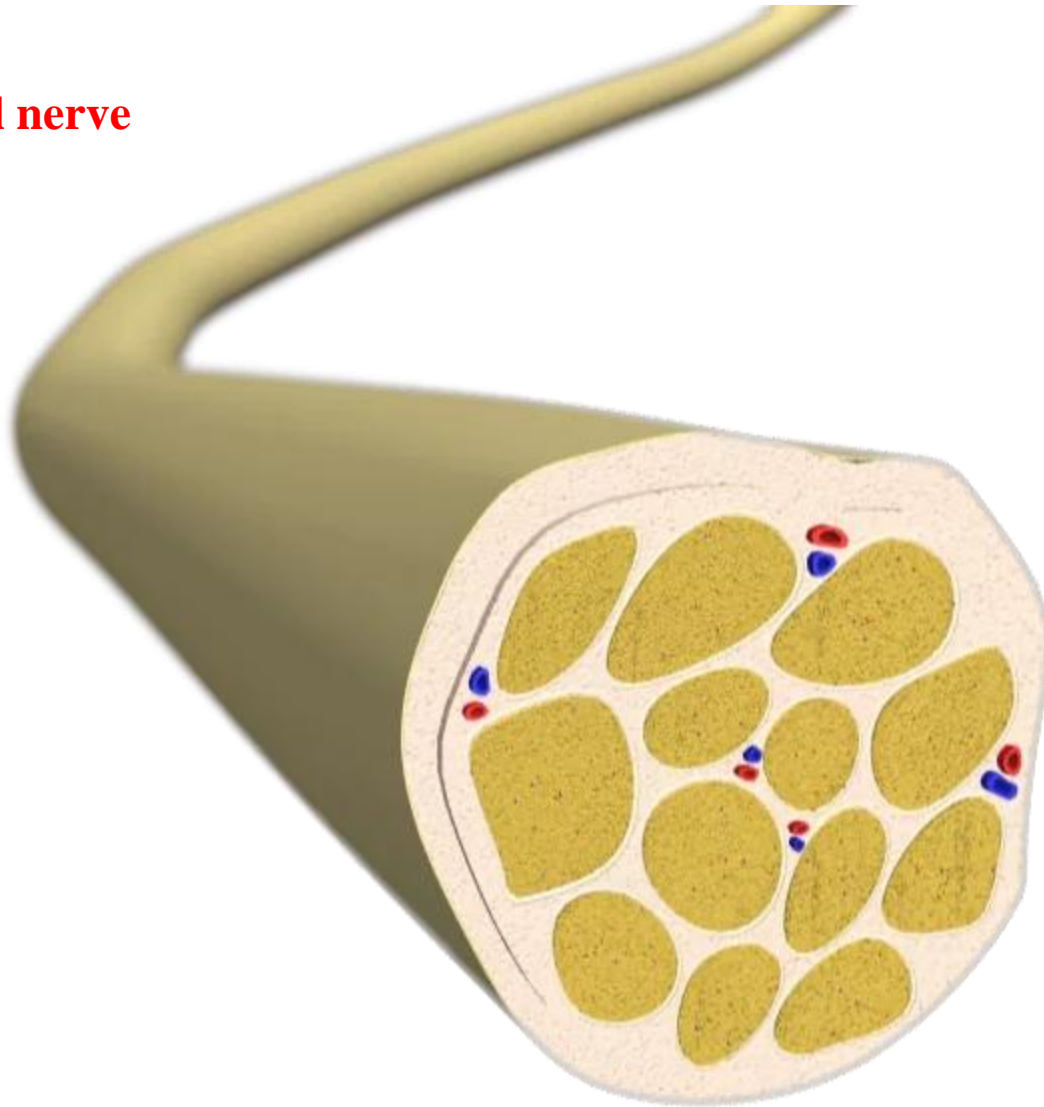
LM



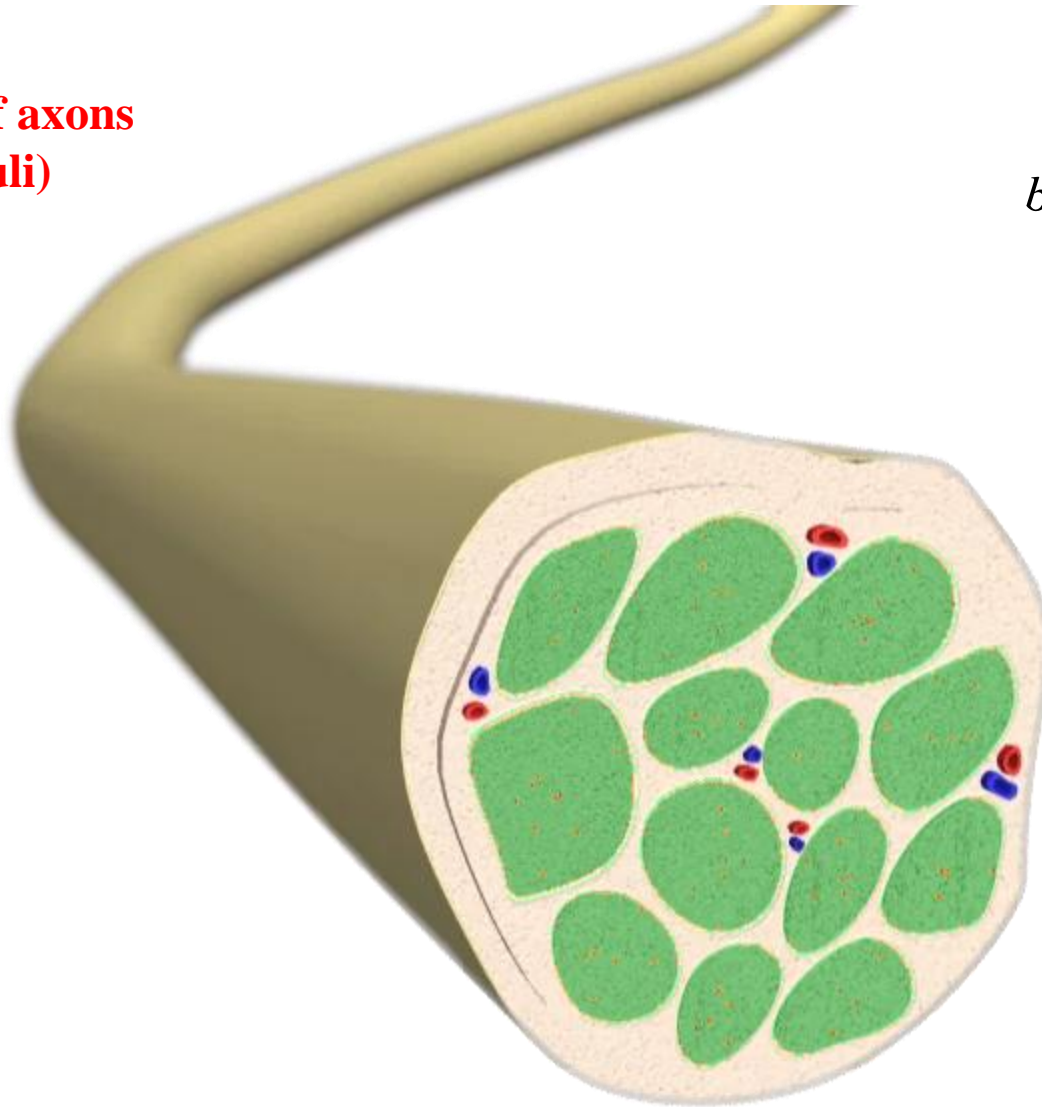
EM



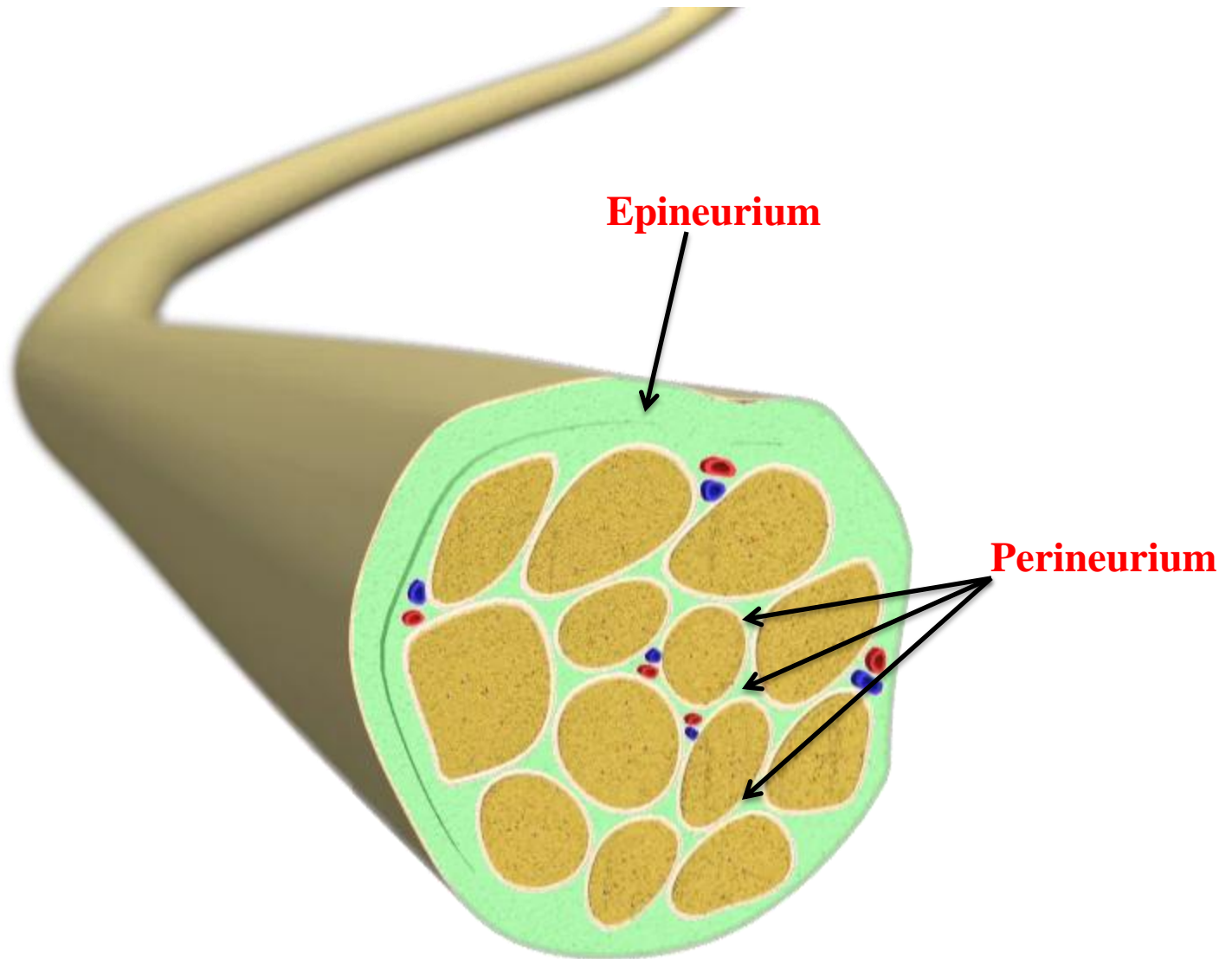
Peripheral nerve



**Bundles of axons
(Fasciculi)**



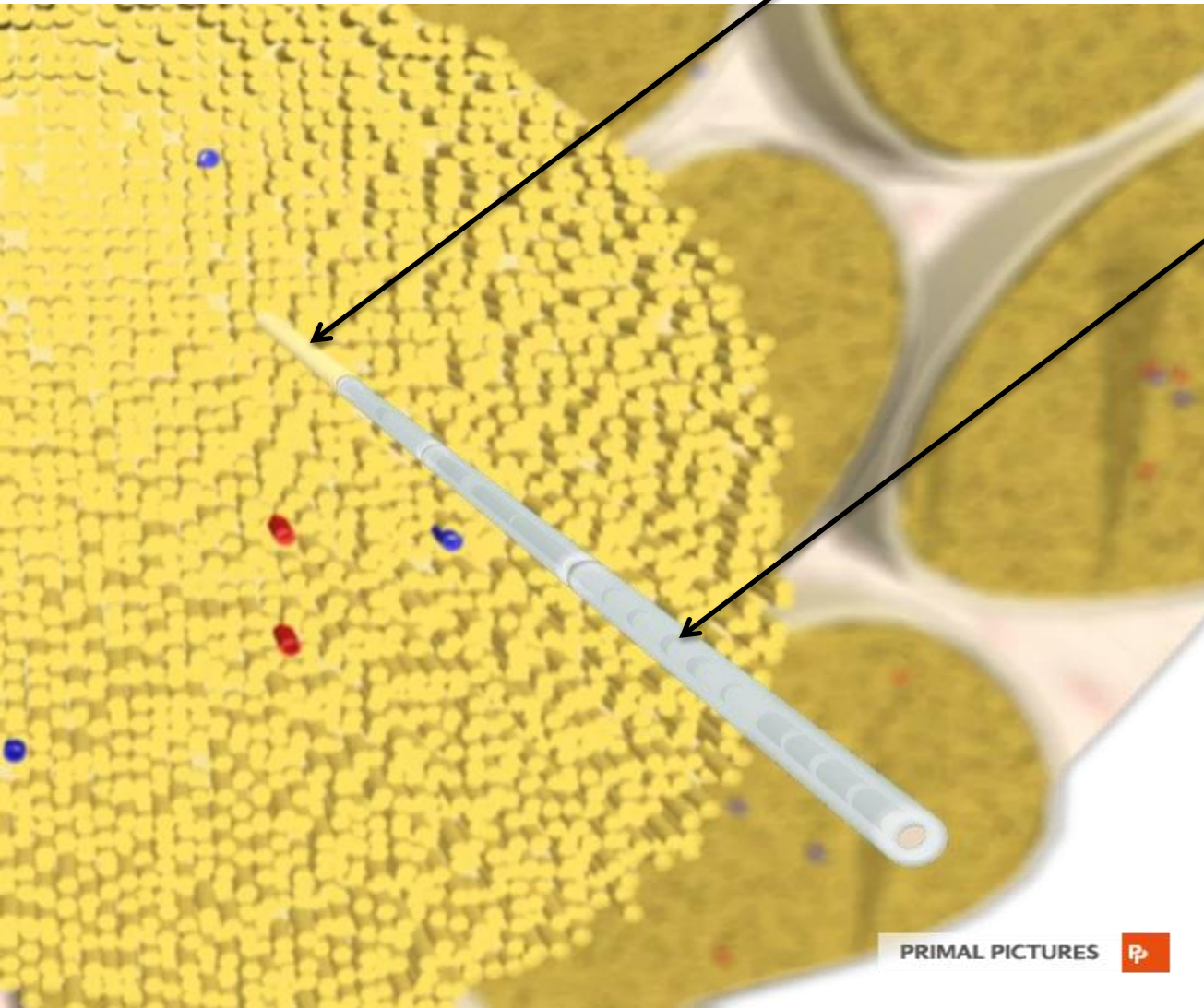
The axons are
bundled together into
groups called
fascicles



Nerve fiber

Axon

Myelin

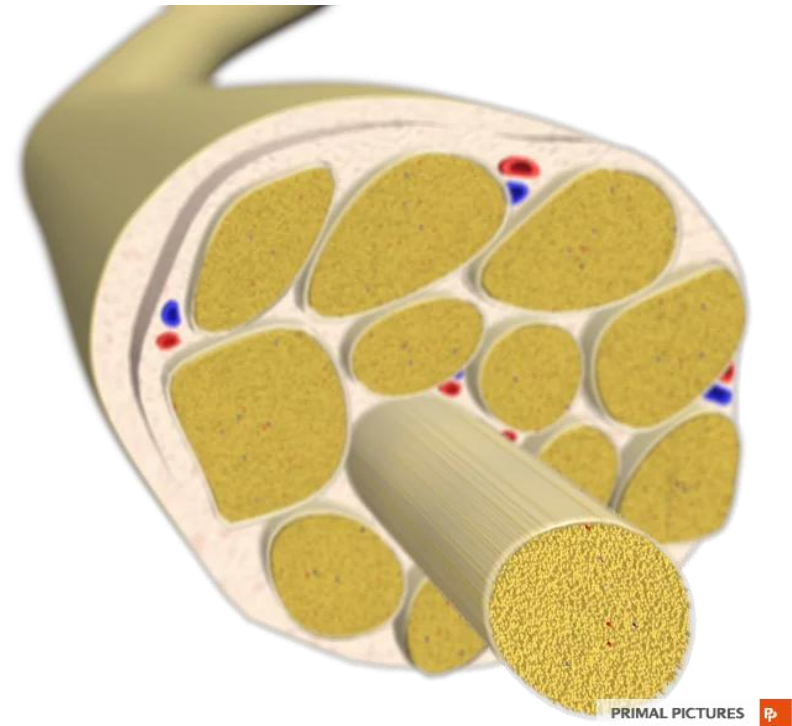


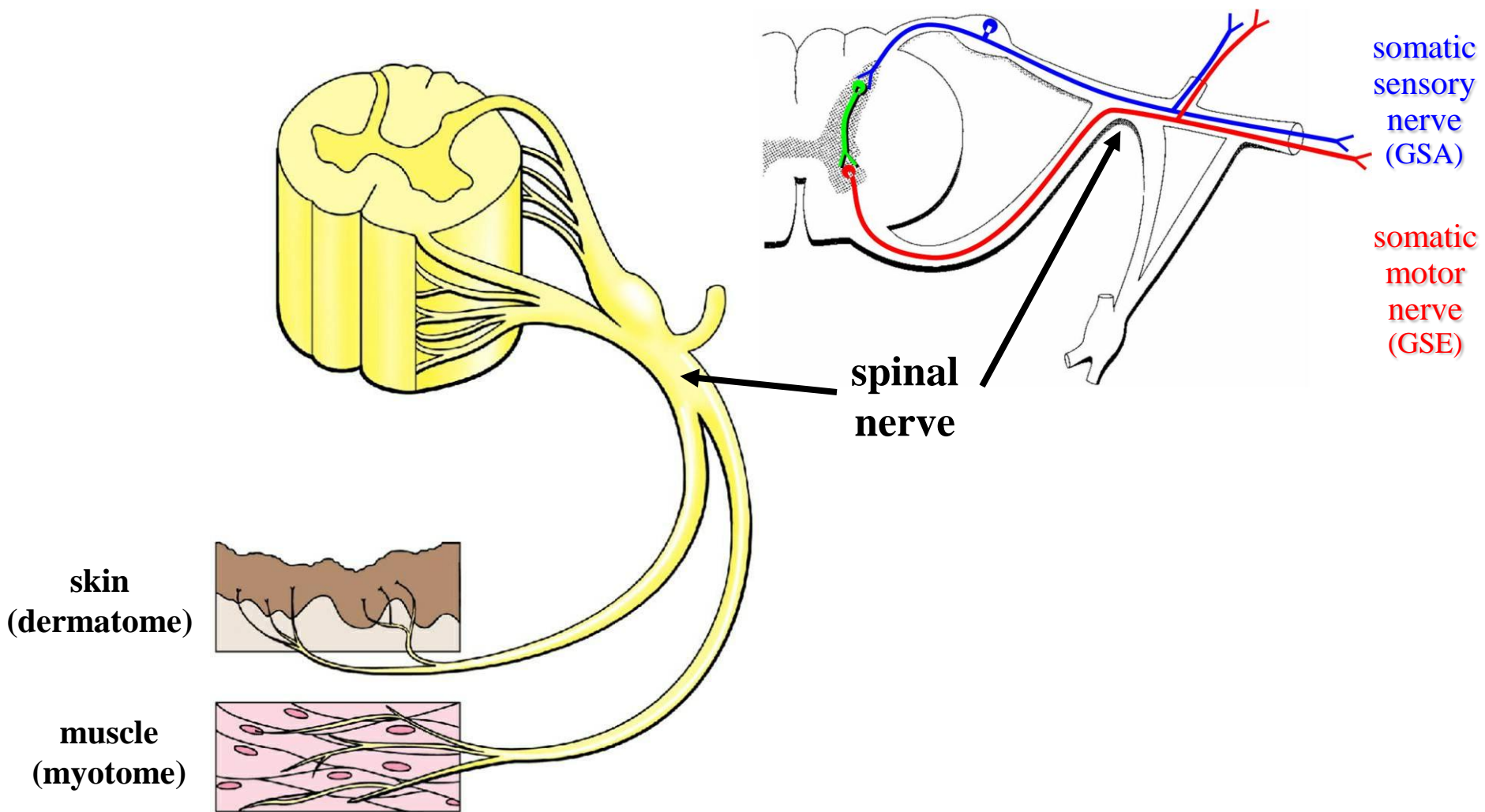
PRIMAL PICTURES

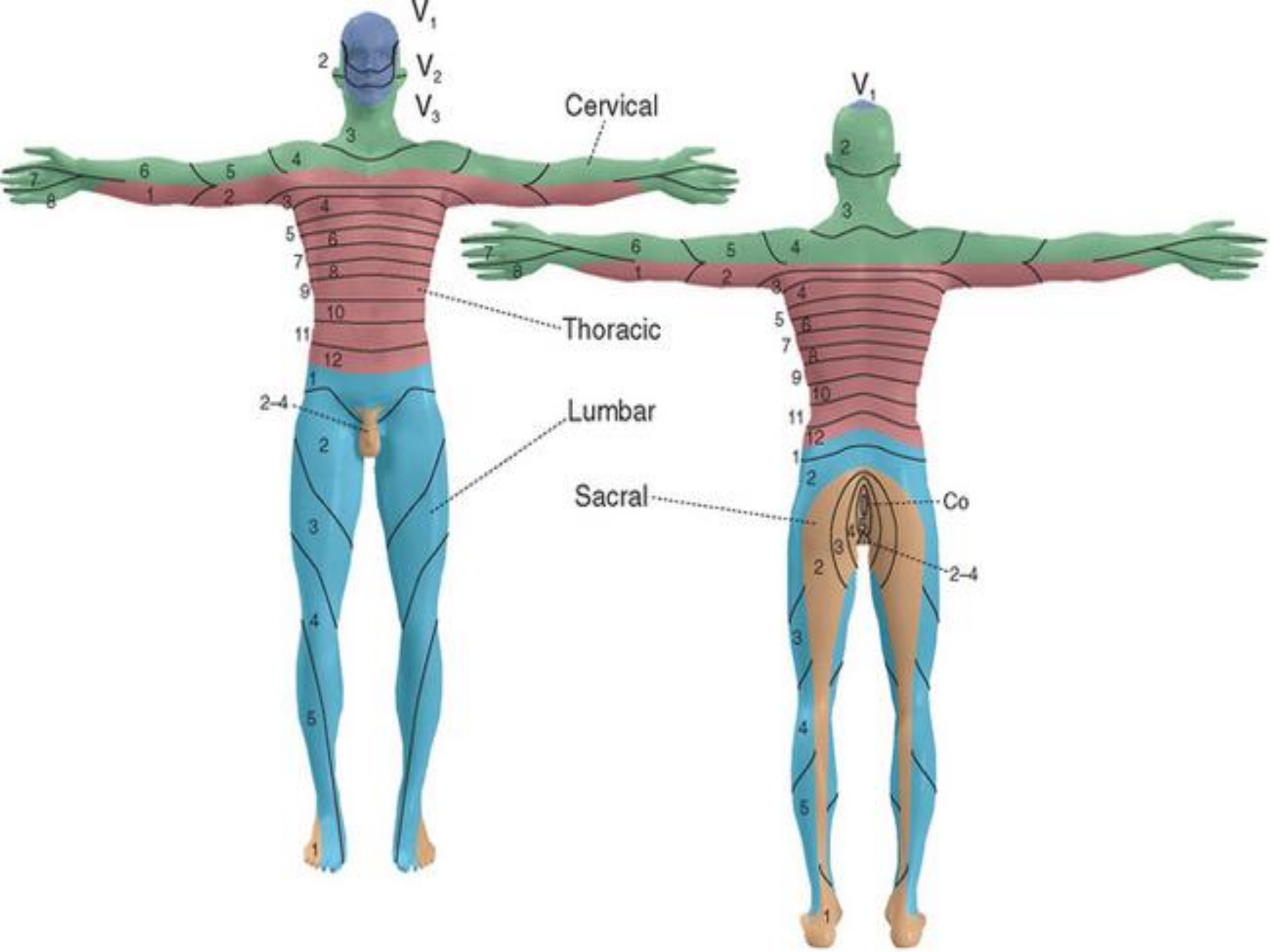


Peripheral nerves

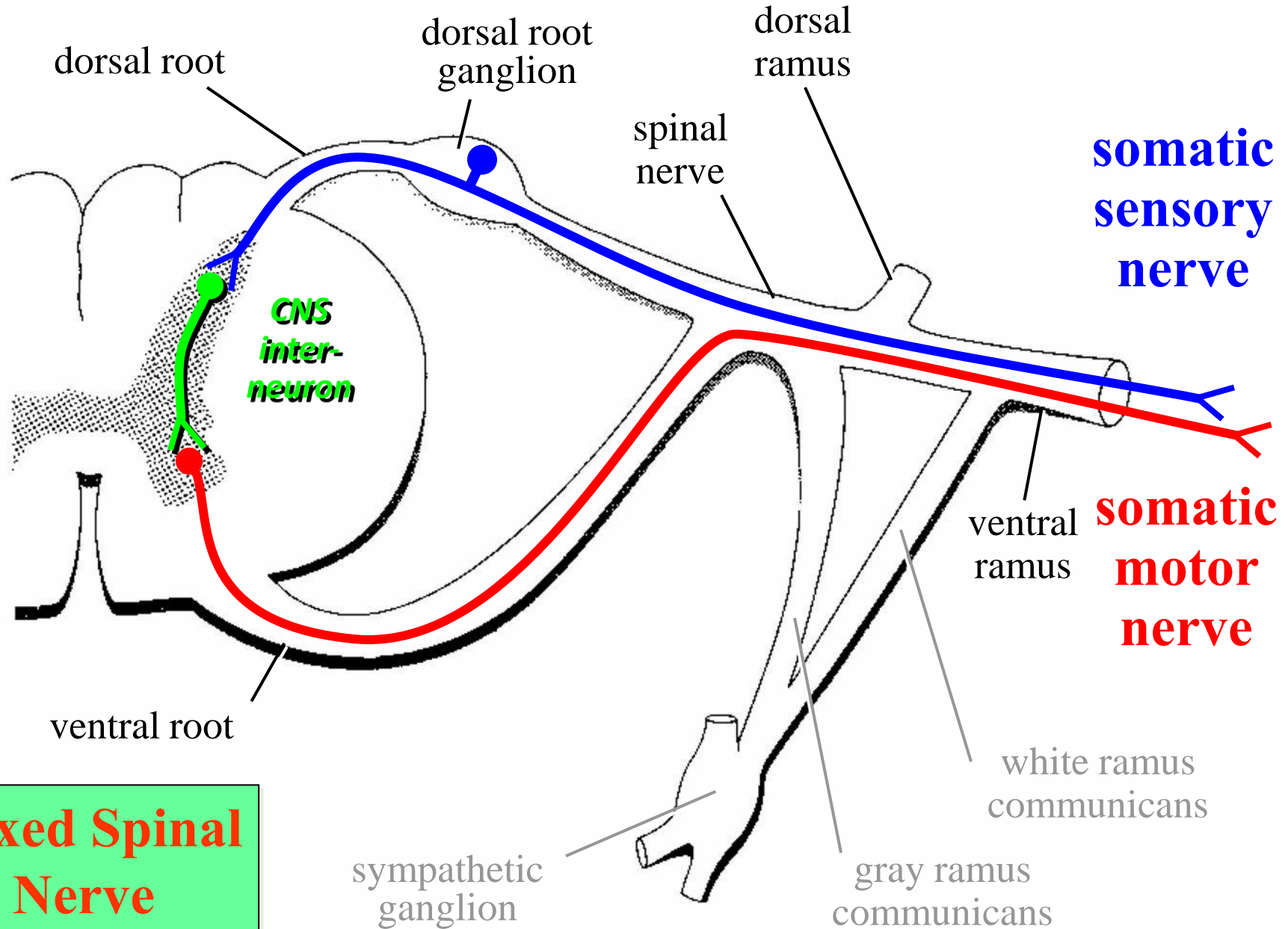
- Consist of **Cranial** and **Spinal** nerves connecting brain and spinal cord to peripheral tissues.
- Peripheral nerves consist of parallel bundles of nerve fibers, **Myelinated** or **Unmyelinated**, surrounded by connective tissue sheaths.
- **Endoneurium:** a layer of loose connective tissue around the nerve fiber
- **Perineurium:** A fibrous connective tissue that surround bundles of axons
- **Epineurium:** is the outermost layer of dense irregular connective tissue surrounding a peripheral nerve
- Spaces between bundles usually contains fat.
- Myelinated fiber = axon + myelin



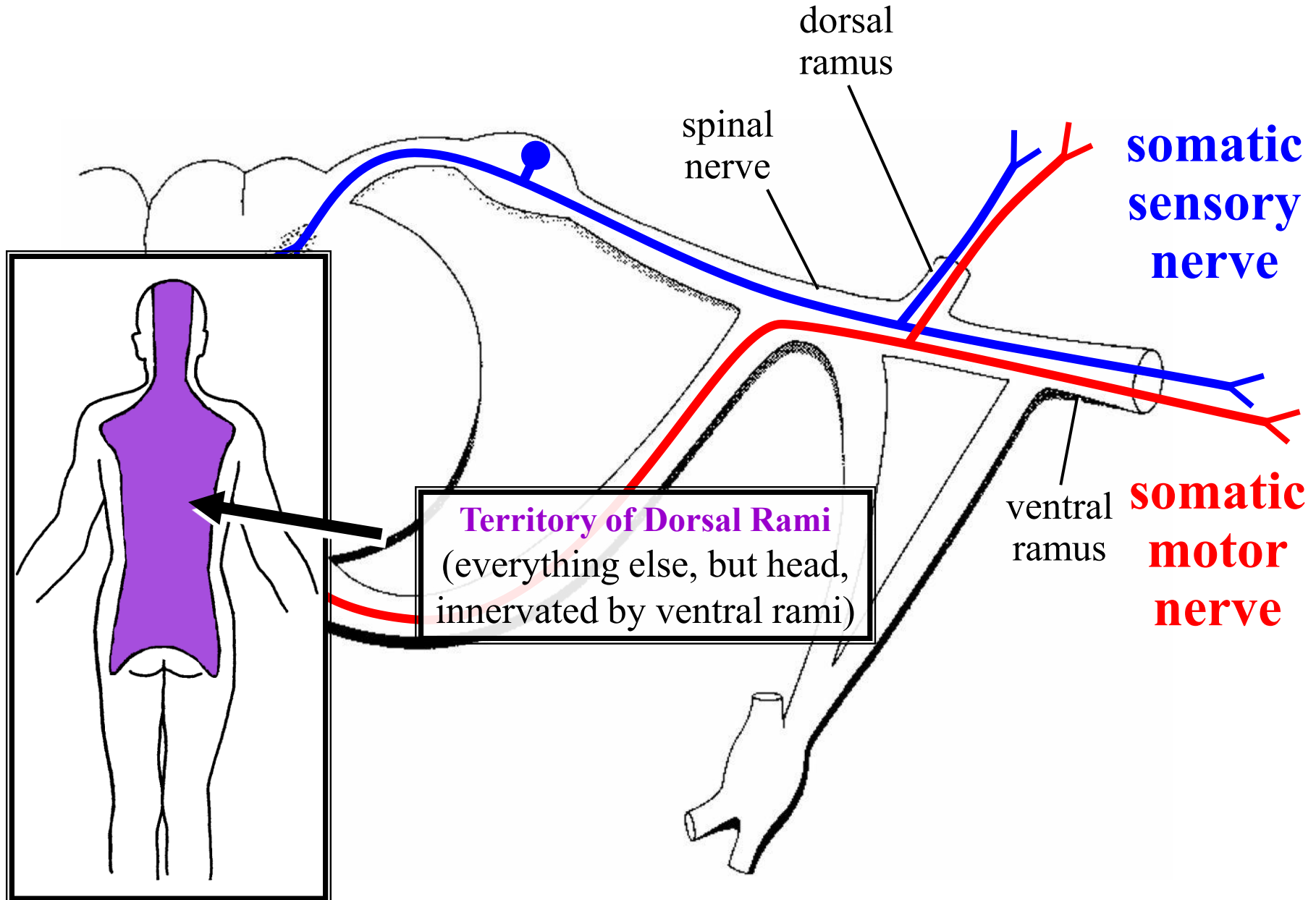


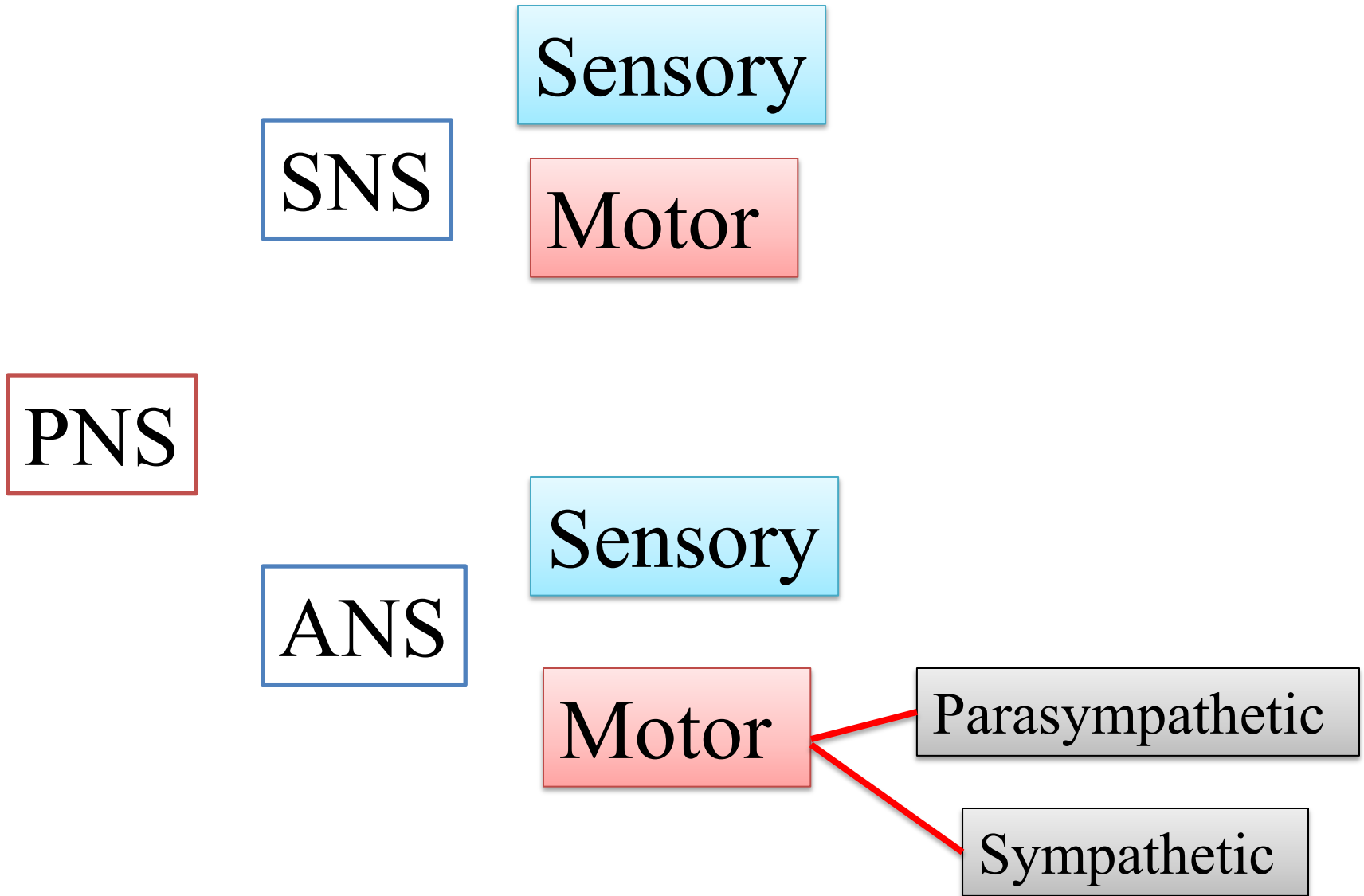


Structure of Spinal Nerves: Somatic Pathways



Structure of Spinal Nerves: Dorsal & Ventral Rami





- ANS is the subdivision of the peripheral nervous system that regulates body activities that are generally **not under conscious control**
- **Visceral motor** innervates **non-skeletal (non-somatic) muscles**

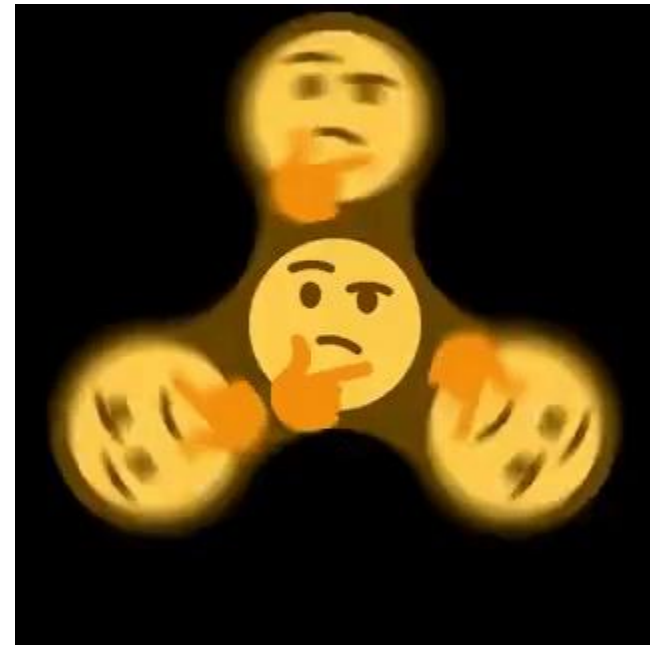
Composed of a special group
of neurons serving:

Cardiac muscle (the heart)

Smooth muscle (walls of
viscera and blood vessels)

Glands

To repeat...



Divisions of the autonomic nervous system

- Parasympathetic division
- Sympathetic division

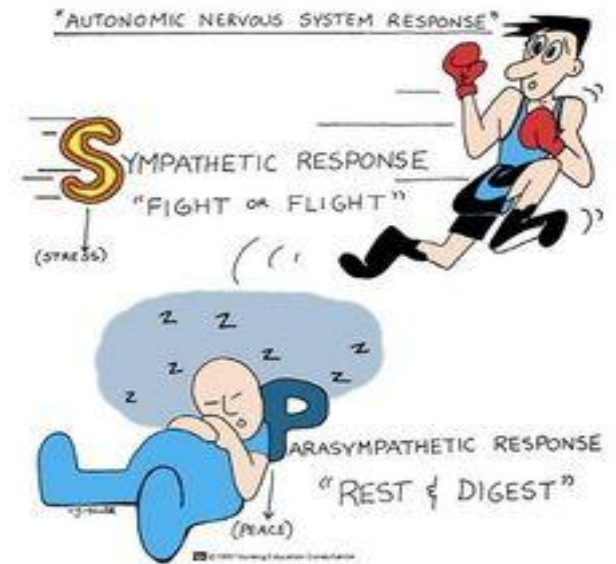
Serve most of the same organs but cause opposing or antagonistic effects

Parasympathetic: routine maintenance

“rest & digest”

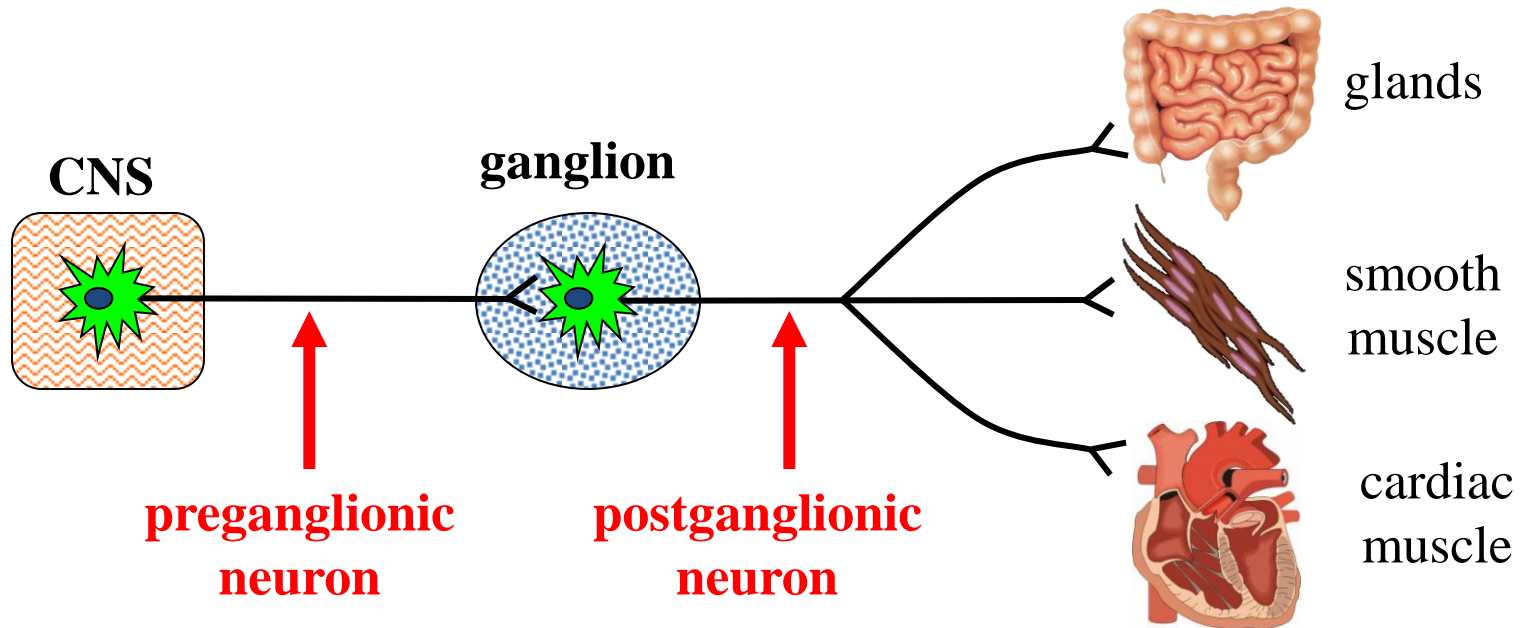
Sympathetic: mobilization & increased metabolism

“fight, flight or fright” or “fight, flight or freeze”

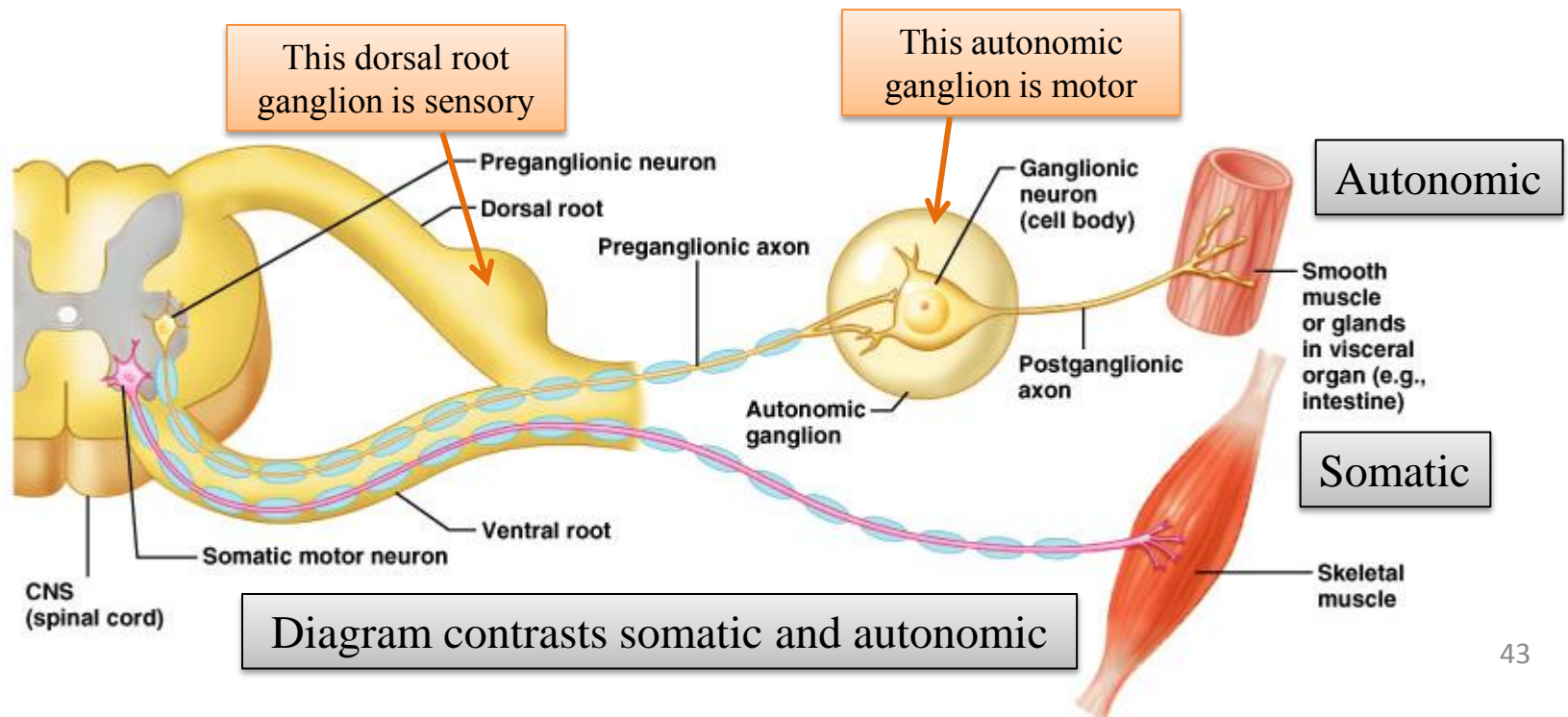


Basic anatomical difference between the motor pathways of the voluntary somatic nervous system (to skeletal muscles) and those of the autonomic nervous system

- Somatic division:
 - Cell bodies of motor neurons reside in CNS (brain or spinal cord)
 - Their axons (sheathed in spinal nerves) extend all the way to their skeletal muscles
- Autonomic system: chains of two motor neurons
 - 1st = preganglionic neuron (cell body in brain or cord)
 - 2nd = postganglionic neuron (cell body in ganglion outside CNS)
 - Slower because lightly or unmyelinated



- Axon of 1st (preganglionic) neuron leaves CNS to synapse with the 2nd (ganglionic) neuron
- Axon of 2nd (postganglionic) neuron extends to the organ it serves

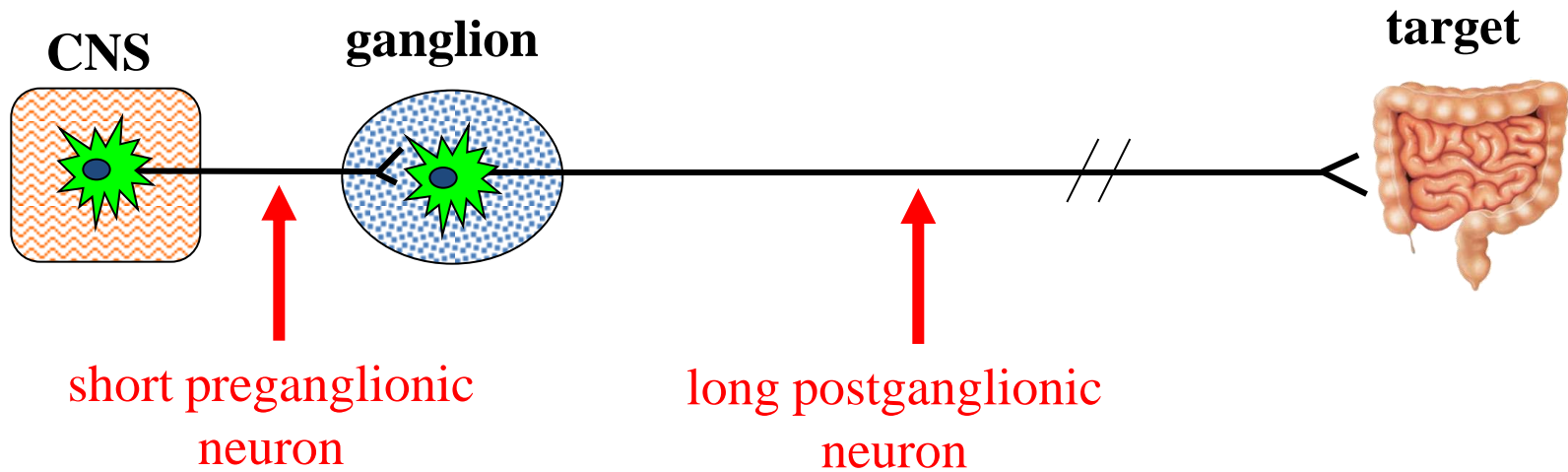


Overview of the Autonomic Nervous System

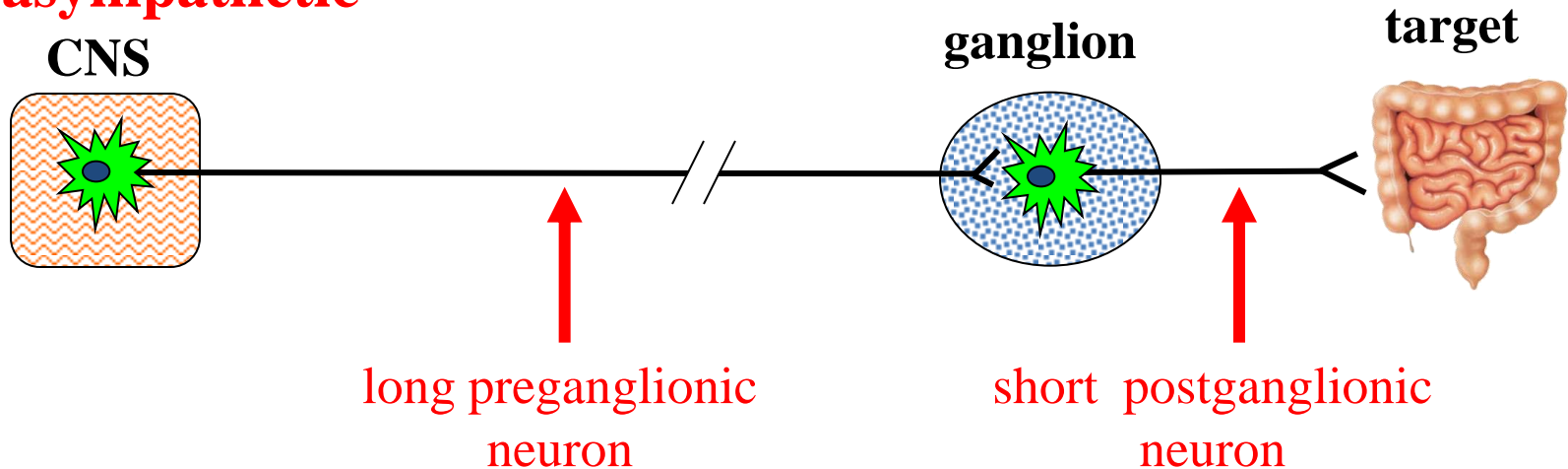
Differences between Sympathetic & Parasympathetic

Relative Lengths of Neurons

Sympathetic



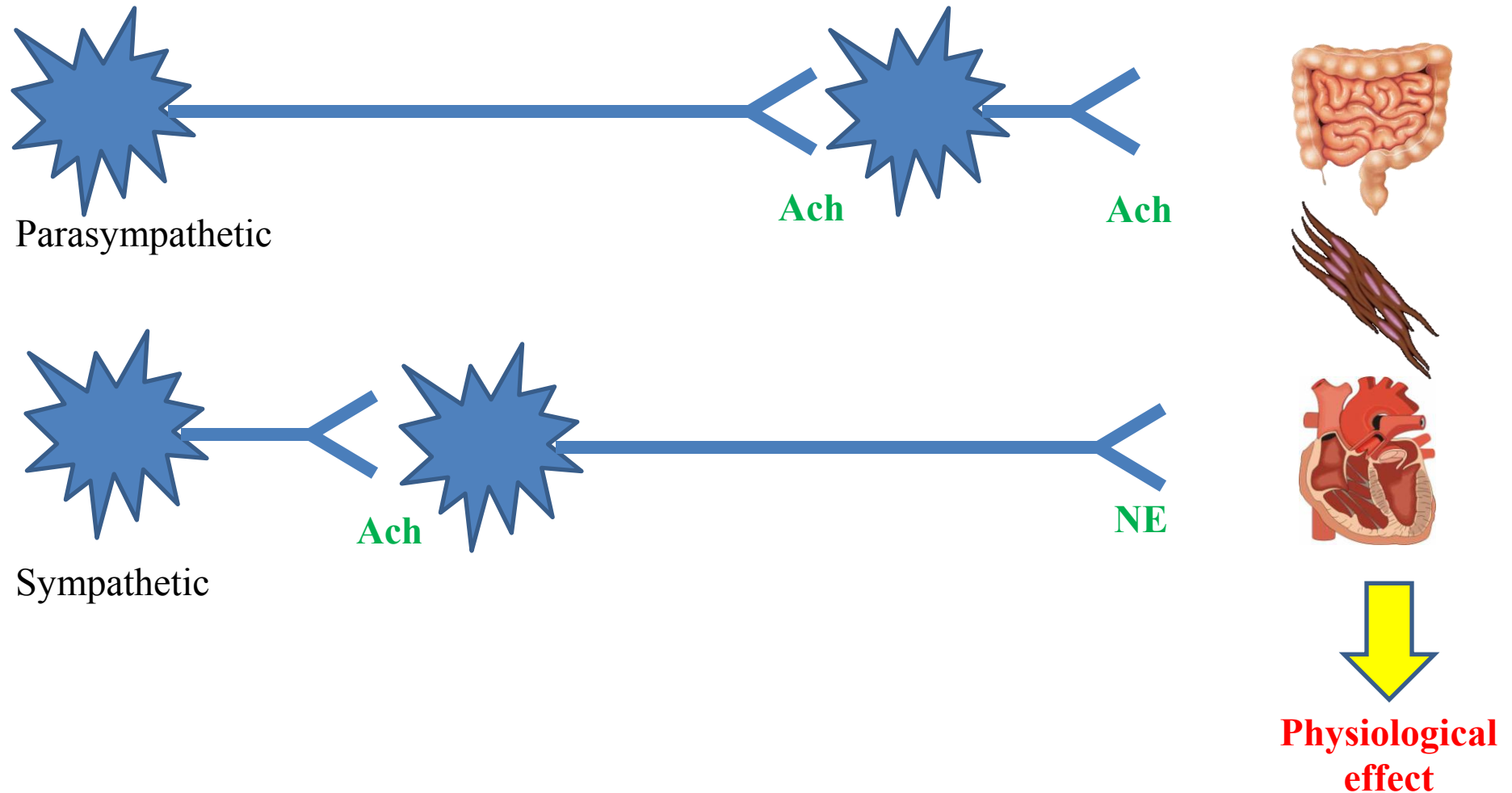
Parasympathetic



Overview of the Autonomic Nervous System

Differences between Sympathetic & Parasympathetic

Types of neurotransmitters



Ganglia

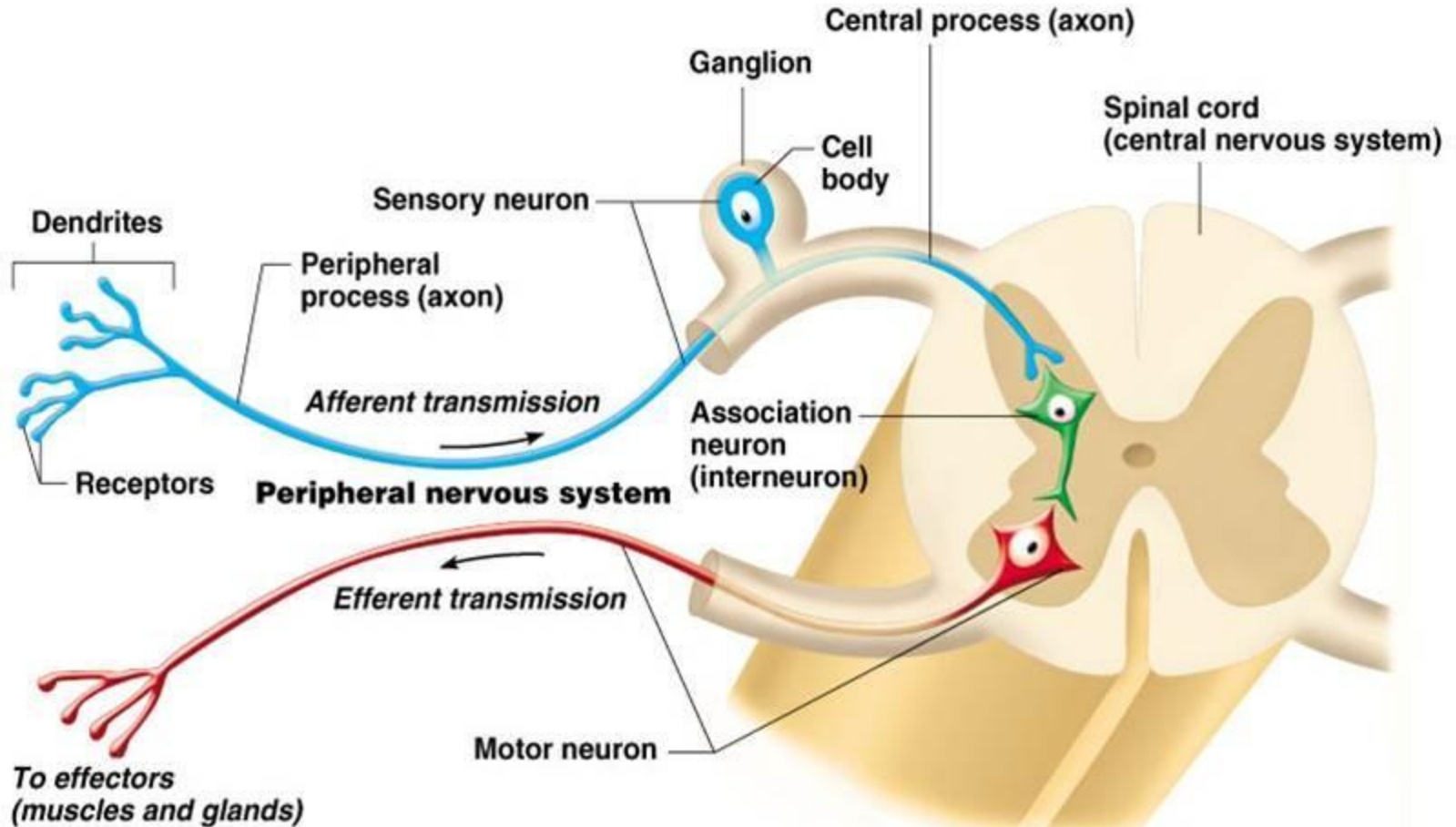
- Ganglia Are Masses Of Neuronal Somas, Usually Defined As Being Outside The Central Nervous System. They Seem To Act As Coordinating Way Stations.

- Two types:

1. Sensory.

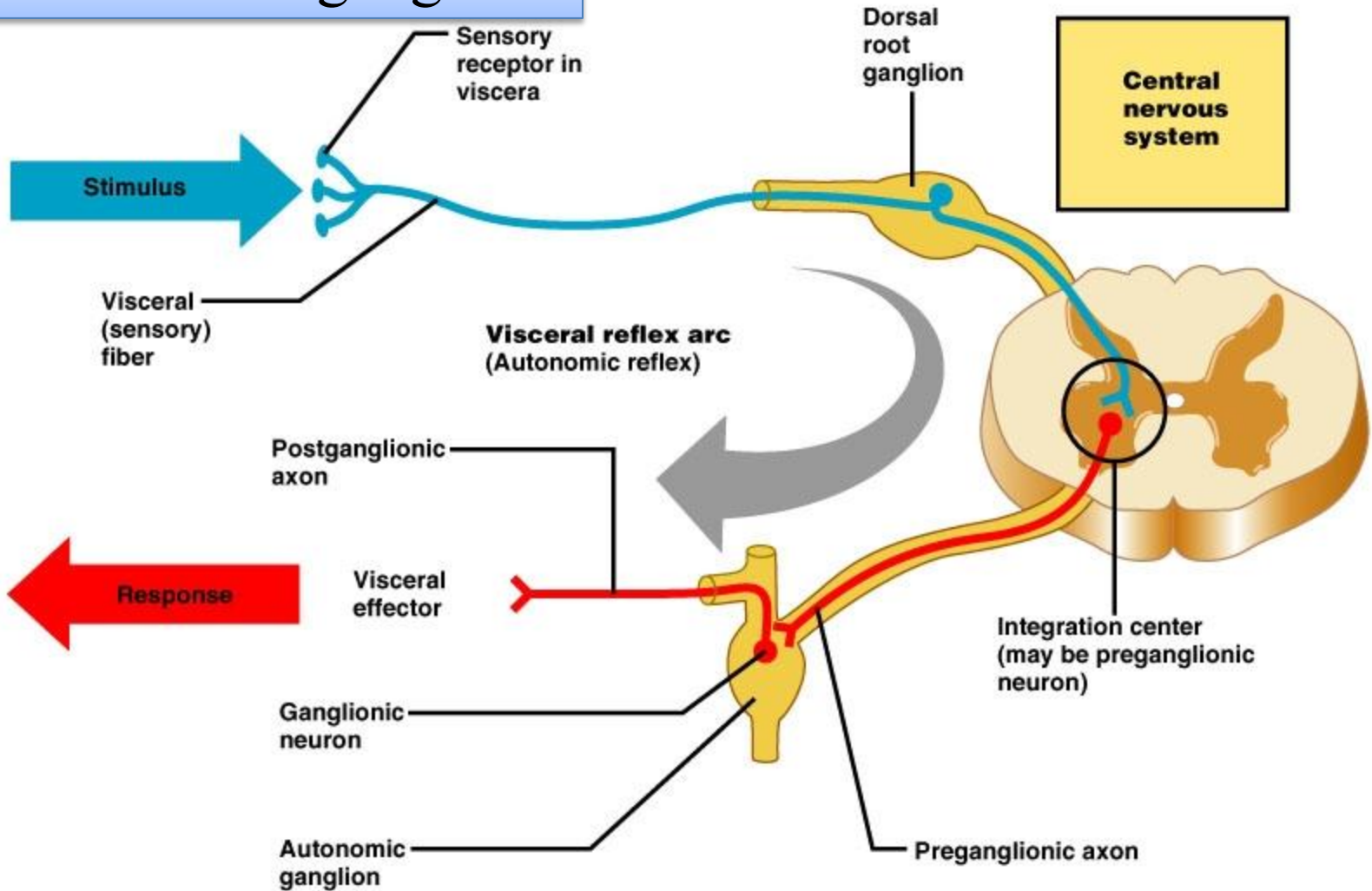
2. Autonomic

Sensory ganglion



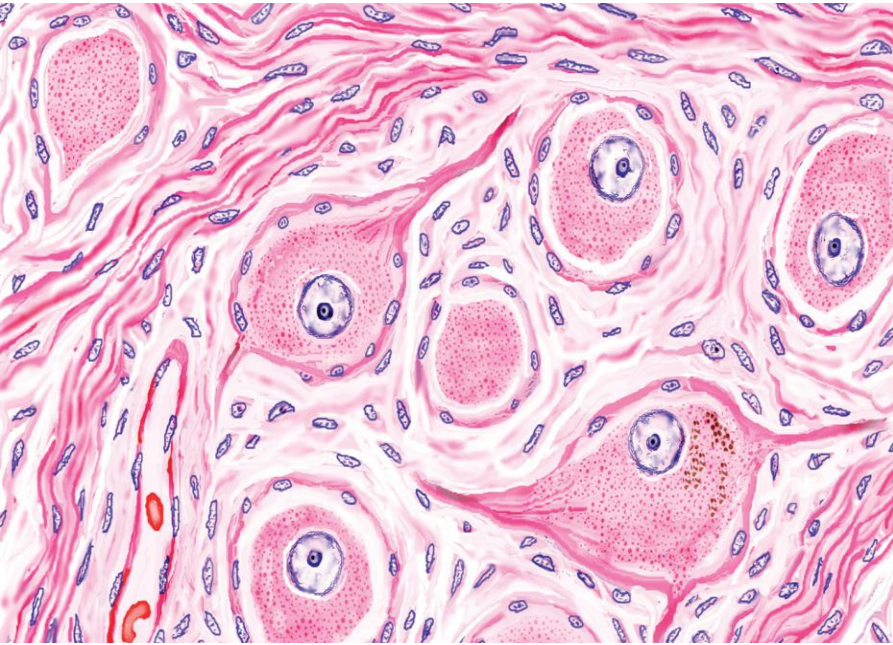
Ganglion cells in dorsal root ganglia do not receive synapses

Autonomic ganglion



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Autonomic ganglia do contain synapses



Autonomic ganglia

with multipolar neurons are less organized than

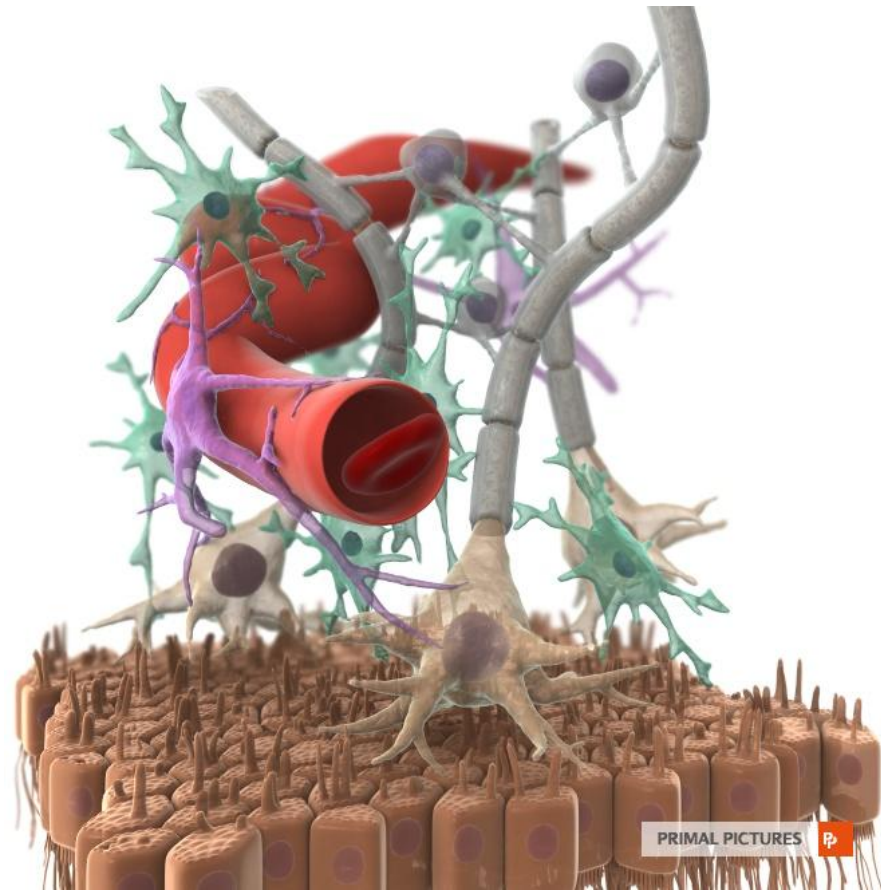


Sensory ganglia

(dorsal root ganglia) with pseudounipolar neurons.

Neuroglial cells (Nerve glue)

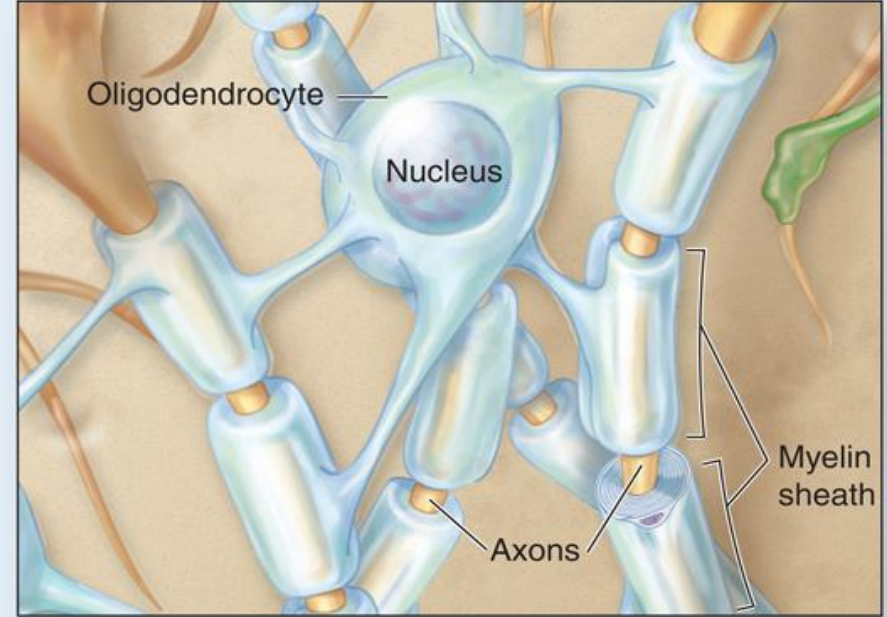
- Non-neuronal cells of CNS & PNS.
- Can divide during adult life, in response to trauma or disease to fill the spaces previously occupied by neurons.
- Held nervous tissue together (support).
- **Neuroglial cells of CNS:**
 - Astrocytes = star cells
 - Oligodendrocytes = few tree
 - Microglia = small
 - Ependyma = above garment
- **Neuroglial cells of PNS:**
 - Schwann cells
 - Satellite cells



Neuroglial cells of CNS

Oligodendrocytes

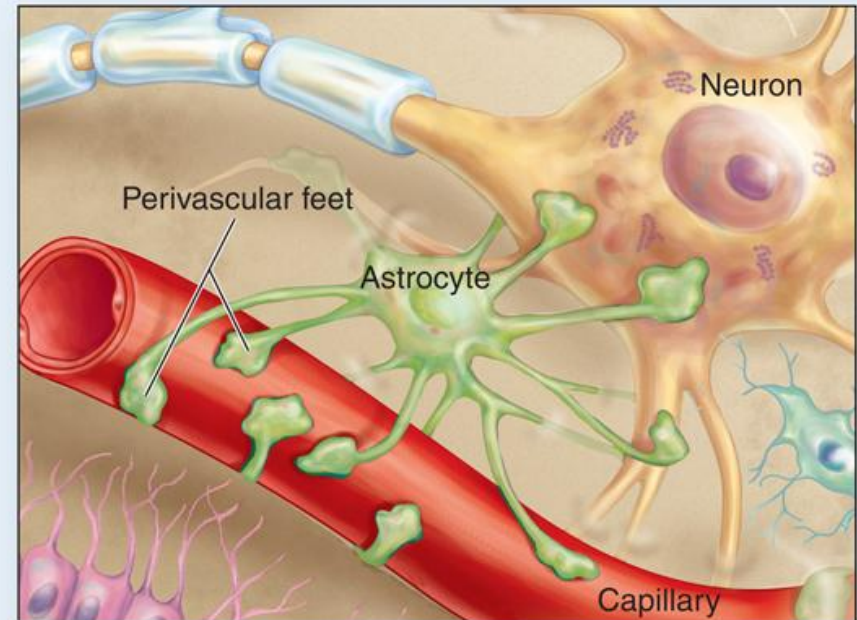
- Small glial cells with few processes
- Myelin-forming cells of CNS



a Oligodendrocyte

Astrocytes

- The most abundant glial cells of the CNS
- Are characterized by numerous cytoplasmic processes
- Astrocytes are an important part of the blood-brain barrier (BBB), regulating entry of molecules and ions from blood into CNS tissue



b Astrocyte

Blood brain barrier BBB

Consists of:

- 1- Tight junctions that seal together the endothelial cells of brain blood capillaries
- 2- Thick basement membrane
- 3- Astrocytes processes

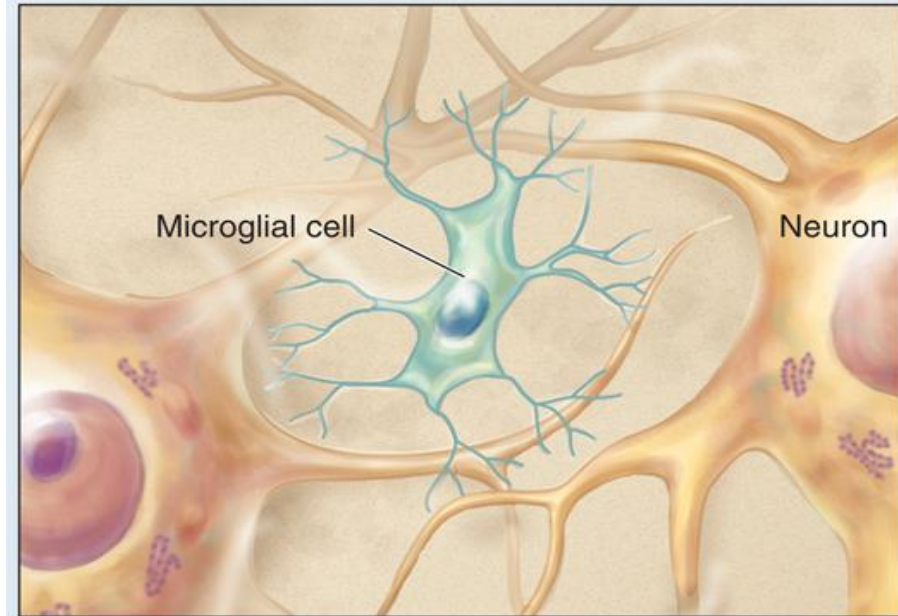
- ✓ A few water soluble substances (glucose) cross the BBB by active transport
- ✓ Proteins and most antibiotic drugs do not pass into brain tissue
- ✓ Lipid soluble substances (oxygen, carbon dioxide, alcohol, most anesthetic agents cross freely

Trauma, certain toxins, and inflammation can cause breakdown of BBB

Neuroglial cells of CNS

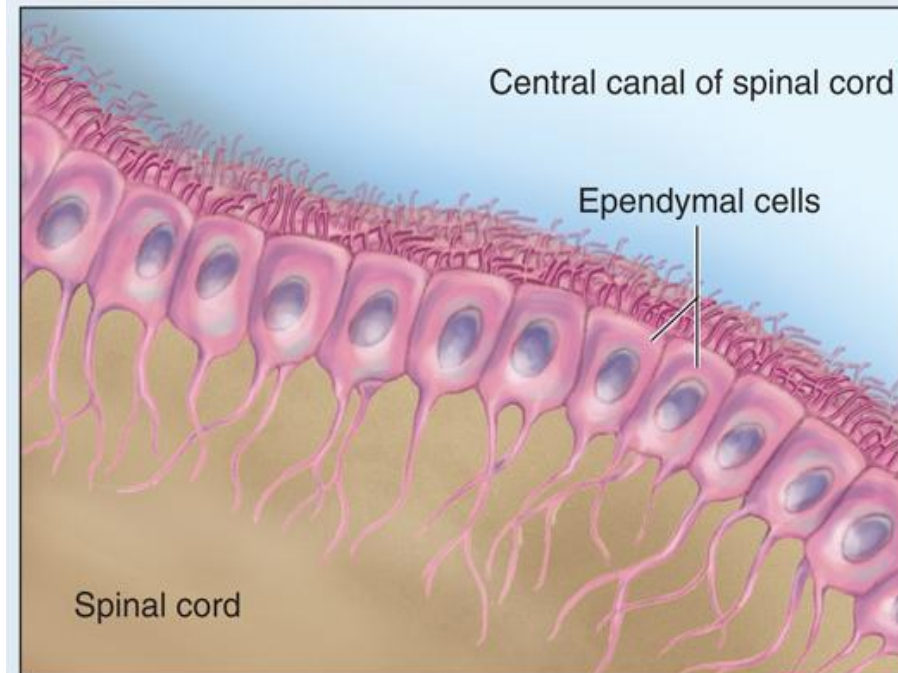
Microglia

- Are monocyte-derived, antigen-presenting cells of the CNS

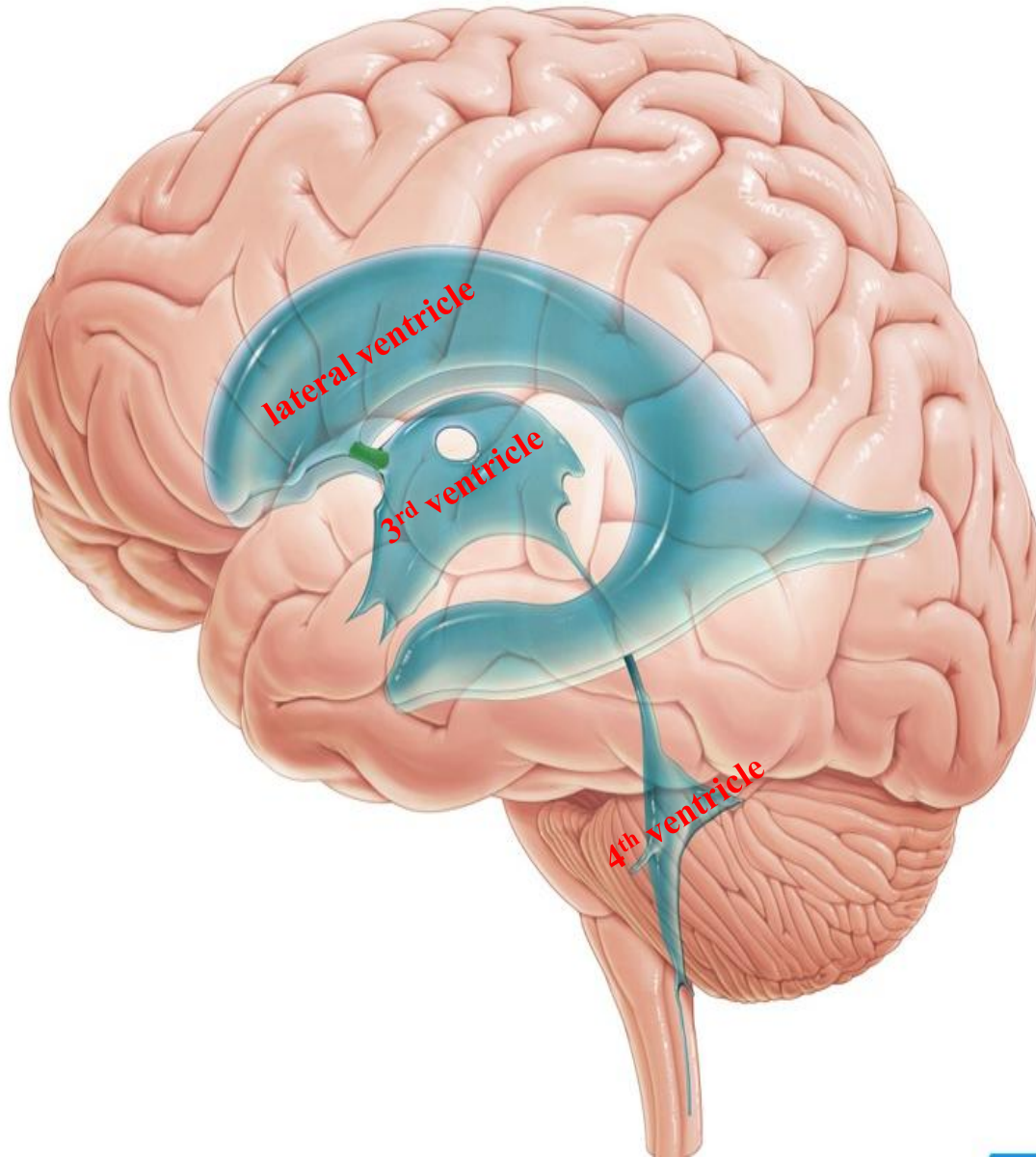


Ependymal cells

- Are epithelial-like cells that form a single layer lining the fluid-filled ventricles and central canal of the CNS.

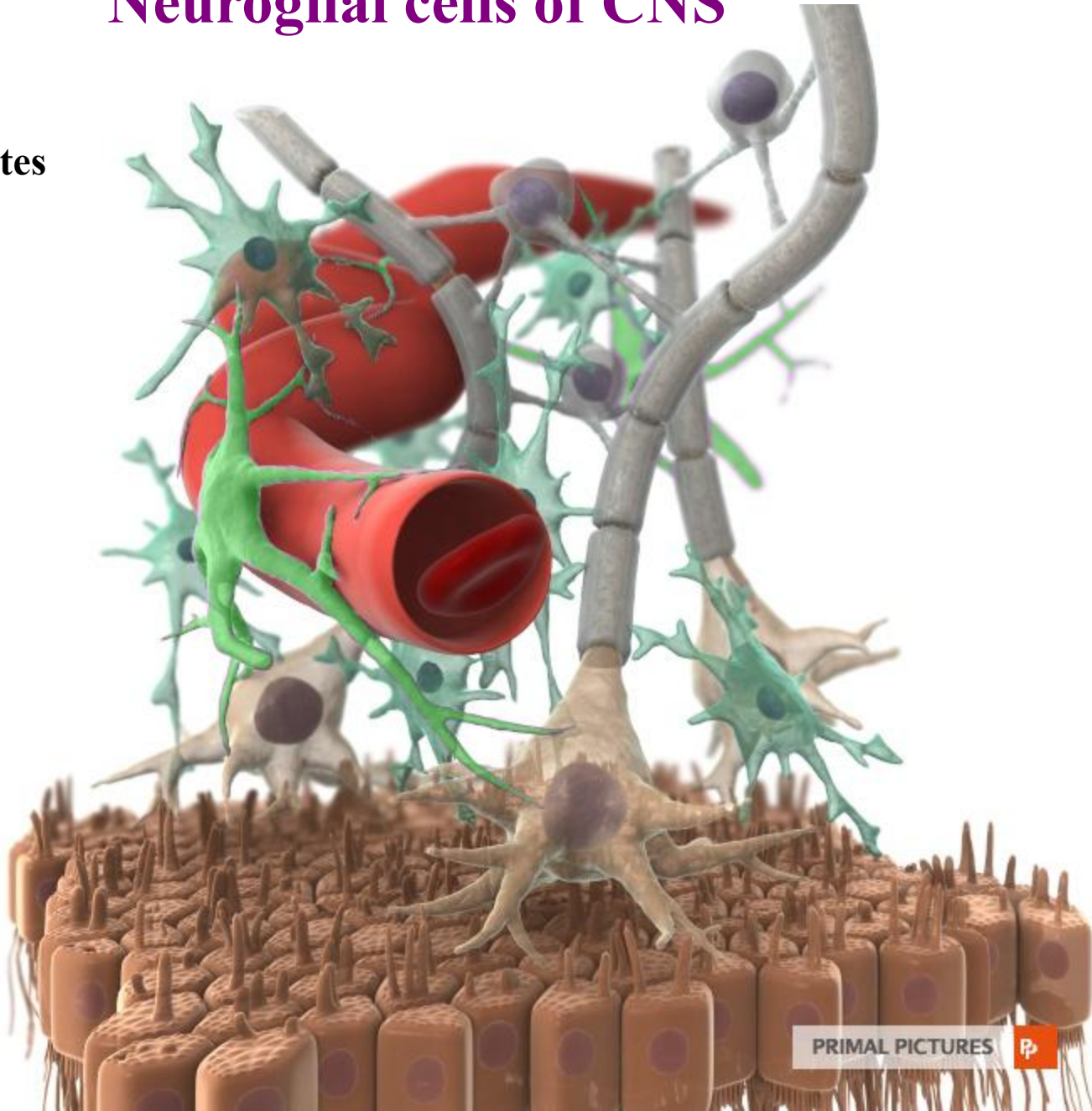


Ventricles are CSF-filled cavities within the brain



Neuroglial cells of CNS

Astrocytes

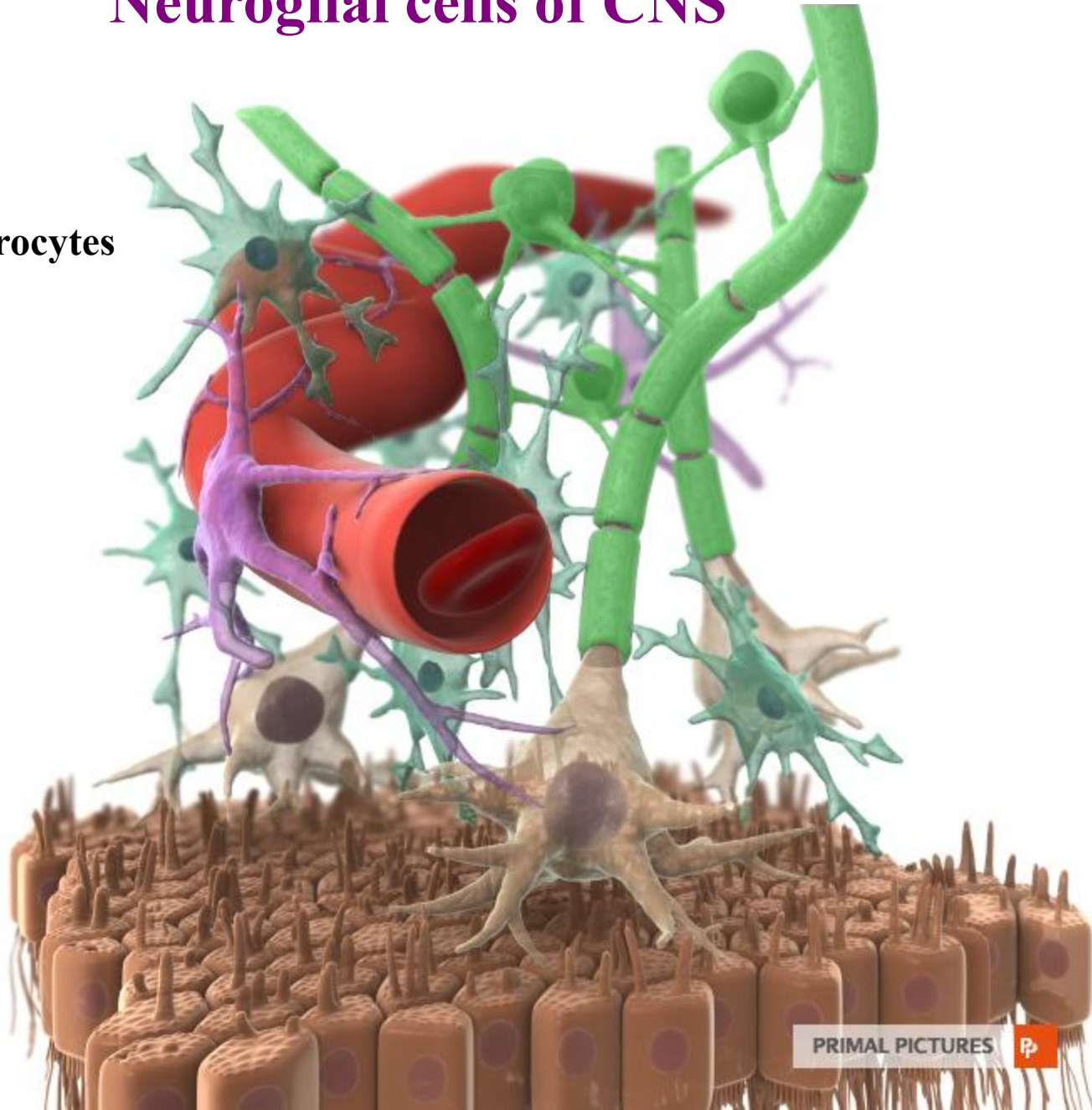


PRIMAL PICTURES



Neuroglial cells of CNS

Oligodendrocytes

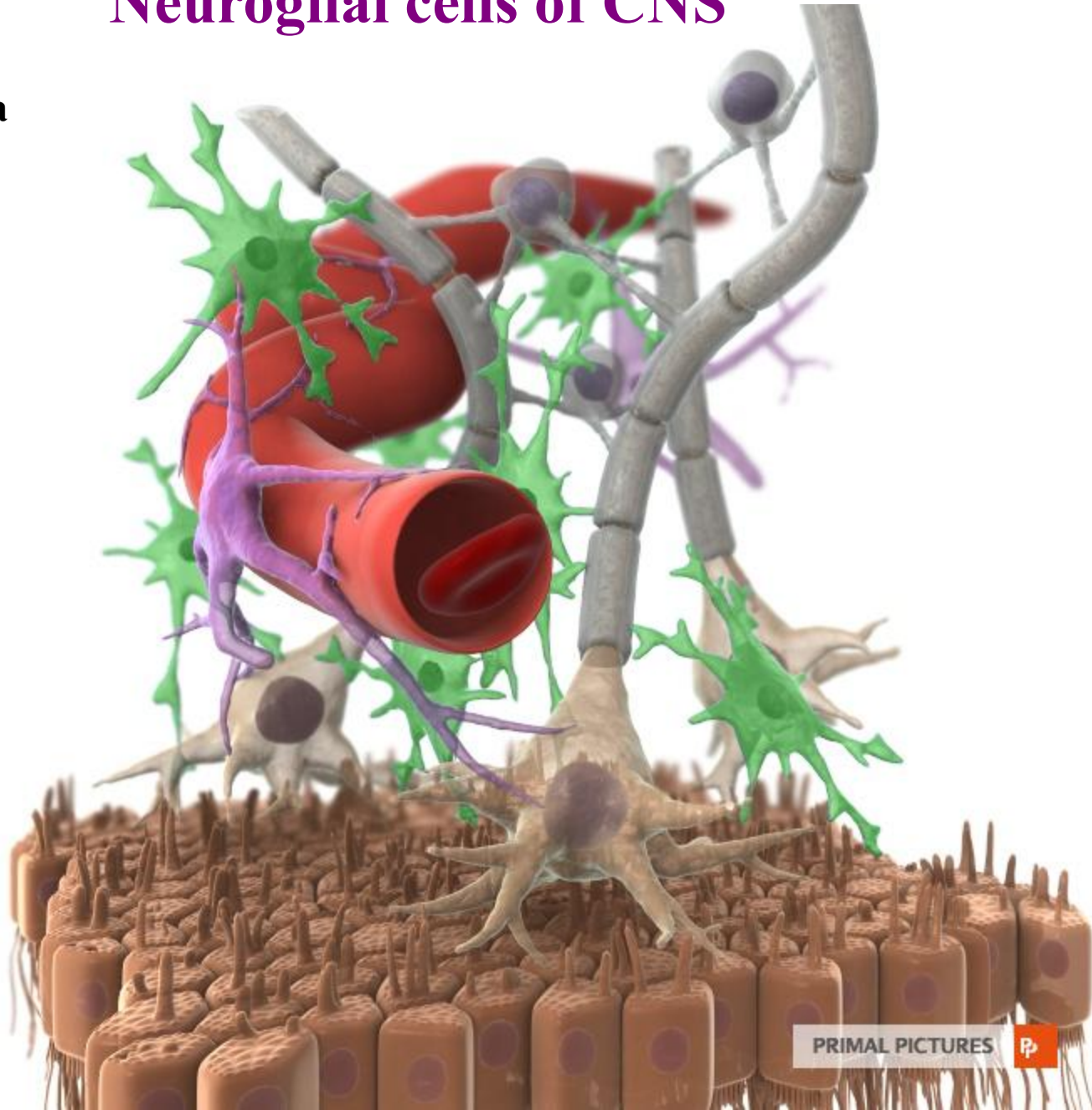


PRIMAL PICTURES



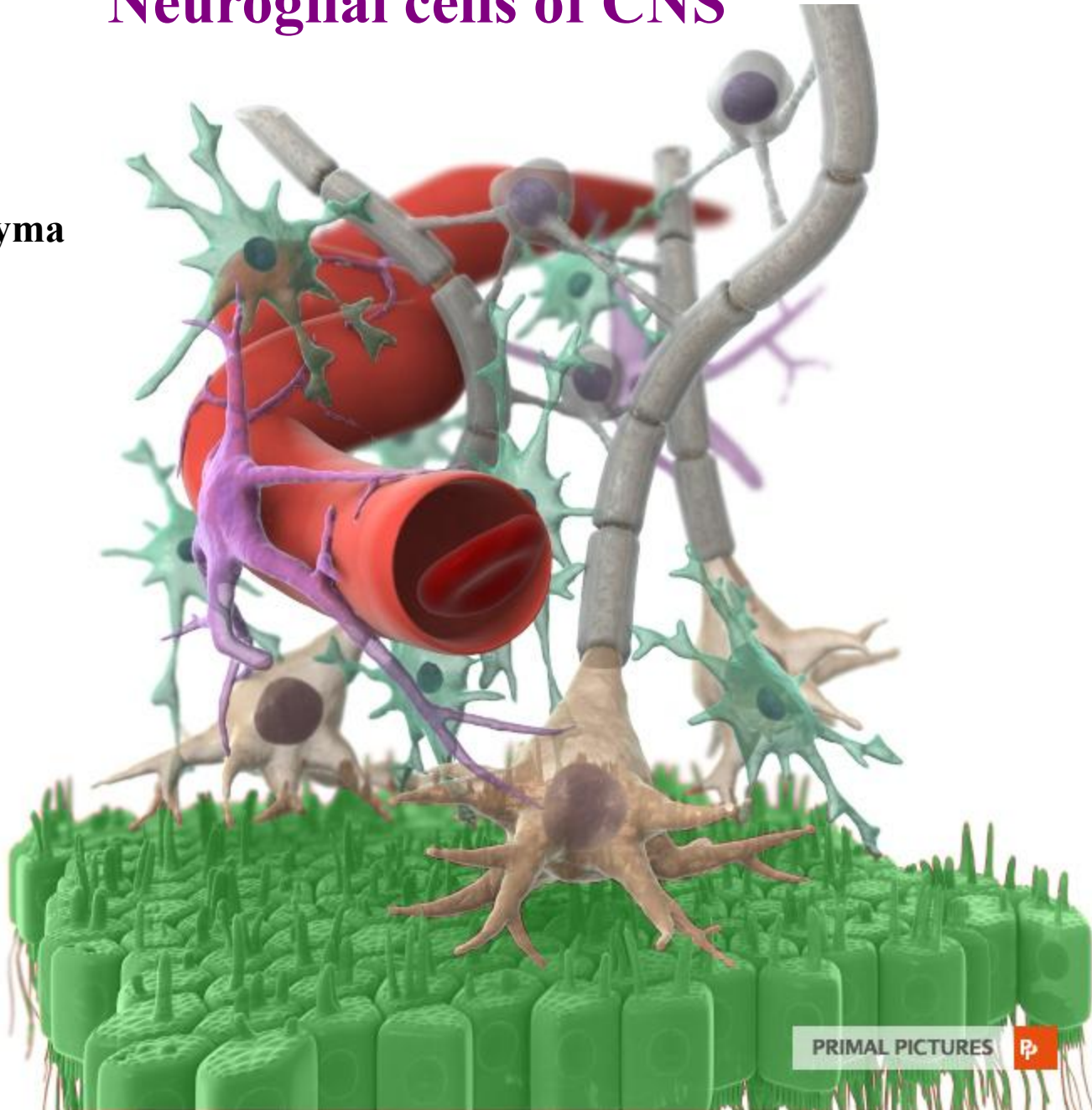
Neuroglial cells of CNS

Microglia



Neuroglial cells of CNS

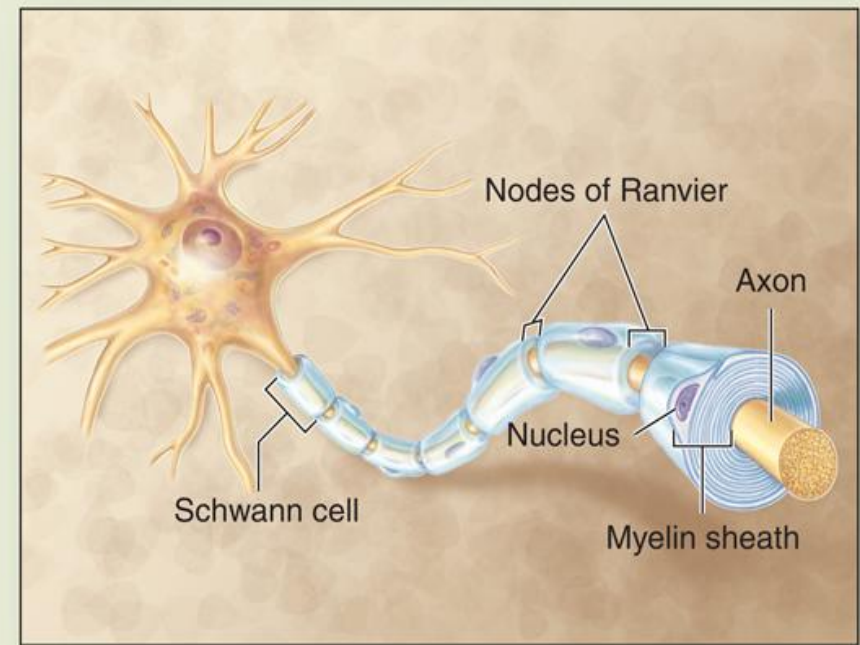
Ependyma



Neuroglial cells of PNS

Schwann cells

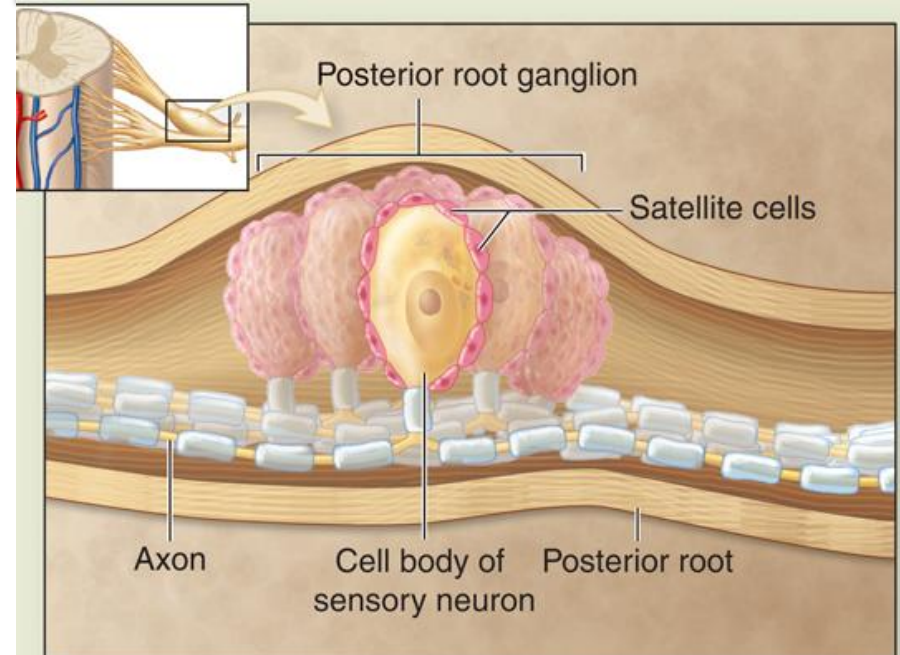
- Flattened cells
- Myelin-forming cells of PNS



e Schwann cells

Satellite cells

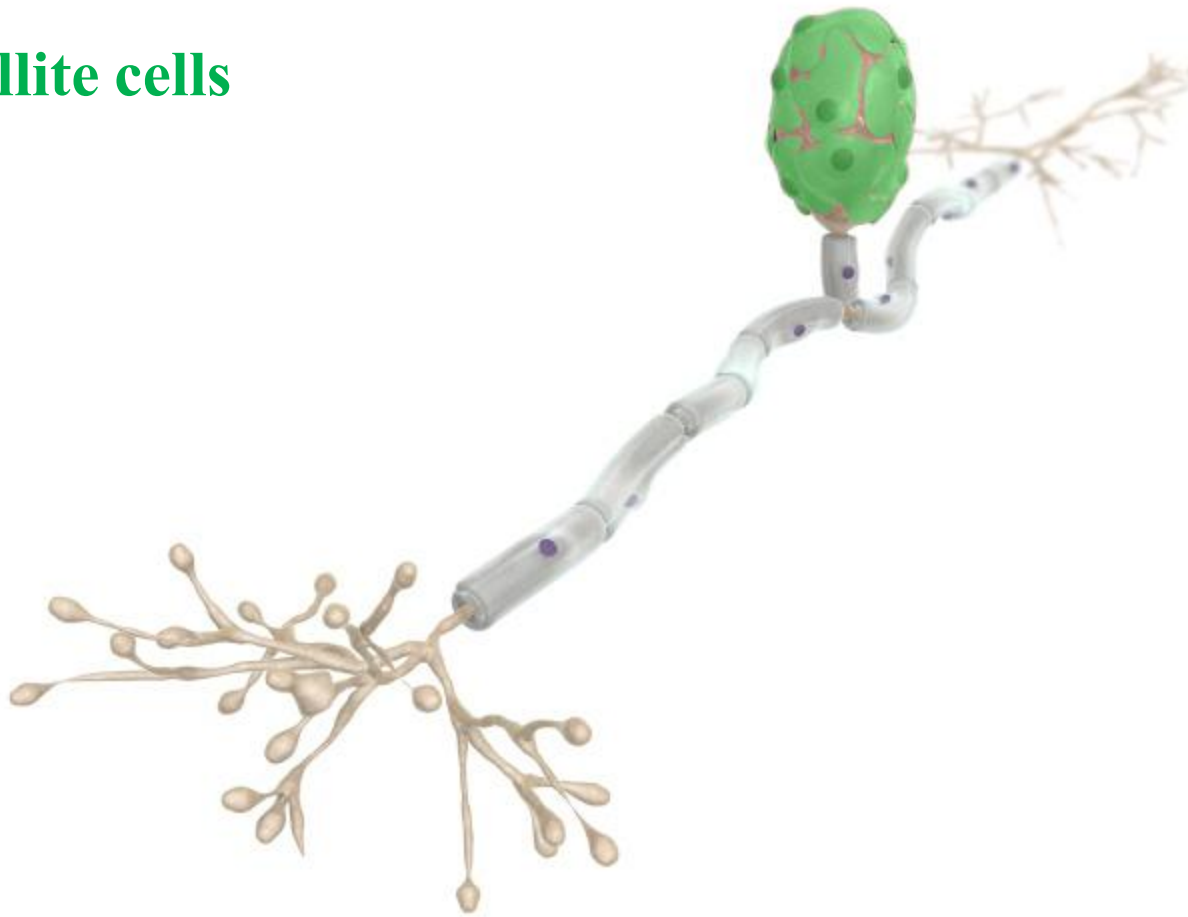
- Flattened cells arranged around cell bodies of neurons within ganglia.
- Support neurons in PNS ganglia.



f Satellite cells

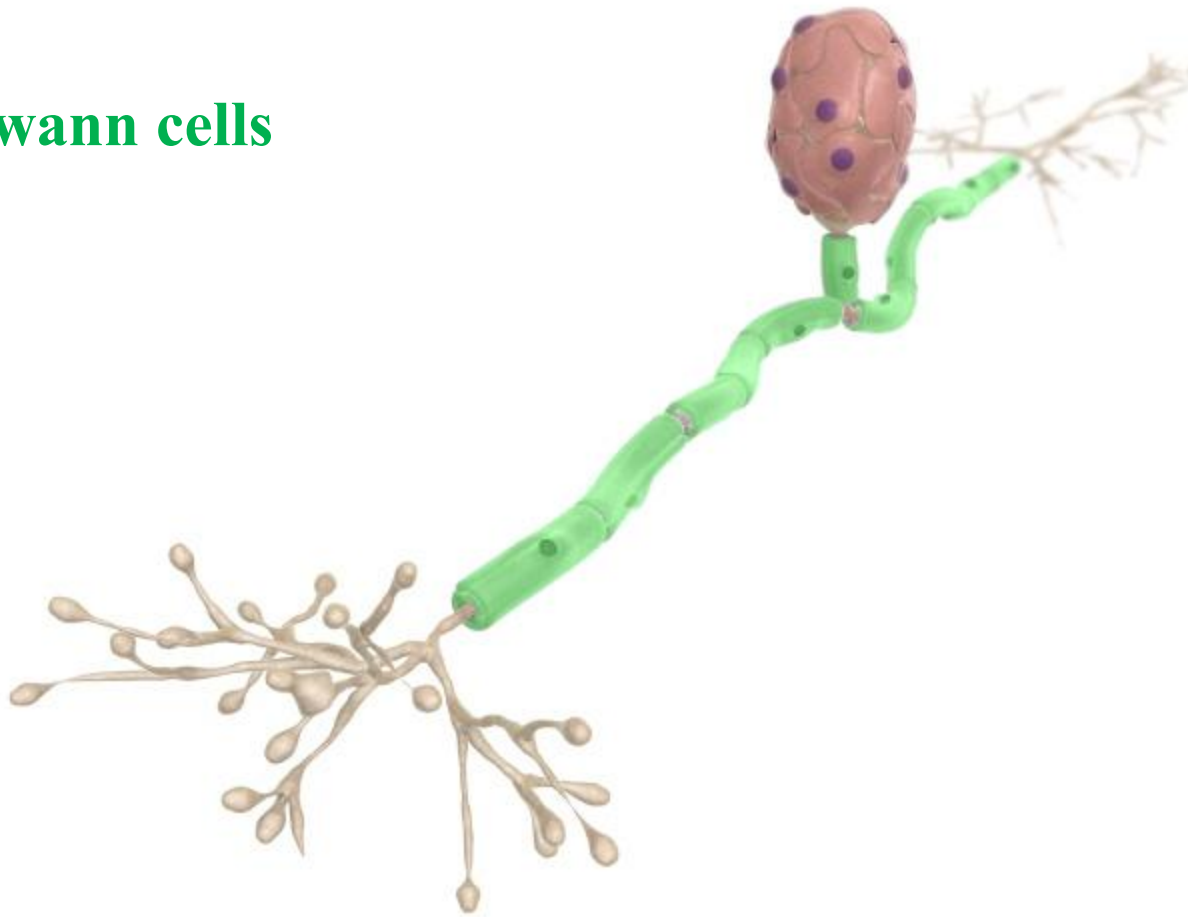
Neuroglial cells of PNS

Satellite cells



Neuroglial cells of PNS

Schwann cells



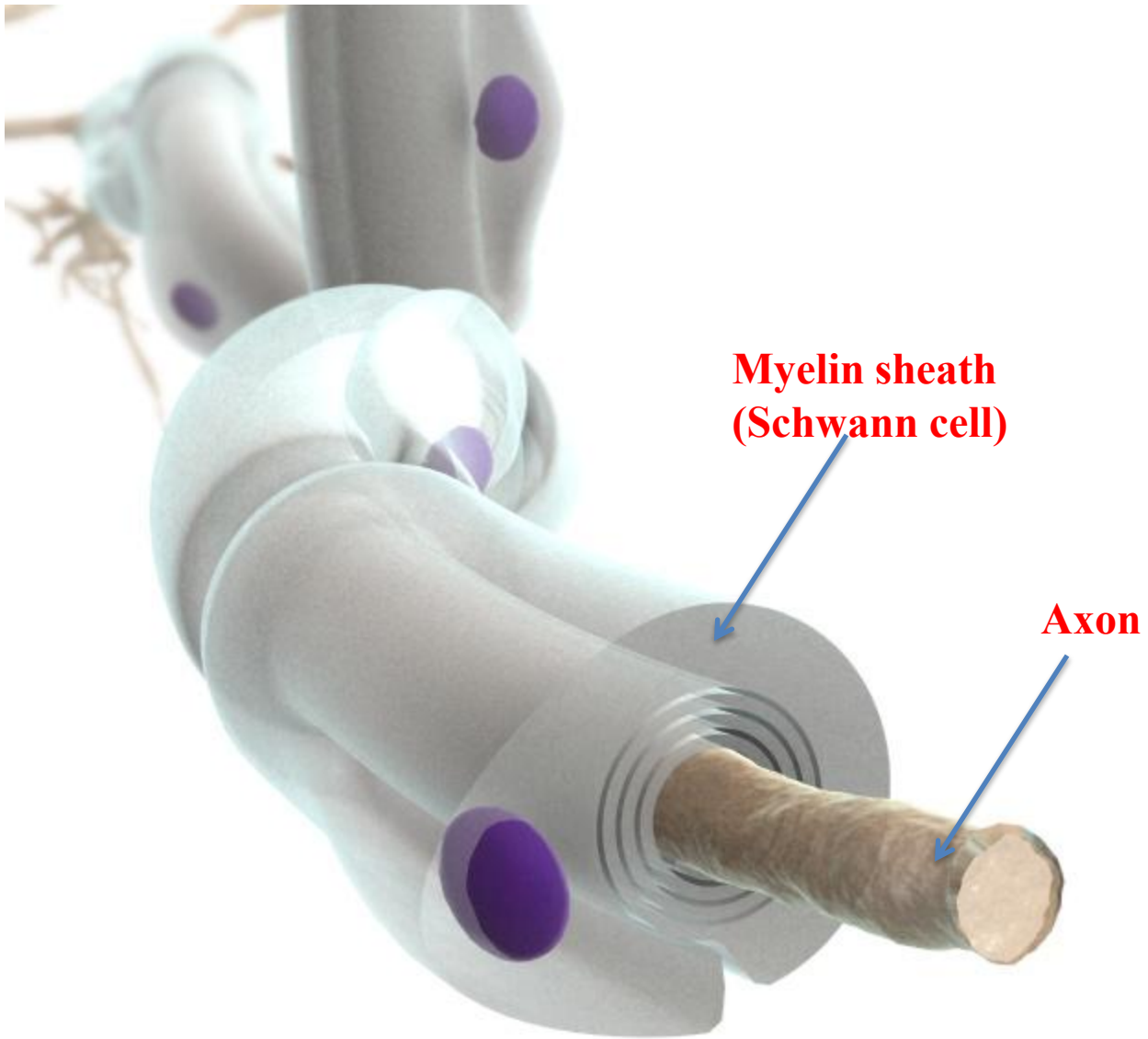
Myelin formation

- Myelin is not part of the neuron but formed by the *Neuroglial* cells.
- Begins during **2nd** trimester of pregnancy and continues well into the **2nd** decade
- Myelin increase the speed of impulse conduction.

Nerve fibers are either:

Myelinated: Impulse conduction is saltatory (jumping from node to node) with a maximum speed of 120m/s.

Unmyelinated: Impulse conduction is continuous with a maximum speed 15m/s.



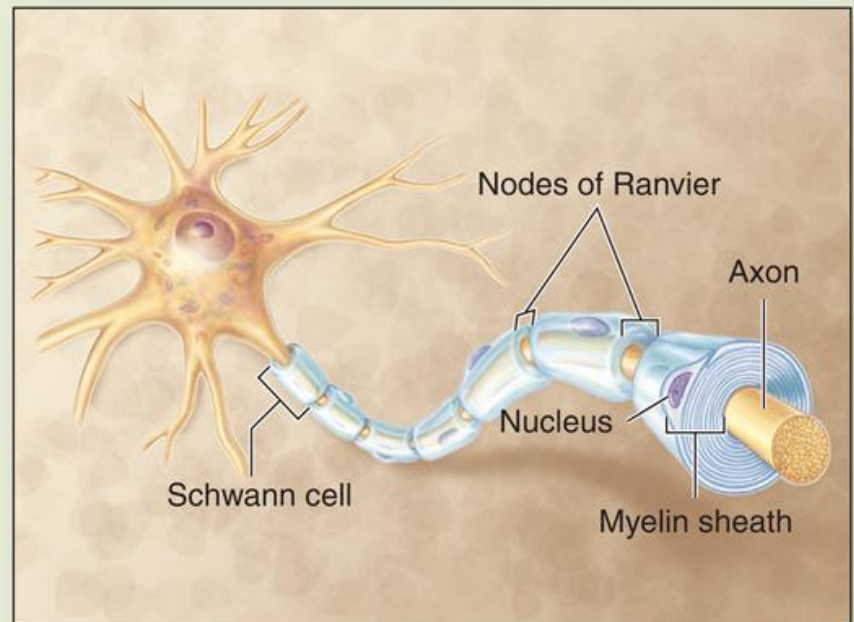
**Myelin sheath
(Schwann cell)**

Axon

Myelination in the PNS:

- Formed by **Schwann cells**
- Each Schwann cell myelinates **only one internodal segment of one axon**

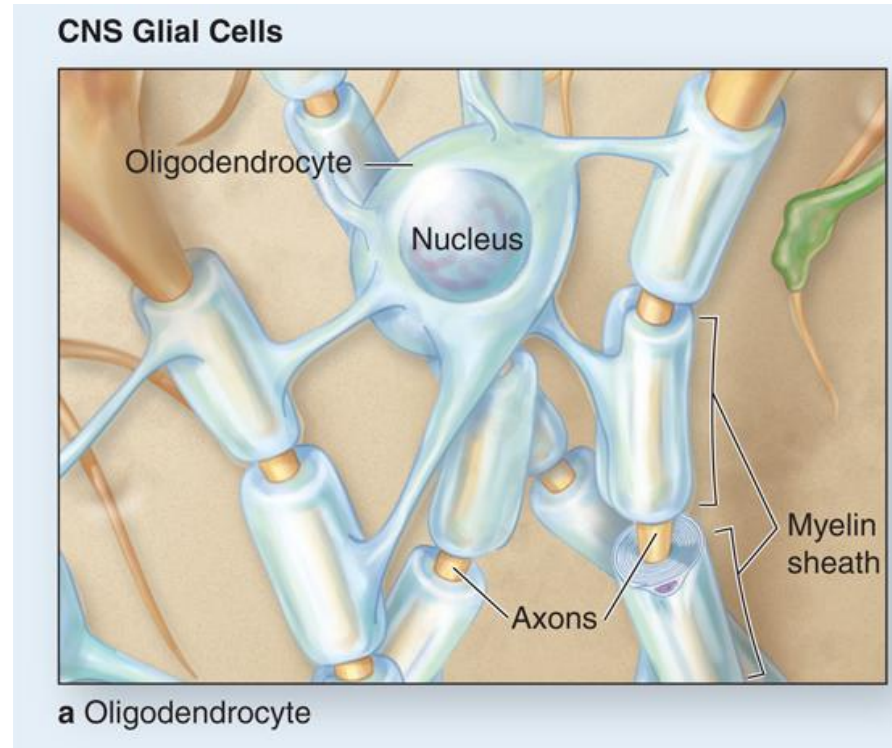
PNS Glial Cells



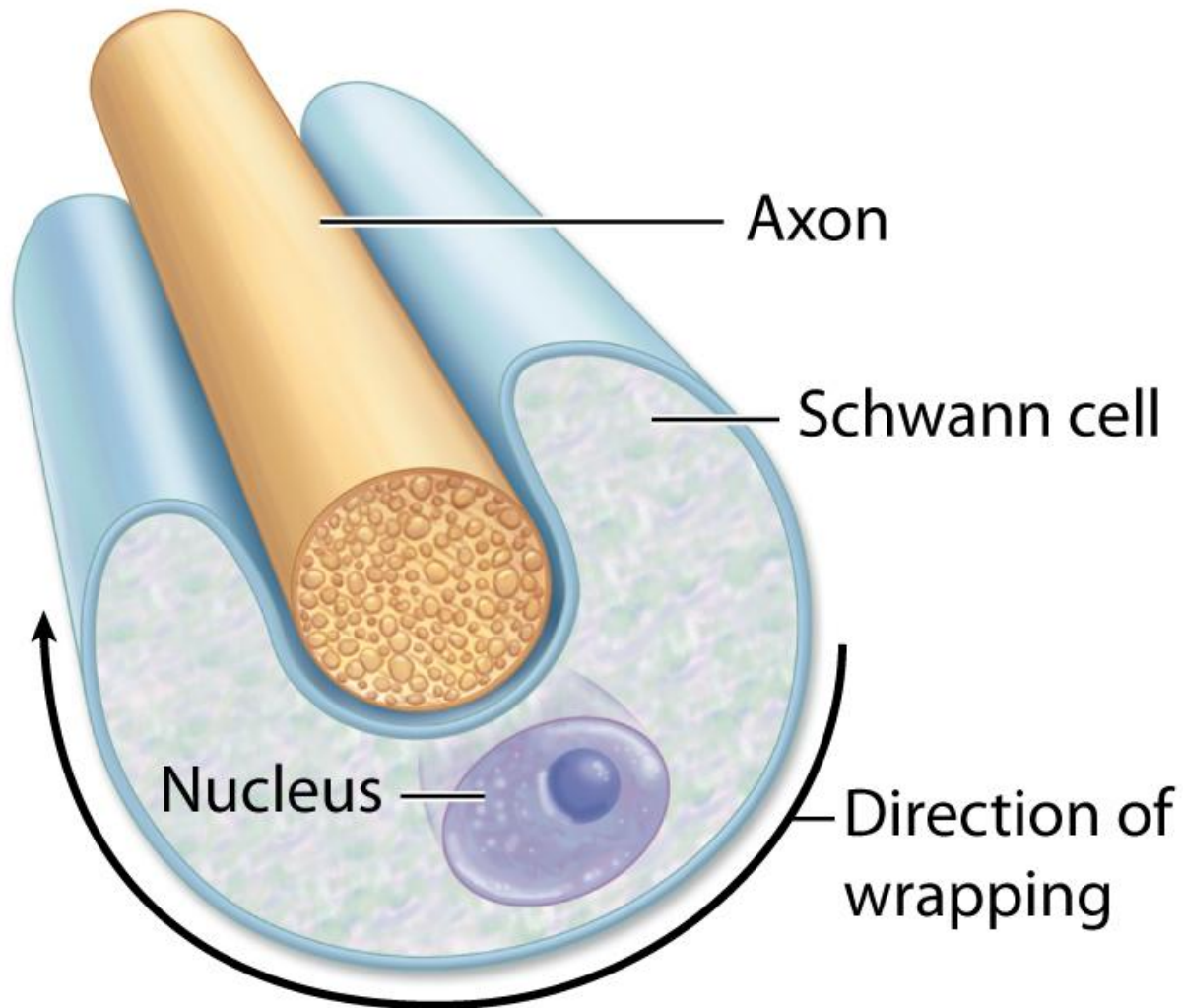
e Schwann cells

Myelination in the PNS:

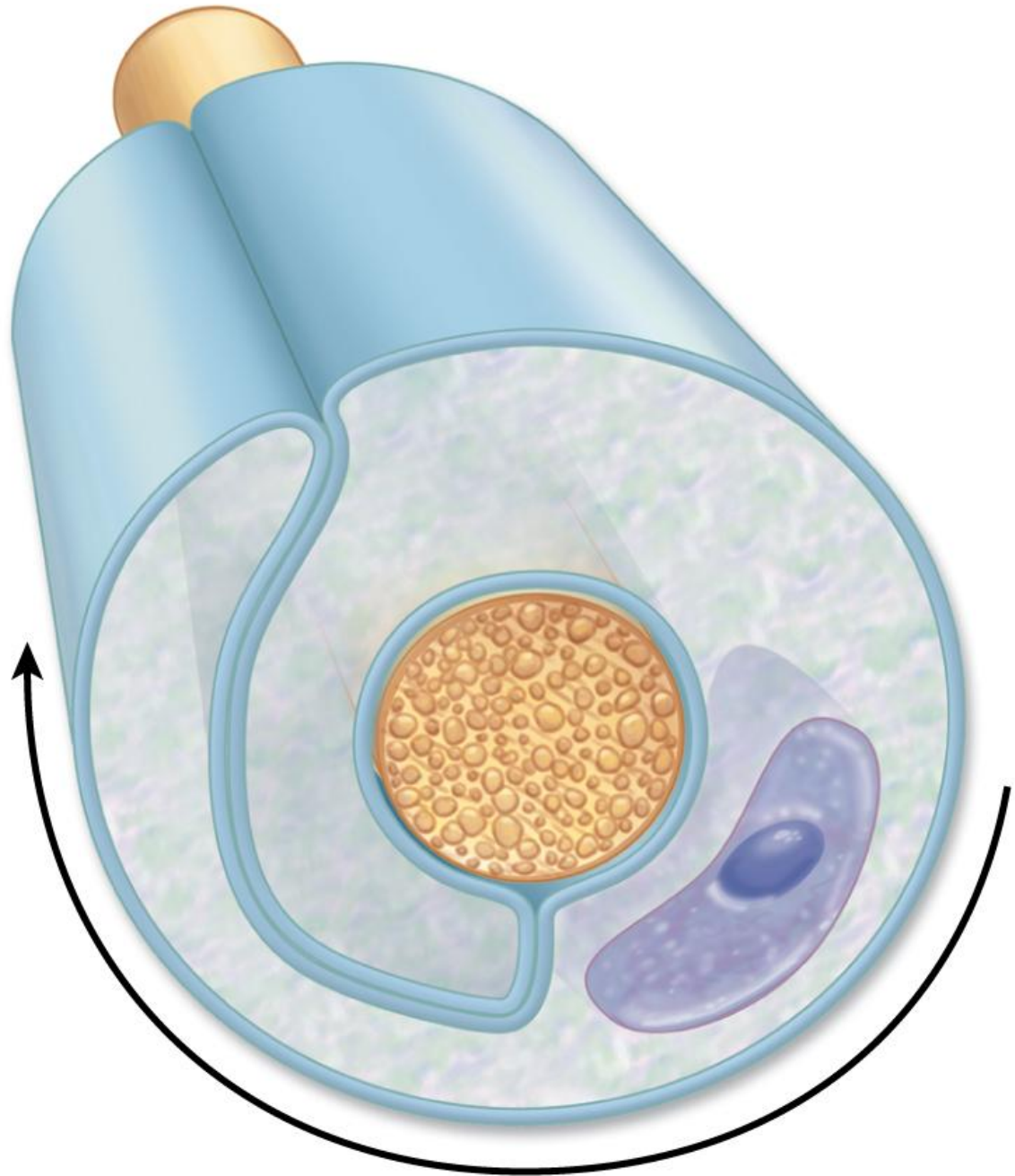
- Formed by **Oligodendrocytes**.
- Each cell can myelinate **internodal segments of about 60 axons** (or internodal segments)



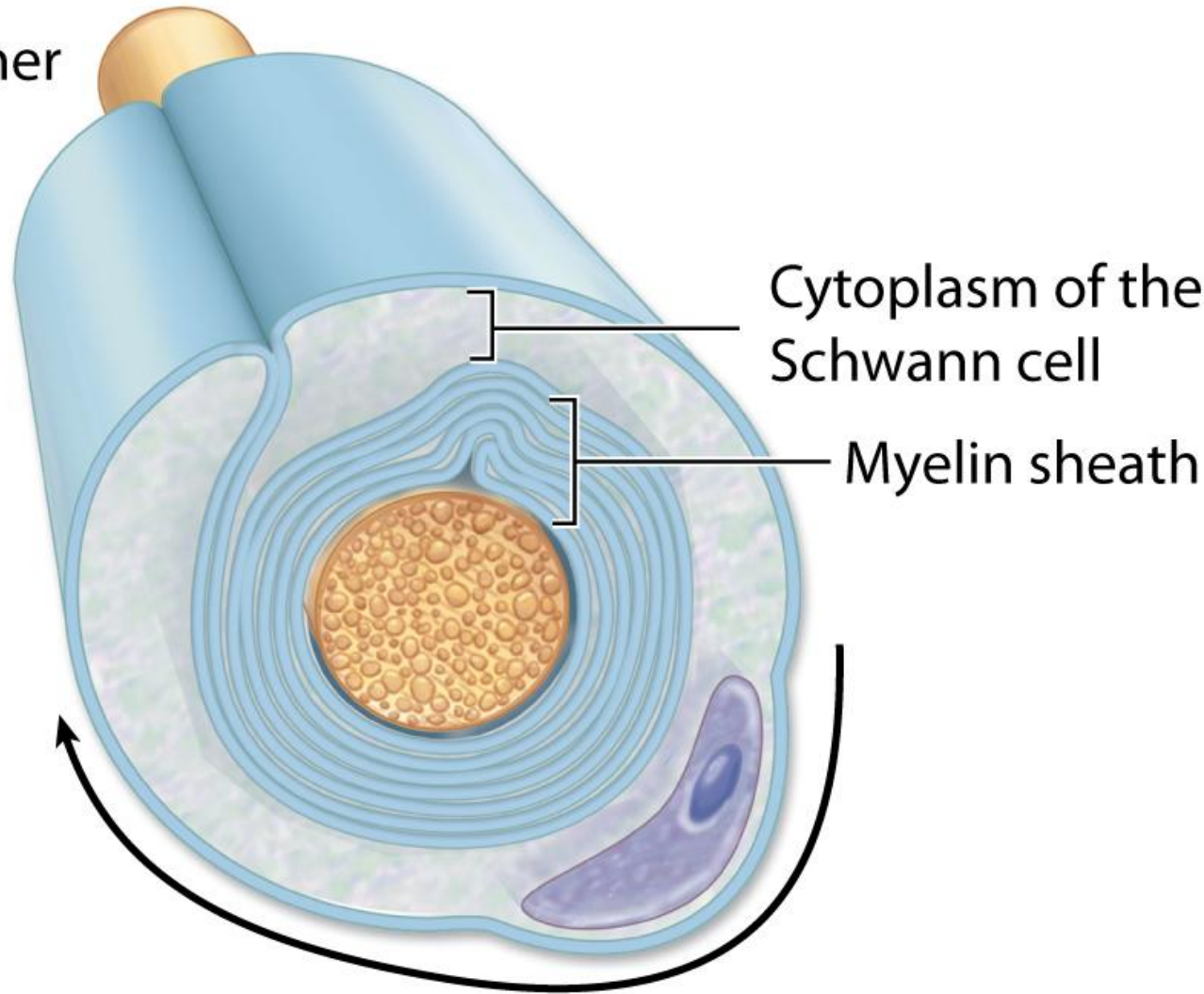
① Schwann cell starts to wrap around a portion of an axon.



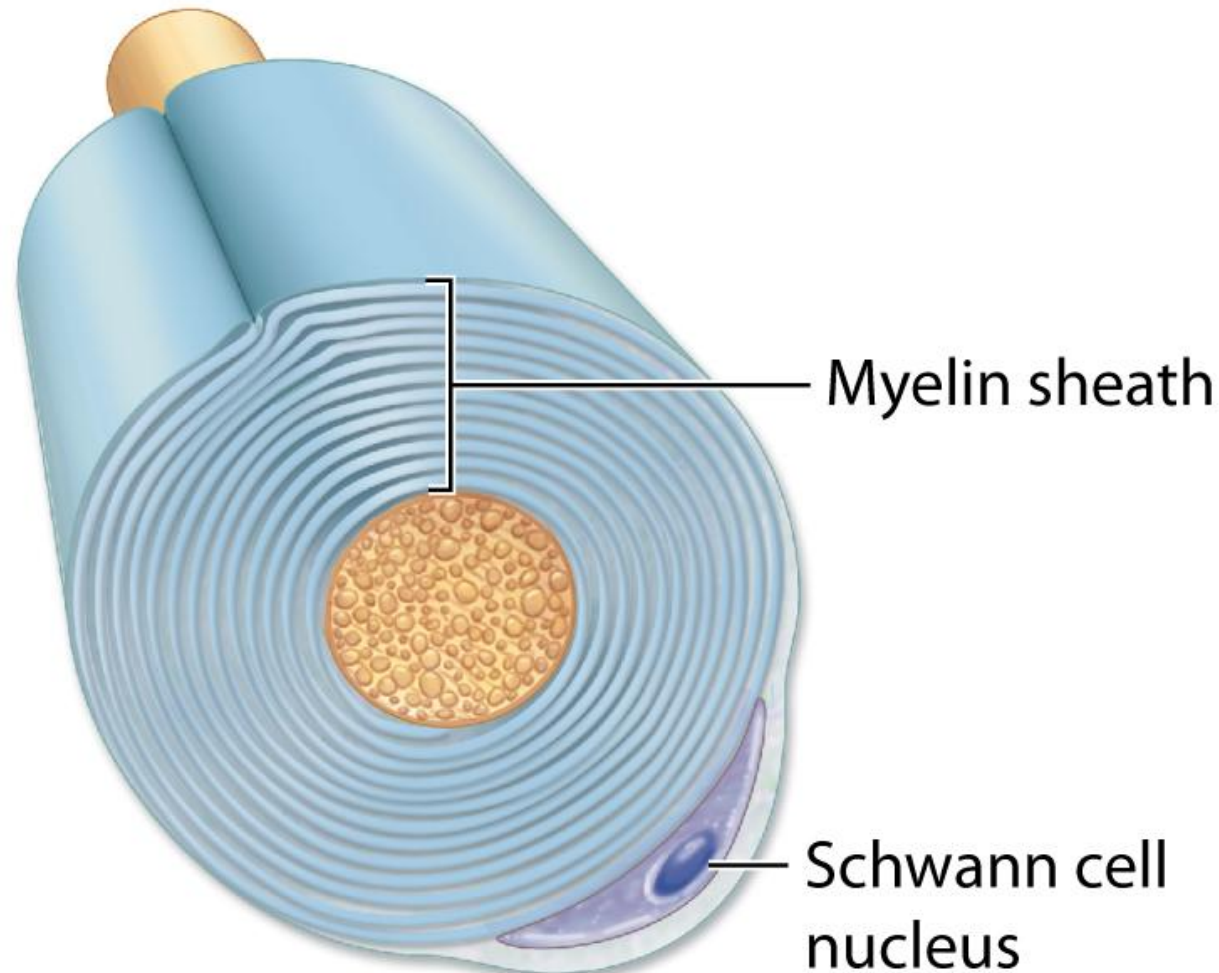
② Schwann cell cytoplasm and plasma membrane begin to form consecutive layers around axon.

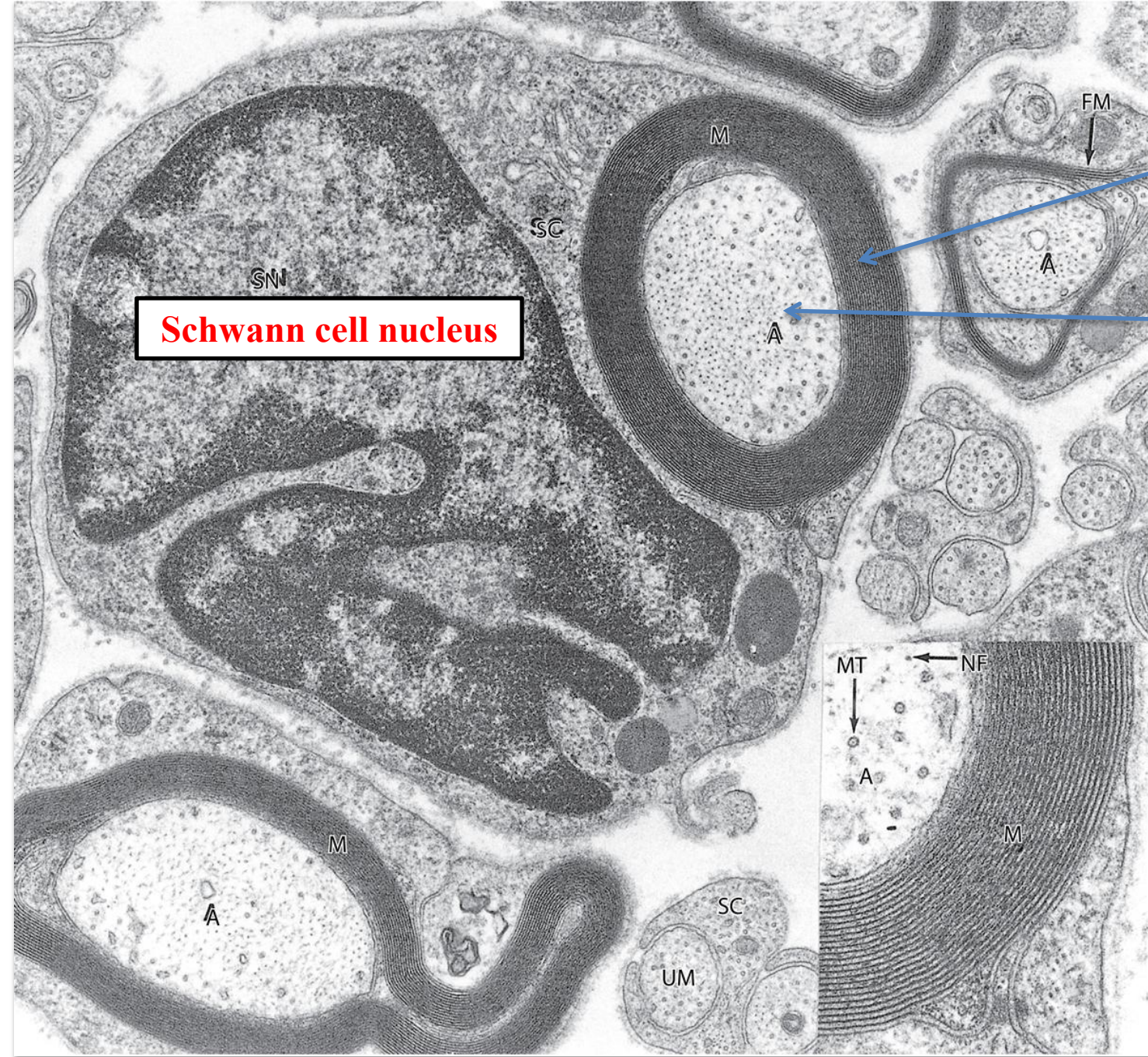


③ The overlapping inner layers of the Schwann cell plasma membrane form the myelin sheath.



- ④ Eventually, the Schwann cell cytoplasm and nucleus are pushed to the periphery of the cell as the myelin sheath is formed.





Schwann cell nucleus

Myelin sheath

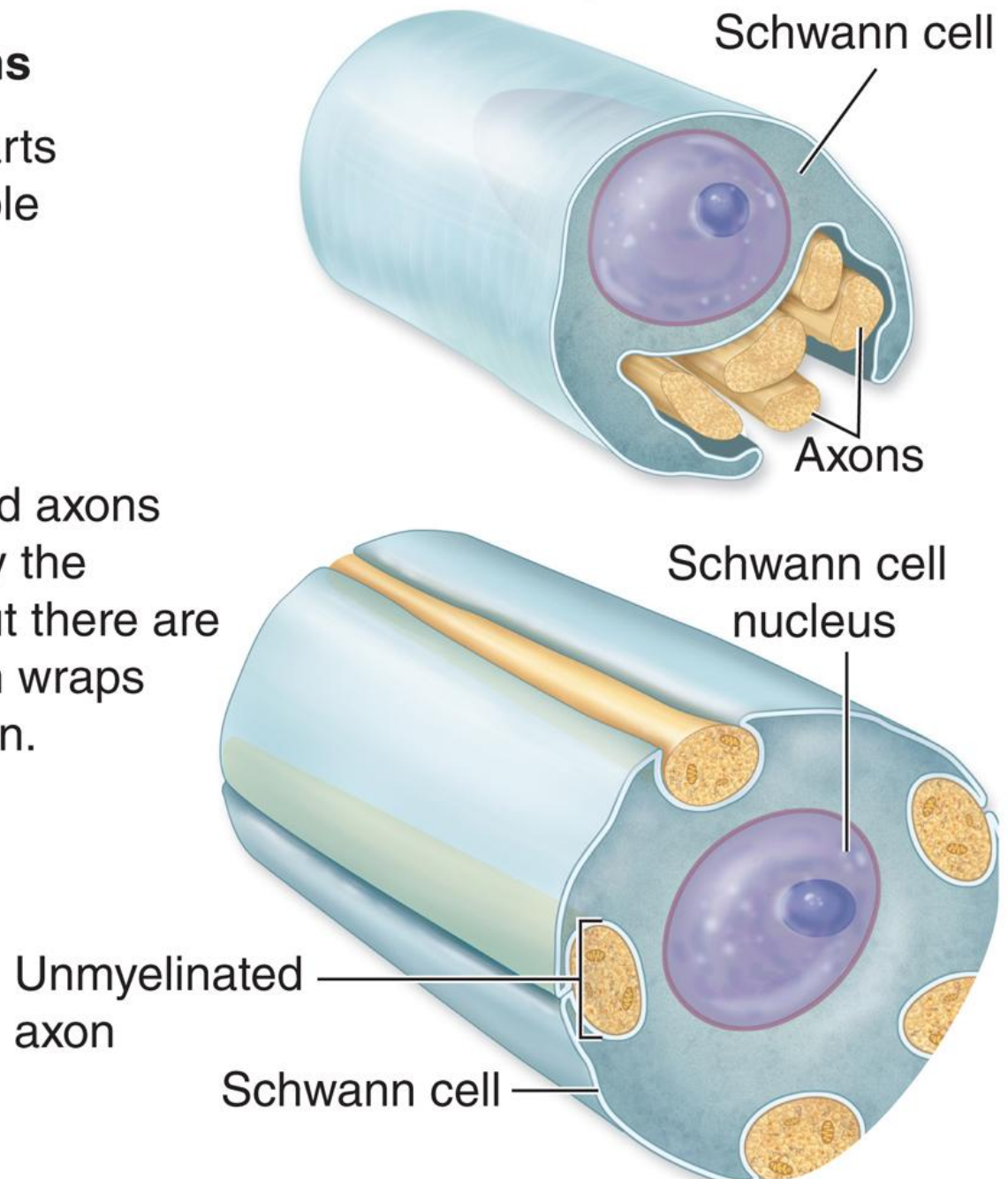
Axon

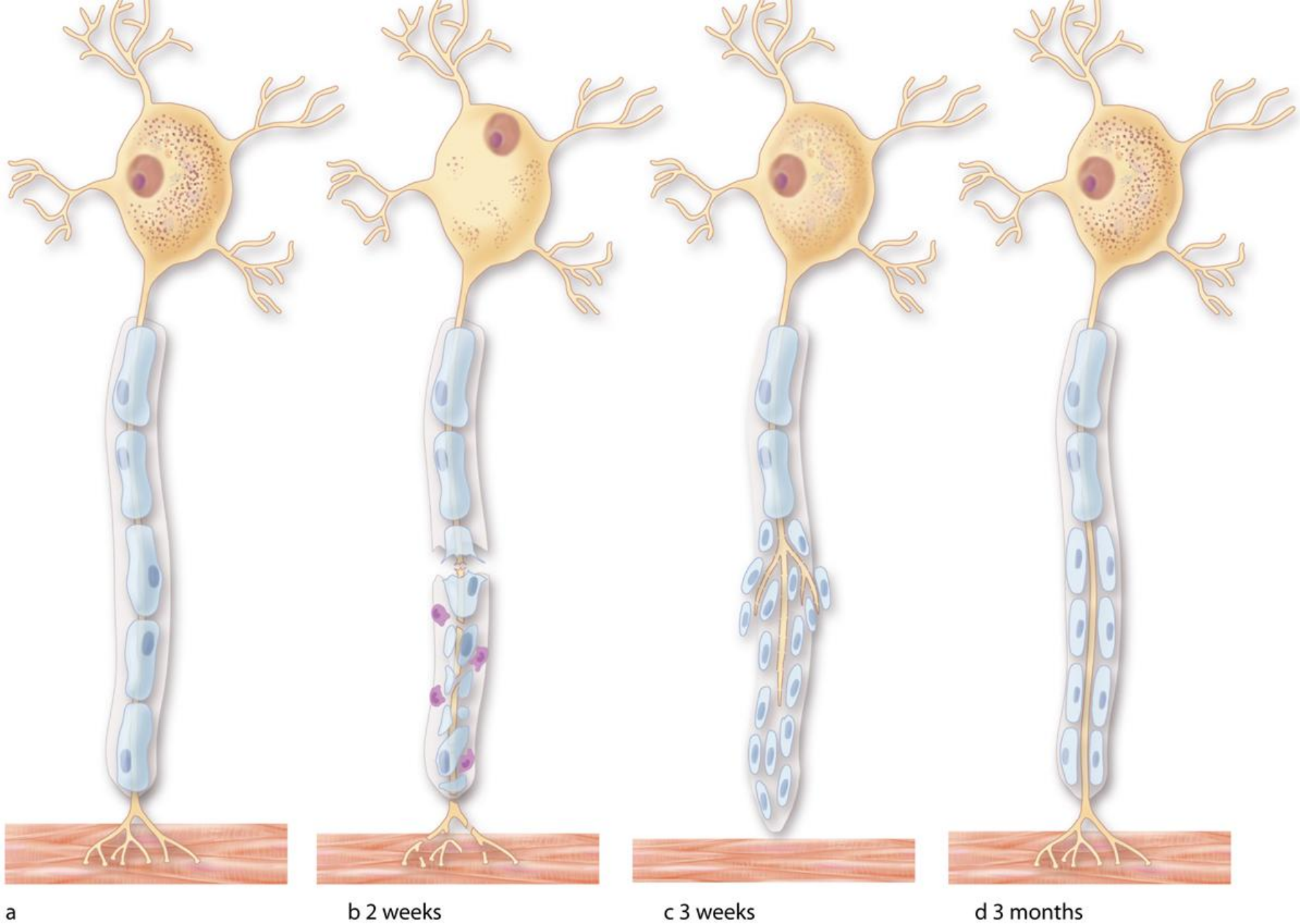


Figure 9-22

Unmyelinated axons

- ① Schwann cell starts to envelop multiple axons.
- ② The unmyelinated axons are enveloped by the Schwann cell, but there are *no* myelin sheath wraps around each axon.





a

b 2 weeks

c 3 weeks

d 3 months

Figure 9-30