Nervous Tissue

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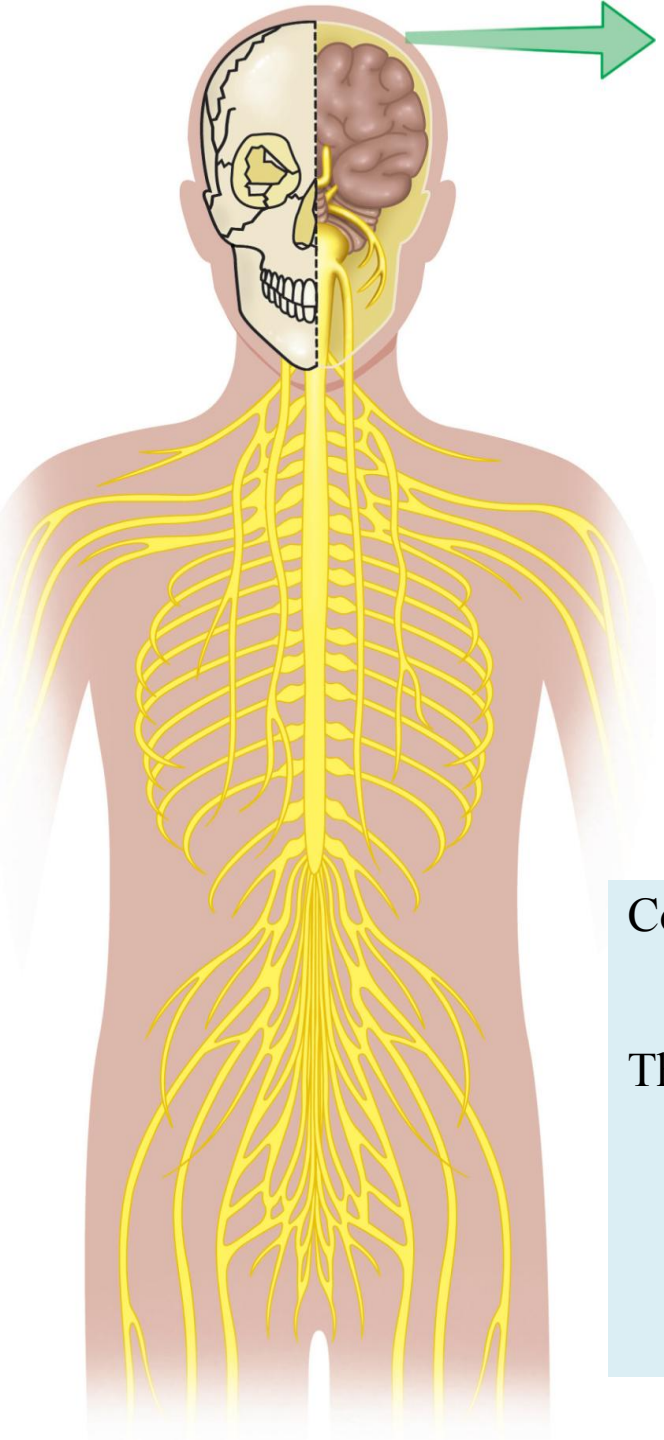
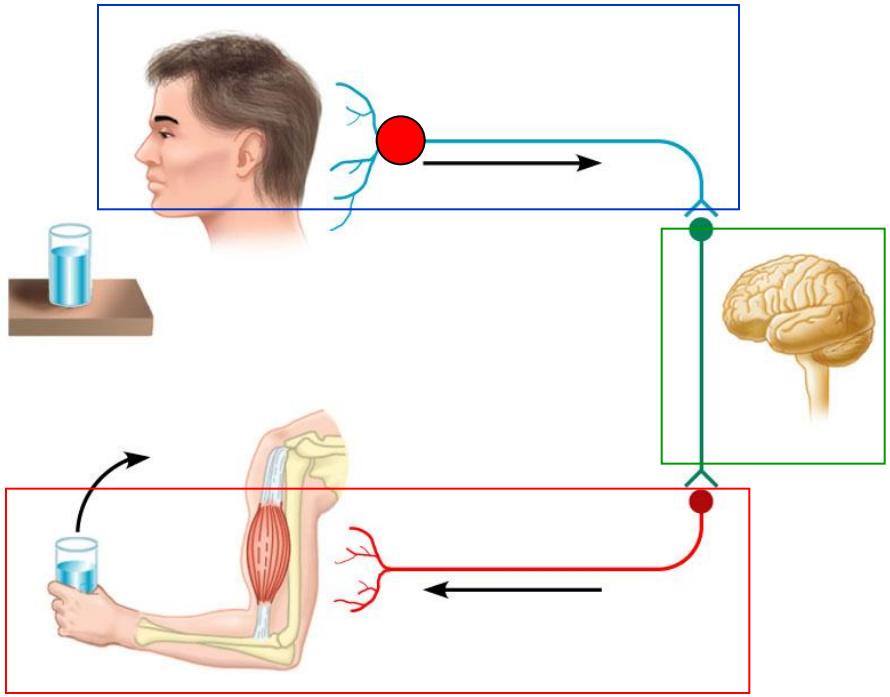
Nervous Tissue

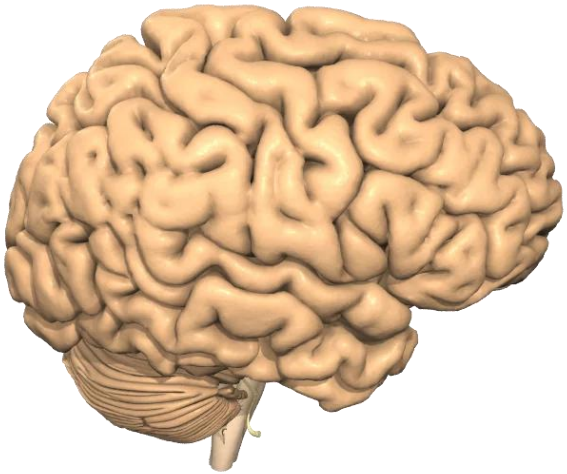




Controls and integrates all body activities within limits that maintain life

Three basic functions

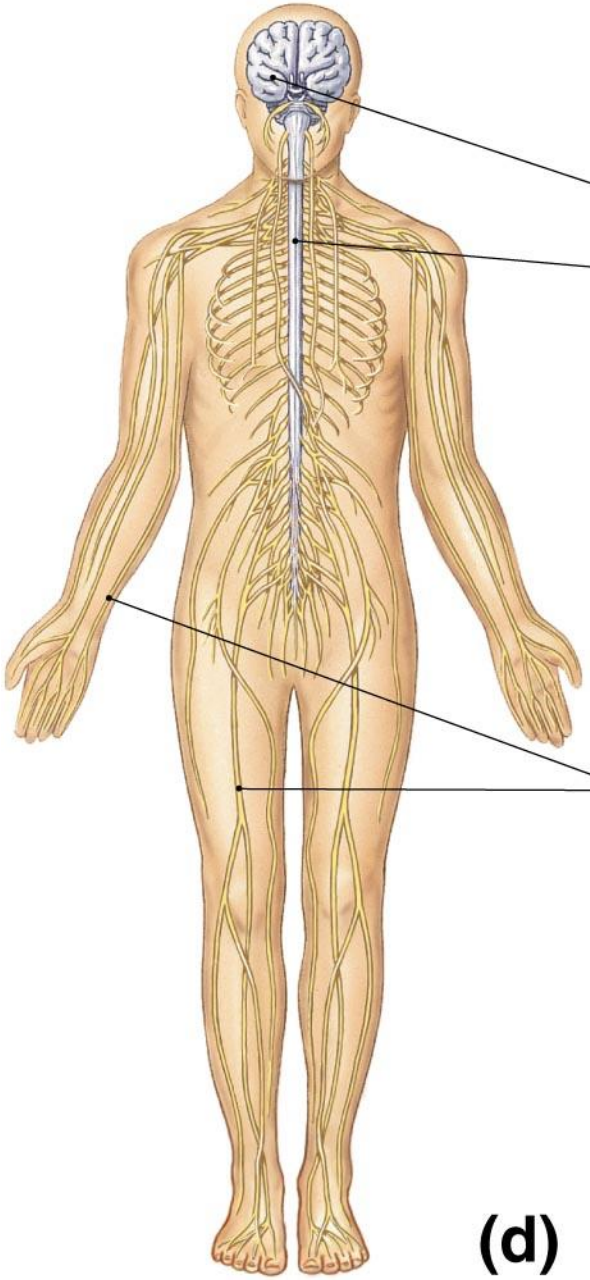
1. sensing changes with sensory receptors
2. interpreting and remembering those changes
3. reacting to those changes with effectors (motor function)



PRIMAL PICTURES

Spinal nerves
31 pairs

Cranial nerves
12 pairs



(d)

Central nervous system

Brain

Spinal cord

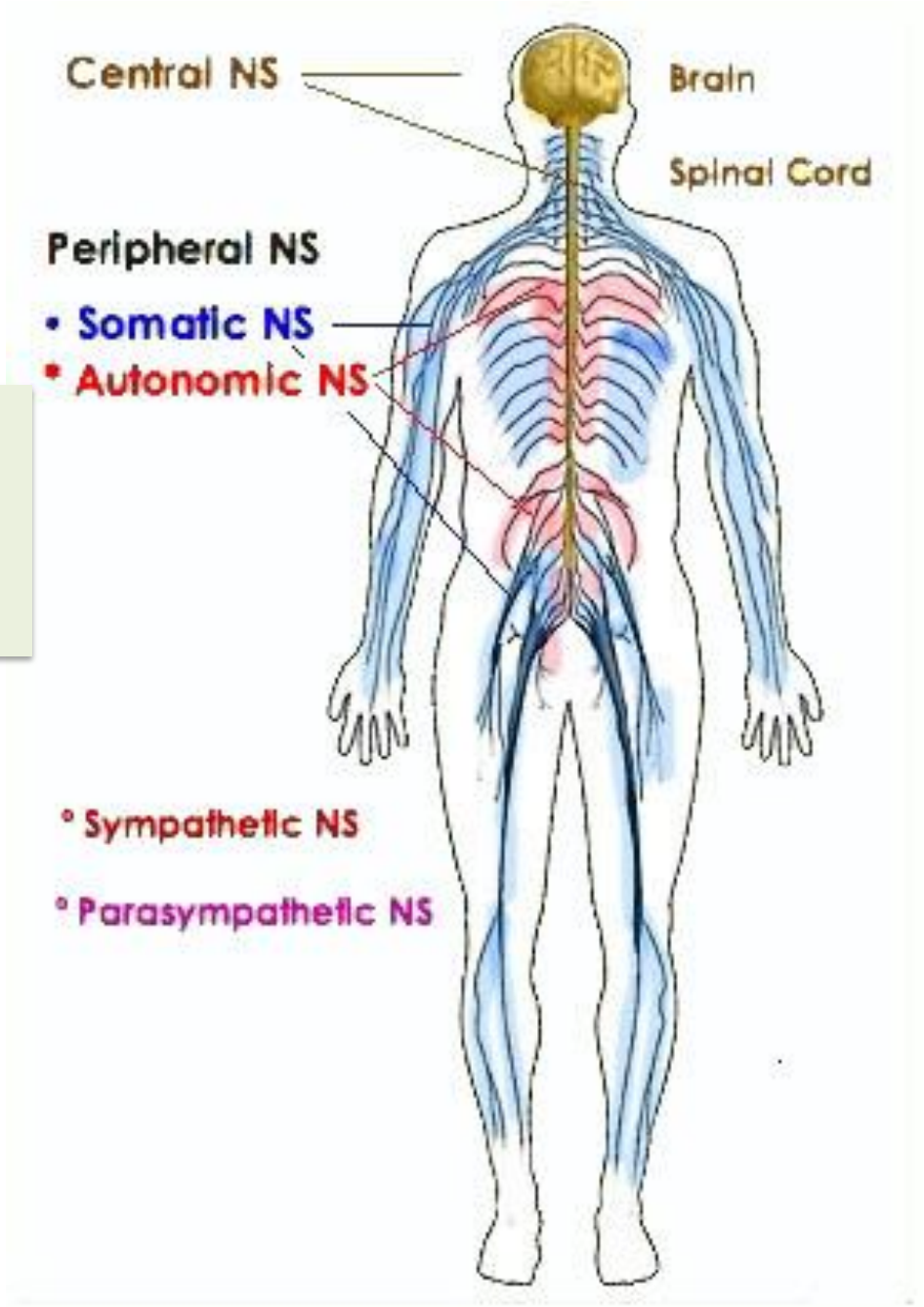
Peripheral nervous system

Peripheral nerves

The PNS is divided into :

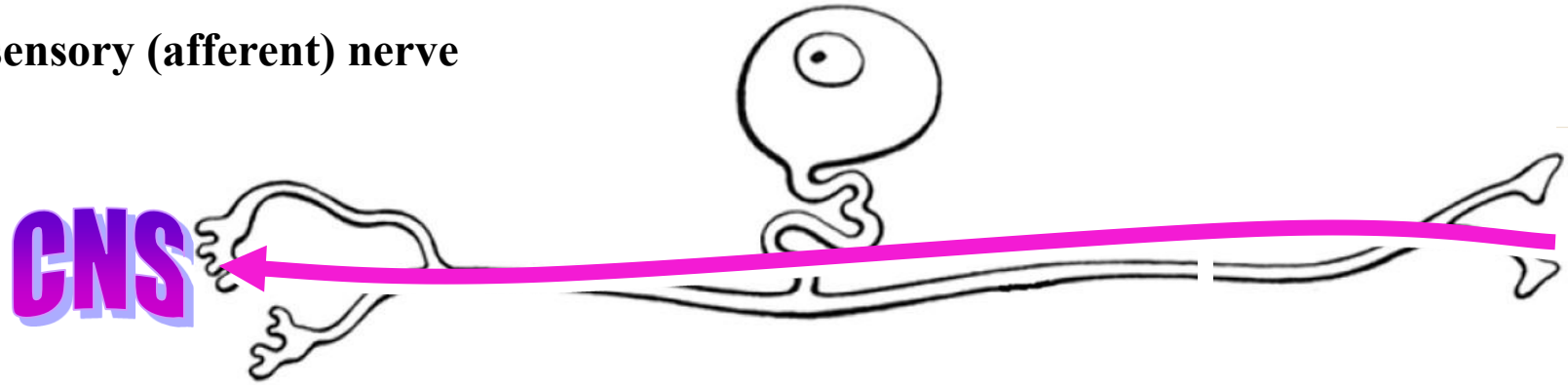
1- **Somatic nervous system** (SNS)

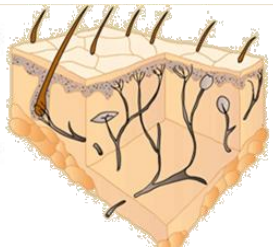
2- **Autonomic nervous system** (ANS)



Sensory (Afferent) vs. Motor (Efferent)

sensory (afferent) nerve

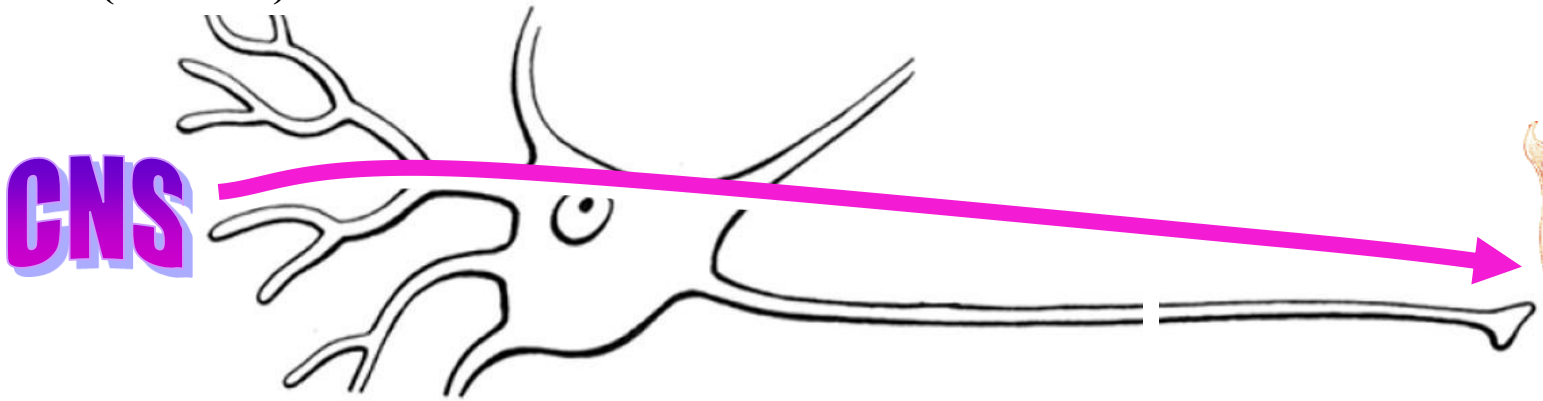


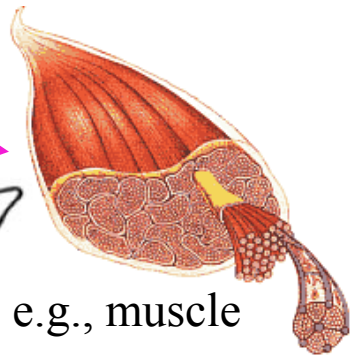


e.g., skin

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

motor (efferent) nerve





e.g., muscle

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

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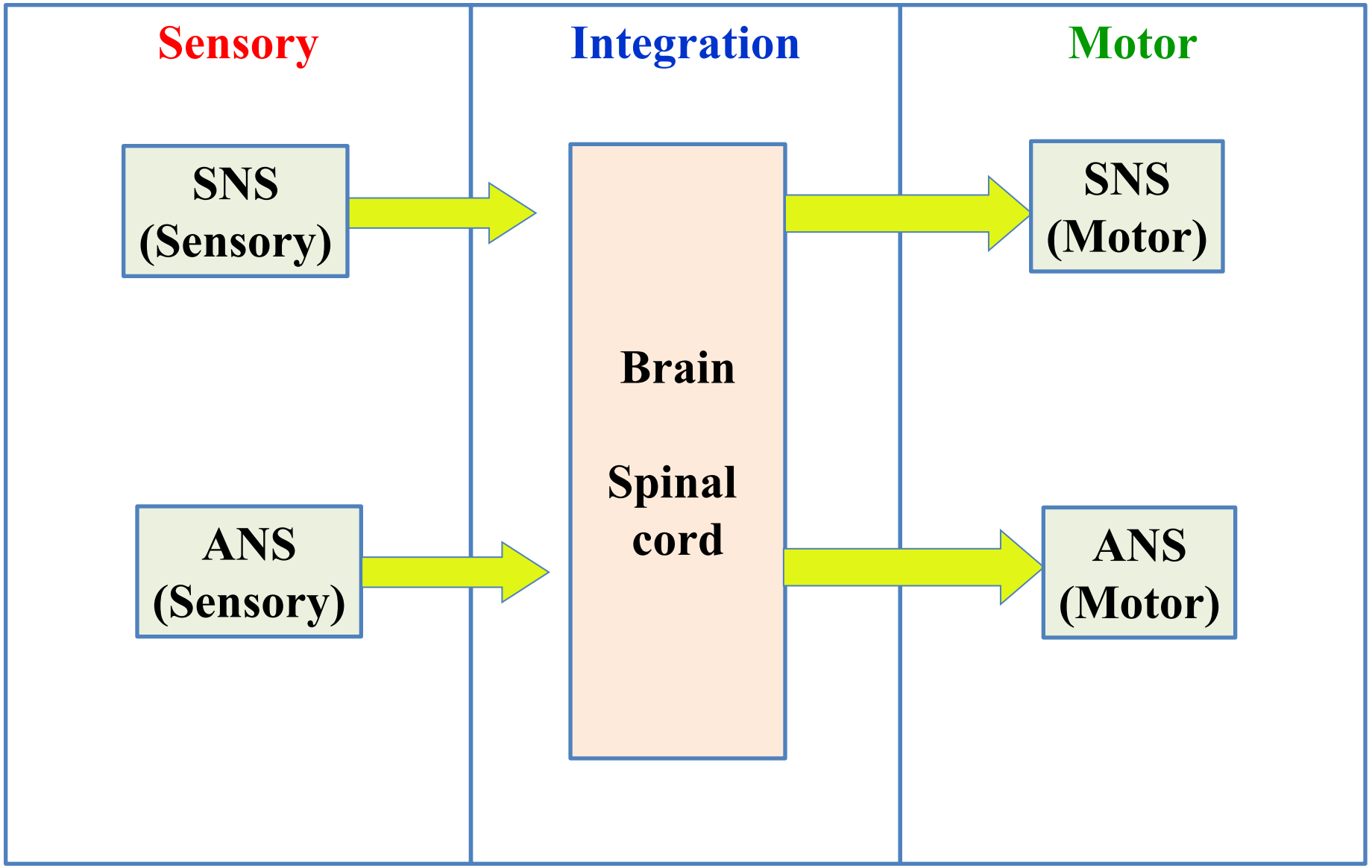
Organization



Neurons

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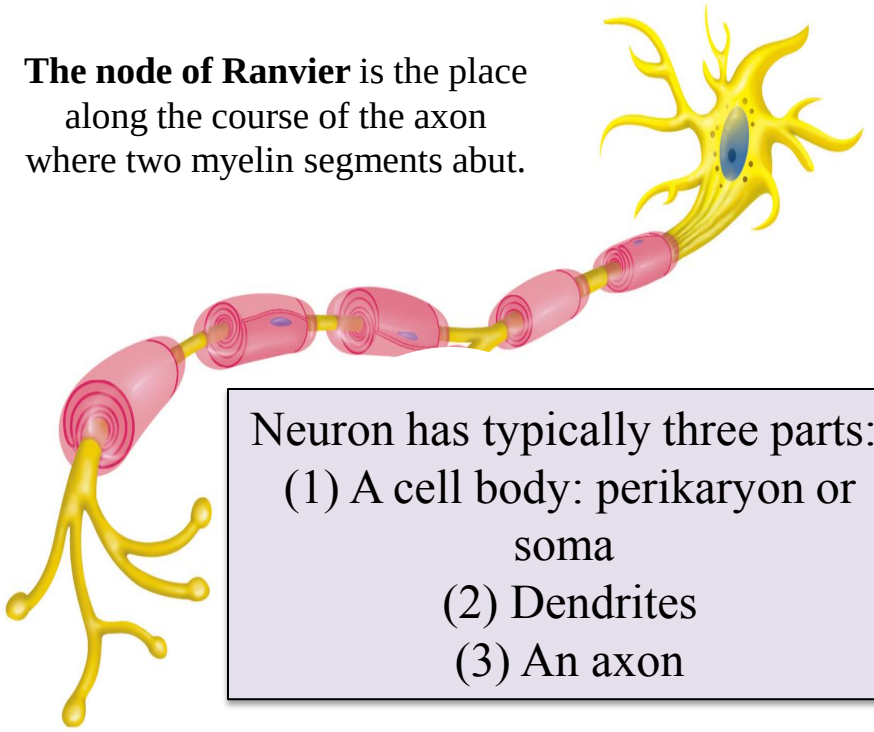
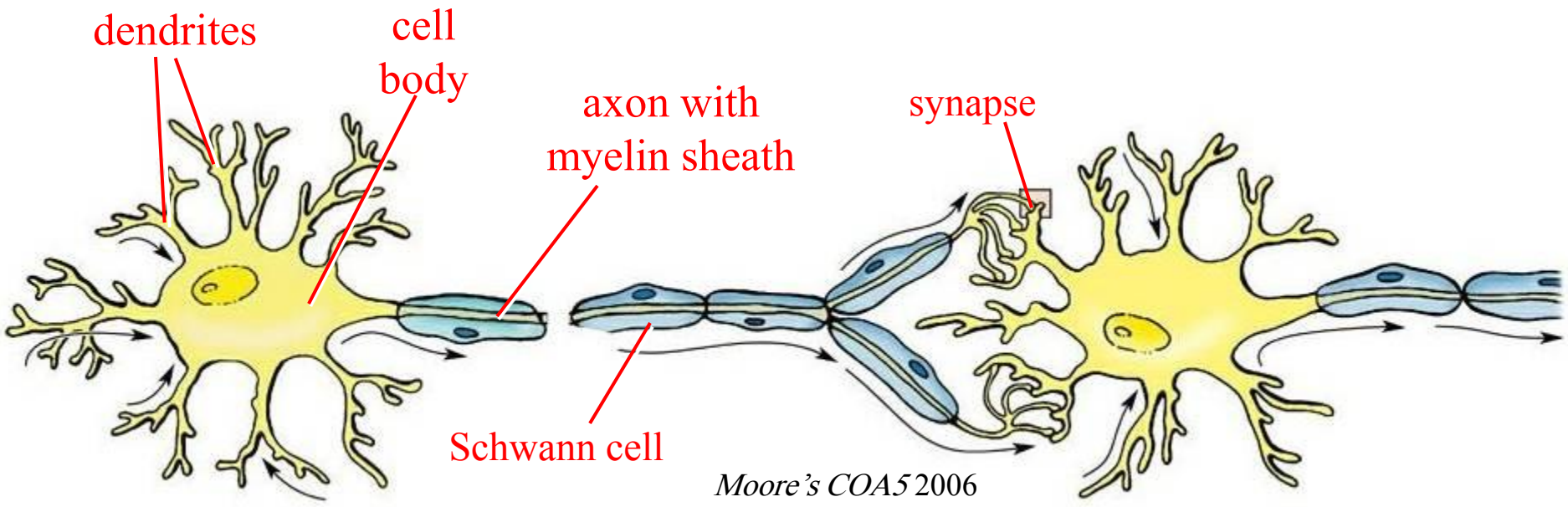
- Dendrites: carry nerve impulses toward cell body
- Axon: carries impulses away from cell body
- Synapses: site of communication between neurons using chemical neurotransmitters
- Myelin & myelin sheath: lipoprotein covering produced by glial cells (e.g., Schwann cells in PNS, oligodendrocytes in the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

The node of Ranvier is the place along the course of the axon where two myelin segments abut.



Neuron has typically three parts:
(1) A cell body: perikaryon or soma
(2) Dendrites
(3) An axon



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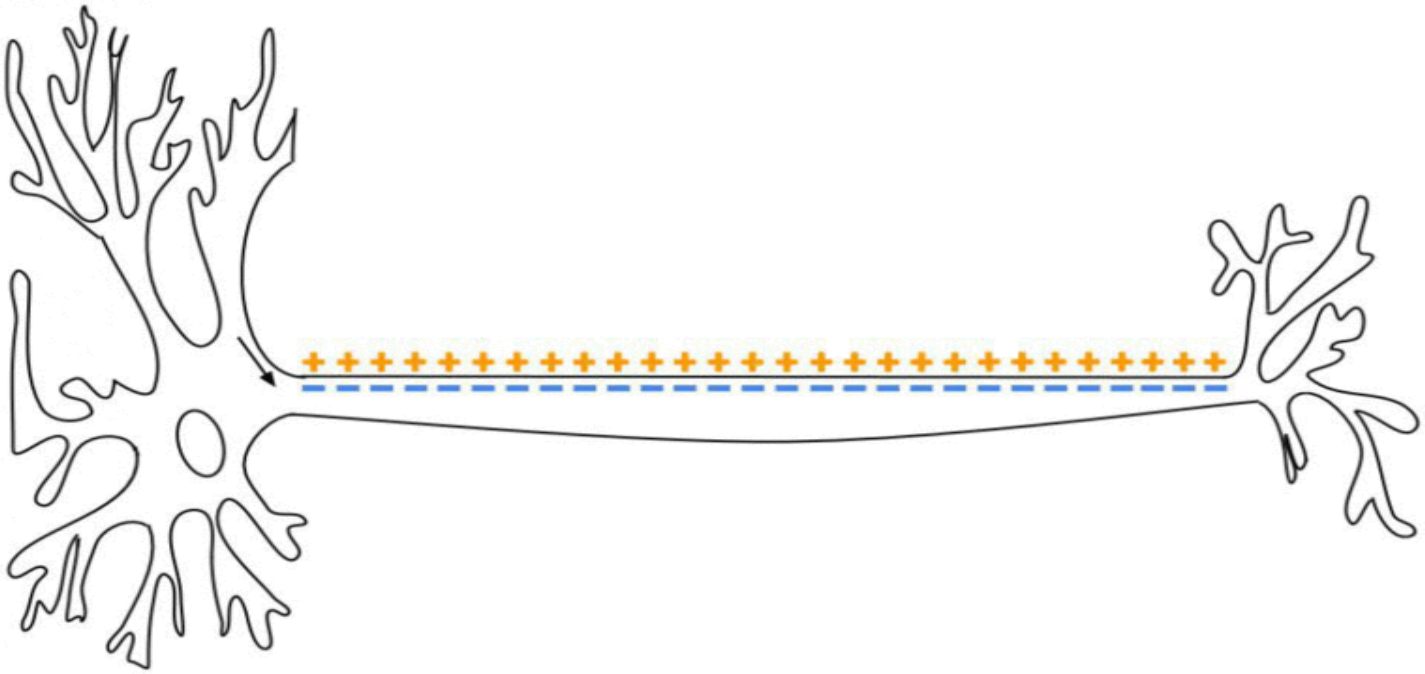
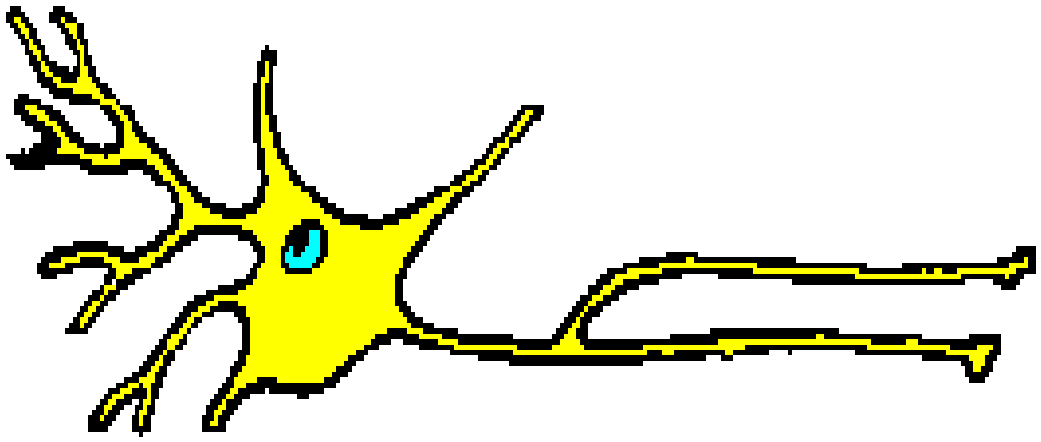


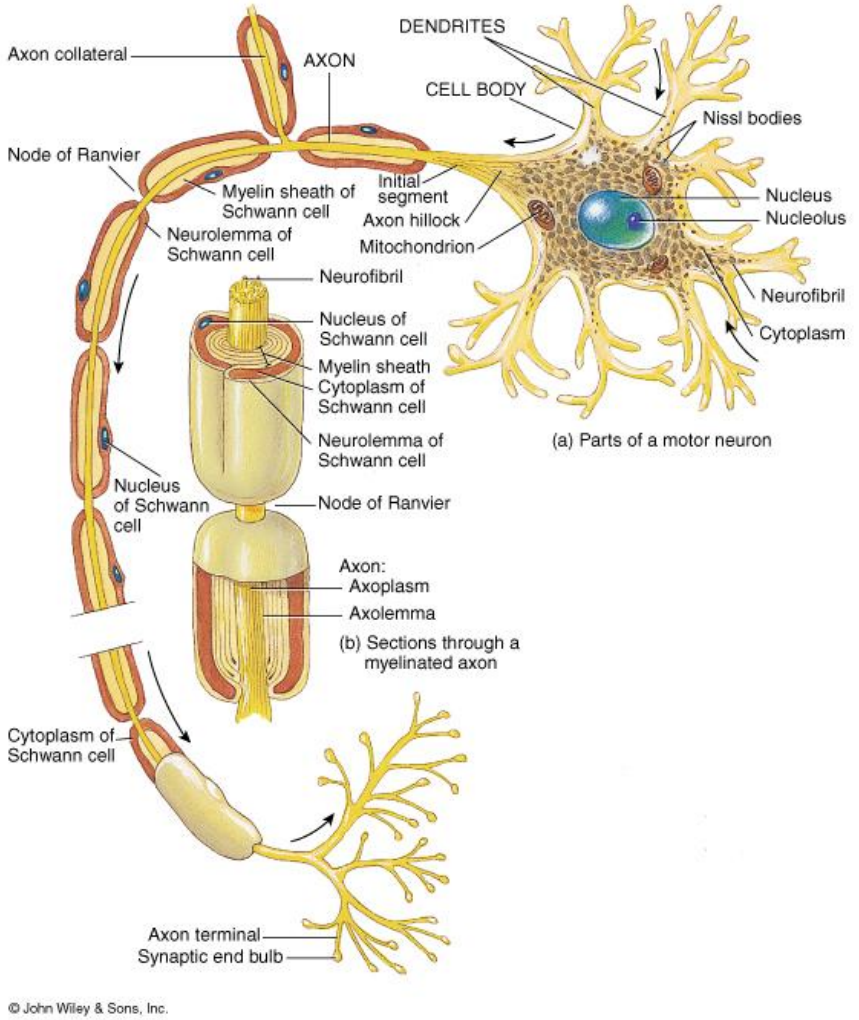
Notice that action potential propagation is unidirectional



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

Lipofuscin consists of residual bodies left from lysosomal digestion.



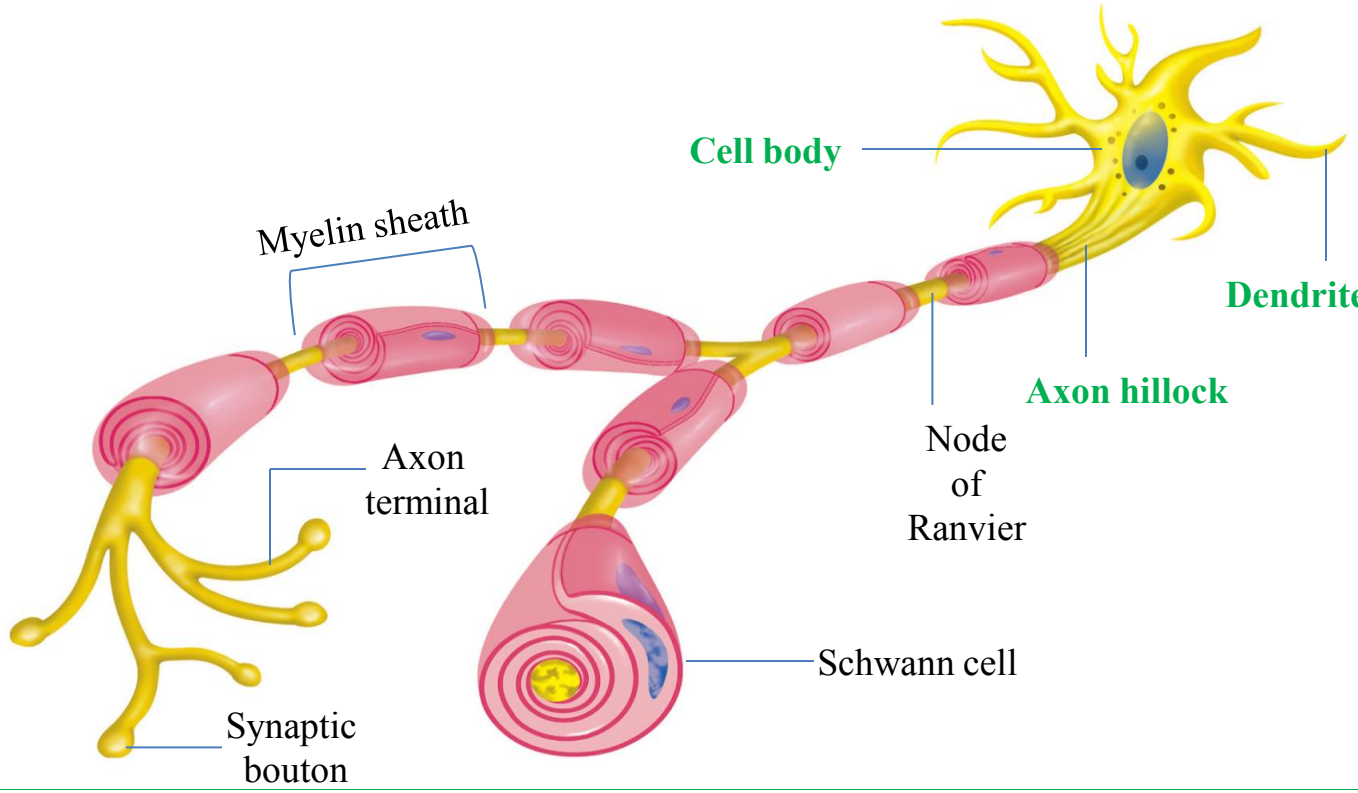
Axoplasm: cytoplasm of axon

Axolemma: cell membrane of axon

Axon hillock: where axon originates from soma

Synaptic boutons: swelling of axon terminal

Synapse: site of transmission of electric nerve impulses between two neurons



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Axon

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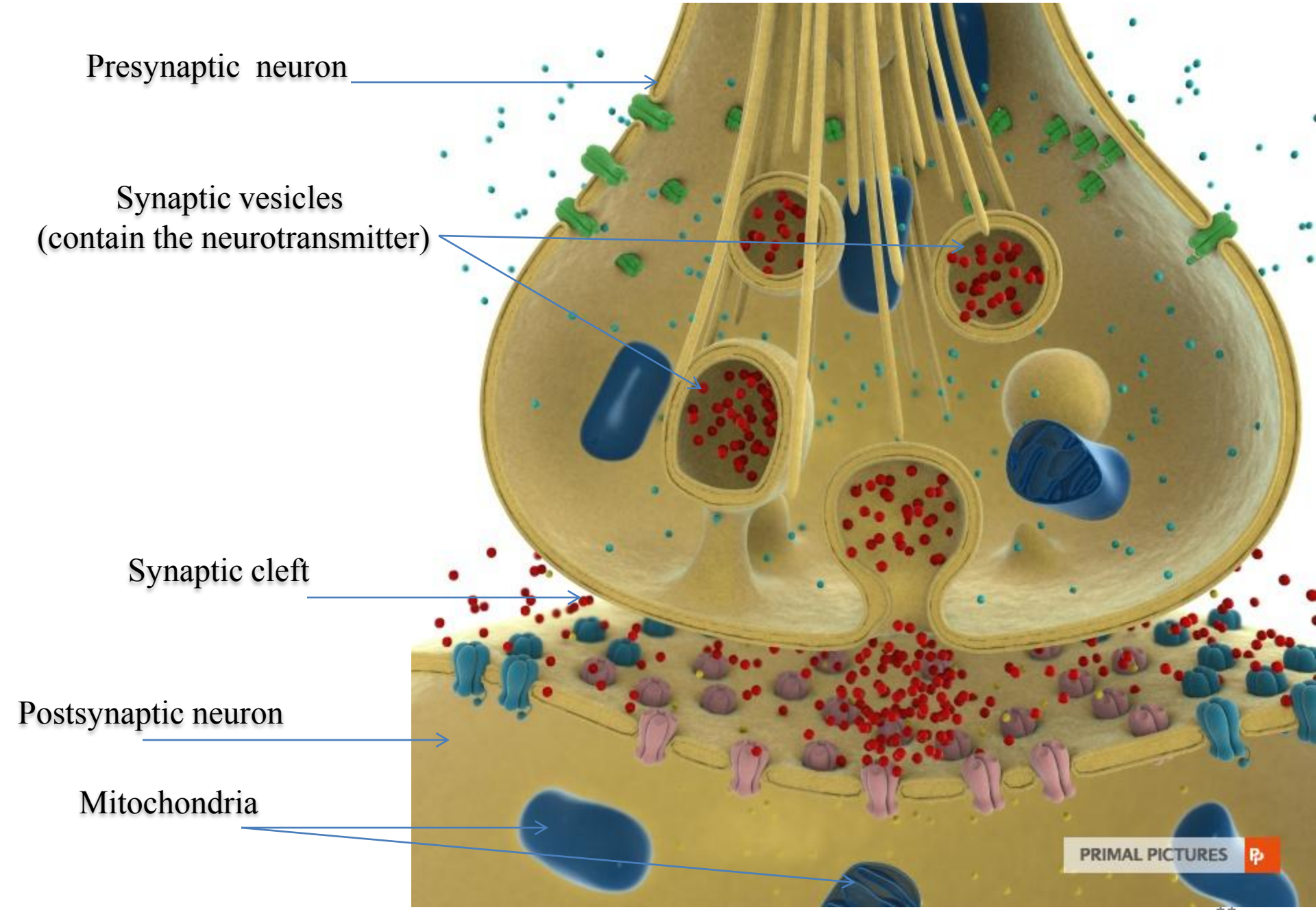
- Nearly constant diameter
- Much Longer → *Axons of the motor neurons that innervate the foot muscles have lengths of nearly a meter*
- Branches less profusely
- Distal end forms terminal arborization and terminal boutons
- Mostly myelinated, could be unmyelinated
- Axoplasm contains mitochondria, microtubules, and neurofilaments but not RER , ribosomes or golgi
- 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
Mitochondria
PRIMAL PICTURES

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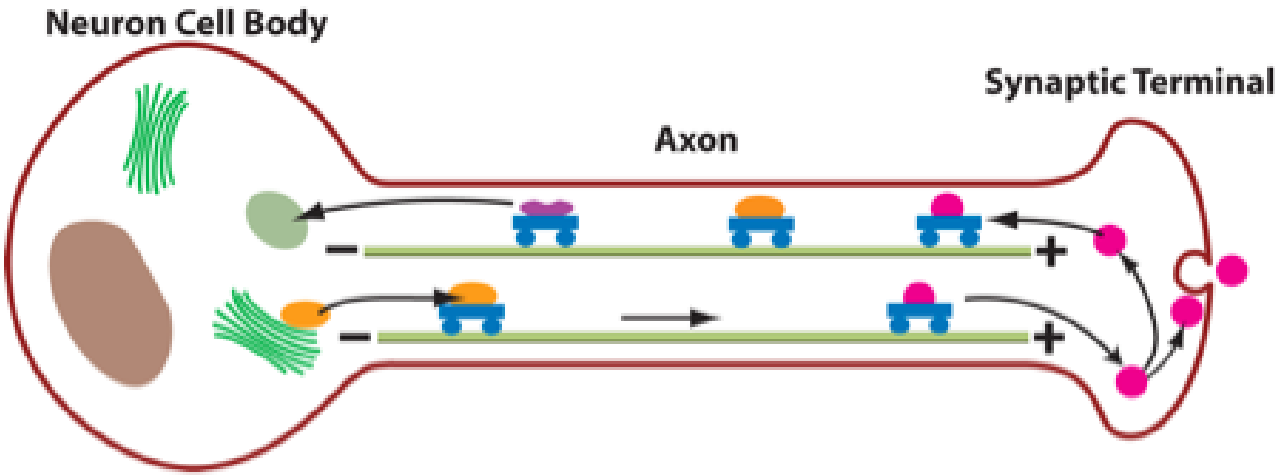
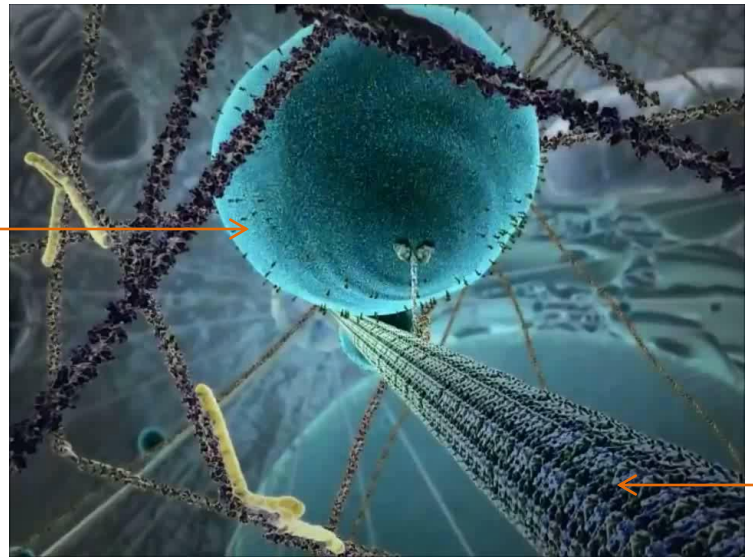
Axonal transport

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

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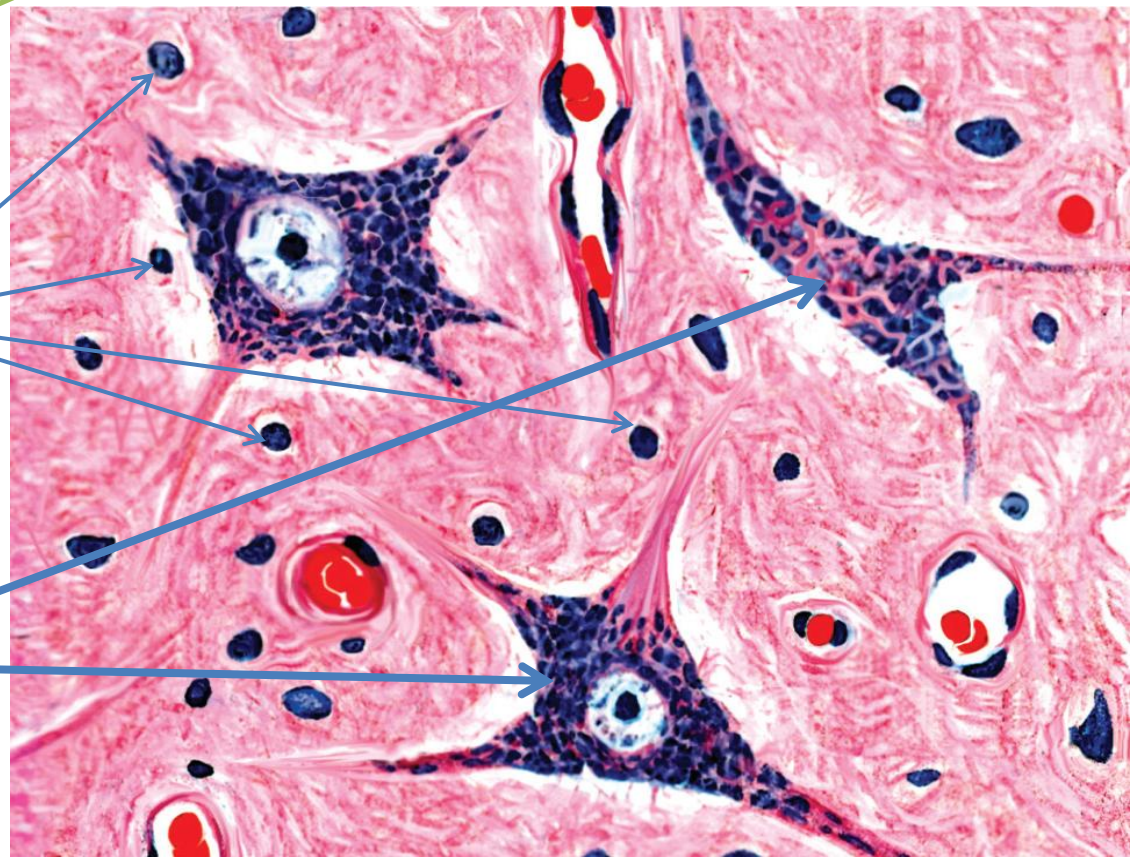
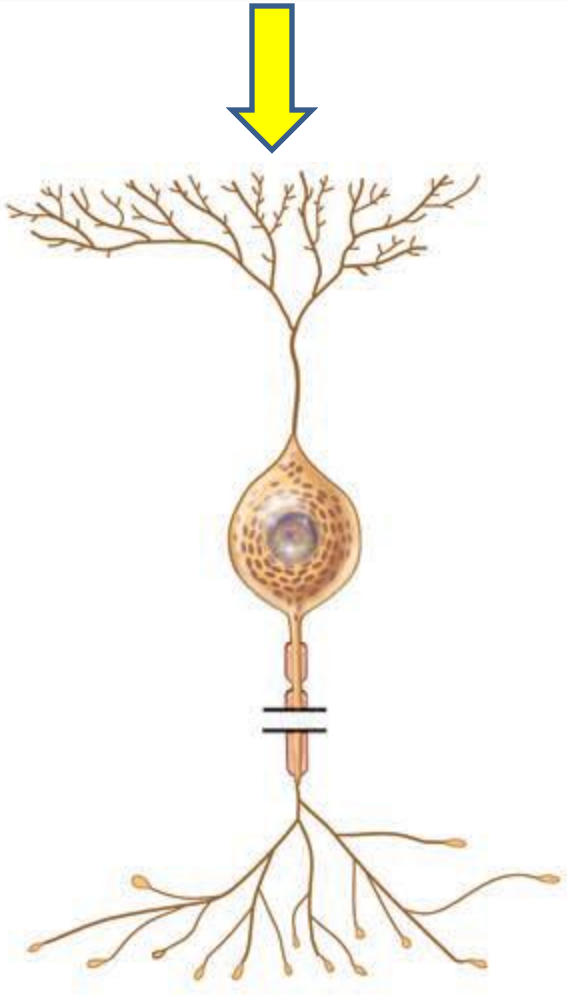
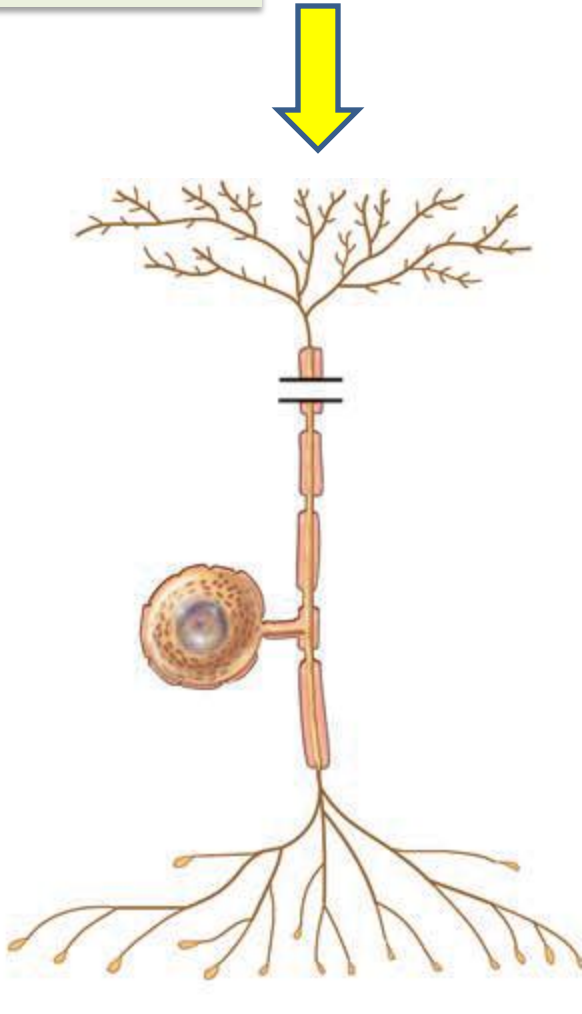


The most wonderful fact is that, working together, nerve cells can perceive and think and dream. They are us

Structural classification of neurons

1. **Multipolar neurons**
   - Usually have several dendrites and one axon
   - Motor neurons
2. **Bipolar neurons**
   - Have one main dendrite and one axon
   - The retina of the eye
3. **Unipolar neurons (pseudounipolar neurons)**
   - Sensory neurons





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Anaxonic neurons:

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

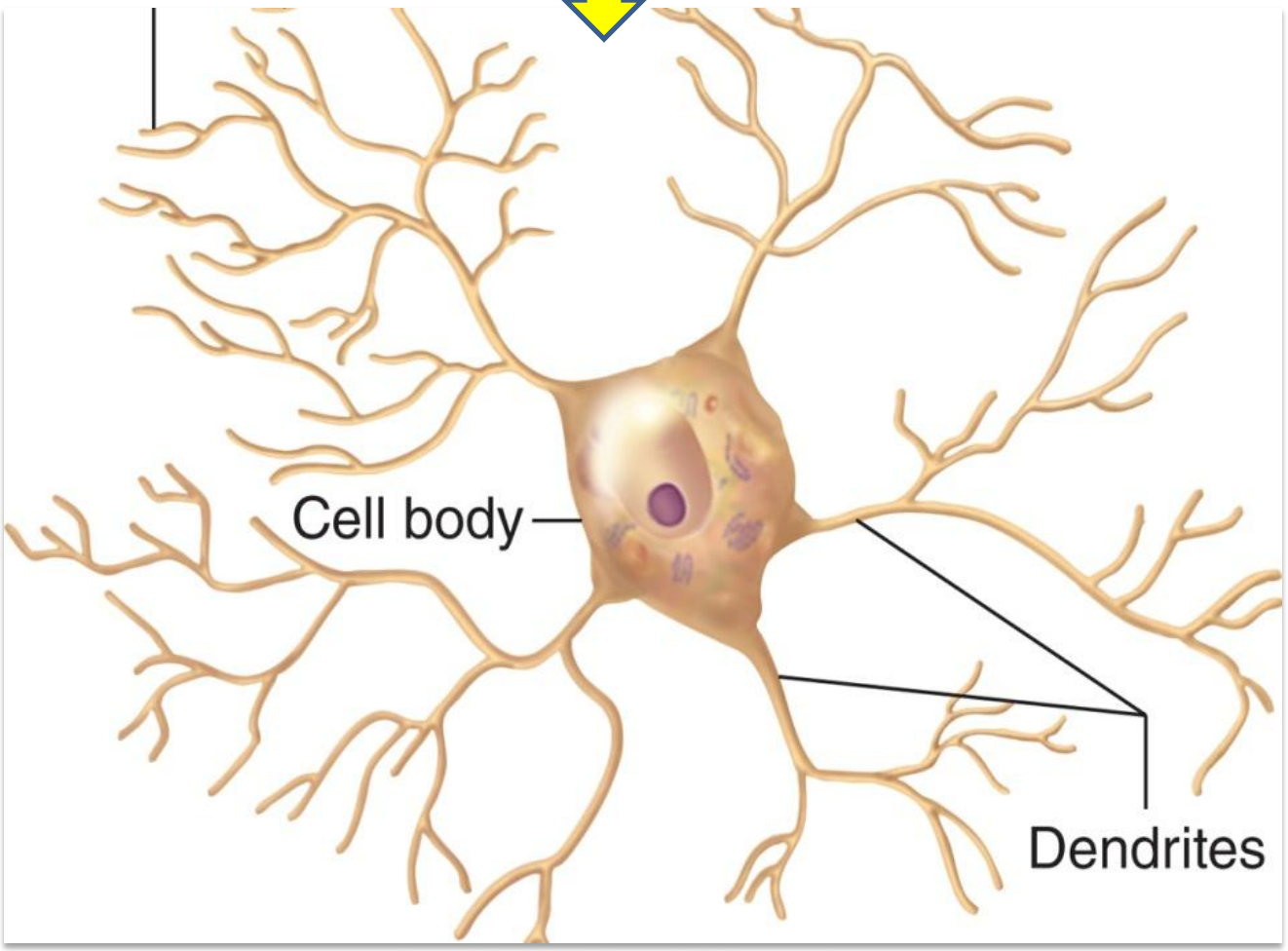
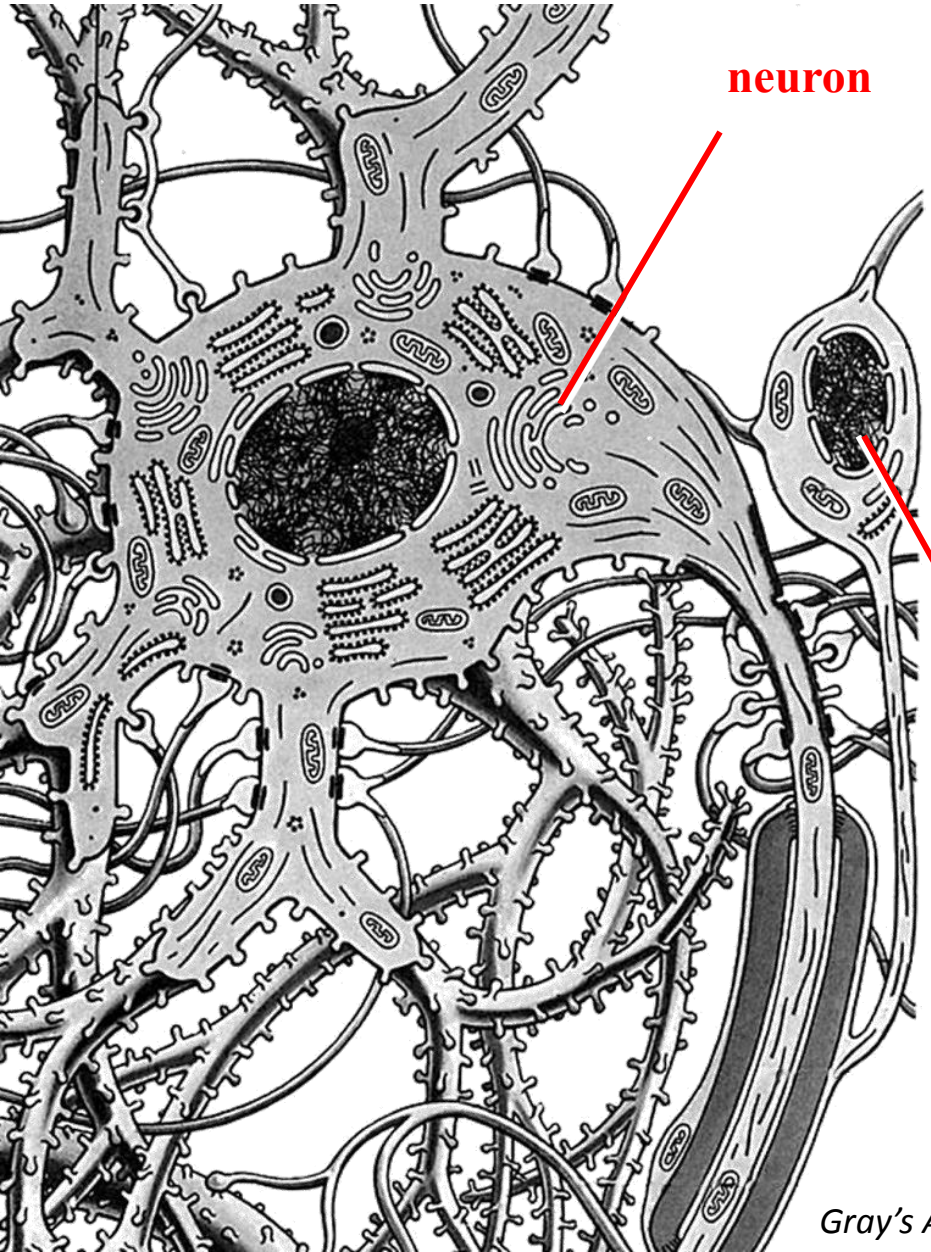


Figure 9-4



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

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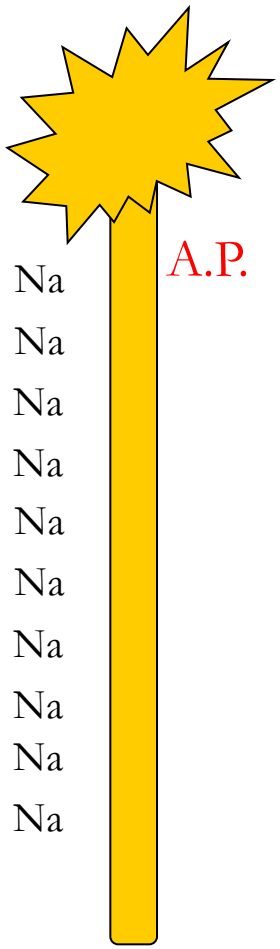
Continuous versus Saltatory Conduction

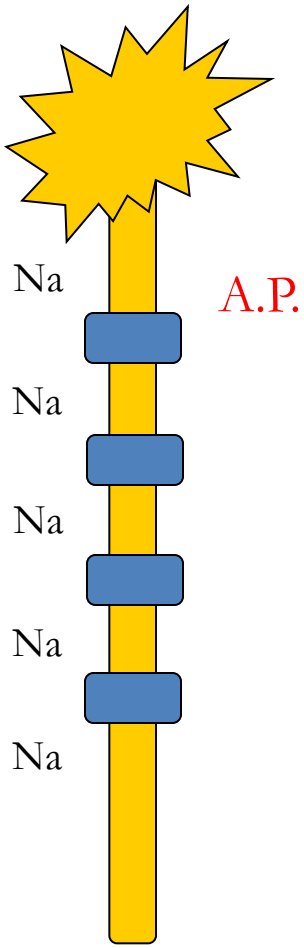
1. **Continuous conduction (unmyelinated fibers)**

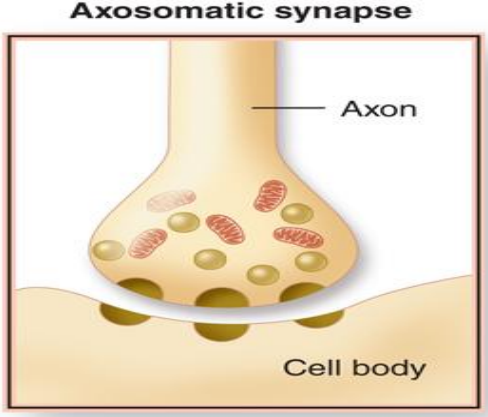
2. Saltatory conduction (myelinated fibers)

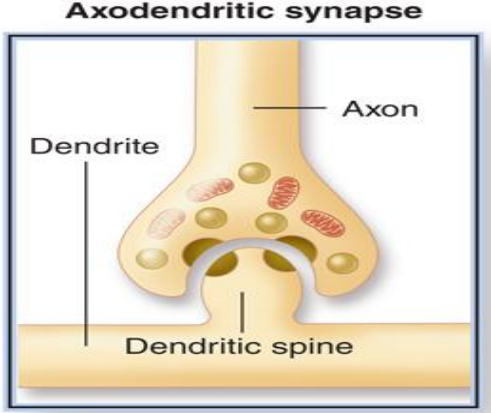


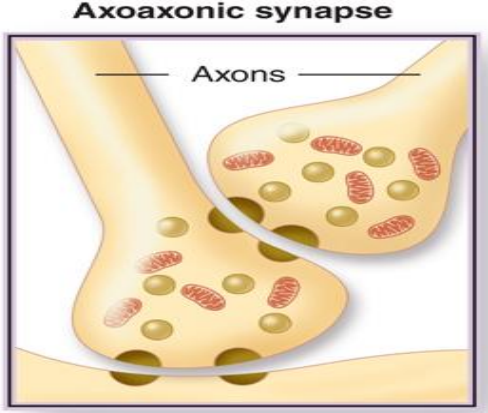
Saltatory Conduction

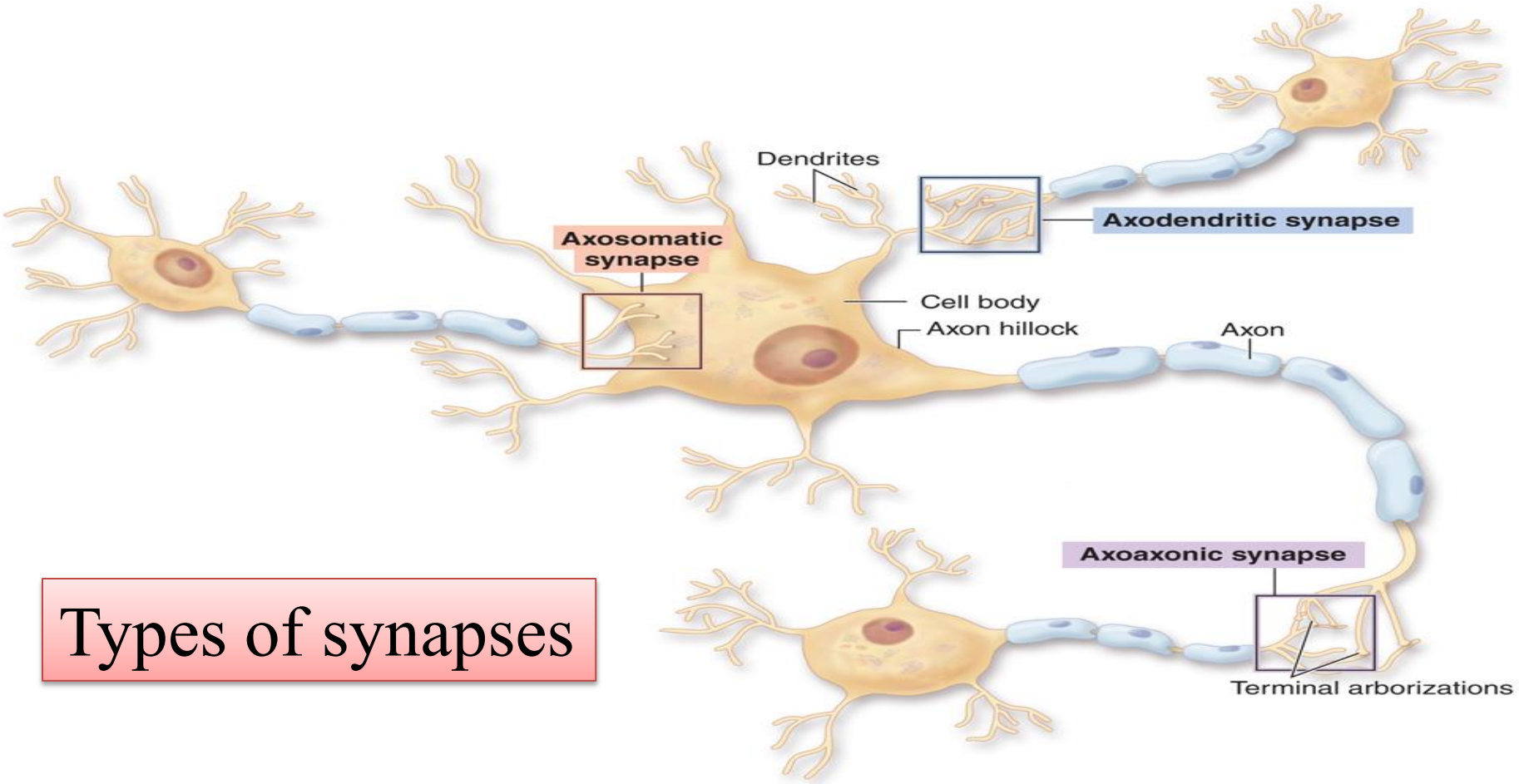
- Nerve impulse conduction in which the impulse jumps (Salta) from node to node











Types of synapses

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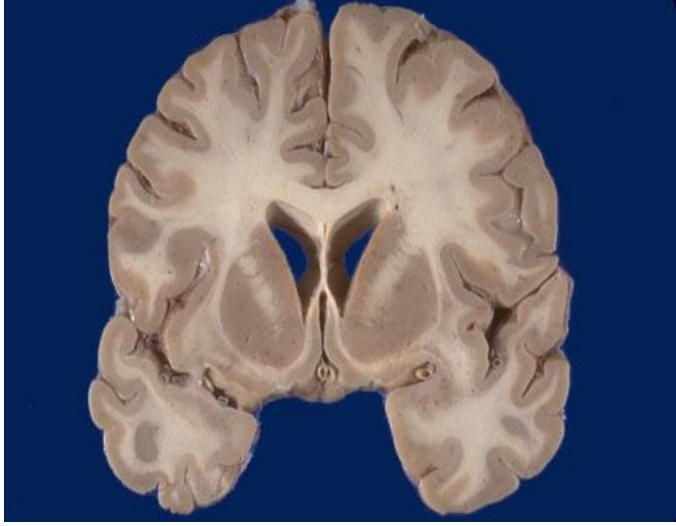
Transverse section of spinal cord

Clusters of Neuronal Cell Bodies

1. **Ganglion** (plural is ganglia): a cluster of neuronal cell bodies located in the PNS.
2. **Grey matter/ Nucleus** (plural is nuclei): a cluster of neuronal cell bodies located in the CNS.



Coronal section of brain

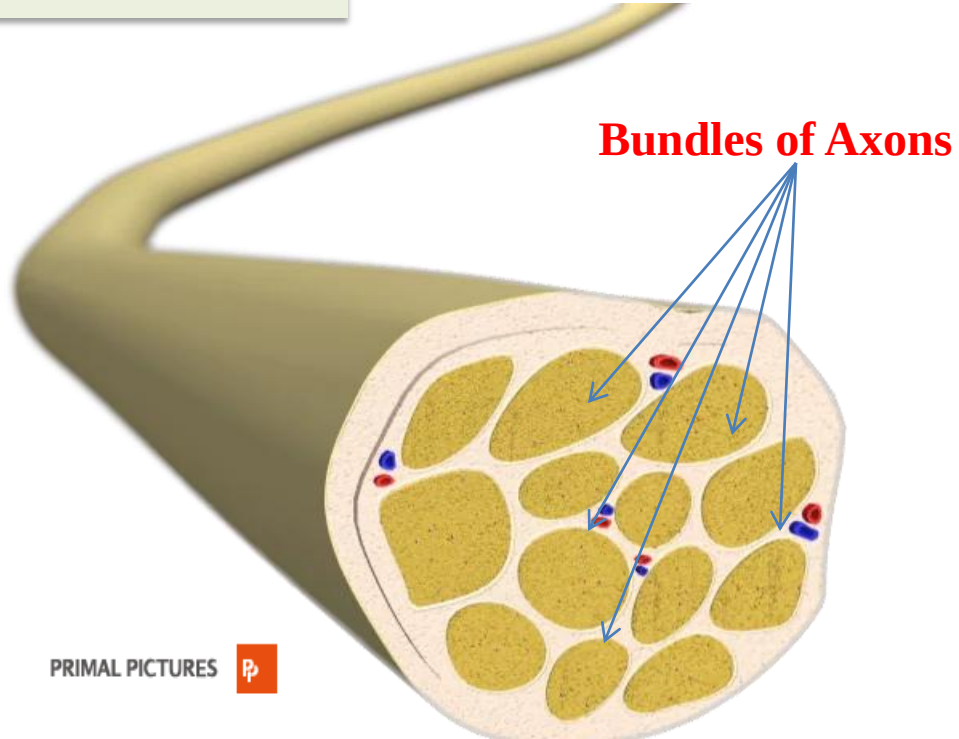
Bundles of Axons

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

White matter/ tract: is a bundle of axons located in the CNS.



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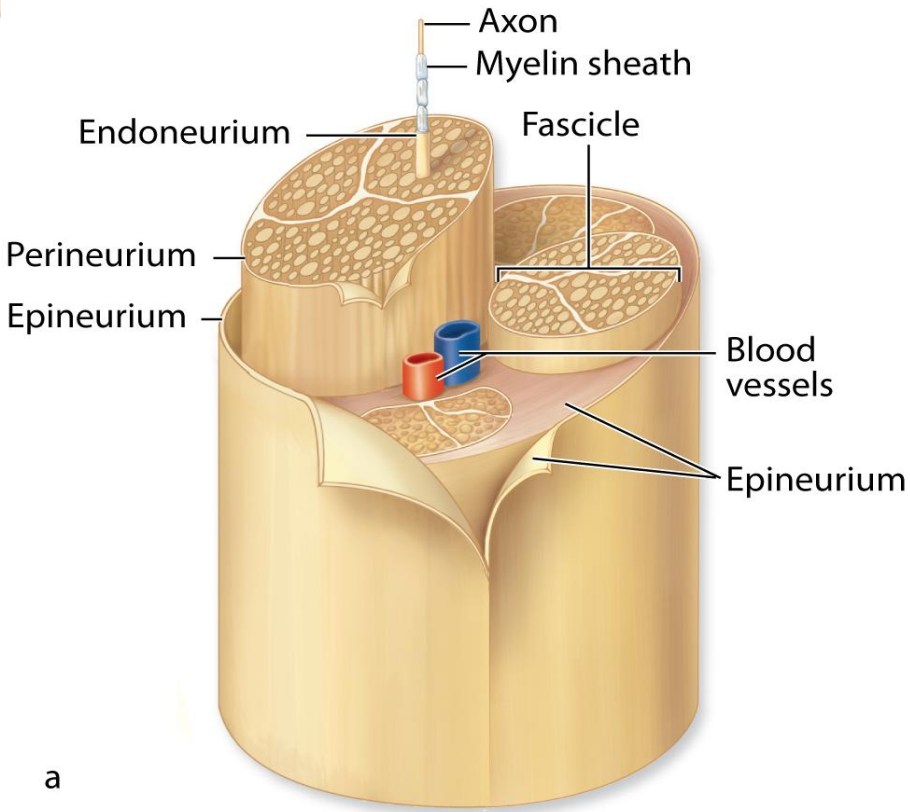
Peripheral nerve

The axons are bundled together into groups called fascicles

Bundles of axons (Fascicles)



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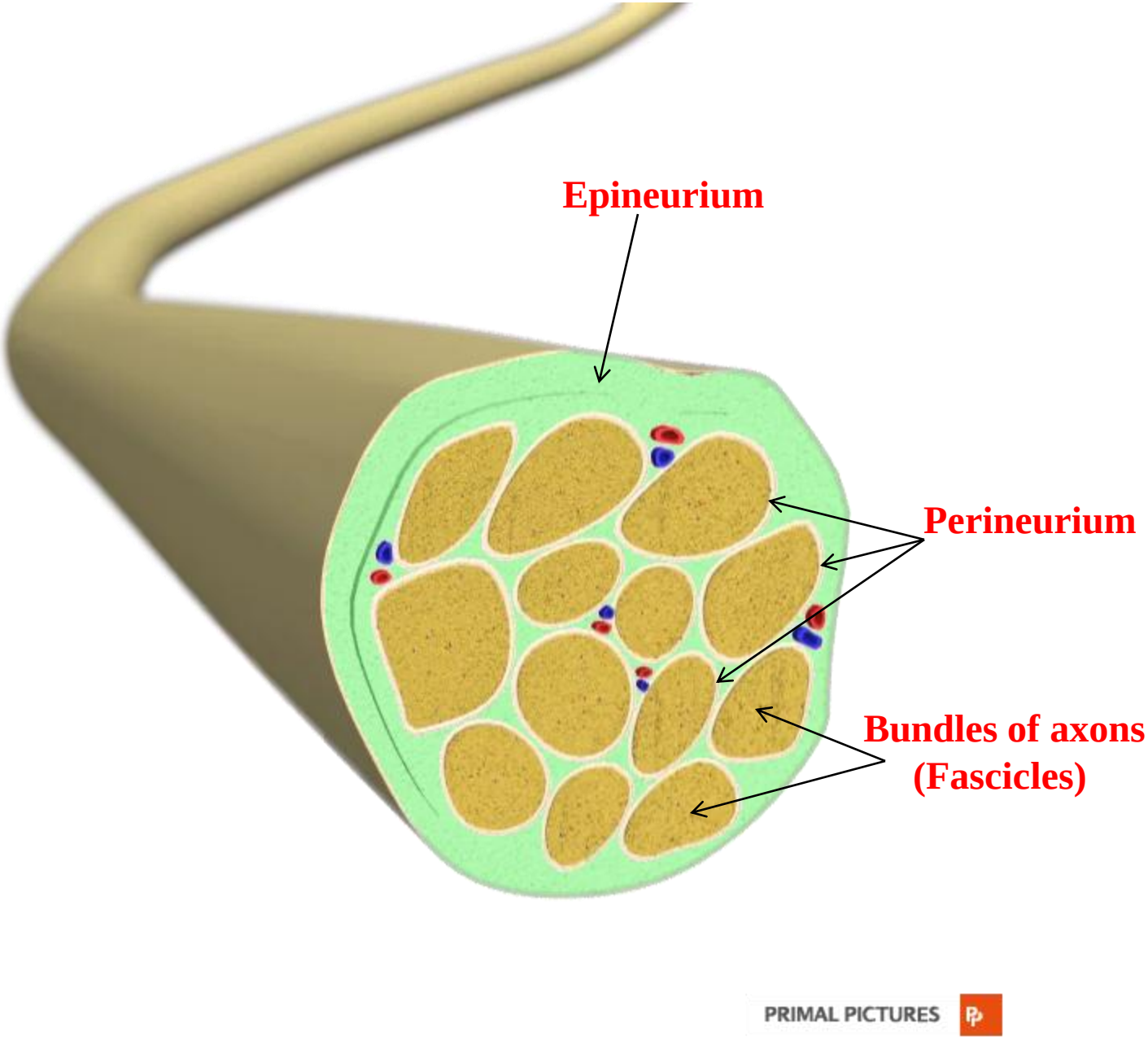
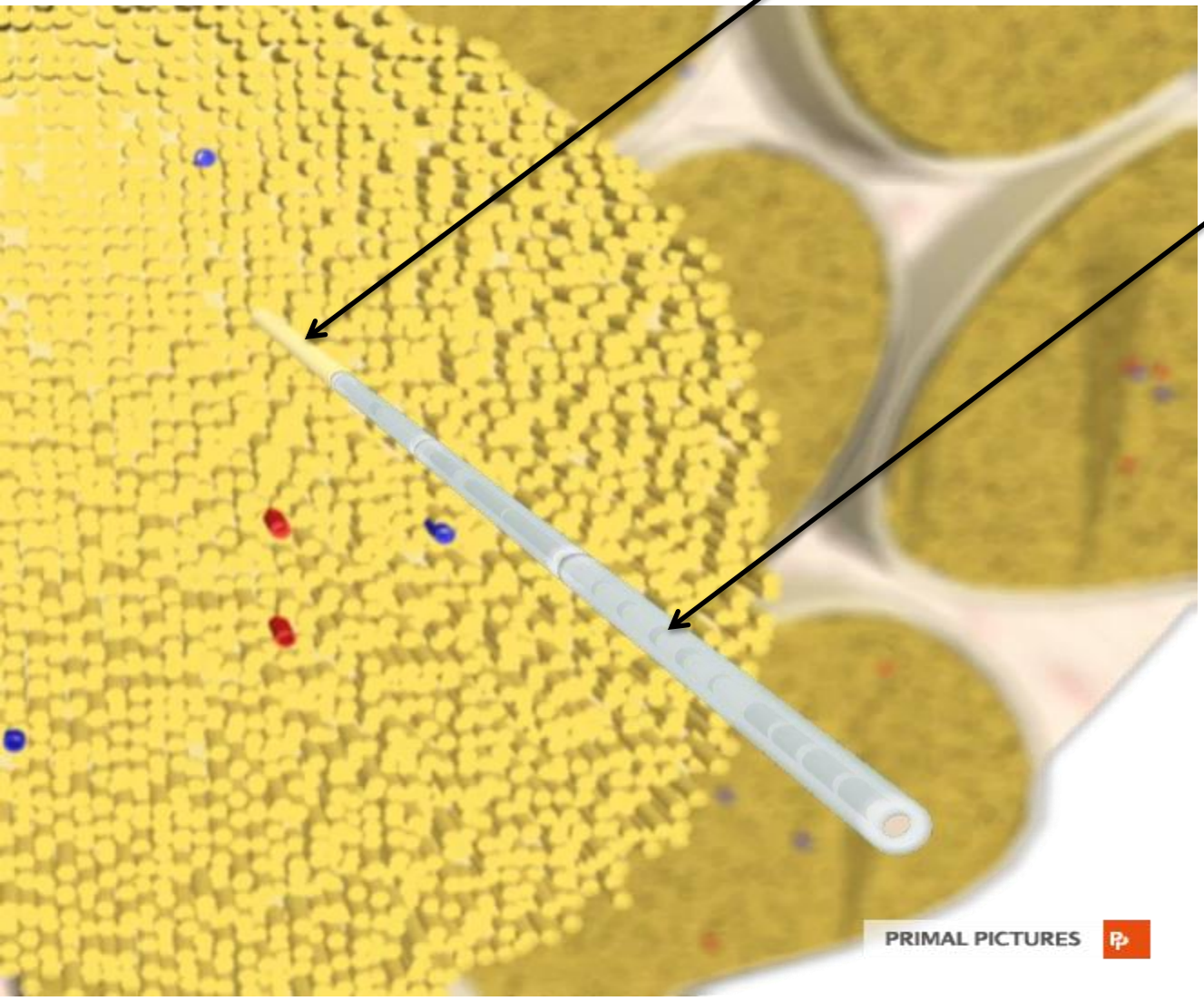


Nerve fiber



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Peripheral nerves

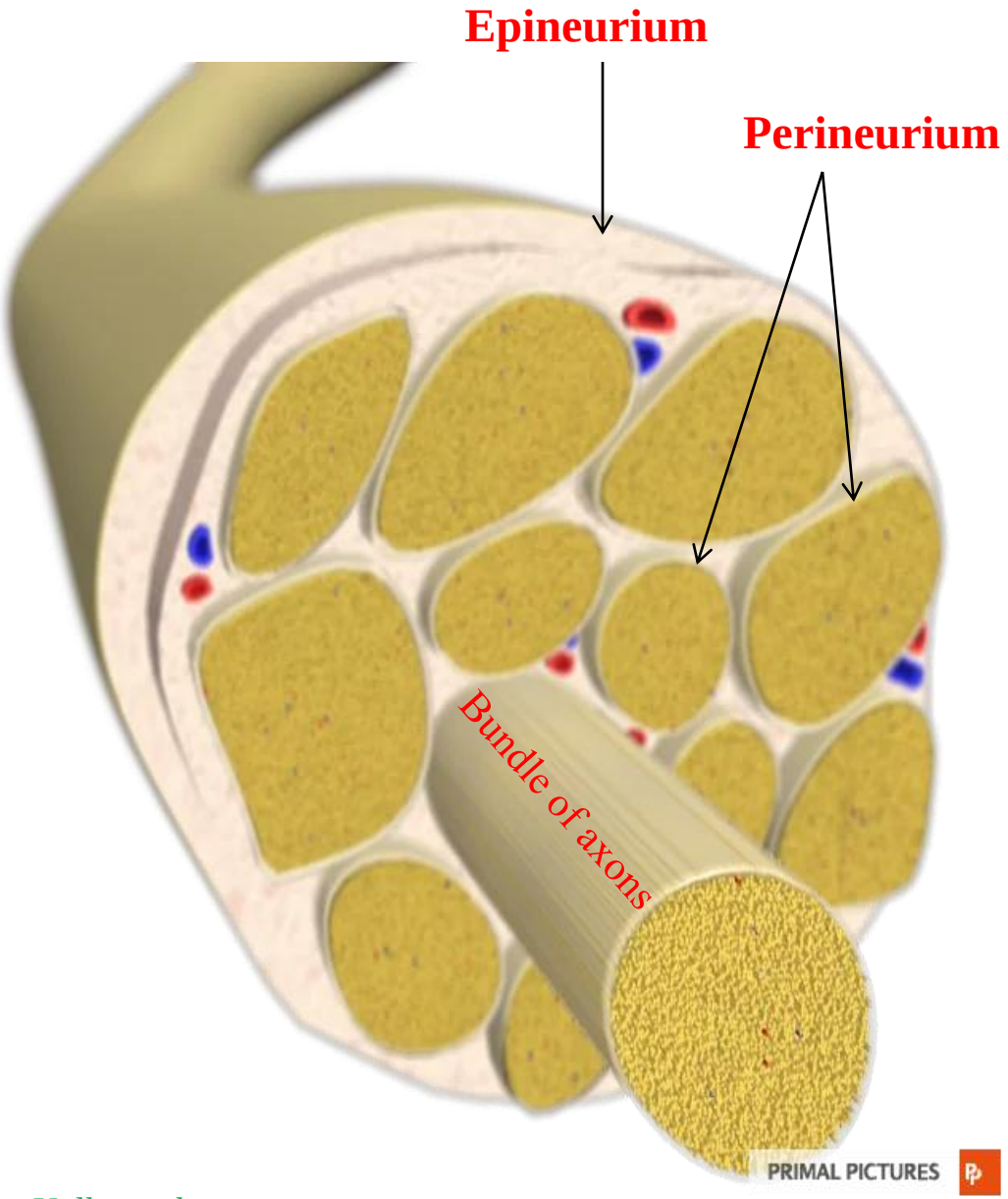
- Consist of **Cranial** and **Spinal** nerves connecting brain and spinal cord to peripheral tissues.

- Peripheral nerves consist of parallel bundles of nerve axons, **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.

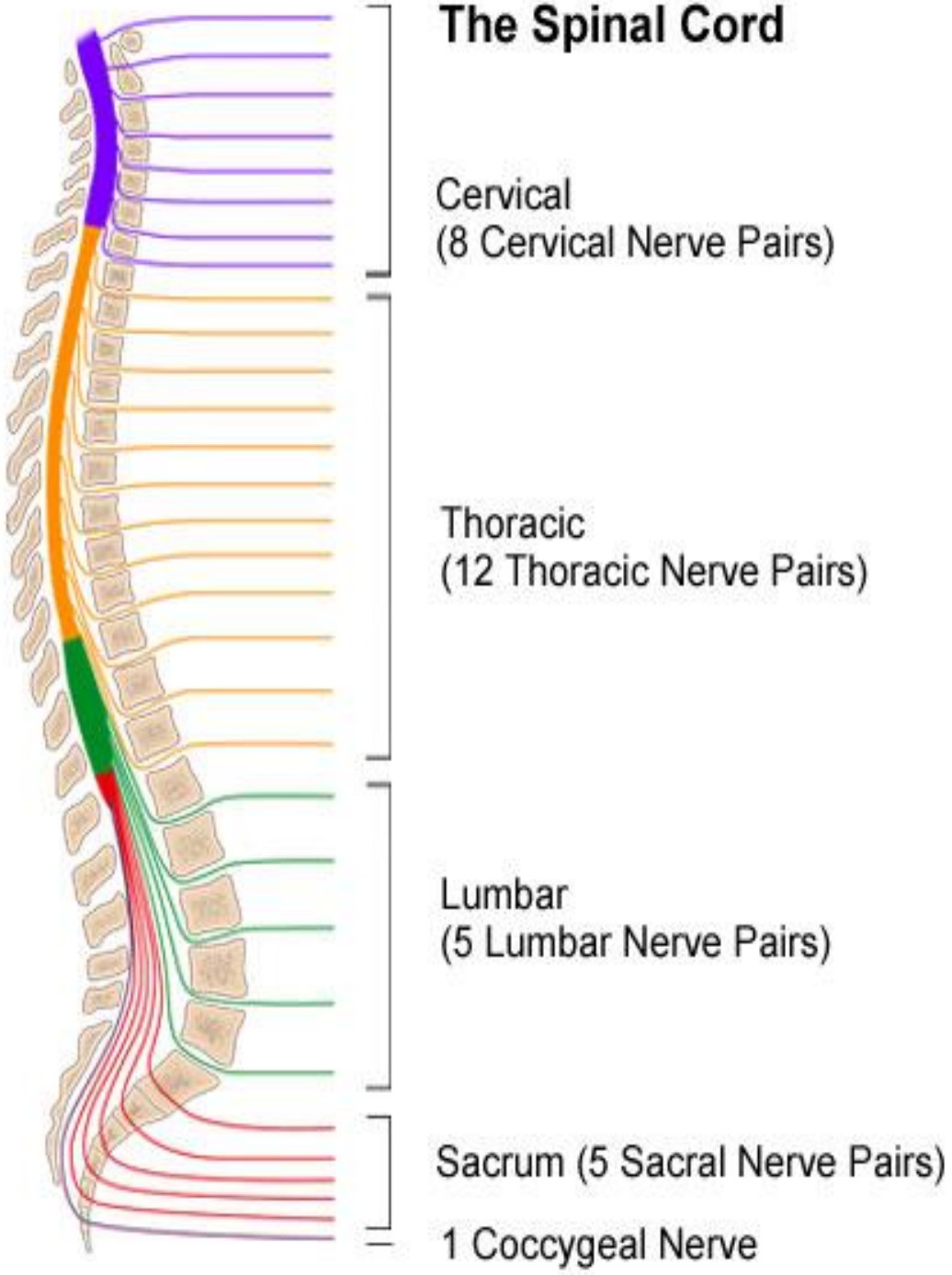
- Nerve fiber = axon + myelin



The spinal cord is divided into 31 segments where pairs of spinal nerves (mixed; sensory and motor) are attached

8 cervical segments forming 8 pairs of cervical nerves
12 thoracic segments forming 12 pairs of thoracic nerves
5 lumbar segments forming 5 pairs of lumbar nerves
5 sacral segments forming 5 pairs of sacral nerves
1 coccygeal segment forming one pair of coccygeal nerves

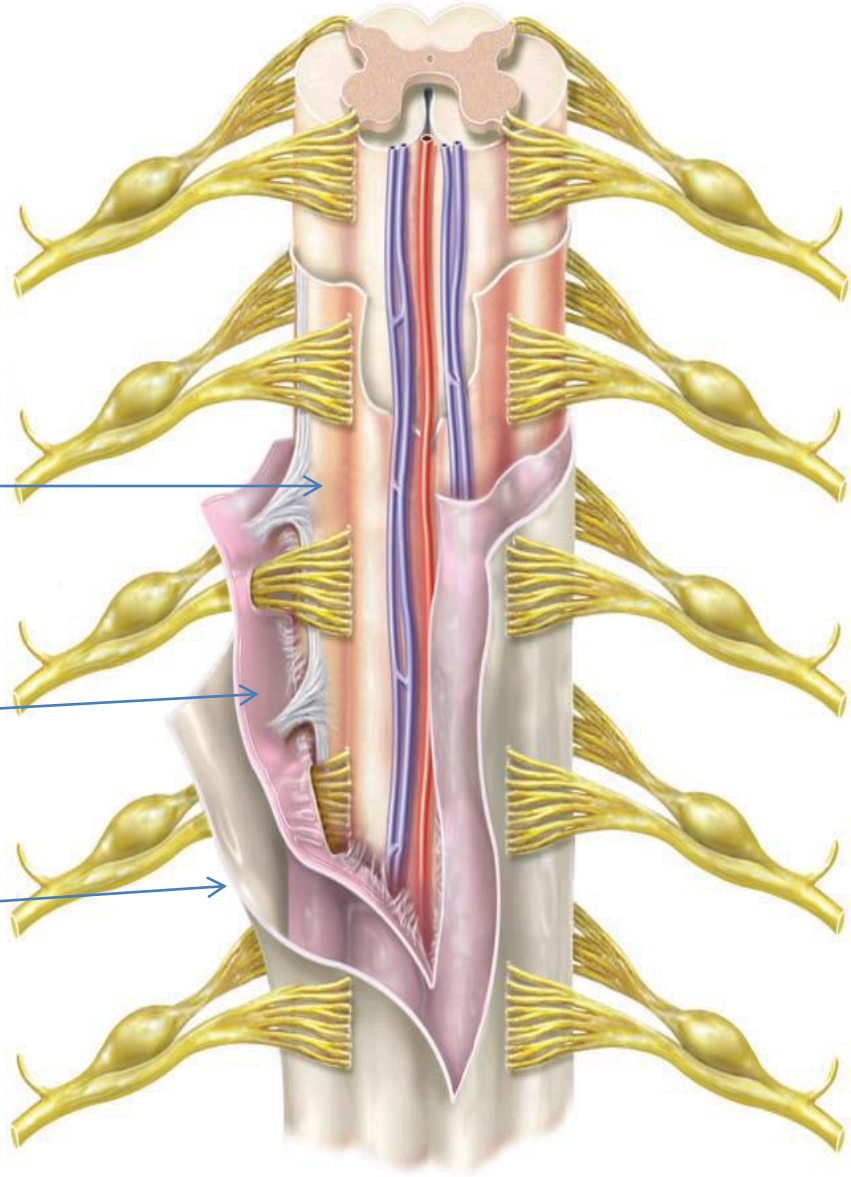
31 pairs of spinal nerves supply all of the body **except head**



Meninges

Connective tissue membranes

- **Pia mater**
- **Arachnoid mater**
- **Dura mater**



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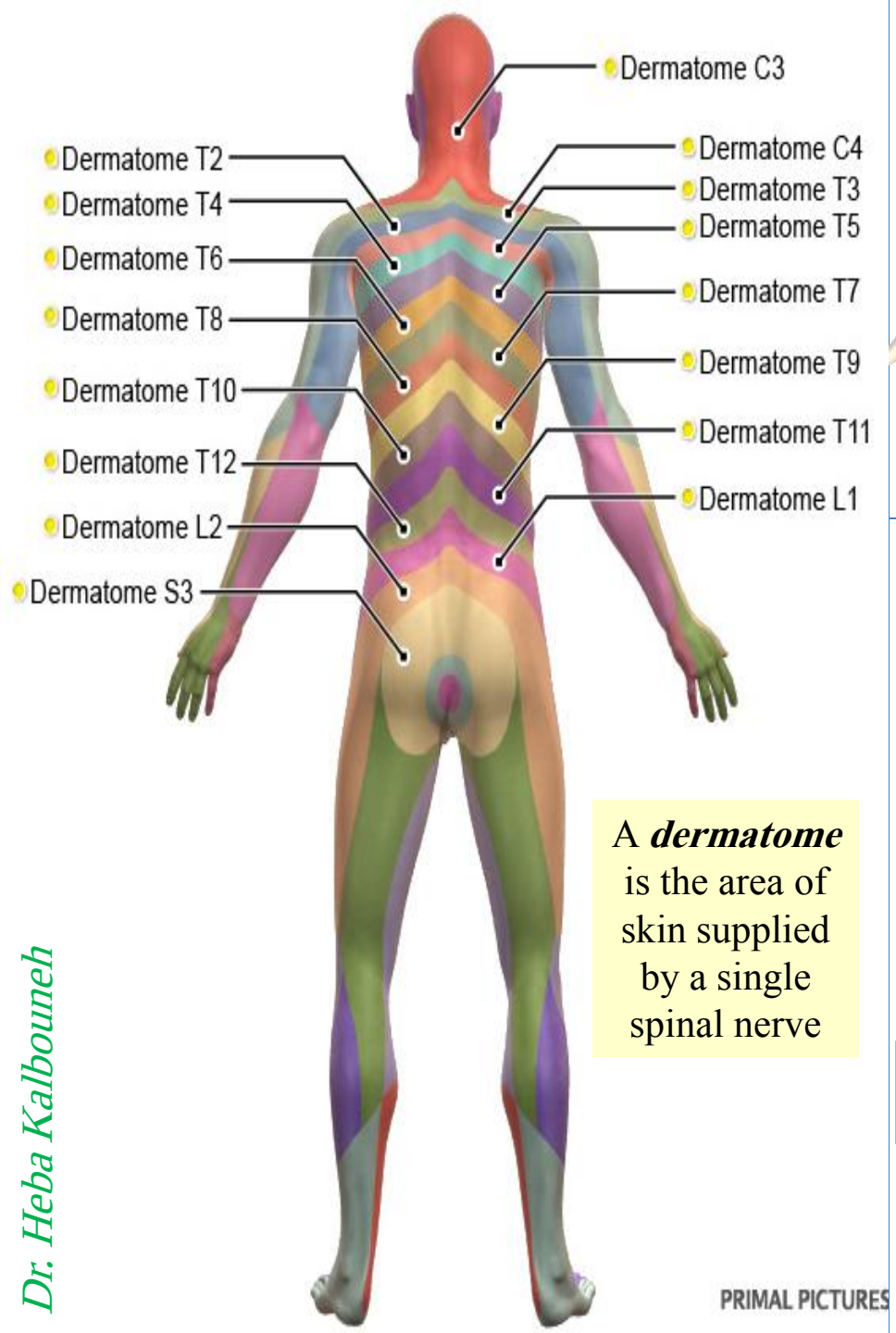
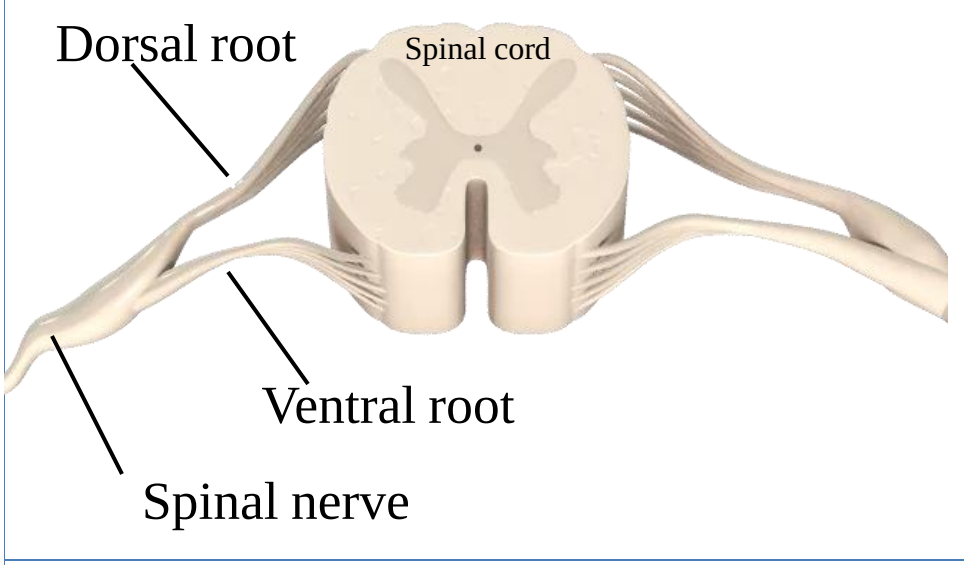
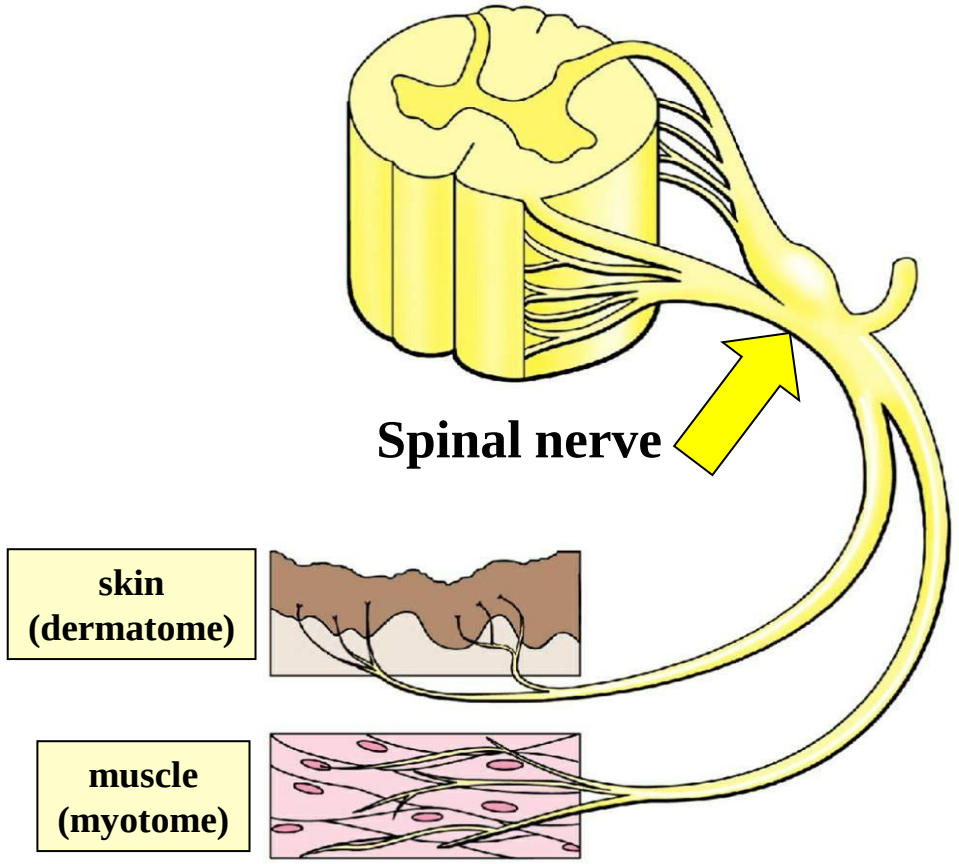
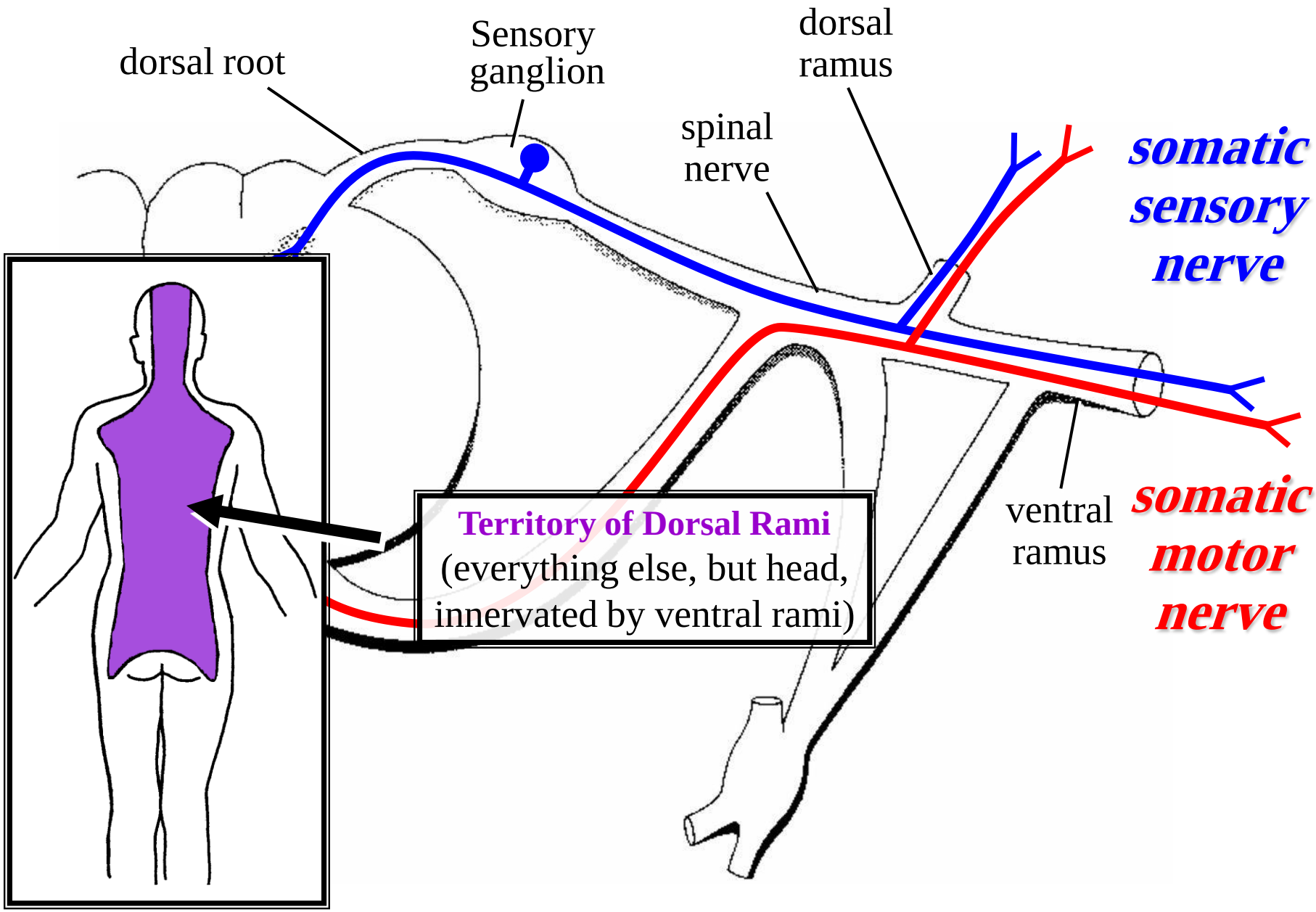


A ***dermatome*** is the area of skin supplied by a single spinal nerve

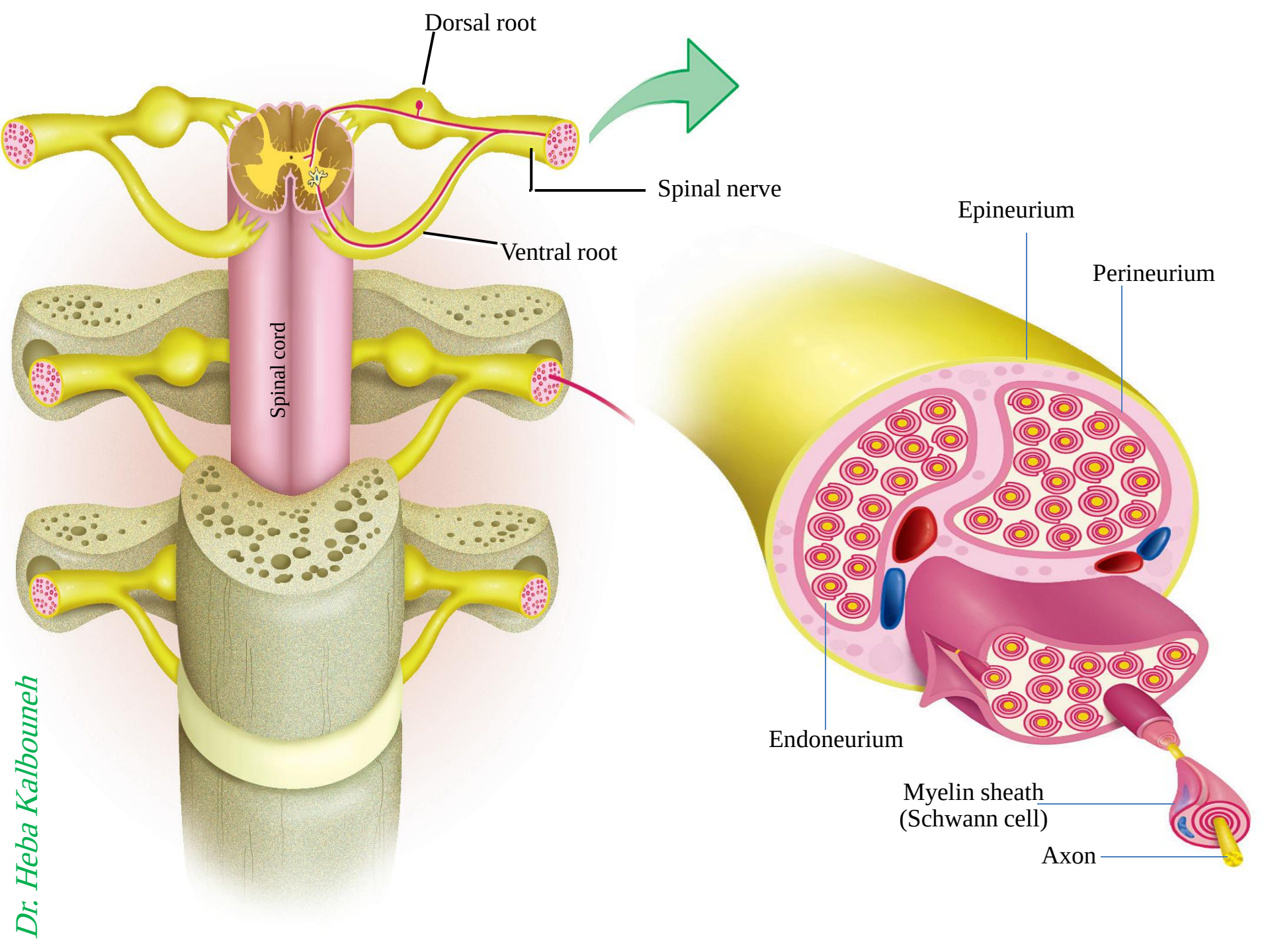




Structure of Spinal Nerves: Dorsal & Ventral Rami

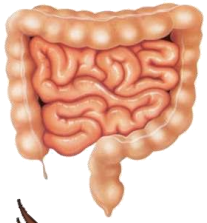


Stern *Essentials of Gross Anatomy*



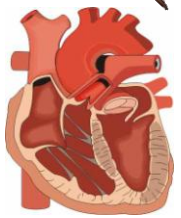
Autonomic nervous system

- 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



glands

smooth muscle

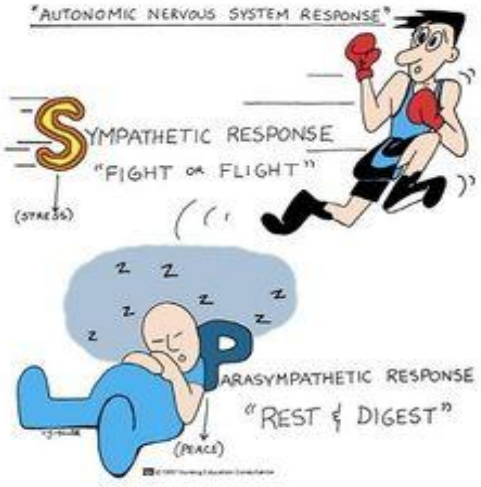


cardiac muscle

Divisions of Autonomic nervous system

- Parasympathetic division
- Sympathetic division

Serve almost the same organs but cause opposing or antagonistic effects



Parasysmpathetic: routine maintenance
"rest &digest"
Sympathetic: mobilization & increased metabolism
"fight, flight or fright"

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 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 = postgangionic neuron (cell body in ganglion outside CNS)
  - Slower because lightly or unmyelinated

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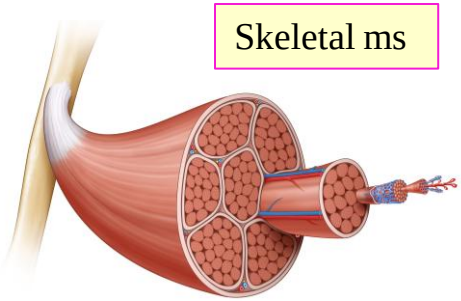
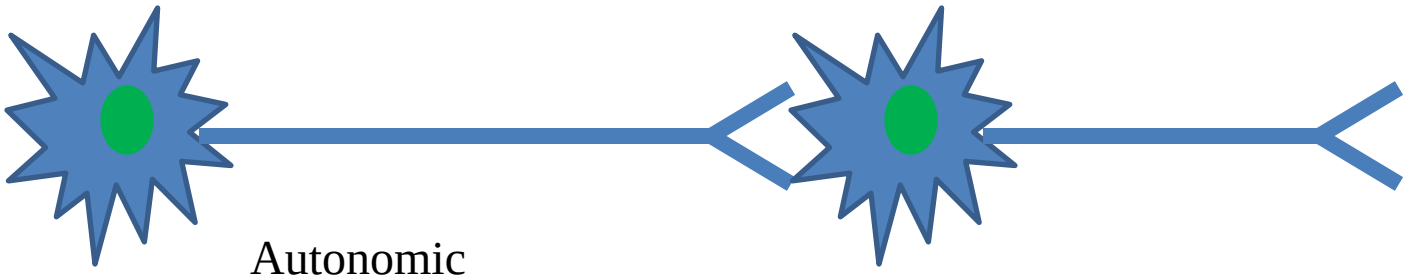
Somatic

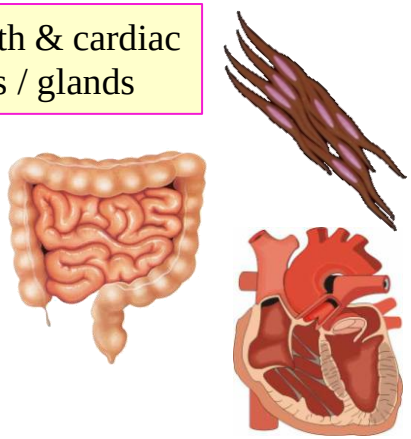
Skeletal ms





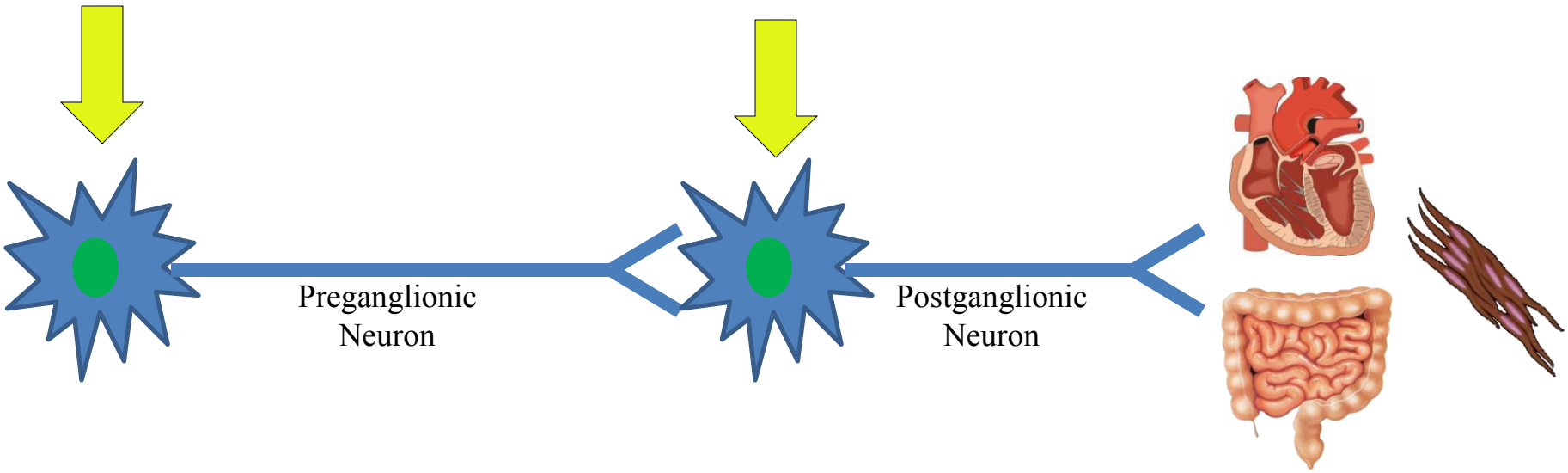
Autonomic

Smooth & cardiac ms / glands



The cell body of preganglionic neuron is in CNS
Nucleus

The cell body of postganglionic neuron is outside CNS
Ganglion



- 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

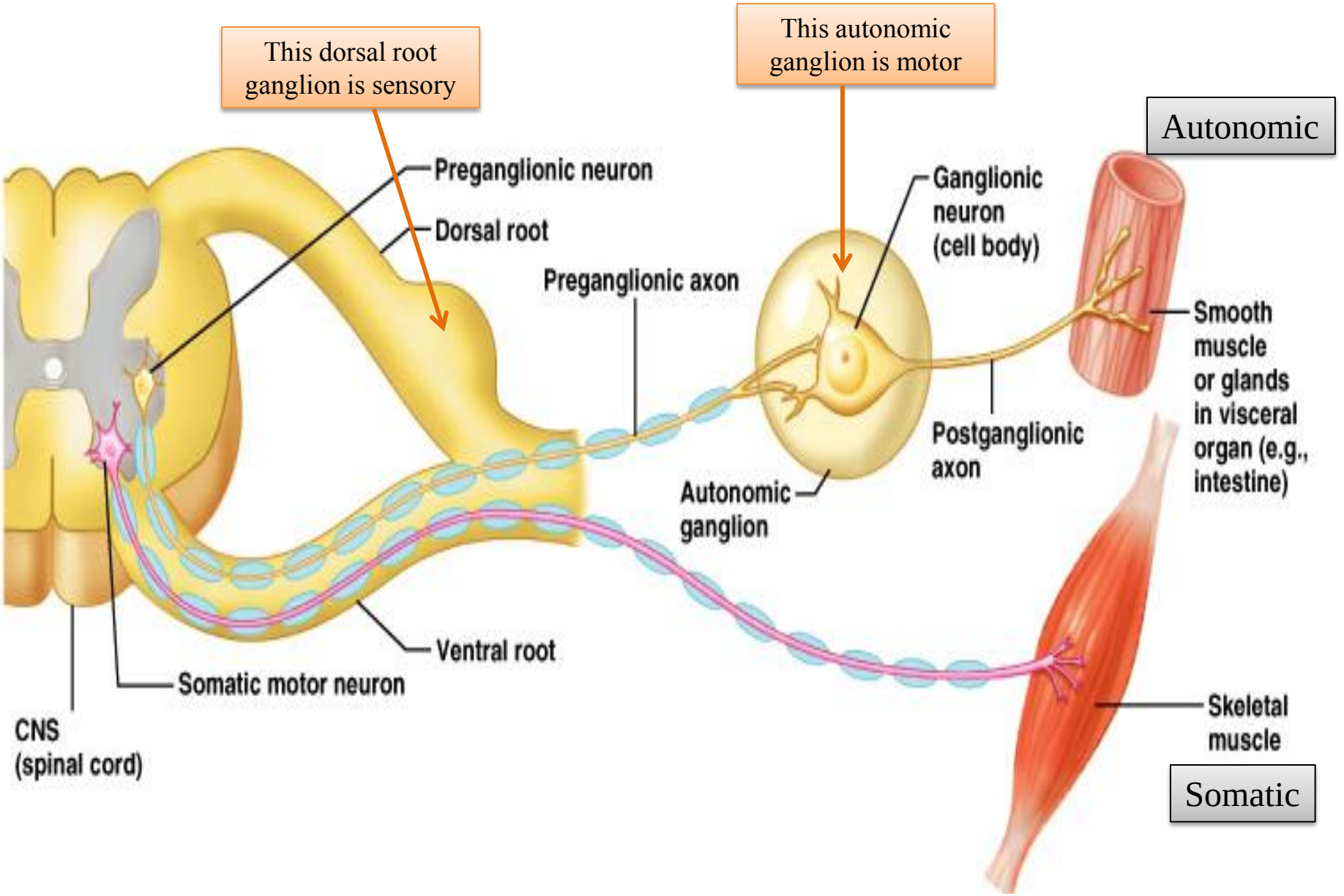


Diagram contrasts somatic and autonomic

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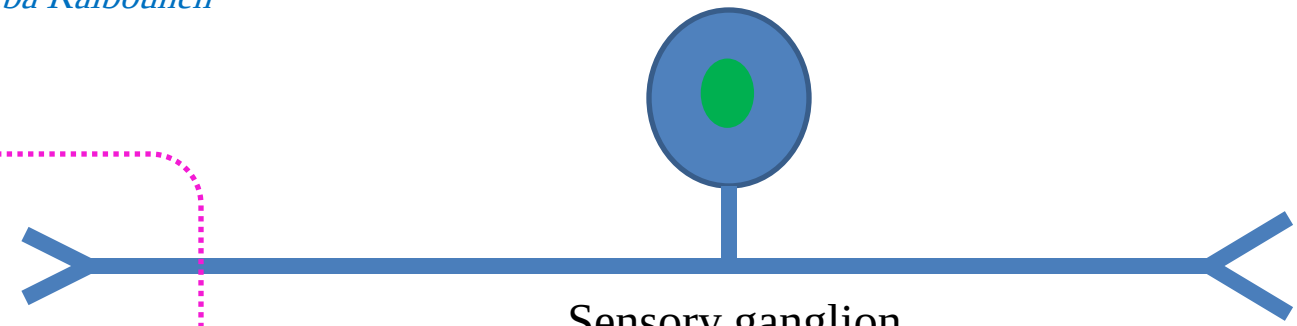
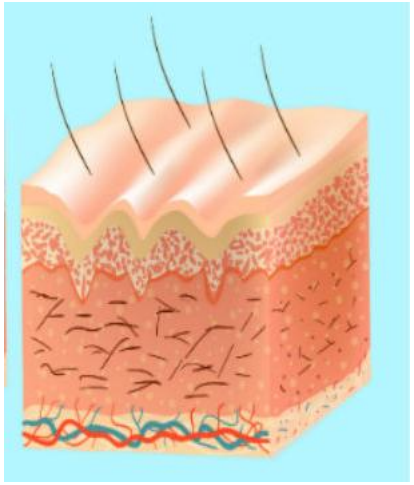


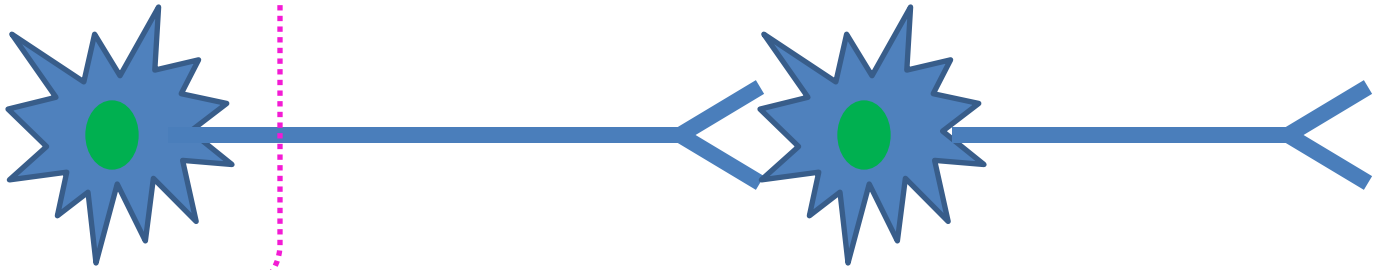
Sensory ganglion

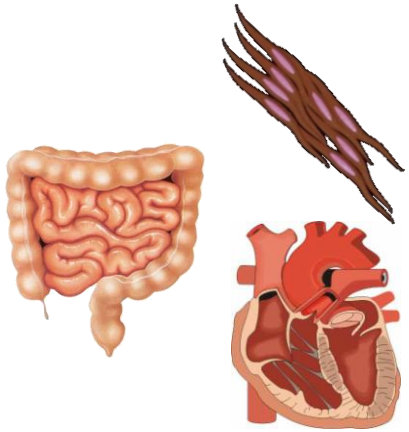


CNS

Ganglia are masses of neuronal cell bodies, usually defined as being outside the central nervous system. They seem to act as coordinating way stations.
Two type ganglia:
1.Sensory
2.Autonomic

Note: Sensory ganglia do not receive synapses While Autonomic ganglia do contain synapses



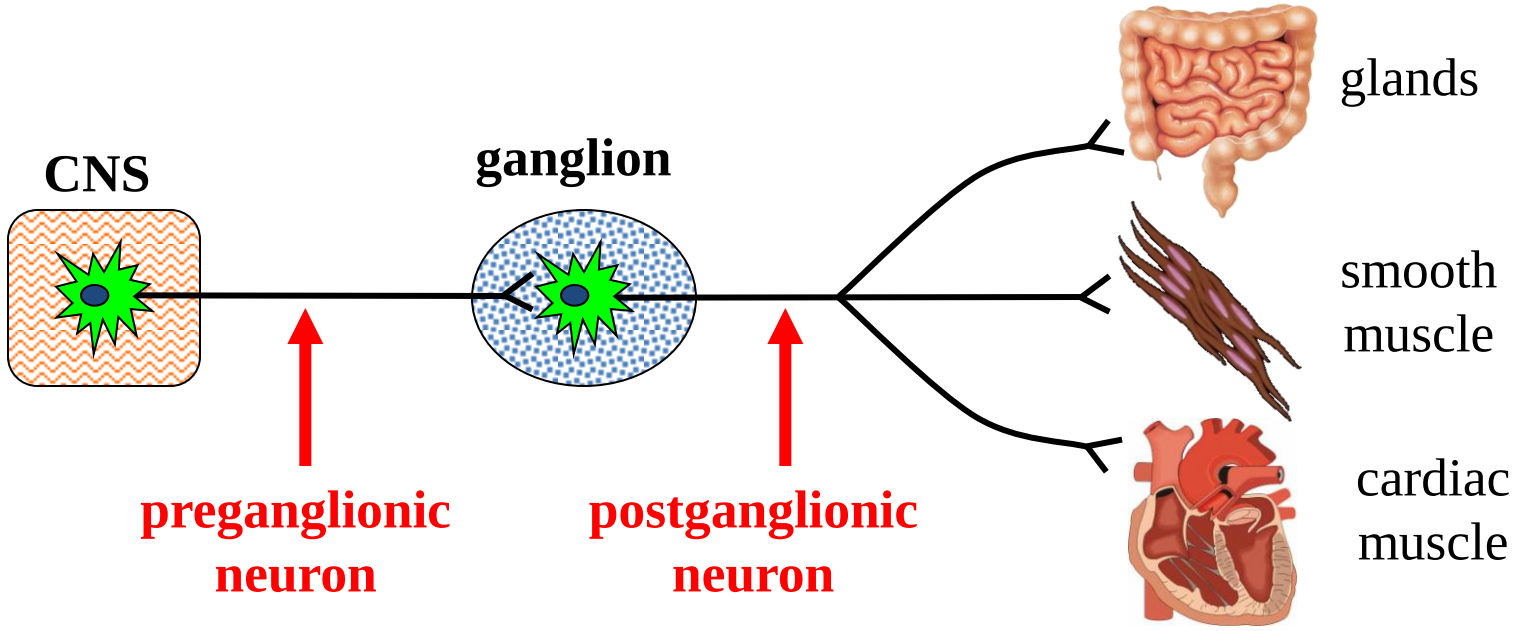


Autonomic ganglion

Autonomic Nervous System

Similarities between Sympathetic & Parasympathetic

- Both are efferent (motor) systems: "visceromotor"
- Both involve regulation of the "internal" environment generally outside of our conscious control: "autonomous"
- Both involve 2 neurons that synapse in a peripheral ganglion
- Innervate glands, smooth muscle, cardiac muscle

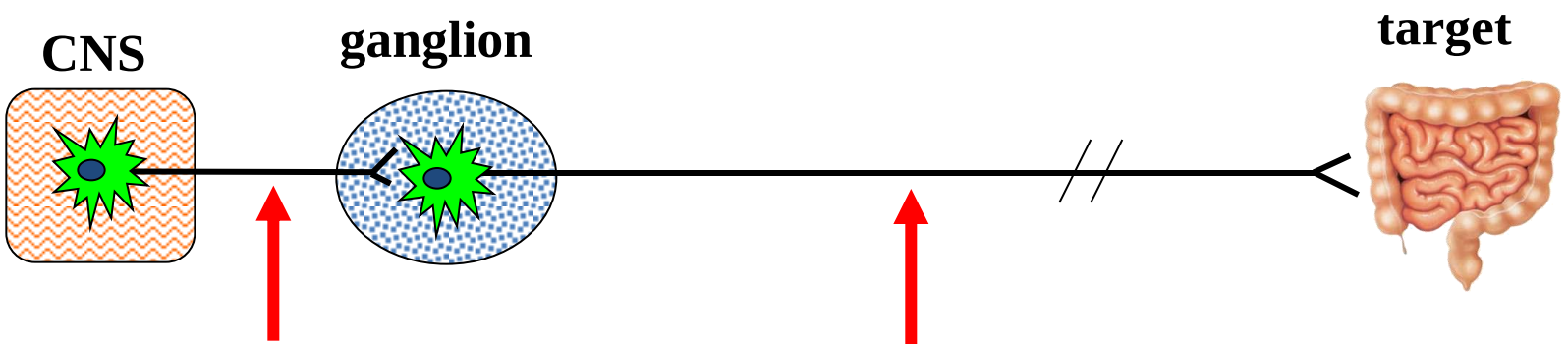


Autonomic Nervous System

Differences between Sympathetic & Parasympathetic

Relative Lengths of Neurons

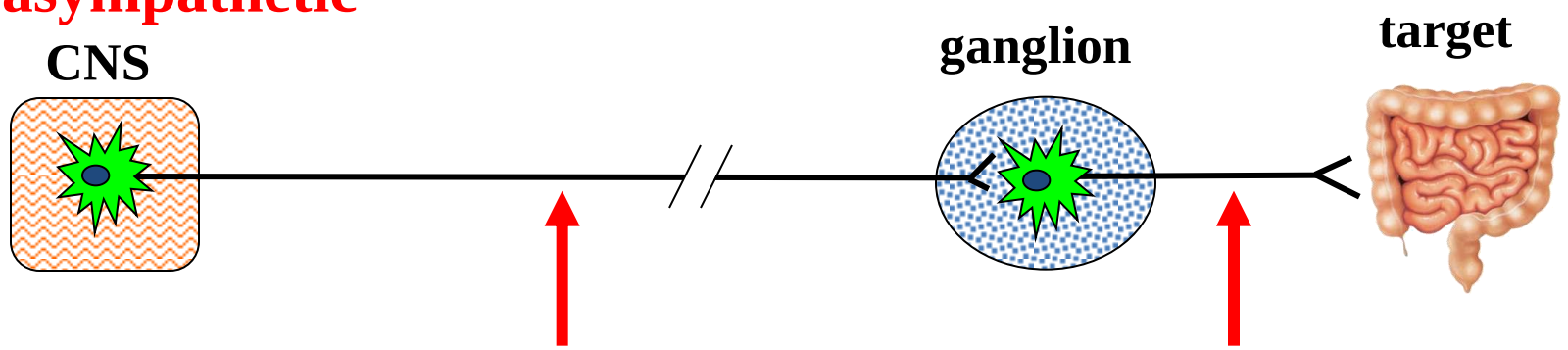
Sympathetic



short preganglionic neuron

long postganglionic neuron

Parasympathetic



long preganglionic neuron

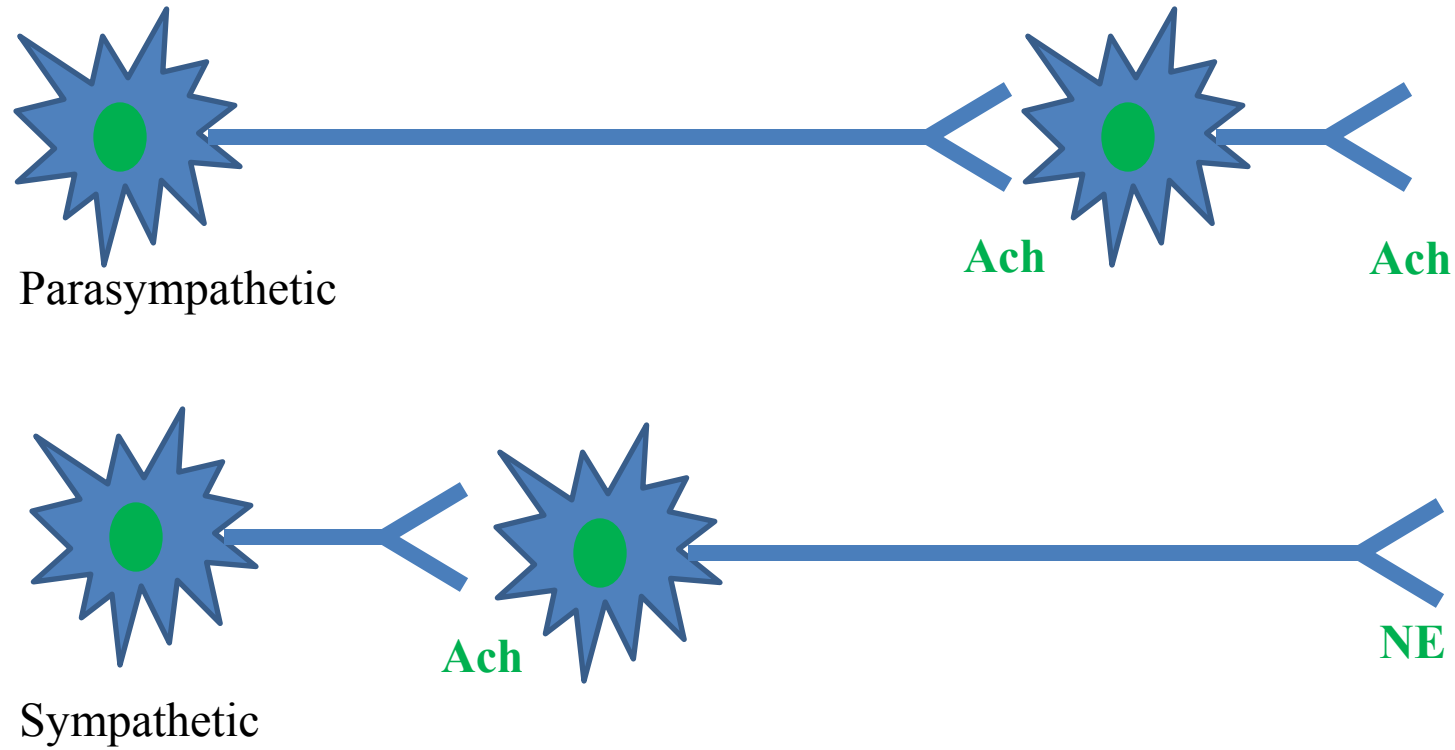
short postganglionic neuron

Overview of the Autonomic Nervous System

Differences between Sympathetic & Parasympathetic

Dr. Heba Kalbouneh

Types of neurotransmitters



Physiological effect

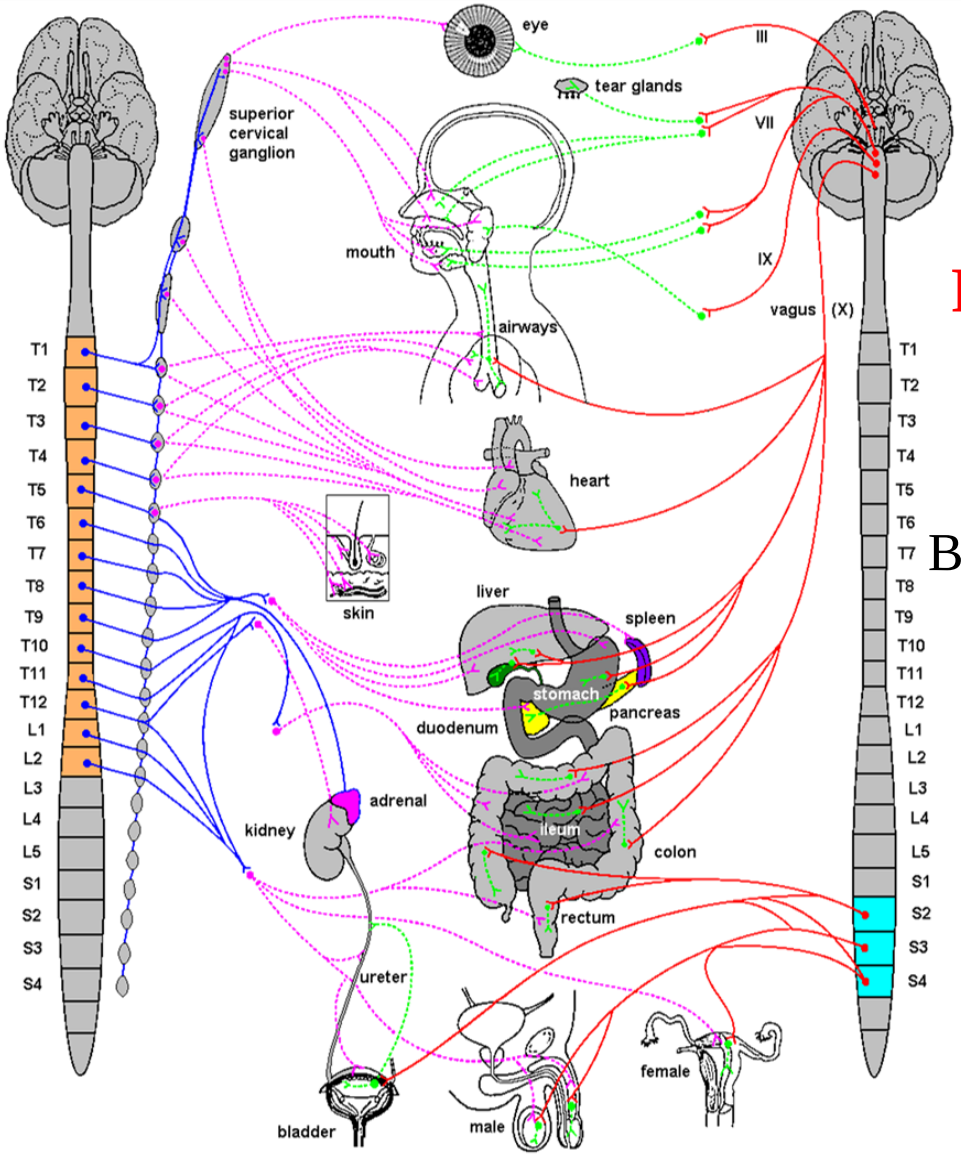
Autonomic Nervous System

Differences between Sympathetic & Parasympathetic

Location of Preganglionic Cell Bodies

Sympathetic

Parasympathetic



Thoracolumbar

T1 – L2 levels of the spinal cord

Craniosacral

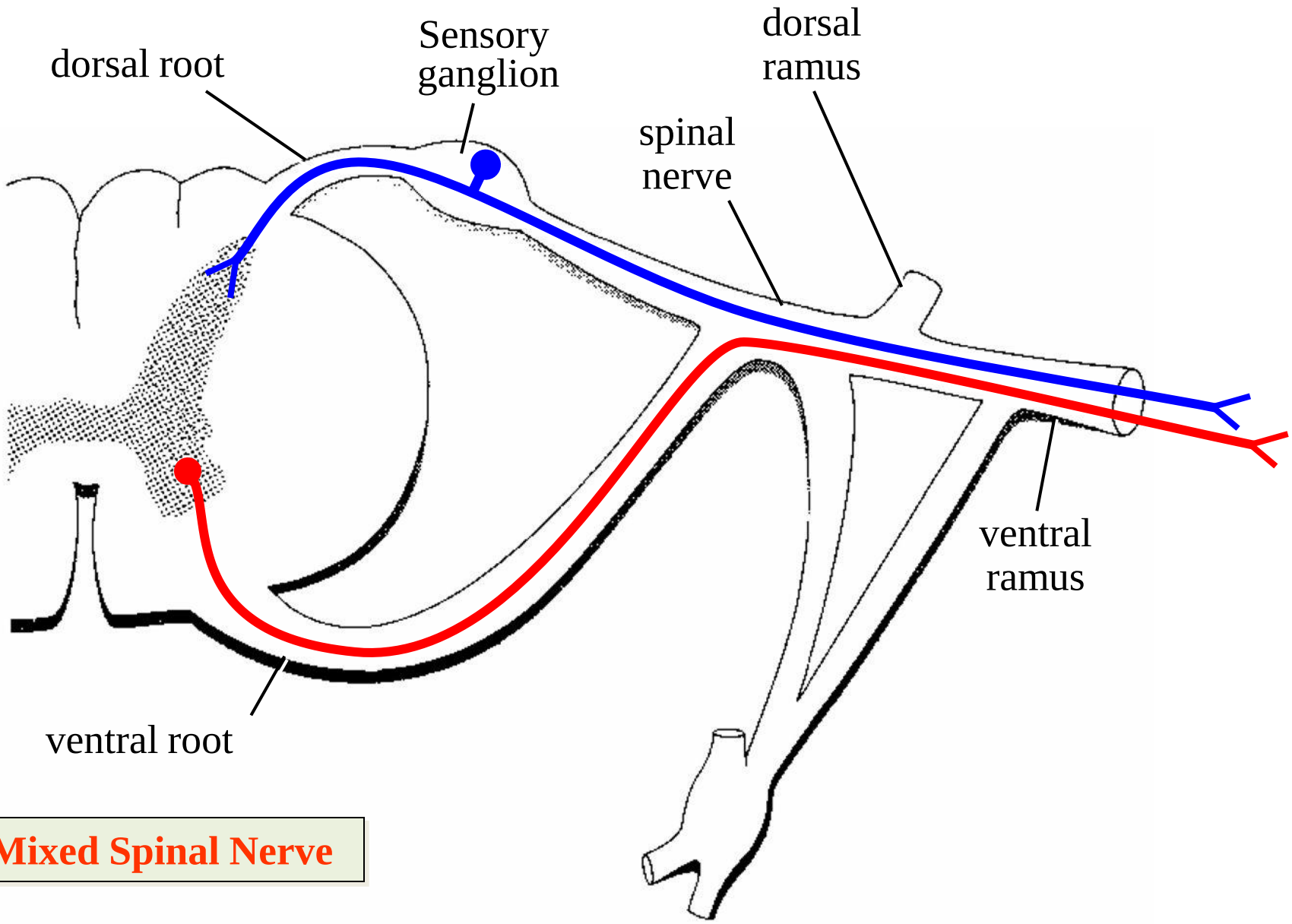
Brain: CN III, VII, IX, X

Spinal cord: S2 – S4

vasomotor

secretomotor

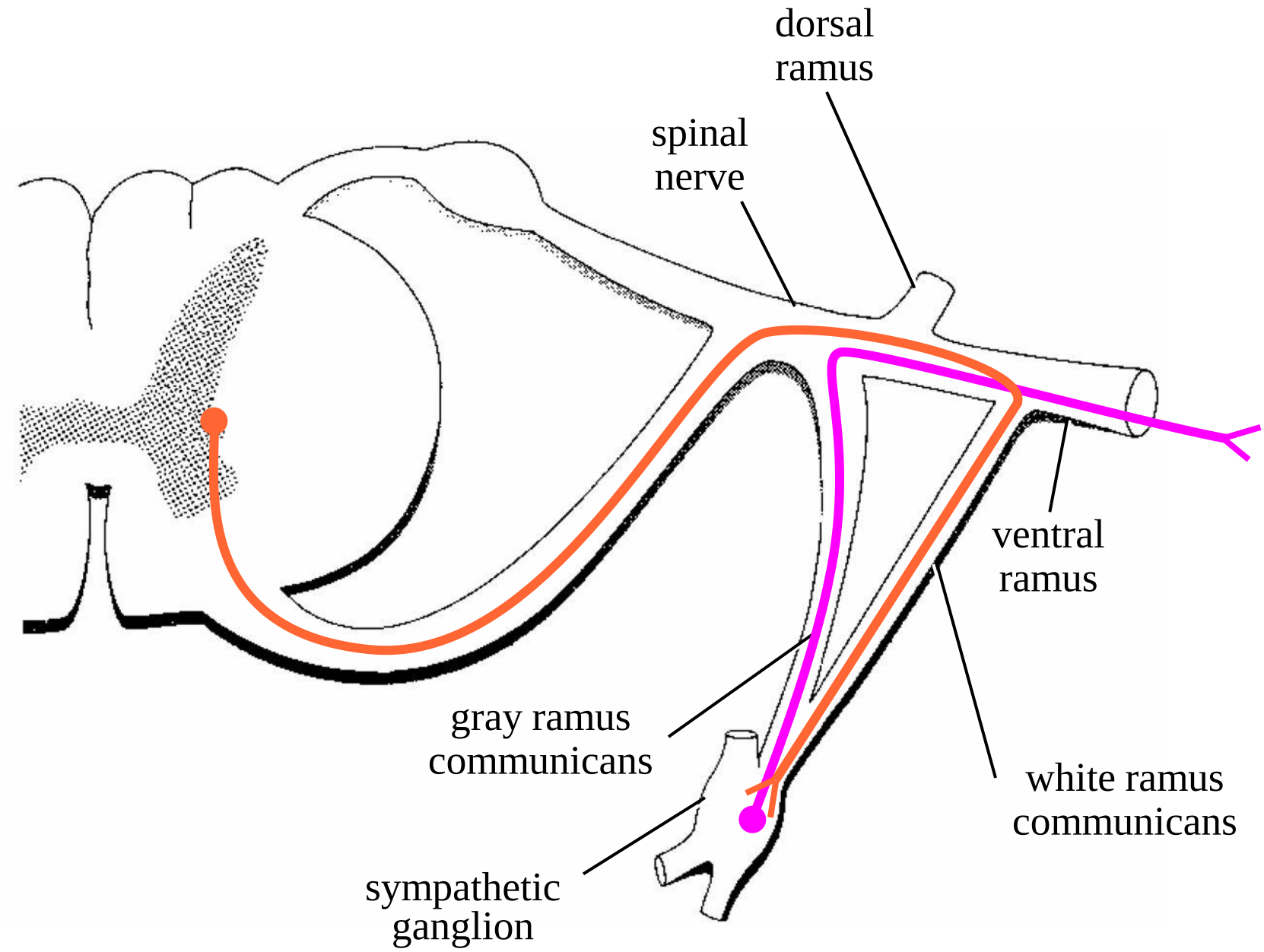
Structure of Spinal Nerves: Somatic Pathways



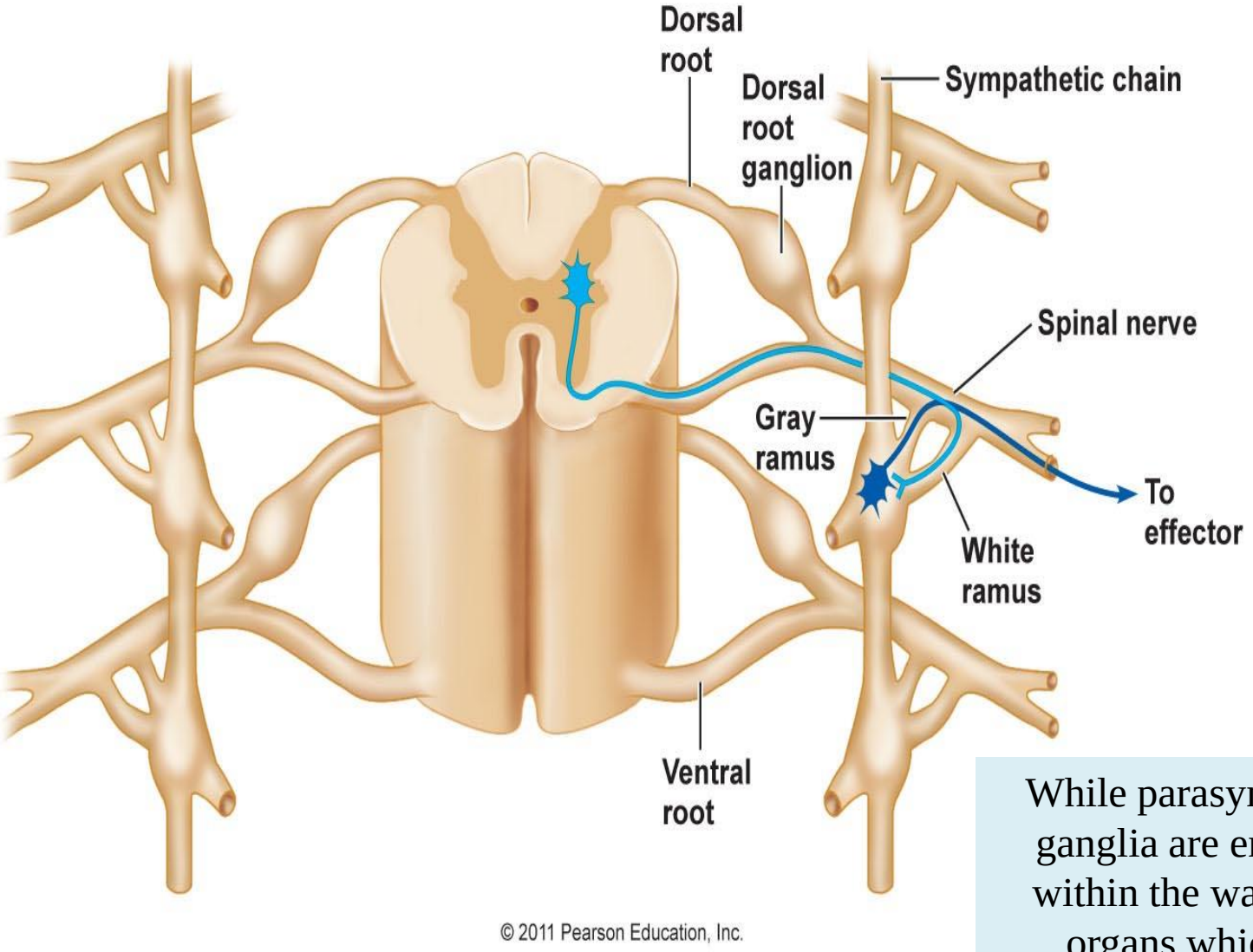
Mixed Spinal Nerve

Stern *Essentials of Gross Anatomy*

Structure of spinal nerves: Sympathetic pathways



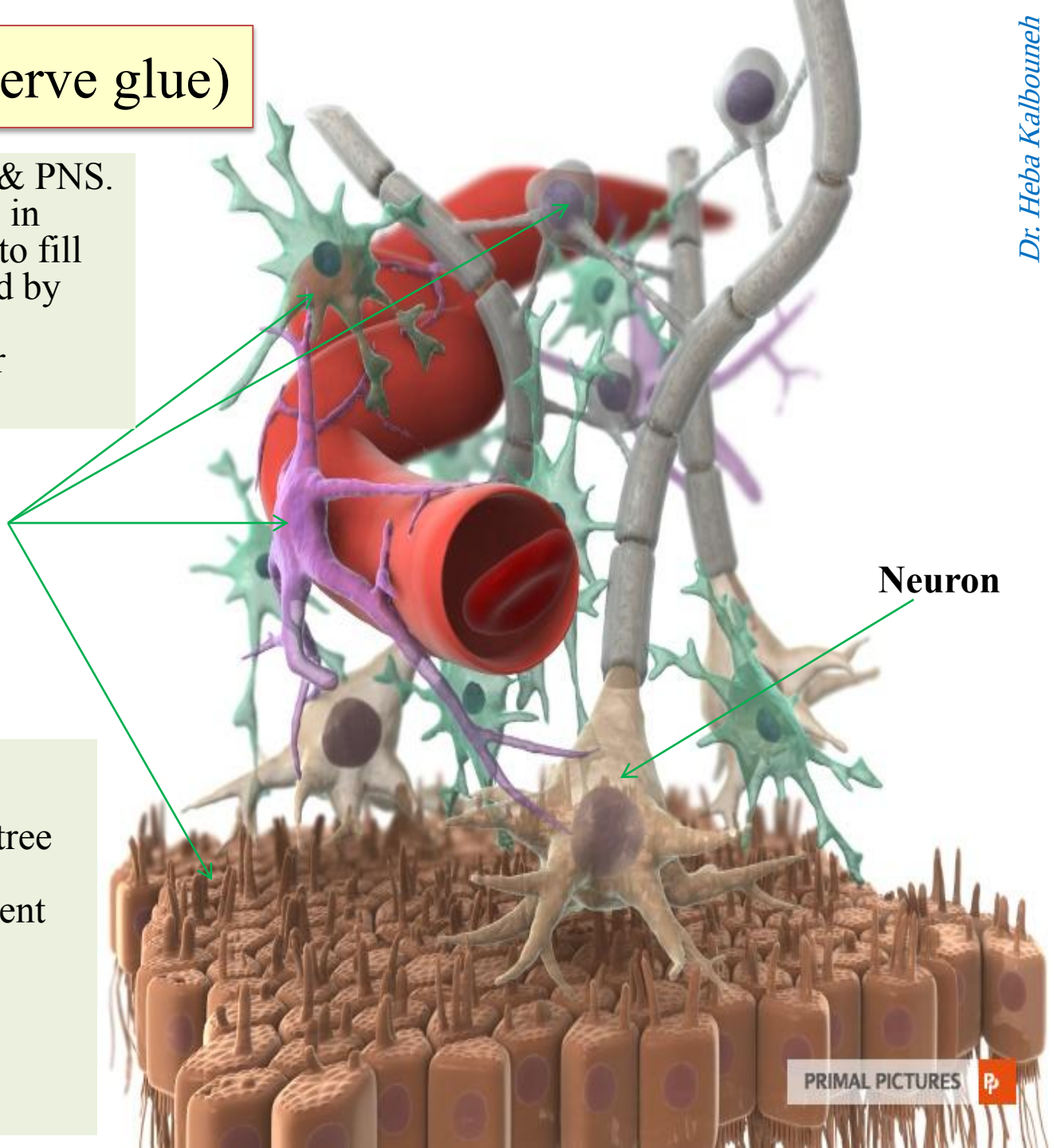
Sympathetic ganglia are the ganglia of the sympathetic nervous system
They are located close to and on either side of the spinal cord in long chains



While parasympathetic ganglia are embedded within the walls of the organs which they innervate

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).



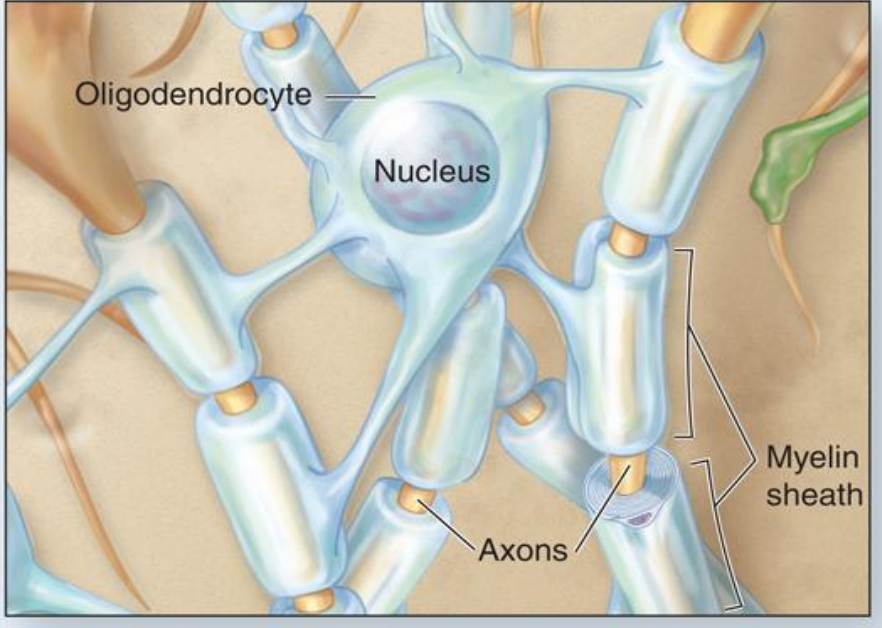
Neuroglial cells of CNS:
- Astrocytes = star cells
- Oligodendrocytes = few tree
- Microglia = small
- Ependyma = above garment

Neuroglial cells of PNS:
- Schwann cells
- Satellite cells

Neuroglial cells of CNS

Oligodendrocytes

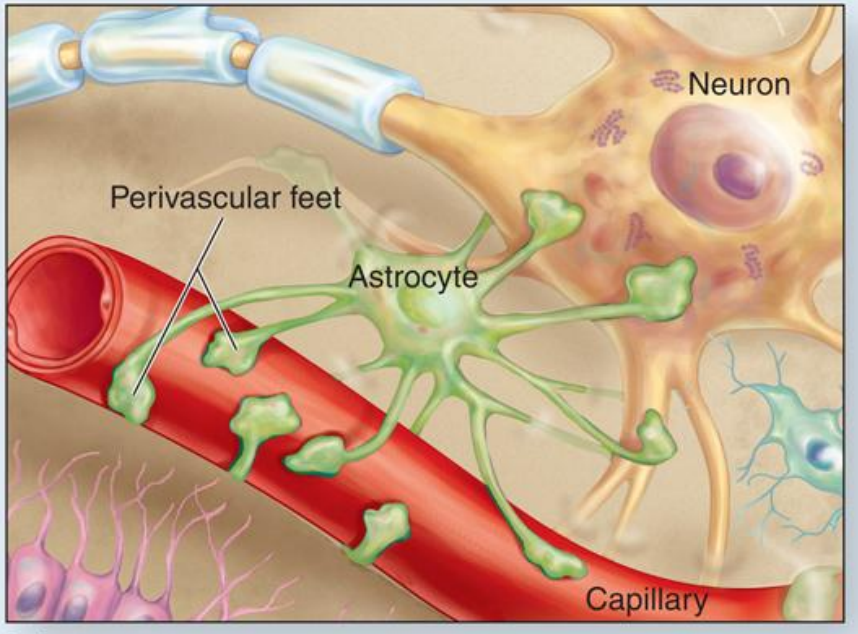
- Small glial cells with few processes
- Myelin-forming cells of CNS



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

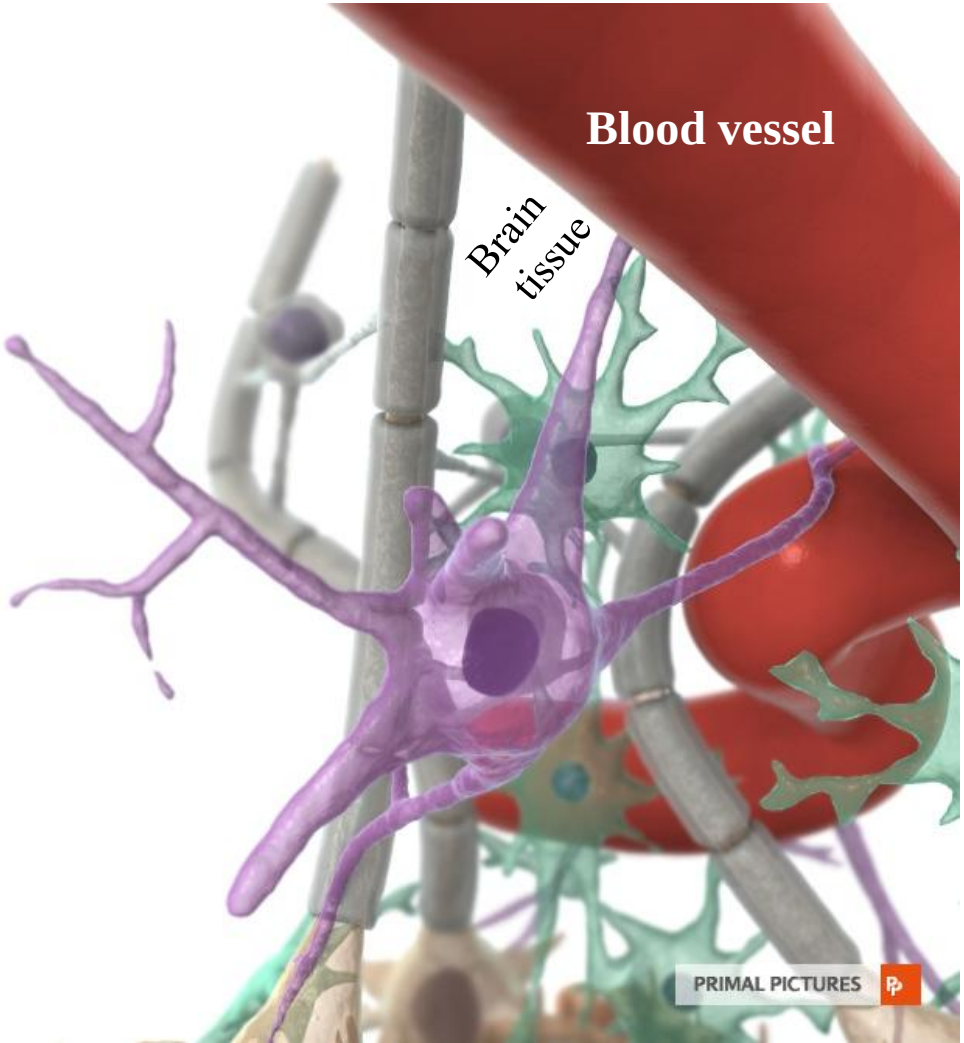
2- Thick basement membrane

3- Astrocytes processes

✓A few water soluble substances (glucose) cross the BBB by active transport

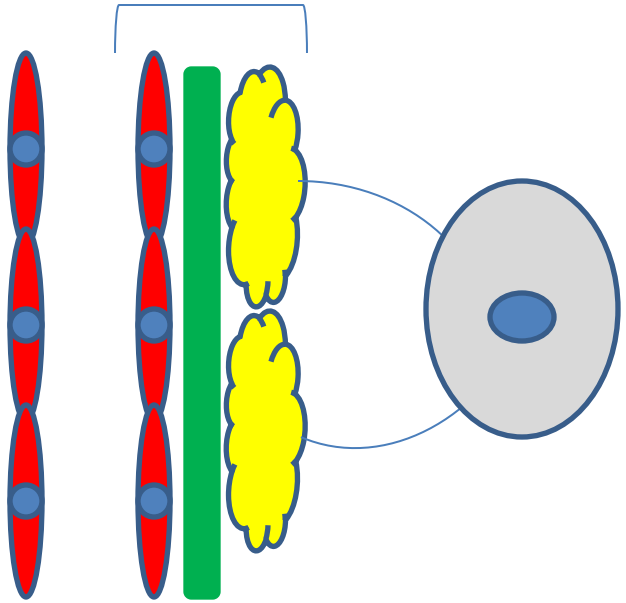
✓Proteins and most antibiotic drugs do not pass into brain tissue

✓Lipid soluble substances (oxygen, carbon dioxide, alcohol, most anesthetic agents cross freely



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

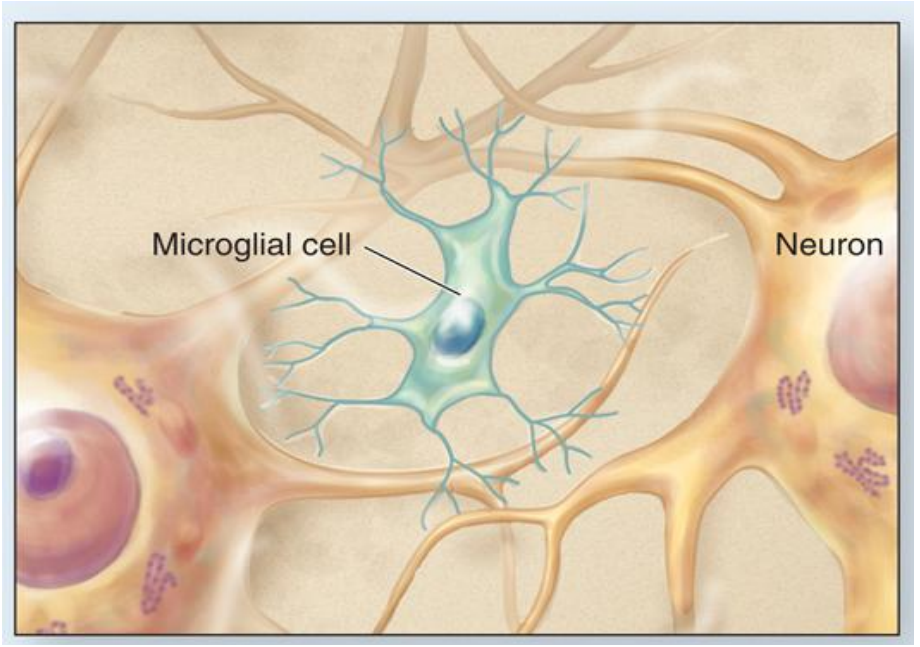
BBB



Neuroglial cells of CNS

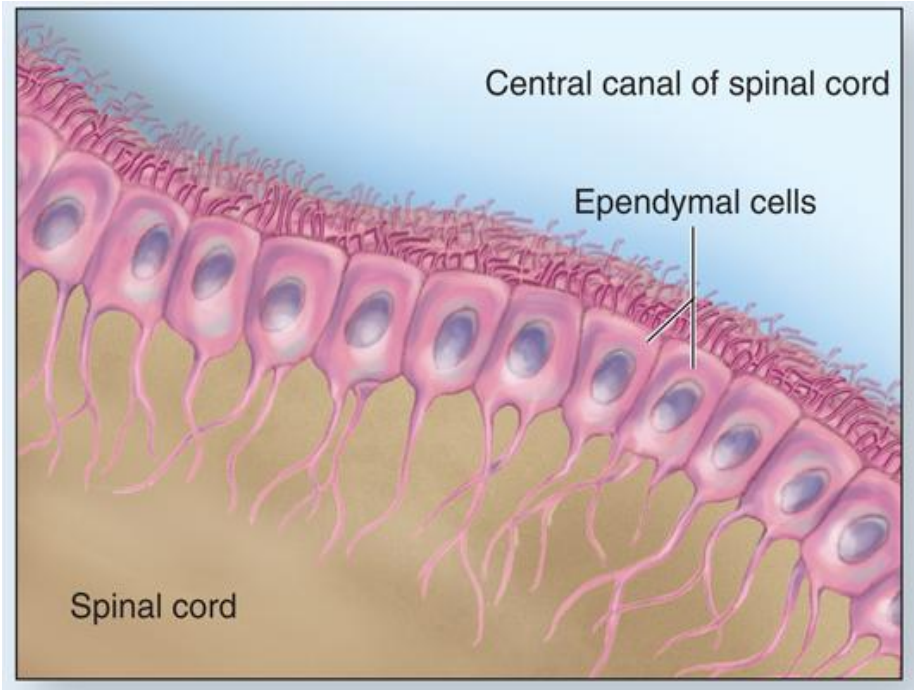
Microglia

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

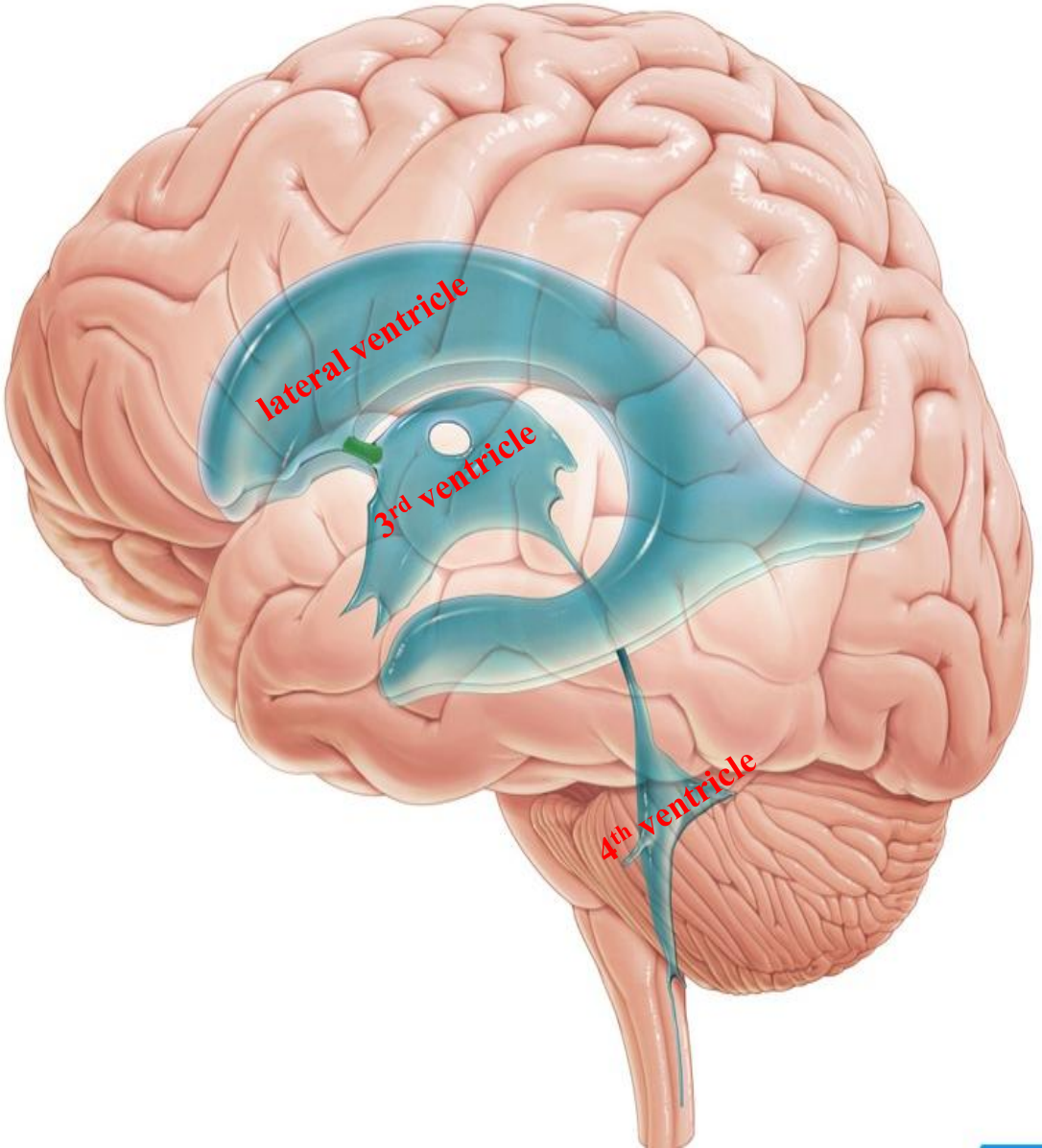


Ependymal cells

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

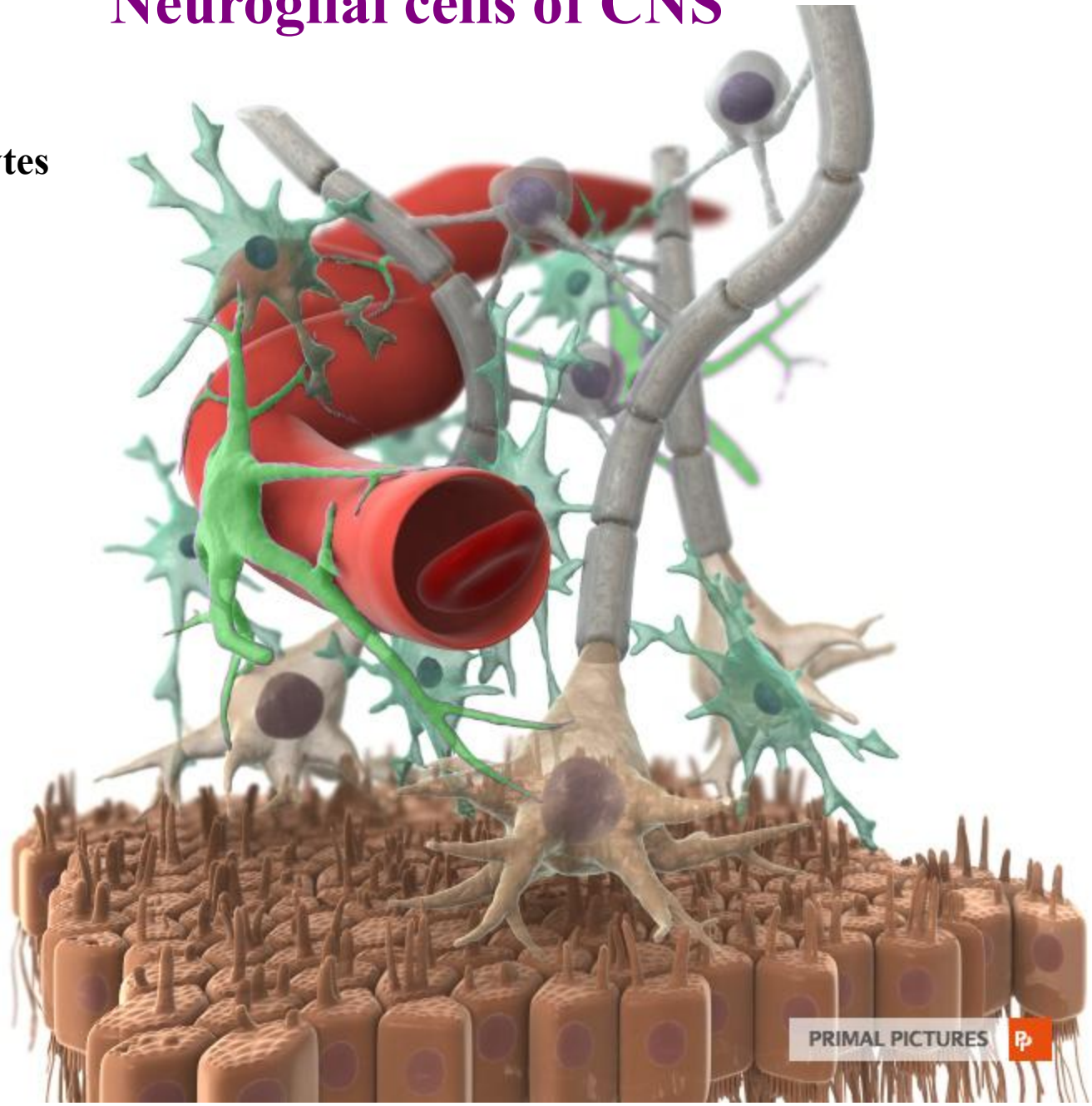


Ventricles are CSF-filled cavities within the brain



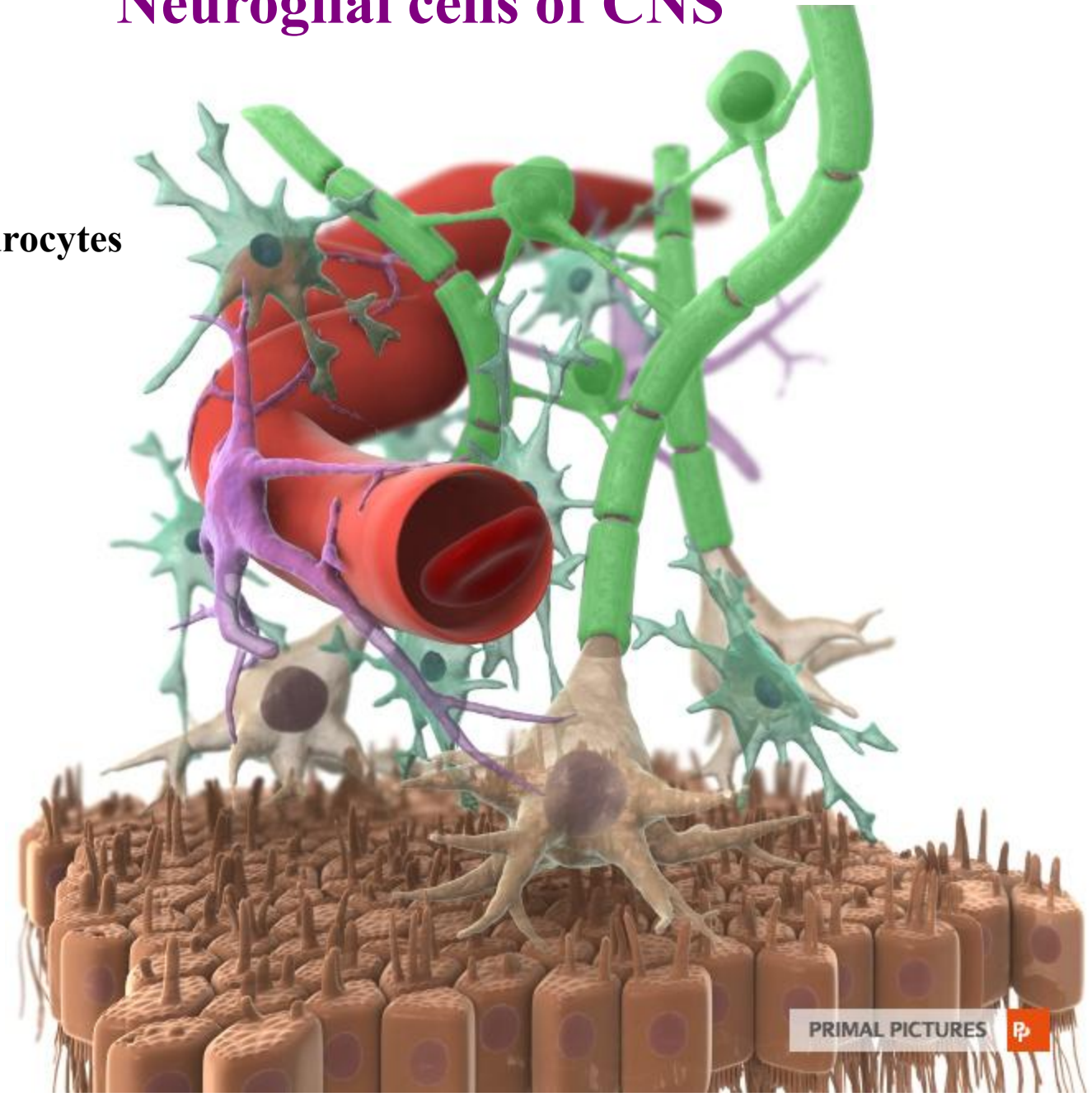
Neuroglial cells of CNS

Astrocytes



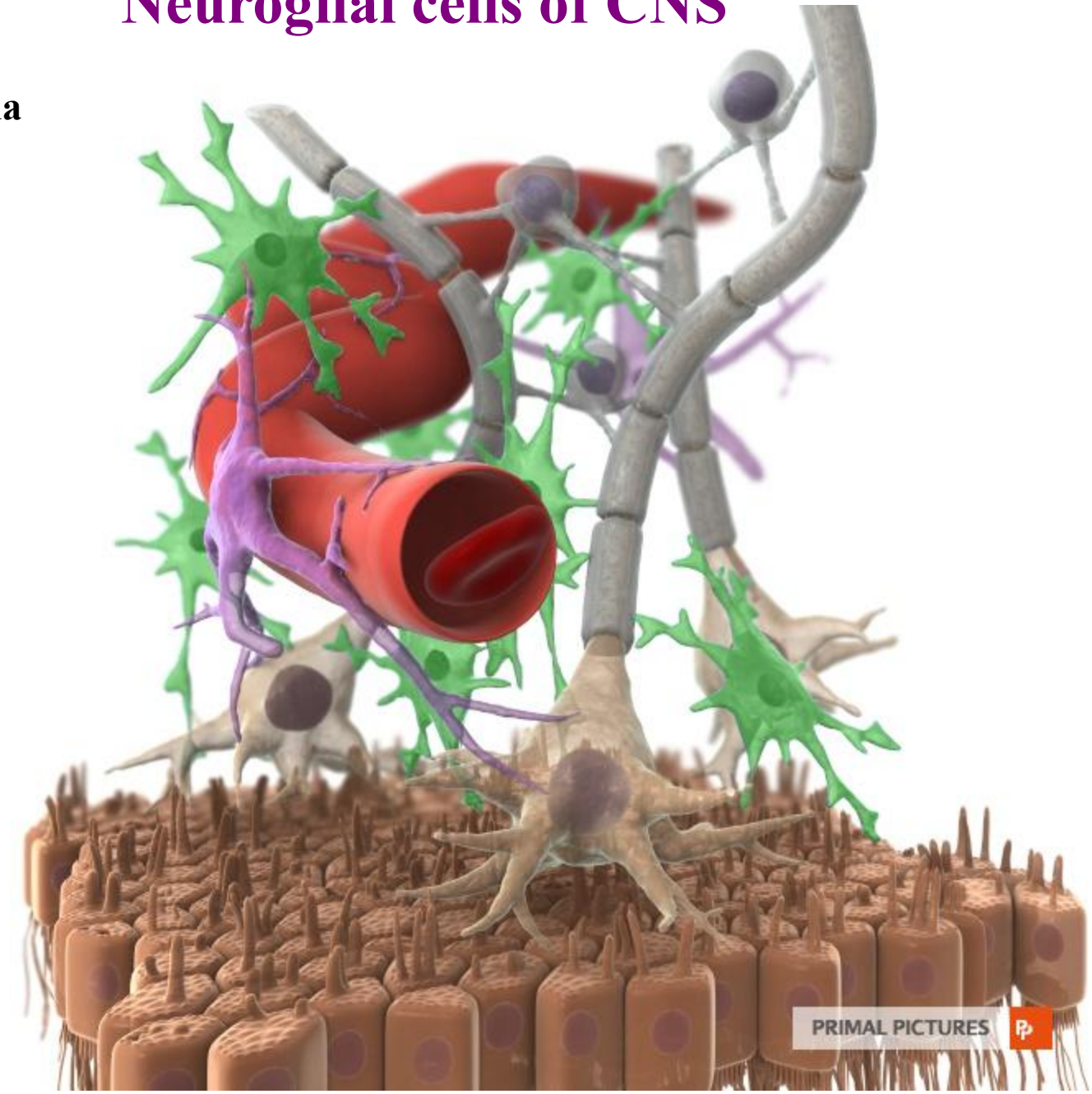
Neuroglial cells of CNS

Oligodendrocytes



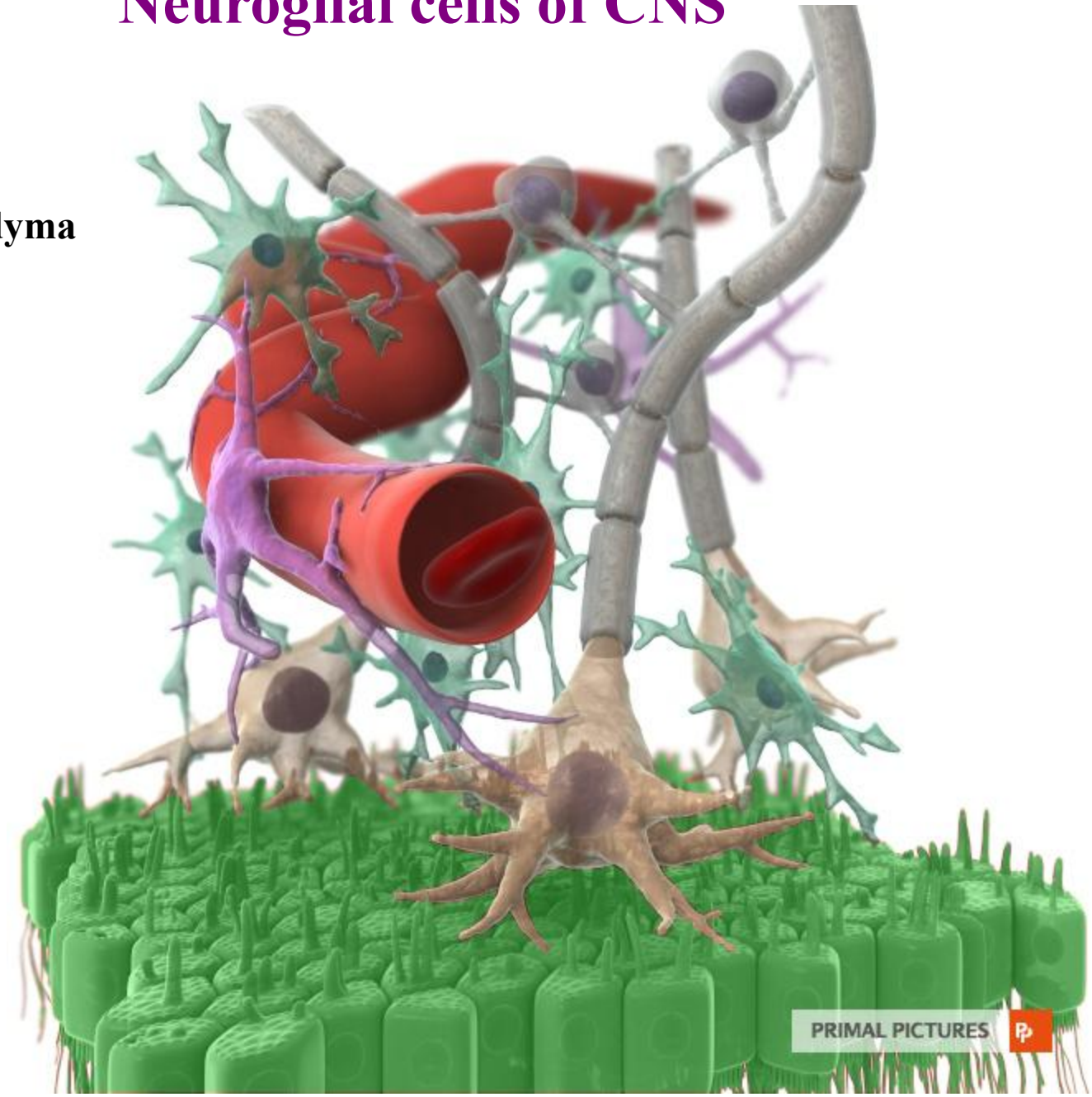
Neuroglial cells of CNS

Microglia



Neuroglial cells of CNS

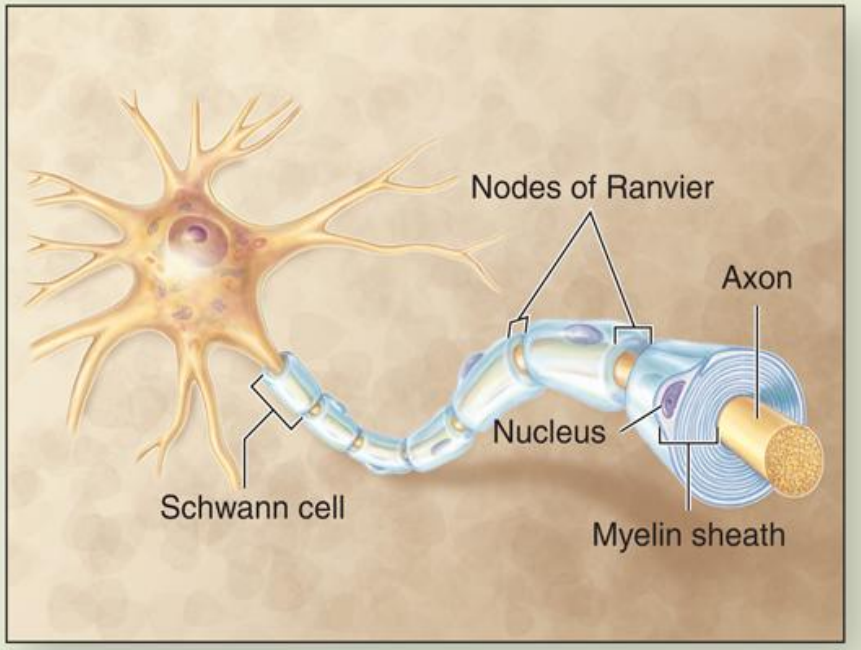
Ependyma



Neuroglial cells of PNS

Schwann cells

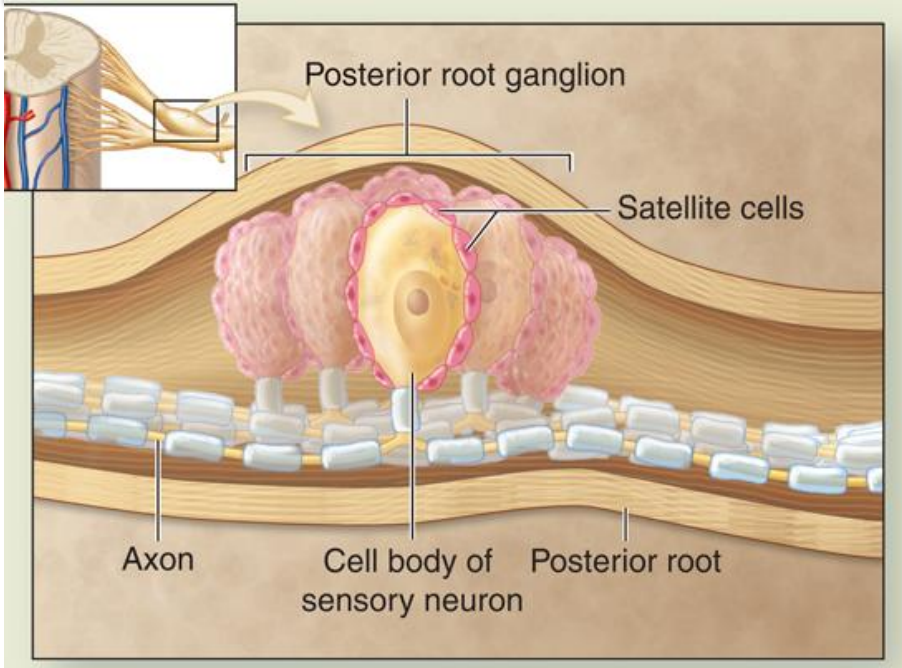
- Flattened cells
- Myelin-forming cells of PNS



e Schwann cells

Satellite cells

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

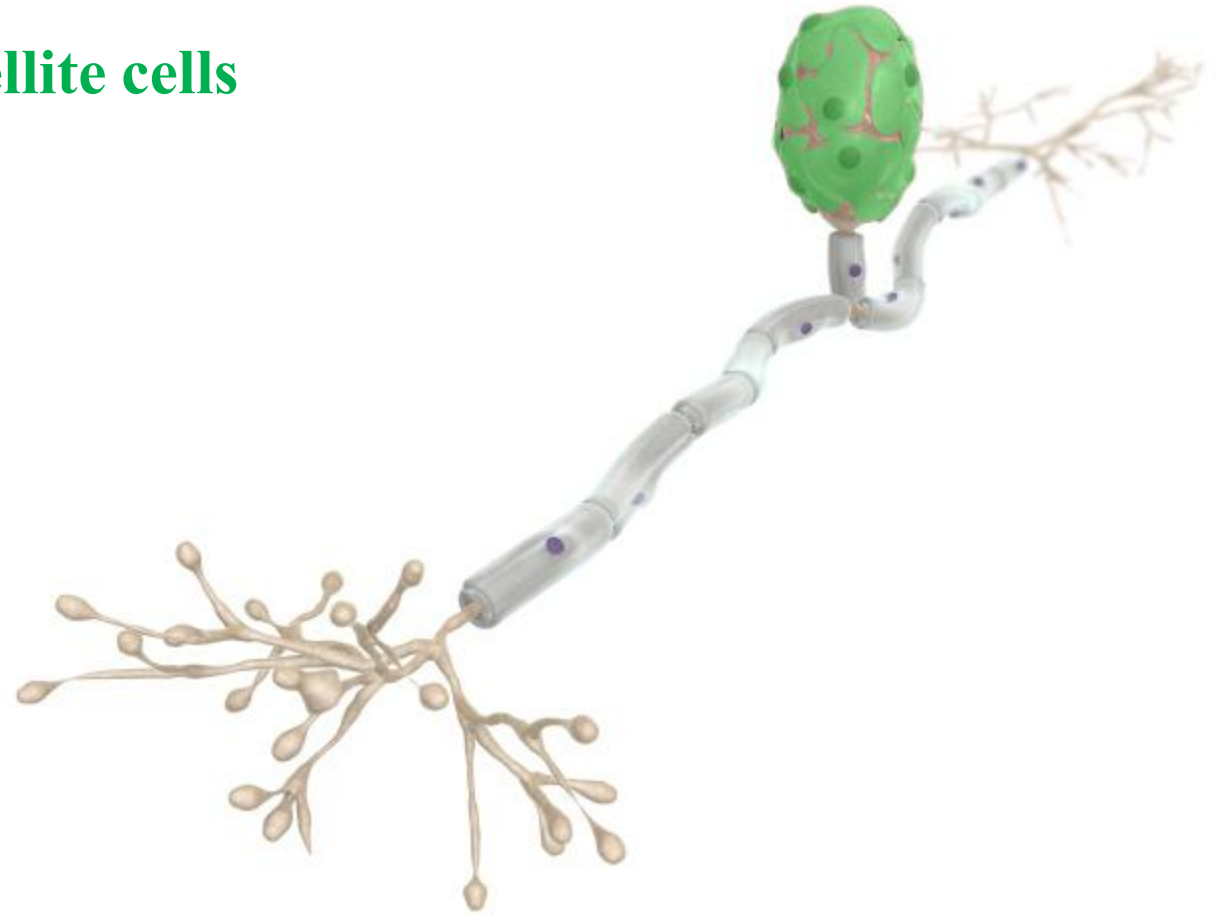


f Satellite cells

Neuroglial cells of PNS

Dr. Heba Kalbouneh

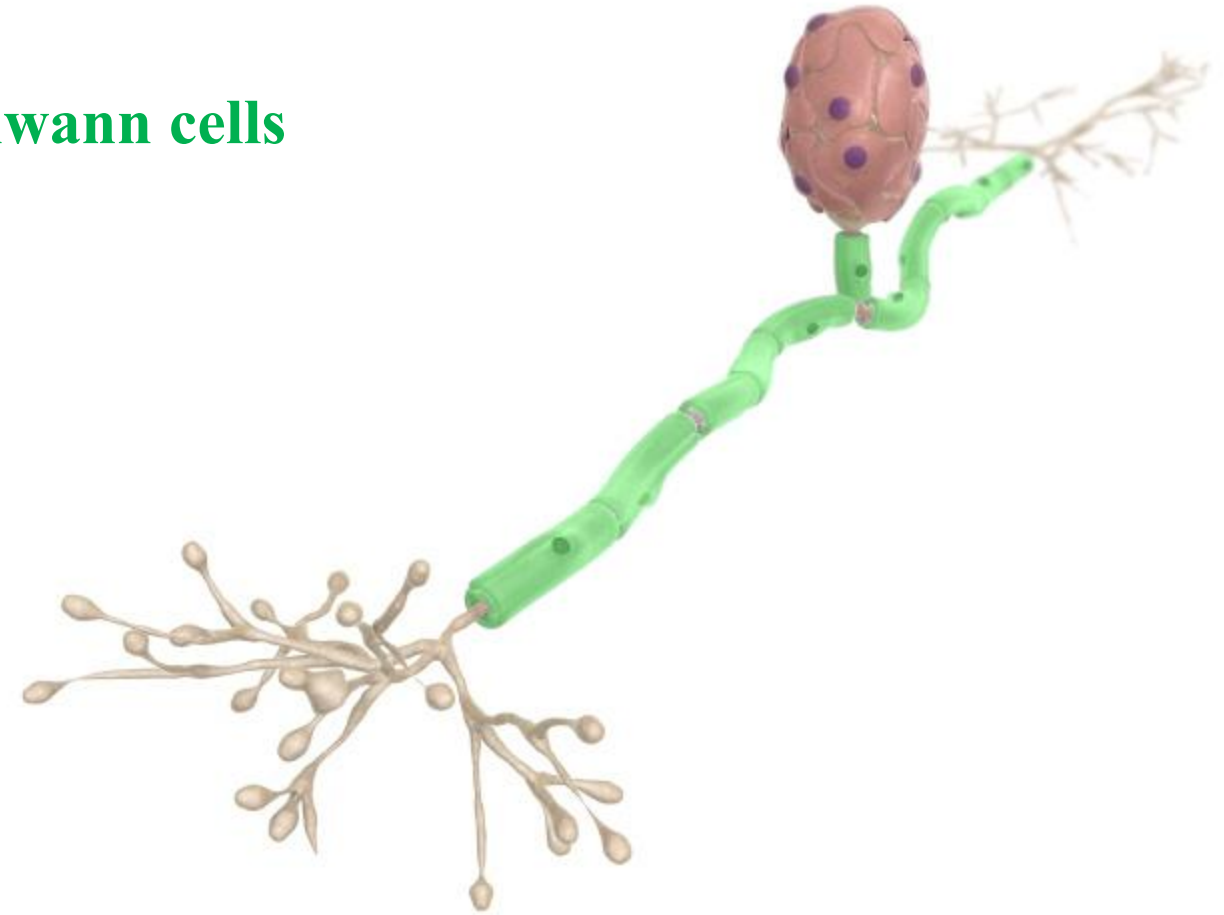
Satellite cells



Neuroglial cells of PNS

Dr. Heba Kalbouneh

Schwann cells



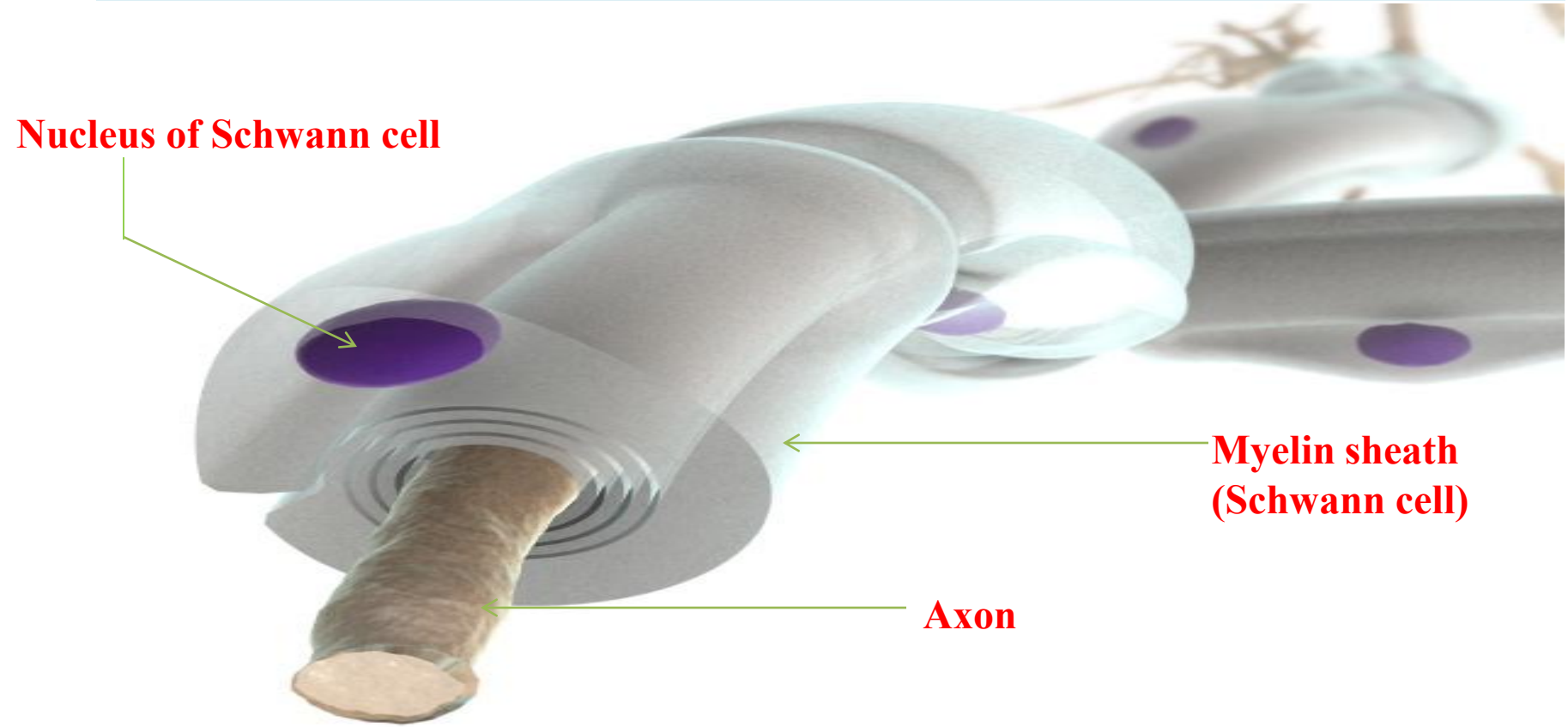
Myelin formation

- 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 increases the speed of impulse conduction.

Nerve fibers are either:

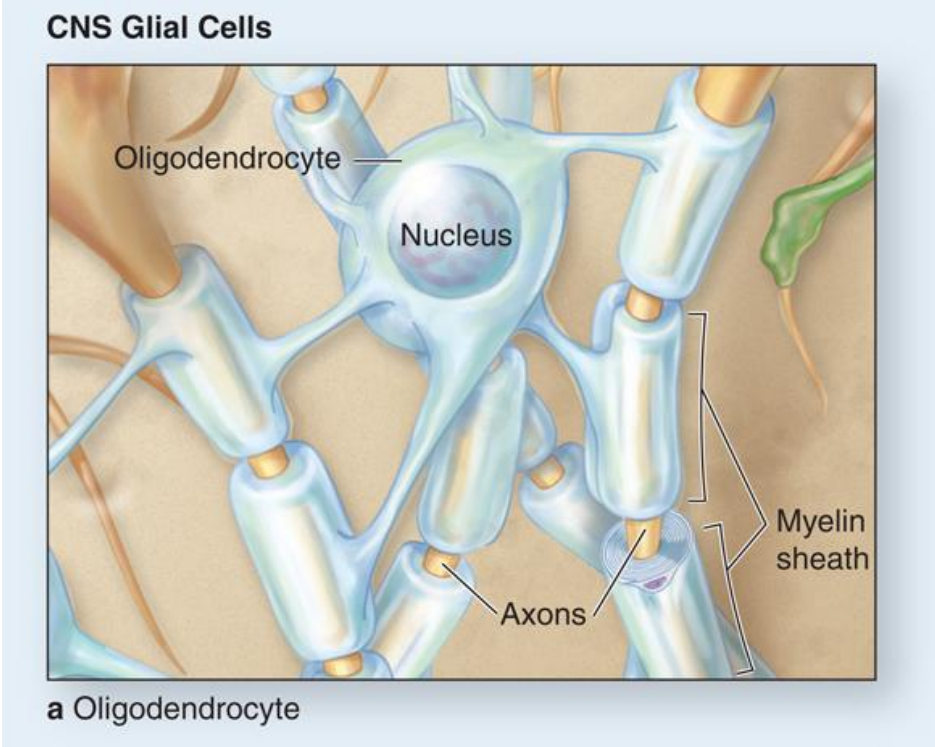
Myelinated: Impulse conduction is saltatory (jumping from node to node) with a maximum speed of 120m/s.

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



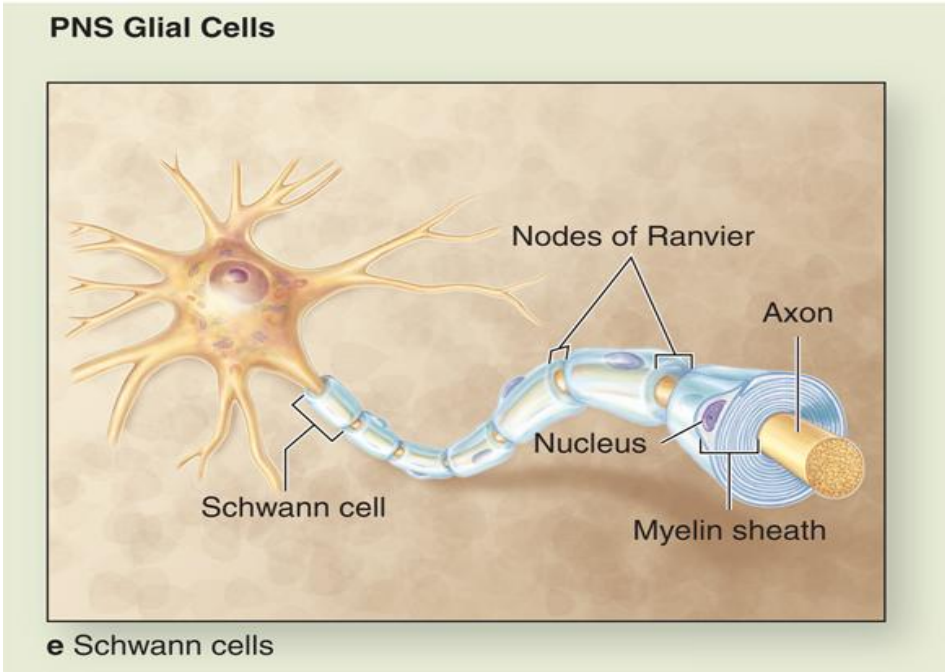
Myelination in the CNS:

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



Myelination in the PNS:

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



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

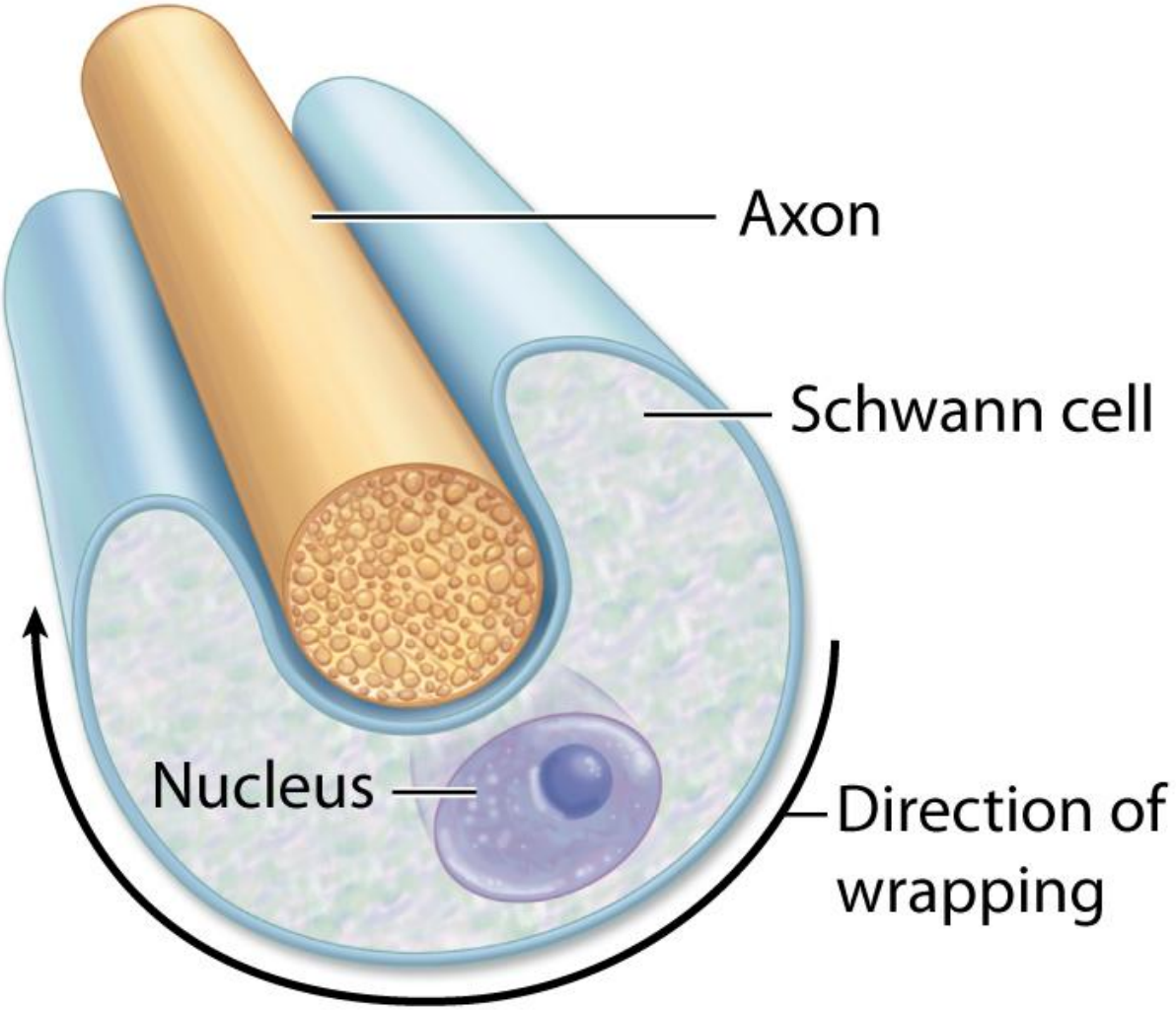


Figure 9-21

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

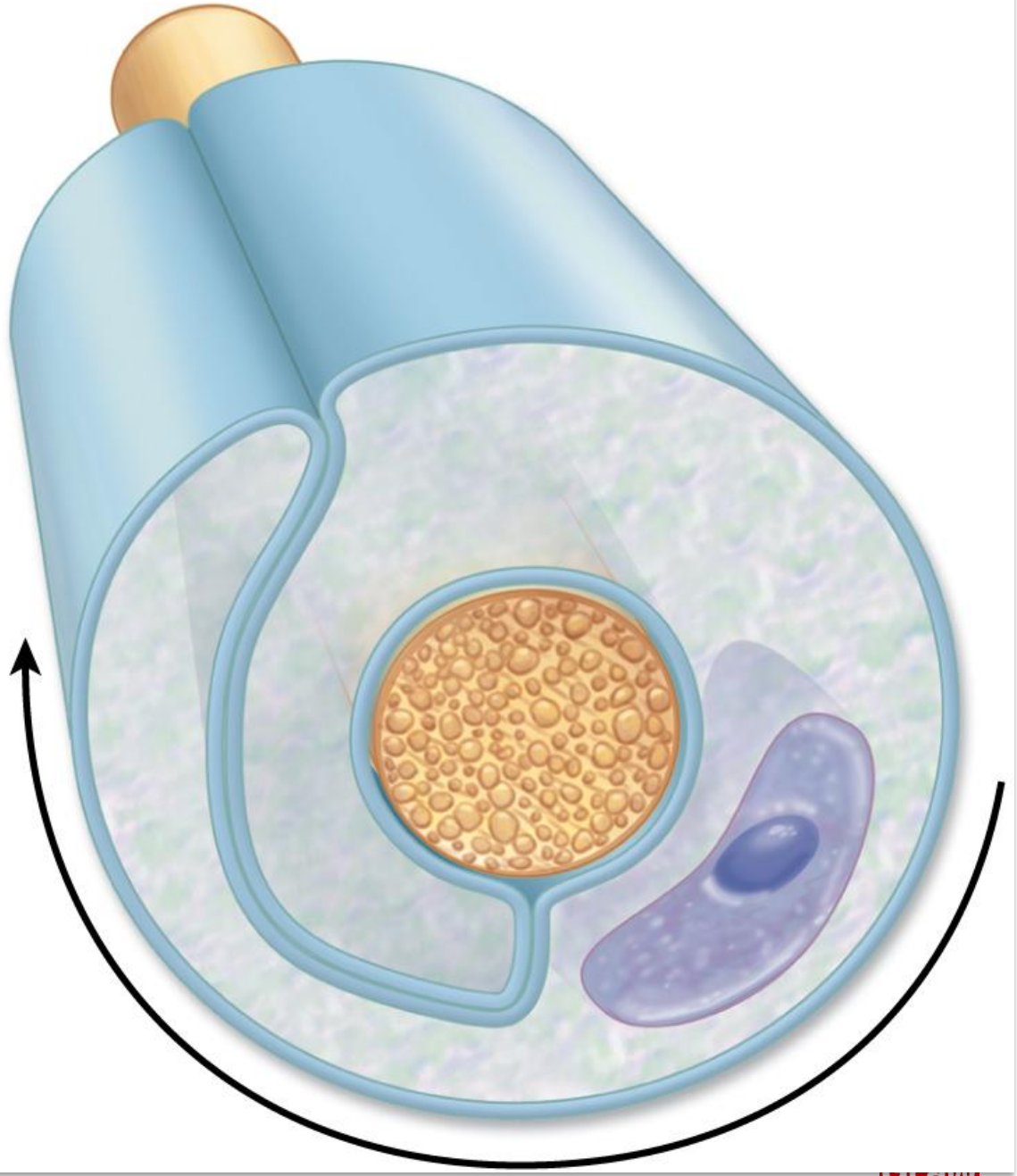


Figure 9-21

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

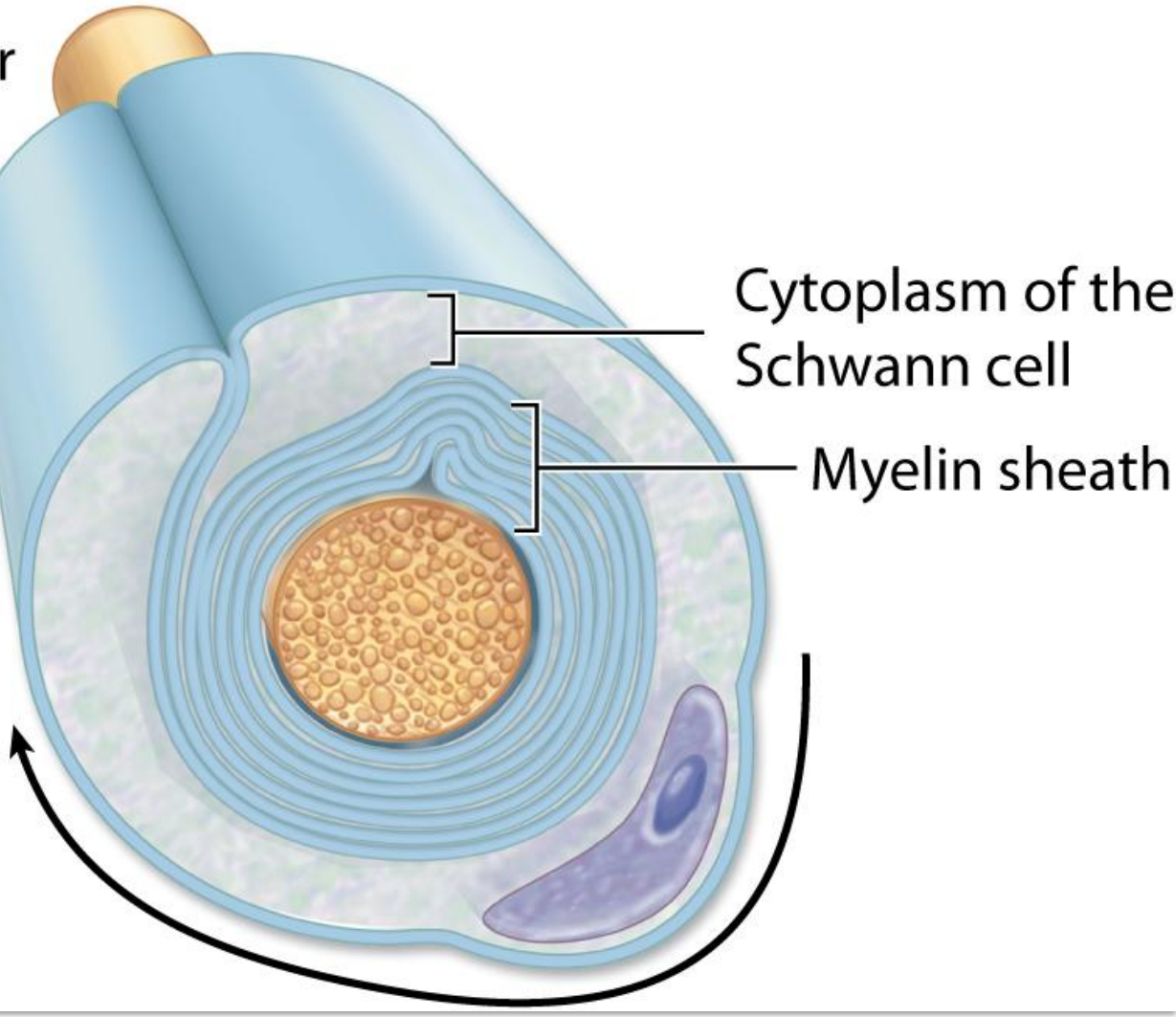


Figure 9-21

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

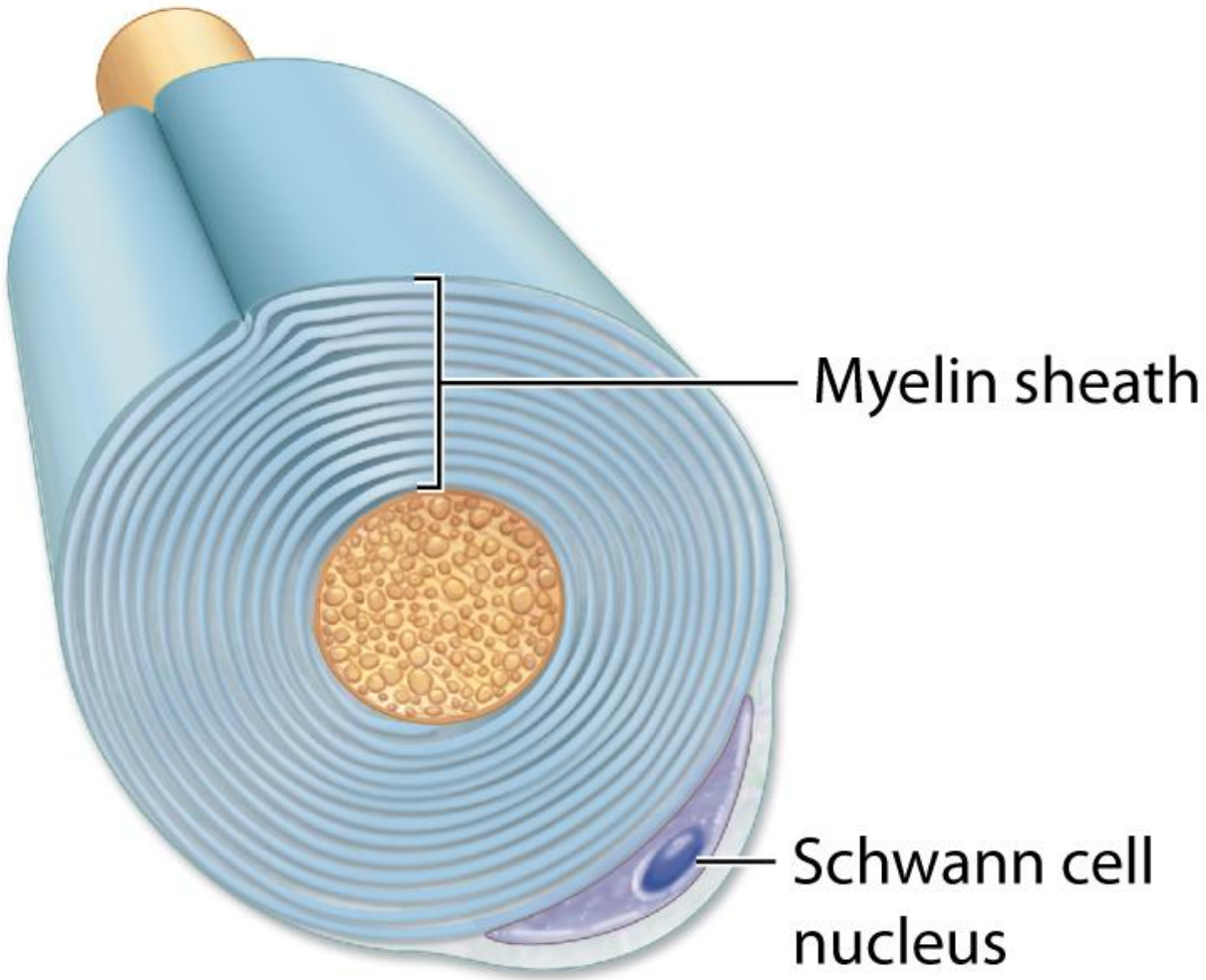


Figure 9-21

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.

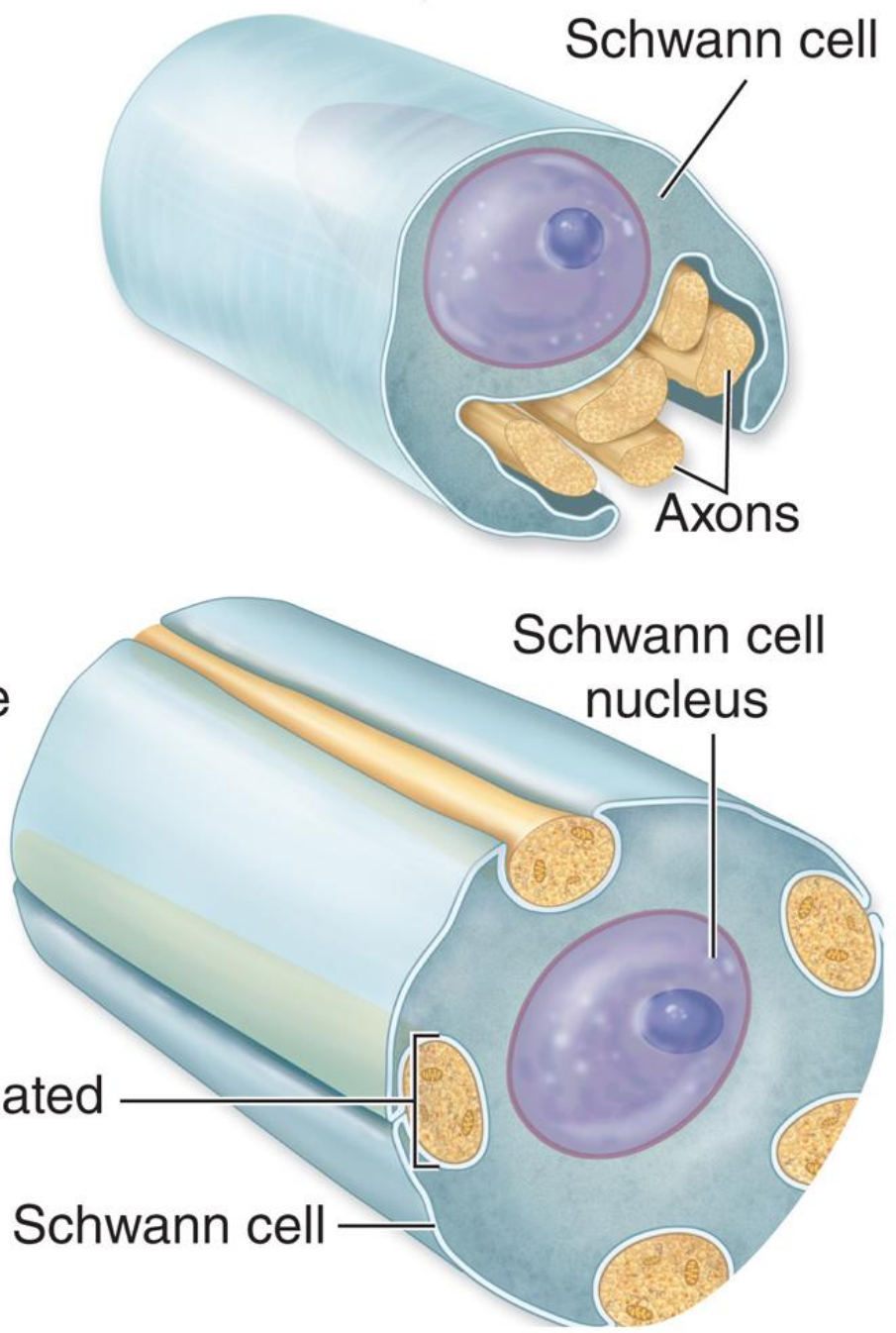


Figure 9-25

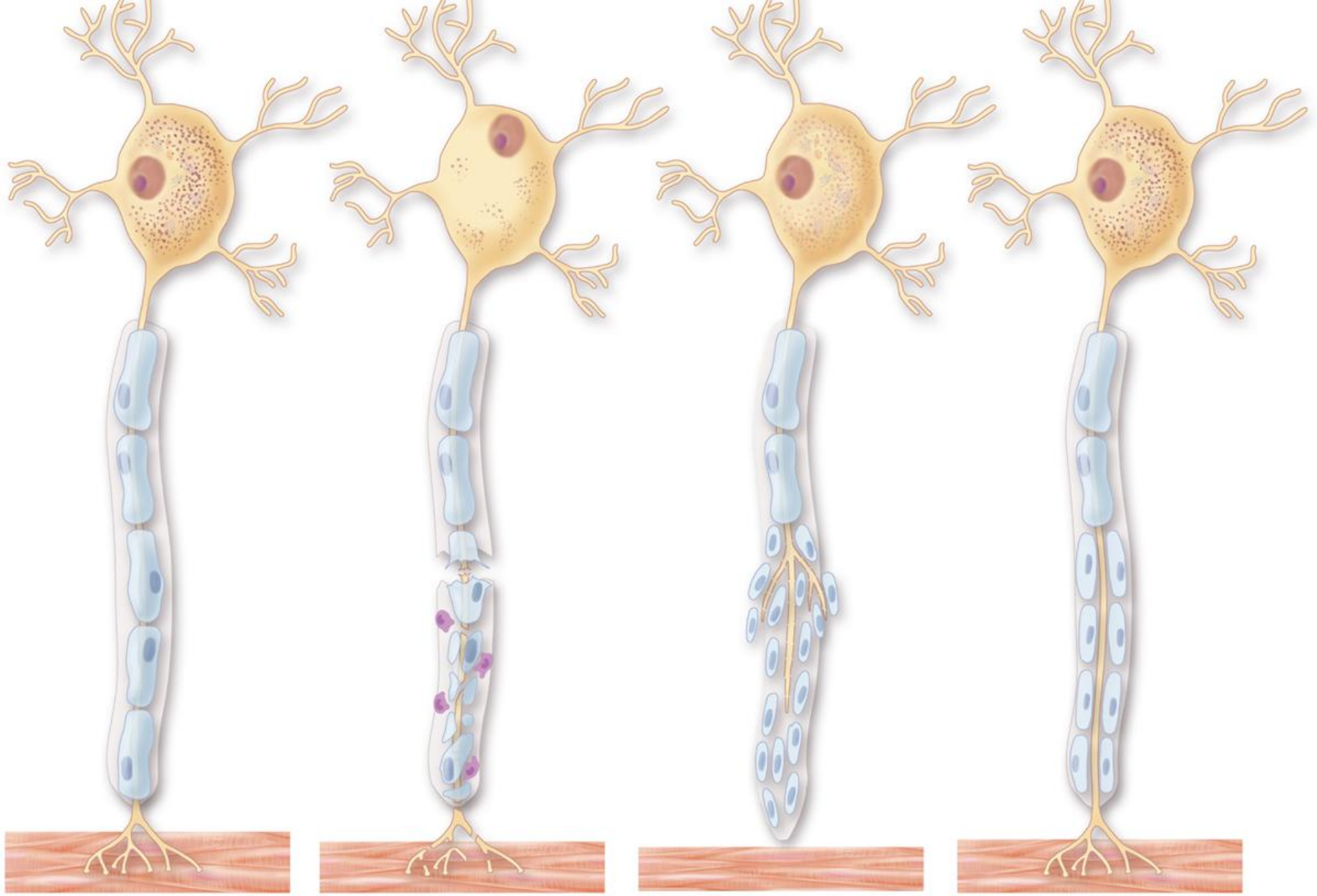


Figure 9-30

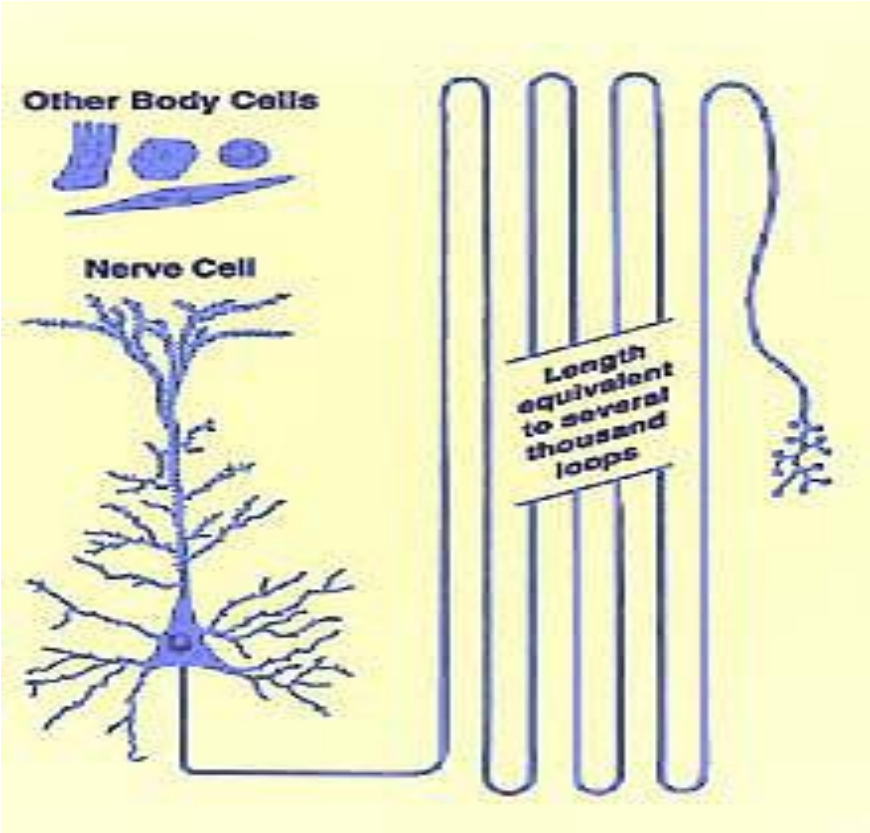
Nervous Tissue

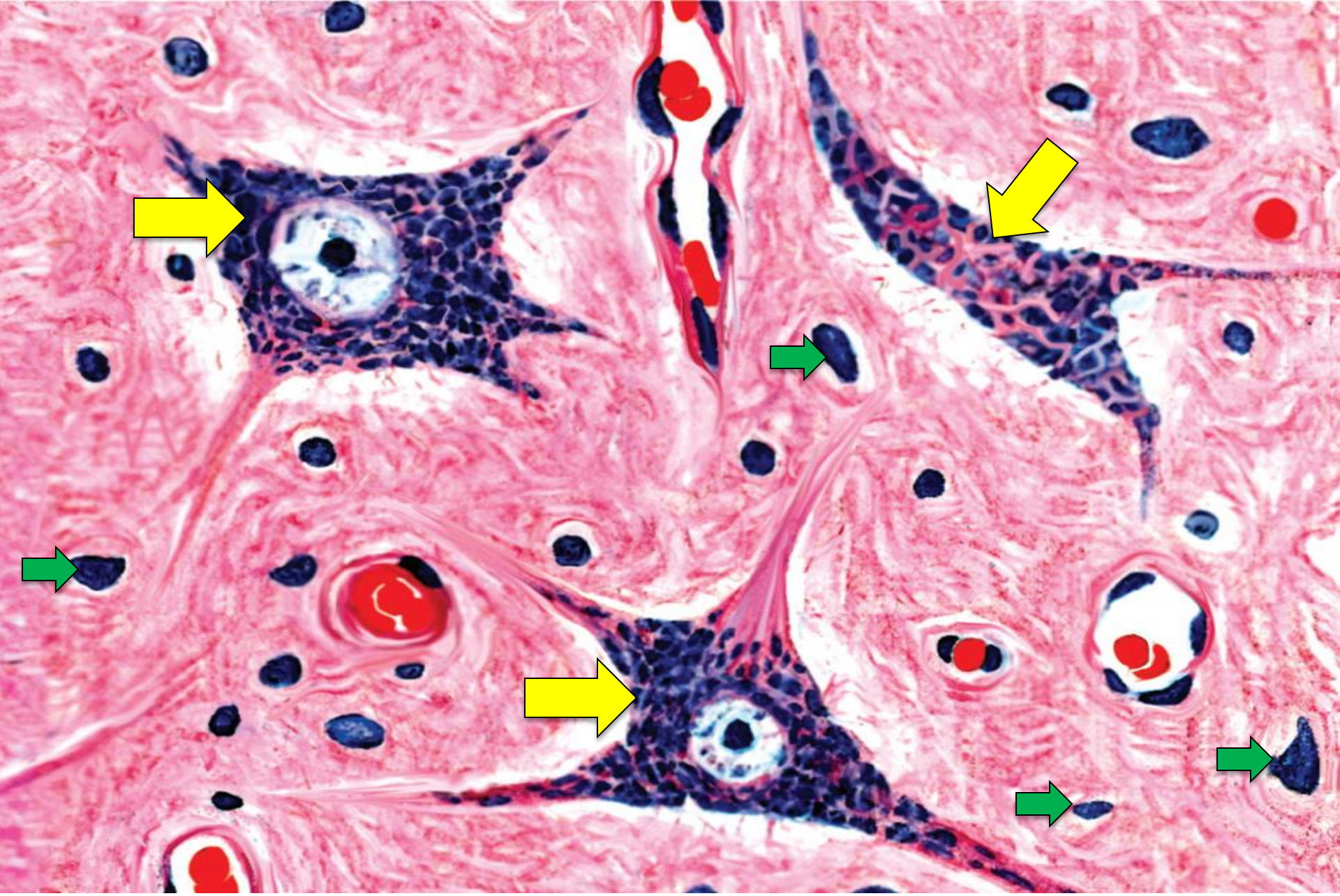
Practical part

Dr. Heba Kalbouneh
Associate Professor of Anatomy and Histology

Nerve cell processes are quite thin, often less than a micron (1μm) in diameter. However, the *length* of axons and dendrites is wondrously great, far greater than ordinary cellular dimensions. Dendrites may extend several millimeters away from the cell body, into a volume the size of a pea. Axon length may exceed a meter (for many sensory and motor axons), and commonly extends for several centimeters. As a simple consequence of this cellular geometry, ***the cell body of a neuron may comprise less than one percent of the entire cell volume***.

From this, you may deduce that the bulk of nervous tissue consists of nerve cell *processes* rather than nerve cell *bodies*.



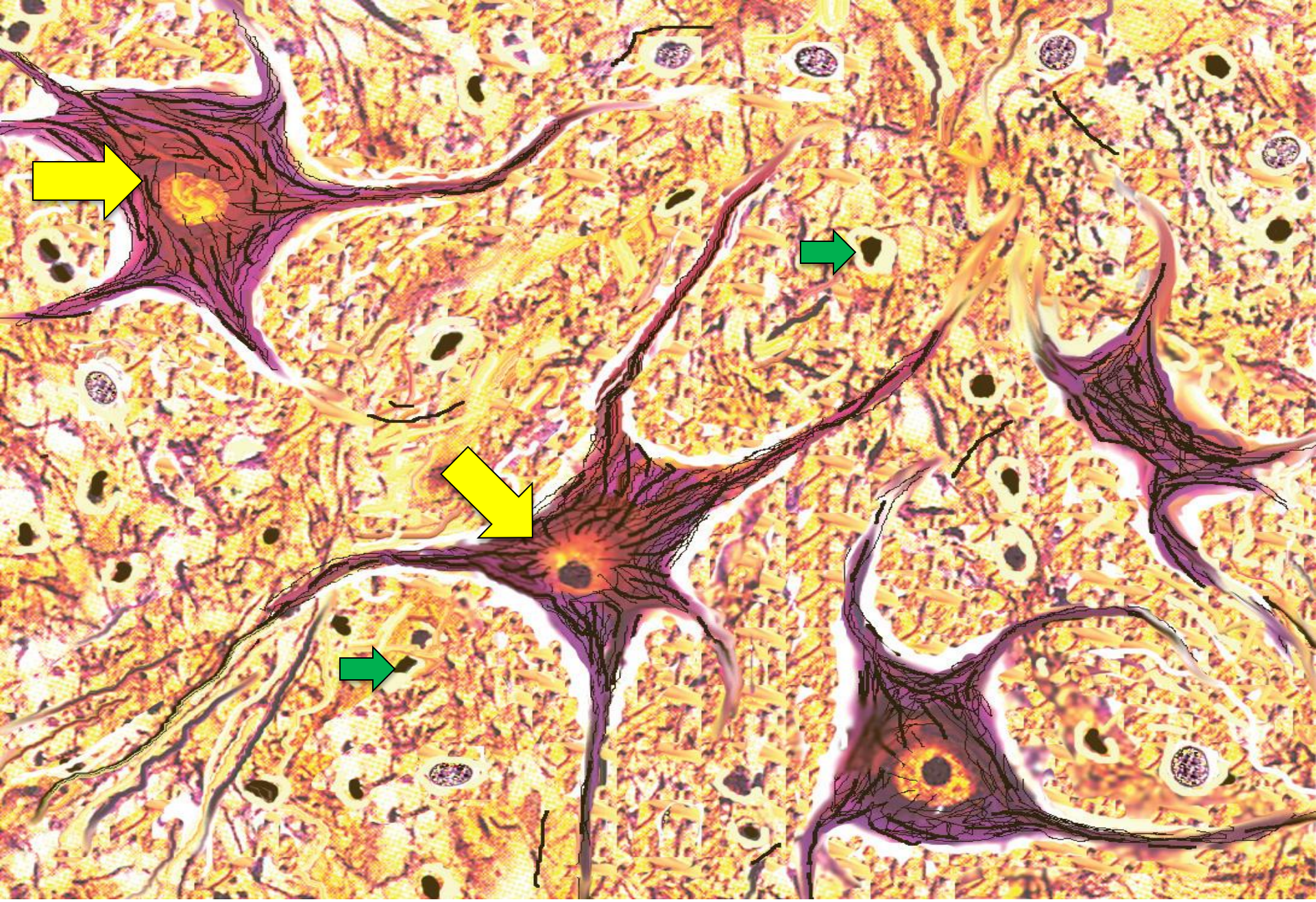


Neuron
Neuroglial cell

H &E

Dr. Heba Kalbouneh

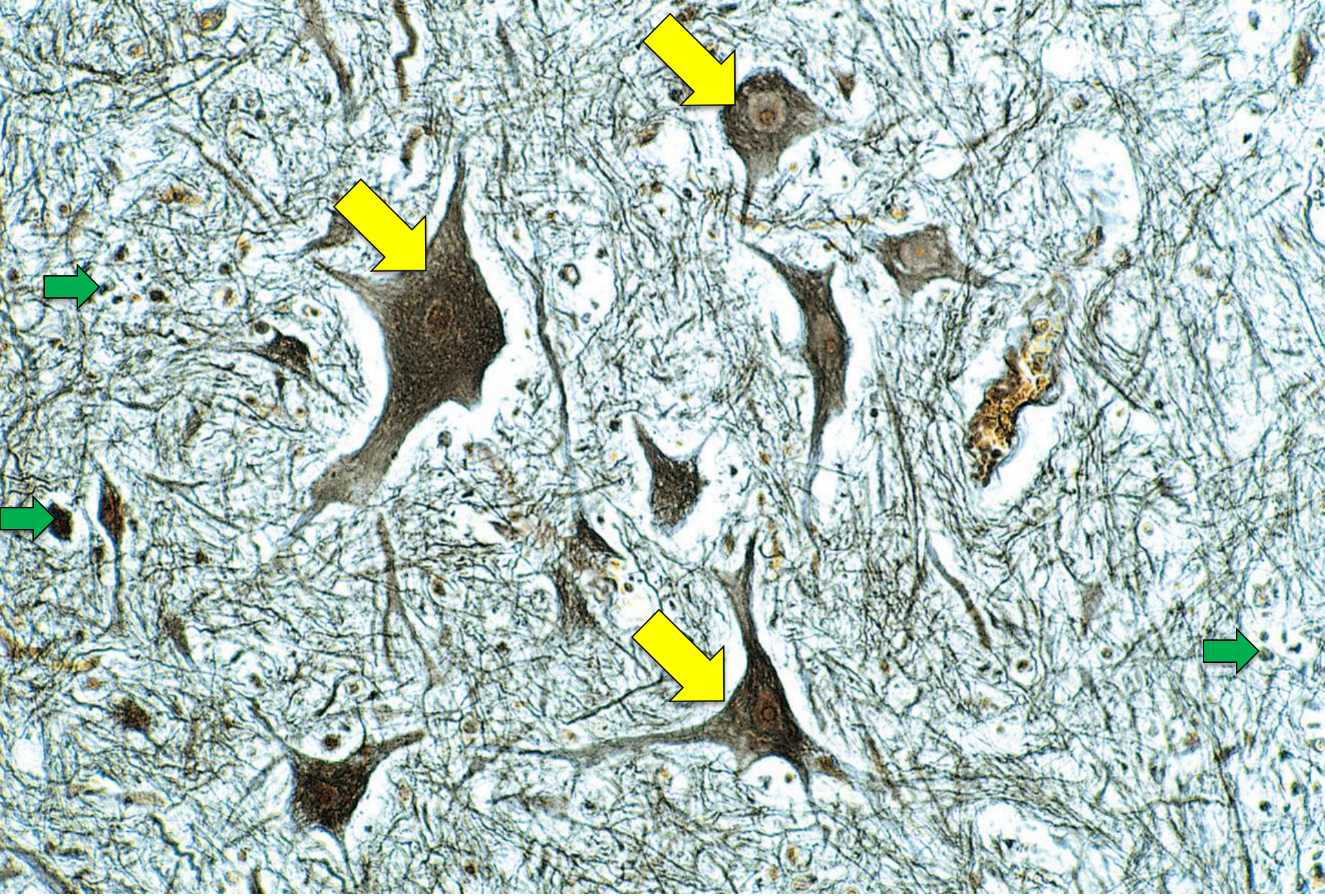
Most neurons have a light, large nucleus with a distinct nucleolus. The cytoplasm contains large amounts of rough endoplasmatic reticulum, which may aggregate within the cytoplasm to form Nissl-bodies



Neuron **Neuroglial cell**

Dr. Heba Kalbouneh

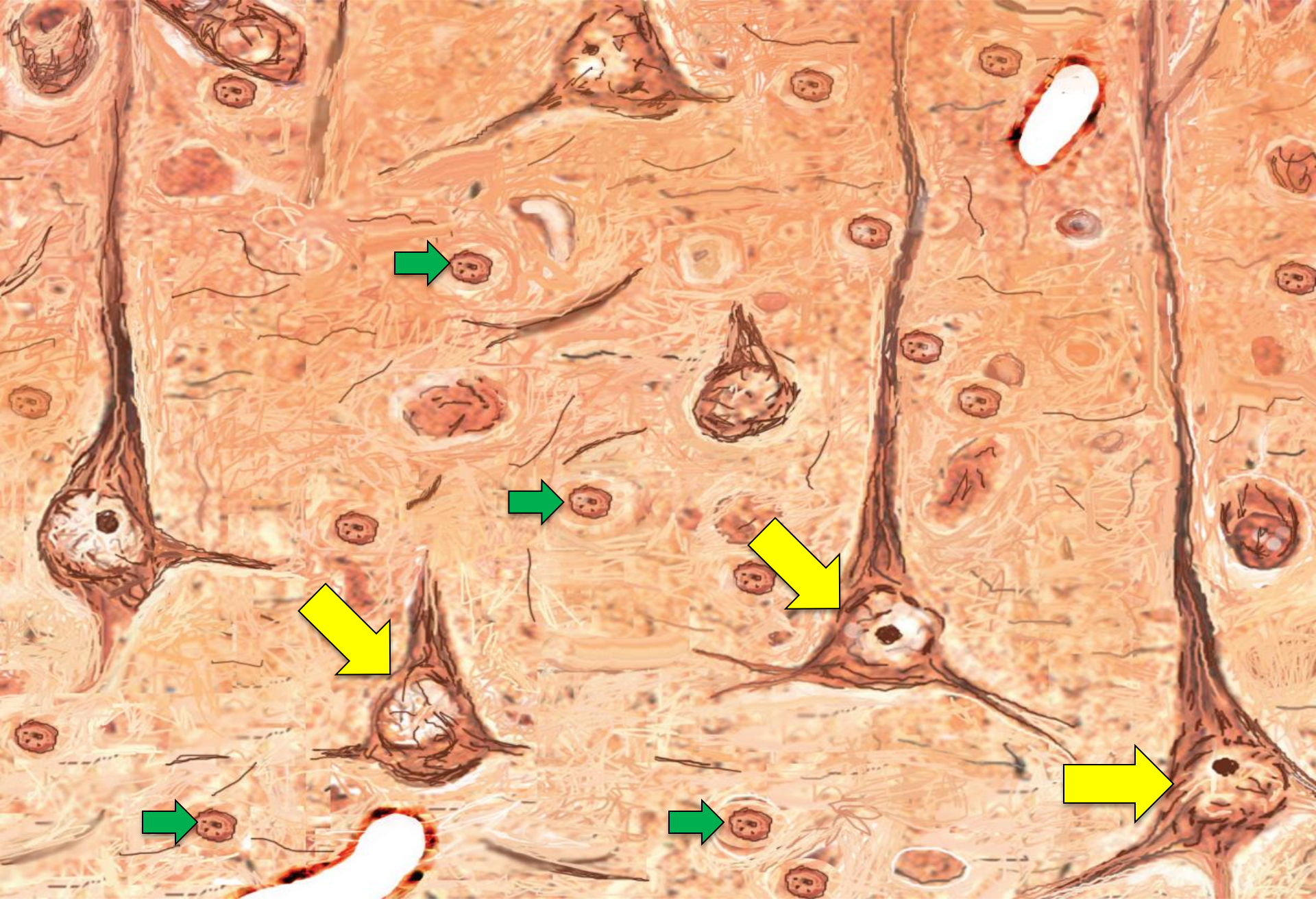
Silver impregnation (Cajal method)



Neuron **Neuroglial cell**

Dr. Heba Kalbouneh

Silver impregnation (Cajal method)



Neuron **Neuroglial cell**

Dr. Heba Kalbouneh

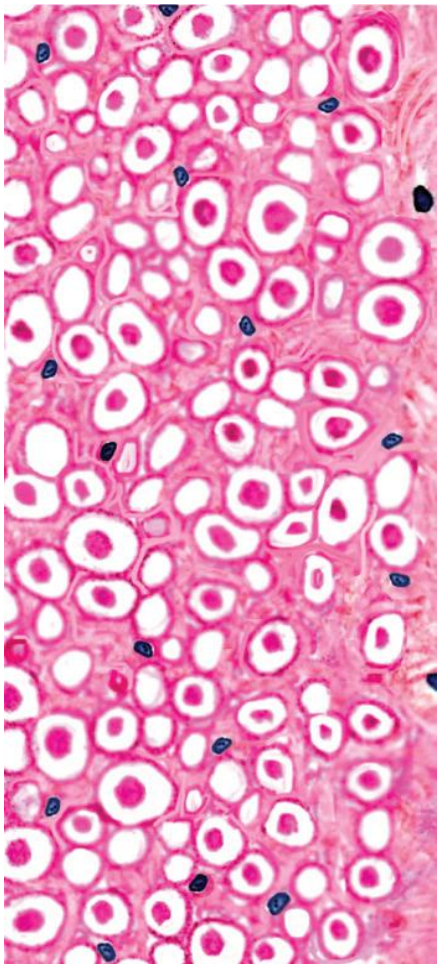
Silver impregnation (Cajal method)

Neuron, Silver stain

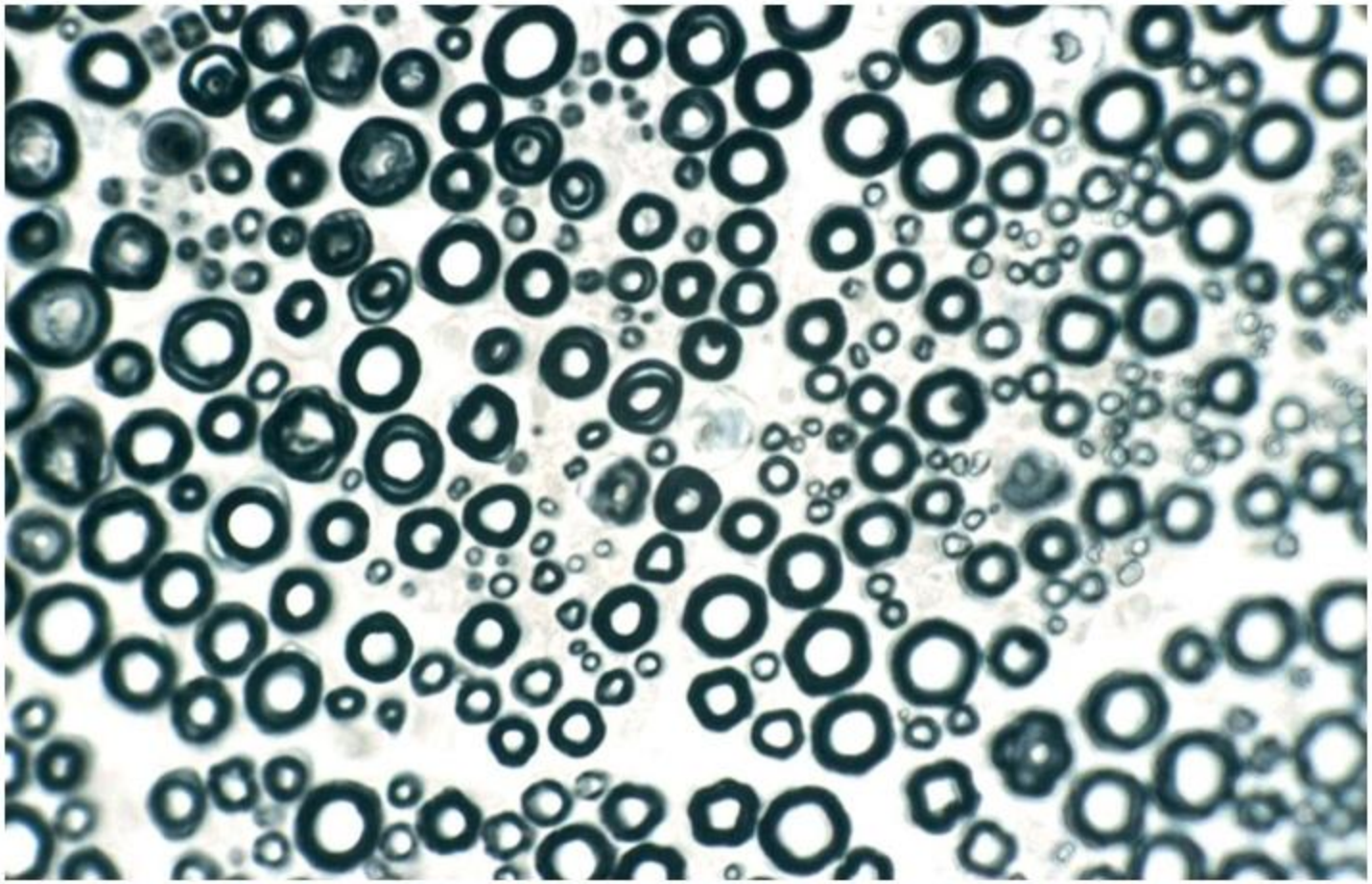
Dr. Heba Kalbouneh

Myelinated and unmyelinated axons - LM

H & E

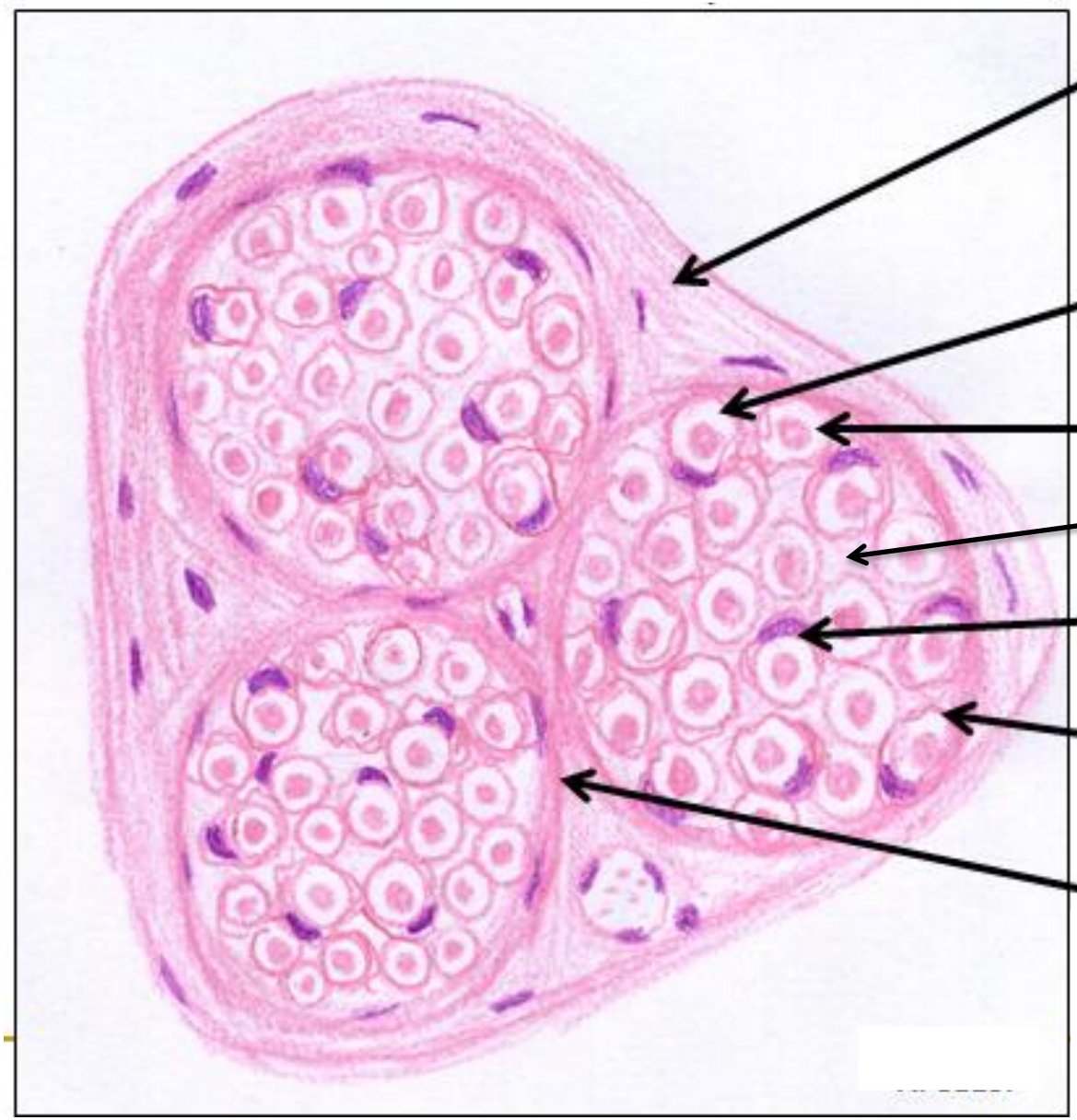


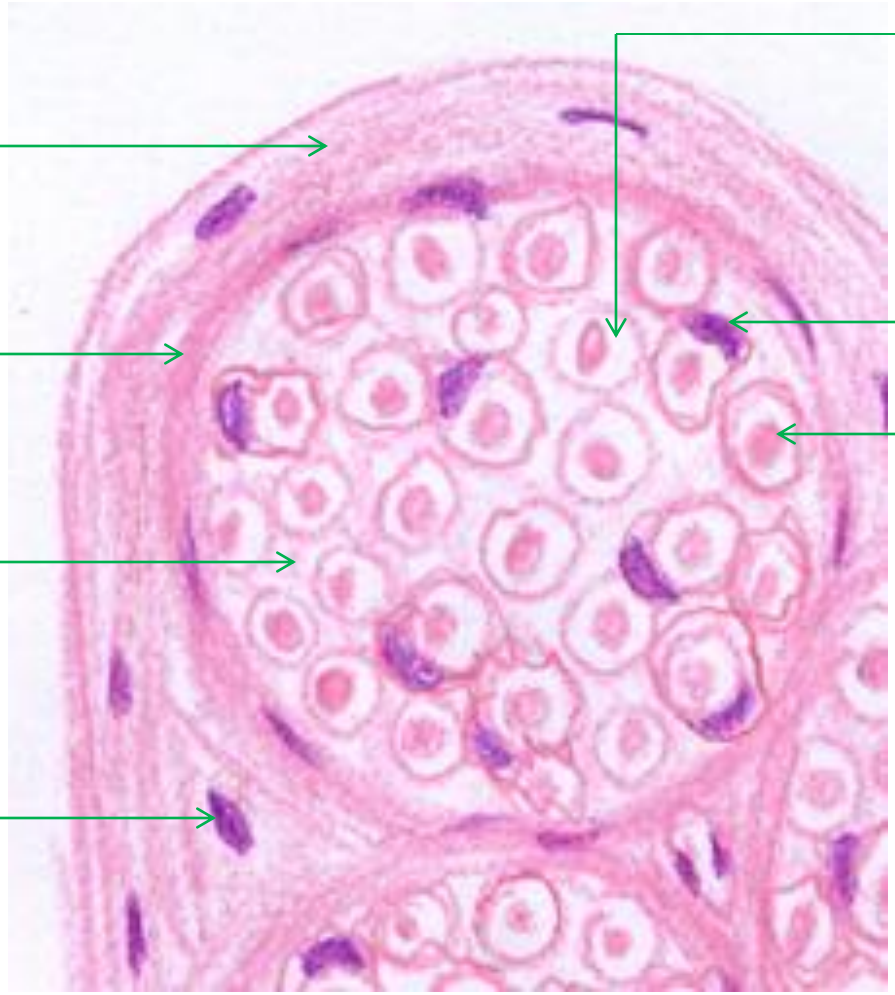
Osmic acid



Osmium gives a black color to lipids. In osmium stained preparations, you observe the myelin sheath surrounding the axon as a black ring.
Note: The axon is usually not well preserved

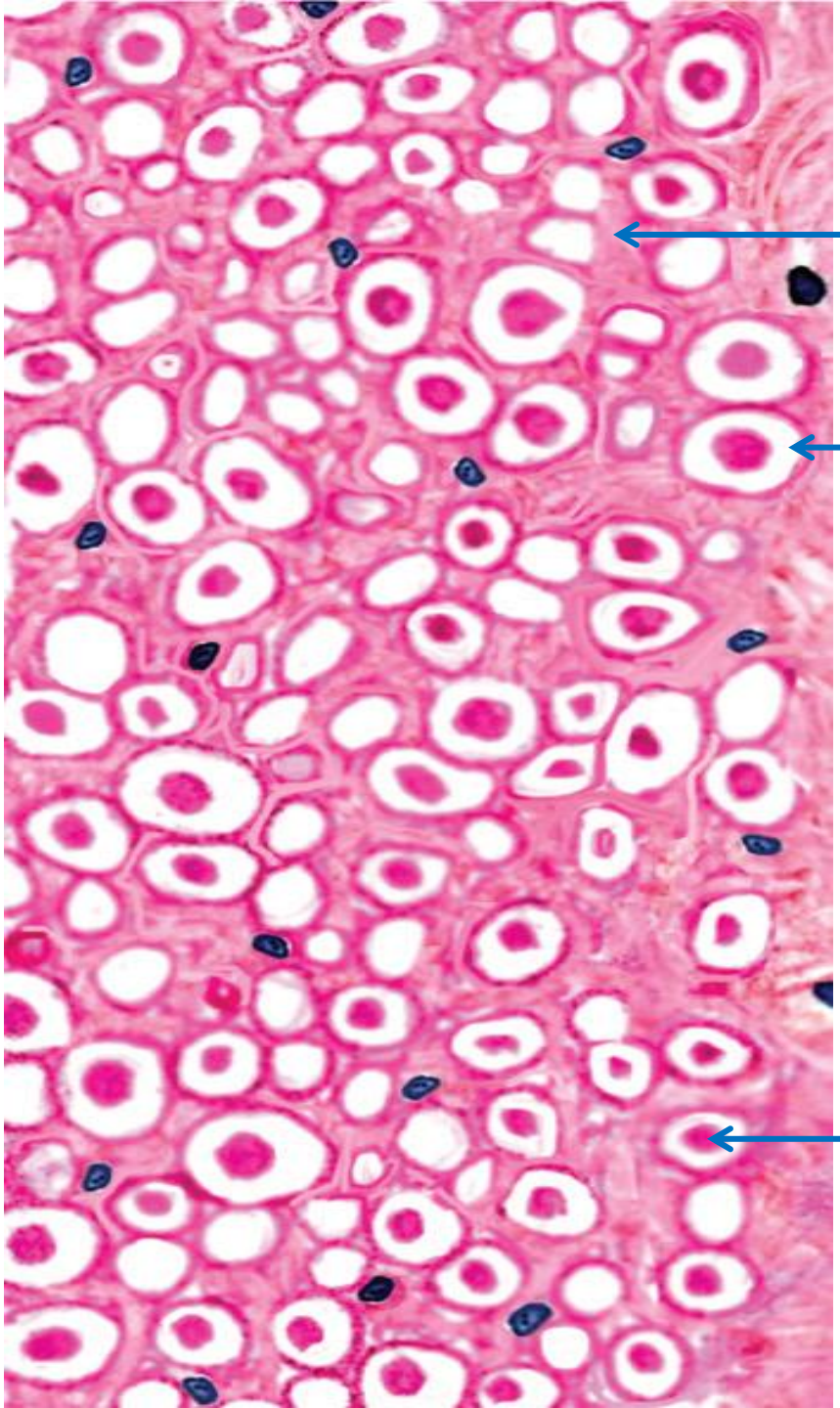
Peripheral Nerve, LM, H&E




Myelin (dissolved)
Epineurium
Schwann cell nucleus
Perineurium
Axon
Endoneurium
Fibroblast

H & E

H & E



Endoneurium

Myelin sheath (dissolved)

Axon

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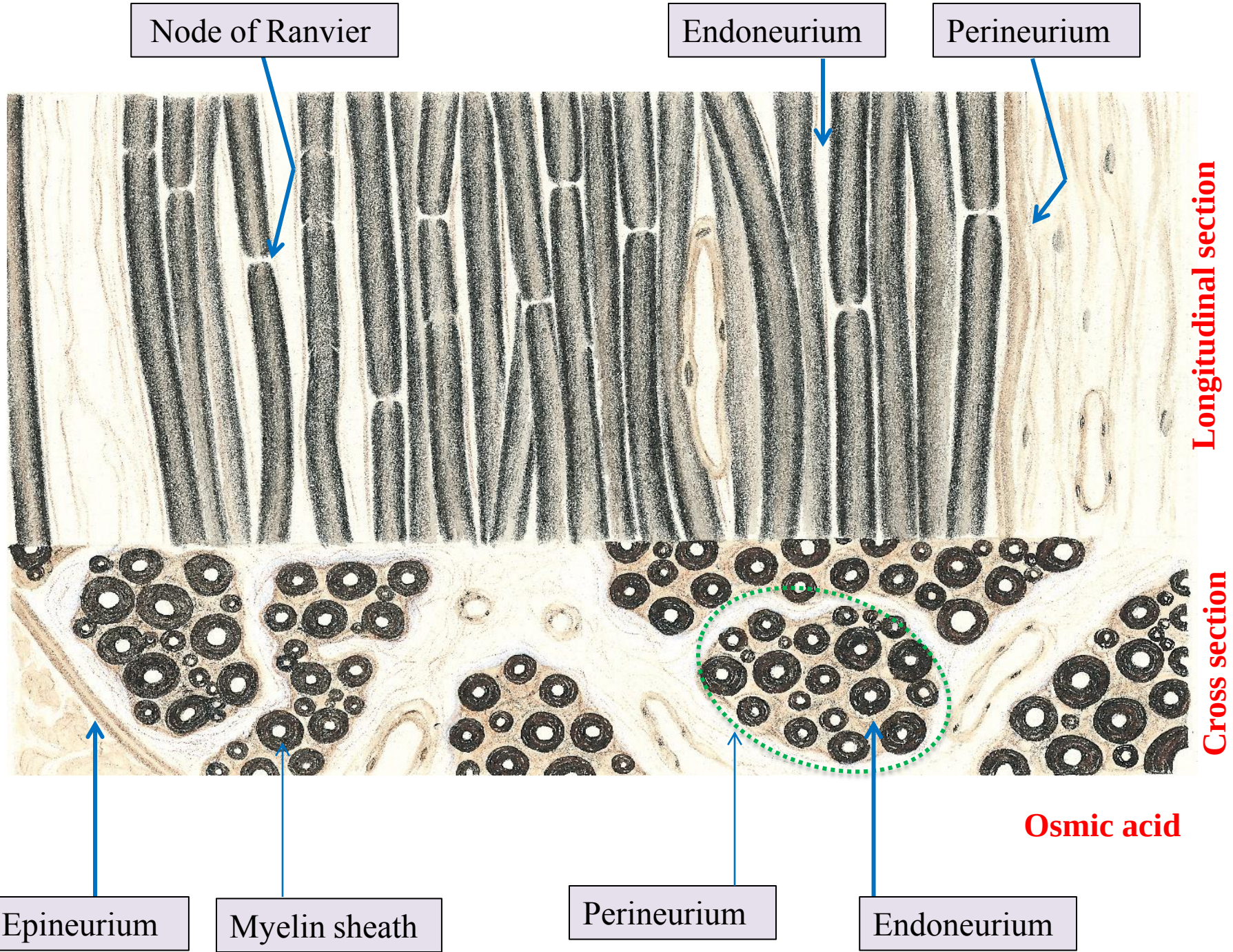


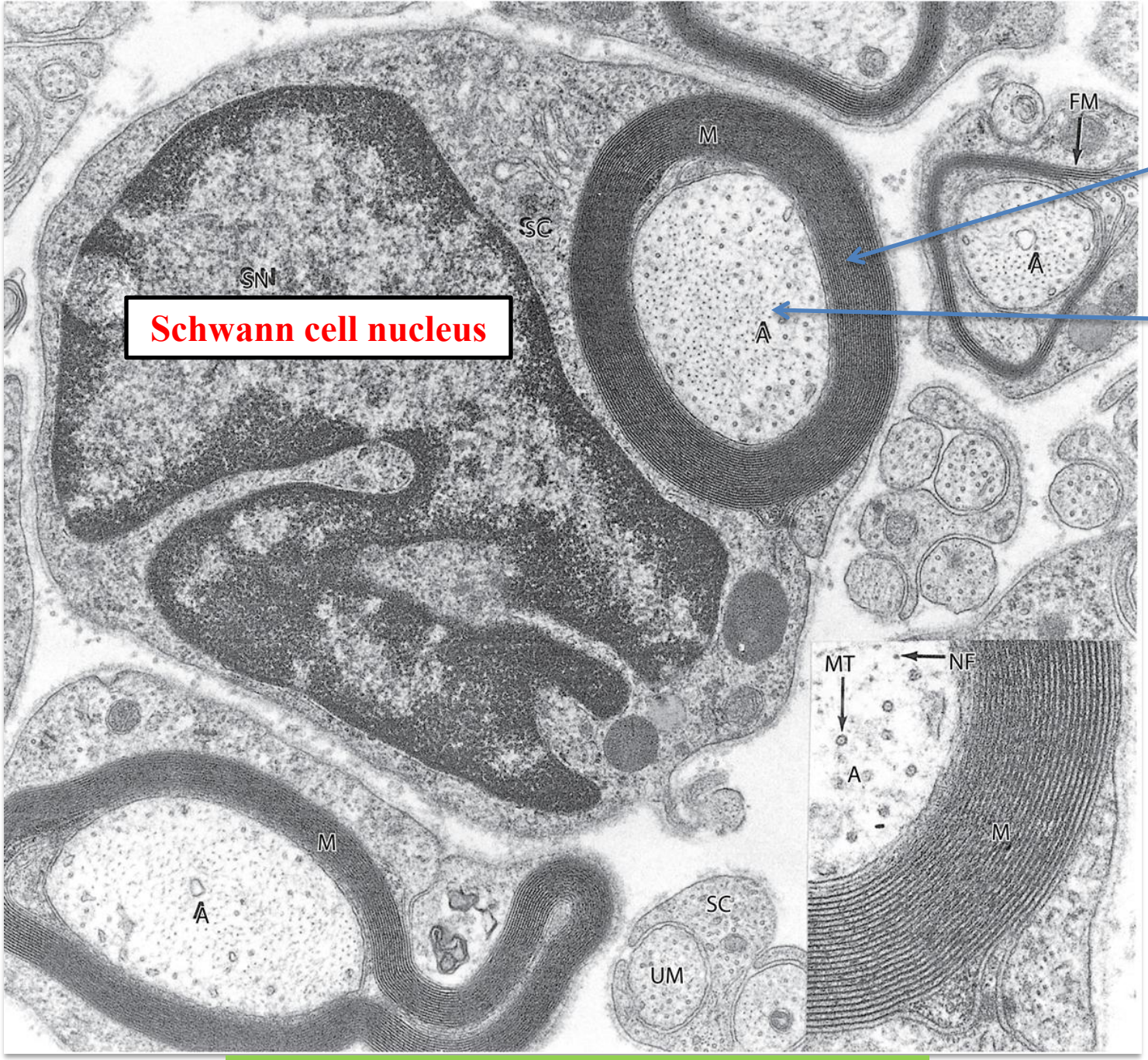
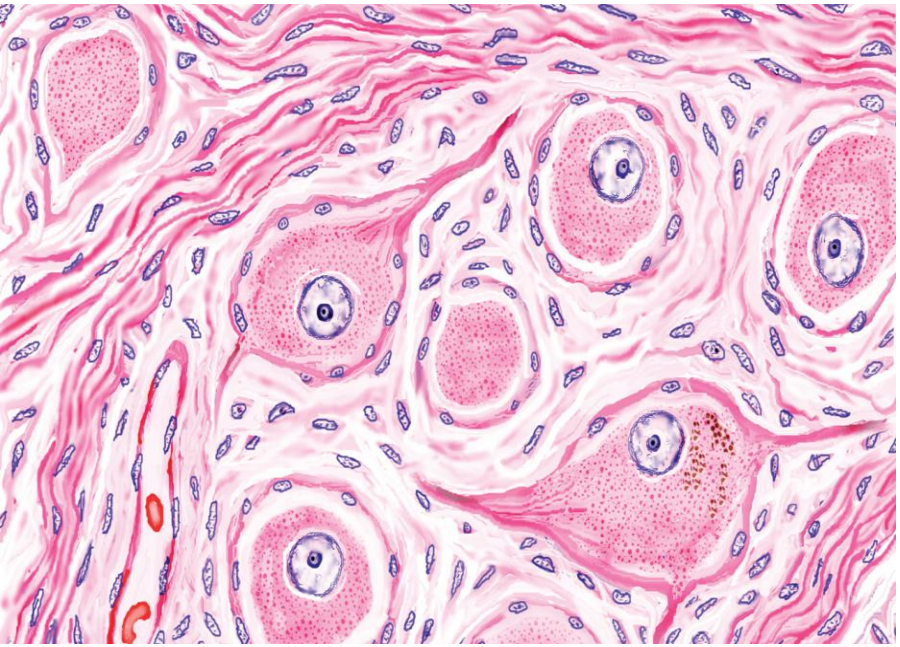


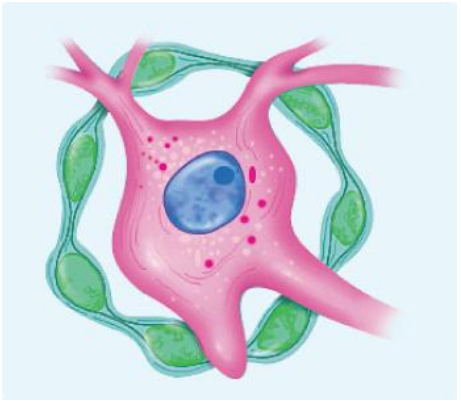
Figure 9-22

Myelinated and unmyelinated axons - EM

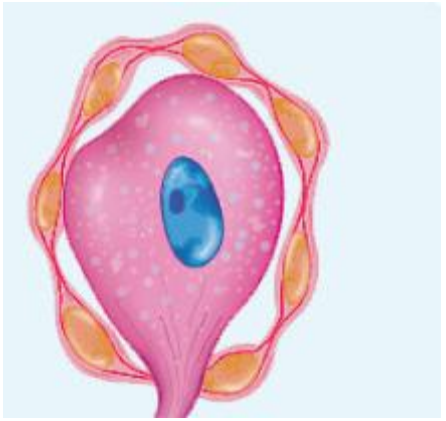
H & E



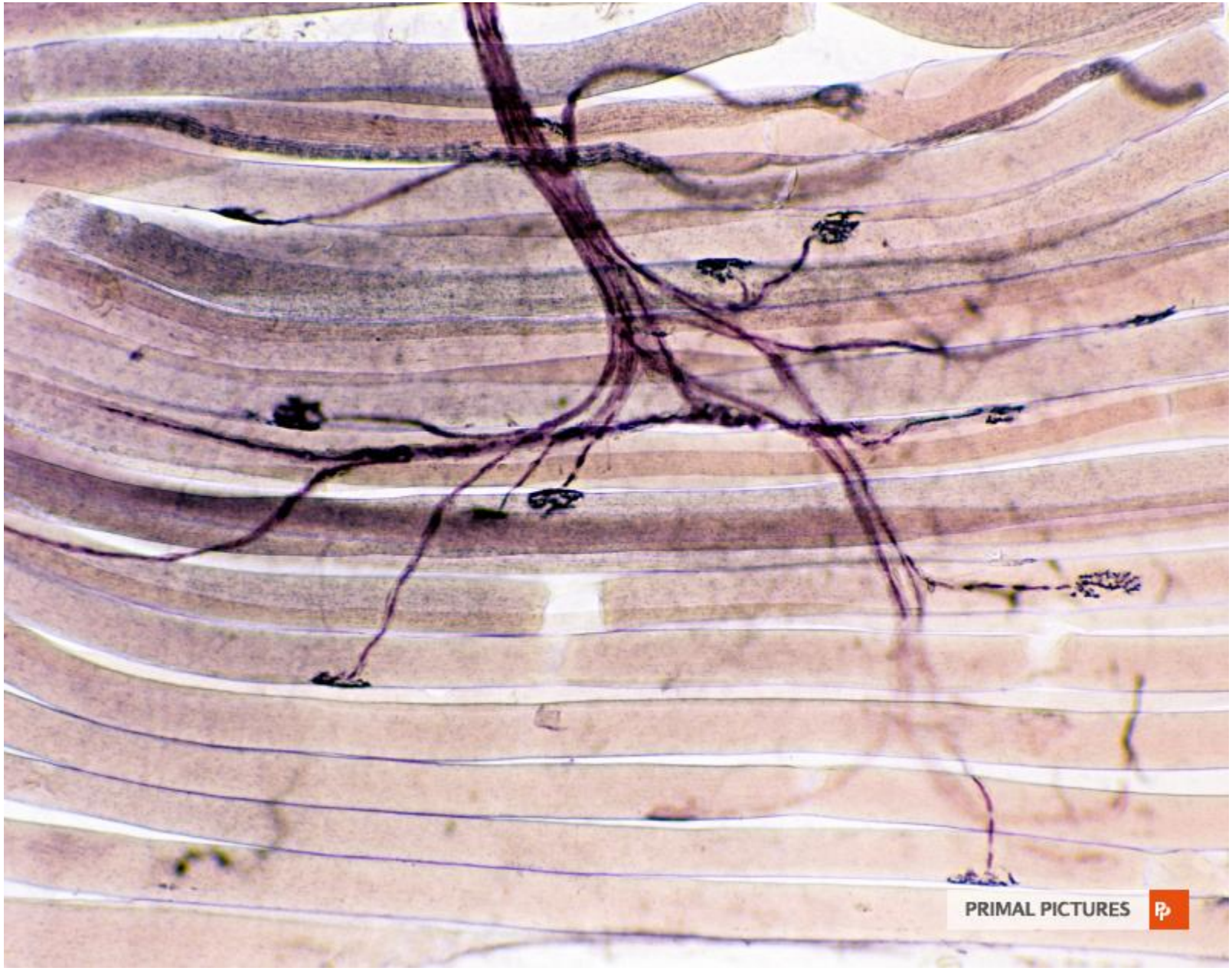
Autonomic ganglia with multipolar neurons are less organized than



Sensory ganglia (dorsal root ganglia) with pseudounipolar neurons.



Neuromuscular junction



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