BAU-Medicine

Sheet no.2
Lecture Date: 21\2\2021
Lecture Title: microscopic structure of NS
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دعاء لزميلنا رشيد

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Microscopic Structure of the NS

Lecture Objectives

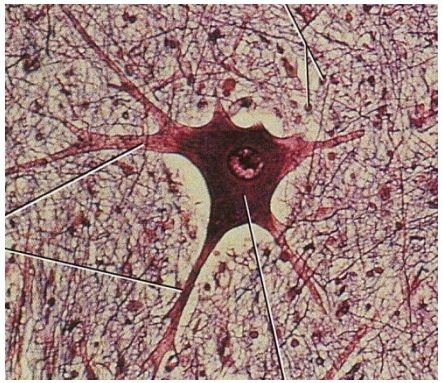
- Classify the types of neurons.
- Describe the structure of the different parts of neurons.
- Describe the types of glia cells and their functions.
- Describe the process of myelination of myelinated axons.
- Describe the structure of peripheral nerves.
- Describe the structure of ganglia (sensory and autonomic).

Nervous Tissue

- Relatively little intercellular space
- Cells rest on a continuous basal lamina
- Some cells have microvilli, cilia
- Strong tendency for cells to be bound to one another
- Clasping structures between connected cells called synapses

Neurons

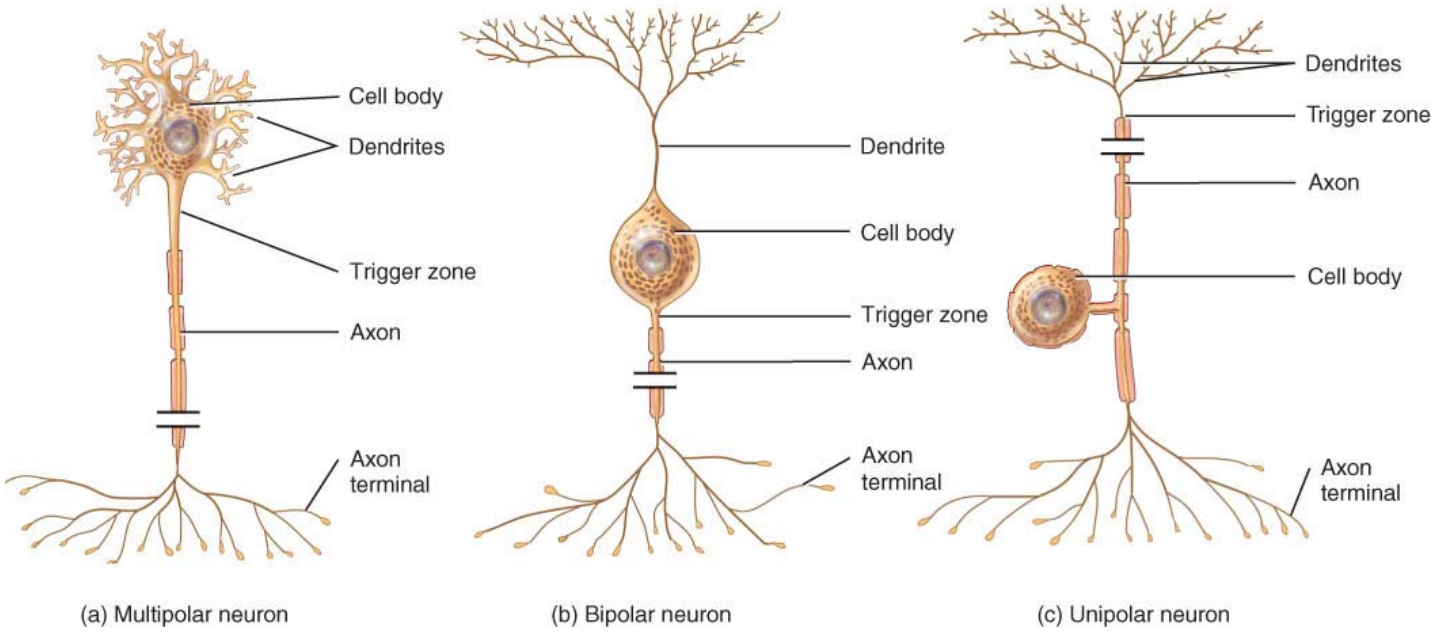
- Functional unit of nervous system
- Have capacity to produce action potentials
  - electrical excitability
- Cell body
- Cell processes = dendrites & axons



Diversity in Neurons

- Both structural and functional features are used to classify the various neurons in the body.
- Based on the number of processes extending from the cell body (structure), neurons are classified as *multipolar*, *bipolar*, and *unipolar*
- Most neurons in the body are interneurons and are often named for the histologist who first described them or for an aspect of their shape or appearance. Examples are *Purkinje cells*

Structural Classification of Neurons

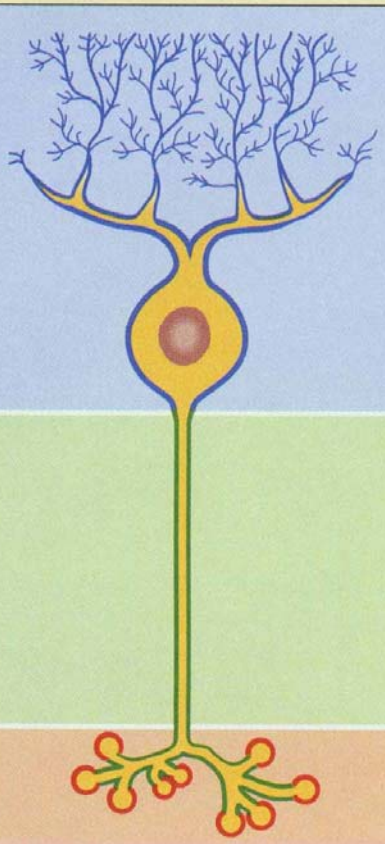


- Based on number of processes found on cell body
  - multipolar = several dendrites & one axon
    - most common cell type
  - bipolar neurons = one main dendrite & one axon
    - found in retina, inner ear & olfactory
  - unipolar neurons = one process only(develops from a bipolar)
    - are always sensory neurons

Functional Classification of Neurons

- Sensory (afferent) neurons
  - transport sensory information from skin, muscles, joints, sense organs & viscera to CNS
- Motor (efferent) neurons
  - send motor nerve impulses to muscles & glands
- Interneurons (association) neurons
  - connect sensory to motor neurons
  - 90% of neurons in the body

Neuronal Structure & Function

Diagram	Structure	Functions
	**Dendrites**	Receive stimuli through activation of chemically or mechanically gated ion channels; in sensory neurons, produce generator or receptor potentials; in motor neurons and association neurons, produce excitatory and inhibitory postsynaptic potentials (EPSPs and IPSPs).
	Cell body	Receives stimuli and produces EPSPs and IPSPs through activation of chemically or mechanically gated ion channels.
	Junction of axon hillock and initial segment of axon	Trigger zone; integrates EPSPs and IPSPs and, if sum is a depolarization that reaches threshold, initiates action potential (nerve impulse).
	Axon	Propagates (conducts) nerve impulses from initial segment (or from dendrites of sensory neurons) to axon terminals in a self-reinforcing manner; impulse amplitude does not change as it propagates along the axon.
	Axon terminals and synaptic end bulbs (or varicosities)	Inflow of Ca^{2+} caused by depolarizing phase of nerve impulse triggers neurotransmitter release by exocytosis of synaptic vesicles.

Plasma membrane includes chemically gated channels

Plasma membrane includes voltage-gated Na^+ and K^+ channels

Plasma membrane includes voltage-gated Ca^{2+} channels

Cell body

- Also called perikaryon
- A trophic center
- Receives a great number of nerve endings that convey excitatory or inhibitory stimuli
- Could be small (4-5µm) or large (150 µm) that is visible by naked eye
- Cell organelles:
  - Single, large, euchromatic (pale-staining) nucleus with prominent nucleolus
  - Nissl bodies (chromatophilic substance)
    - rough ER & free ribosomes for protein synthesis
  - neurofilaments (10nm) give cell shape and support. When stained by silver form neurofibrils that can be seen by light microscope
  - microtubules (22nm) move material inside cell
  - lipofuscin granules (harmless aging). They are residual lysosomal products.

sheet # 1:

-A trophic center means that all parts (like axons and dendrites) depend on cell body .

- if axon or dendrite damage or cut , the distal part will die and disappear (degeneration) because its nourishment come from cell body .

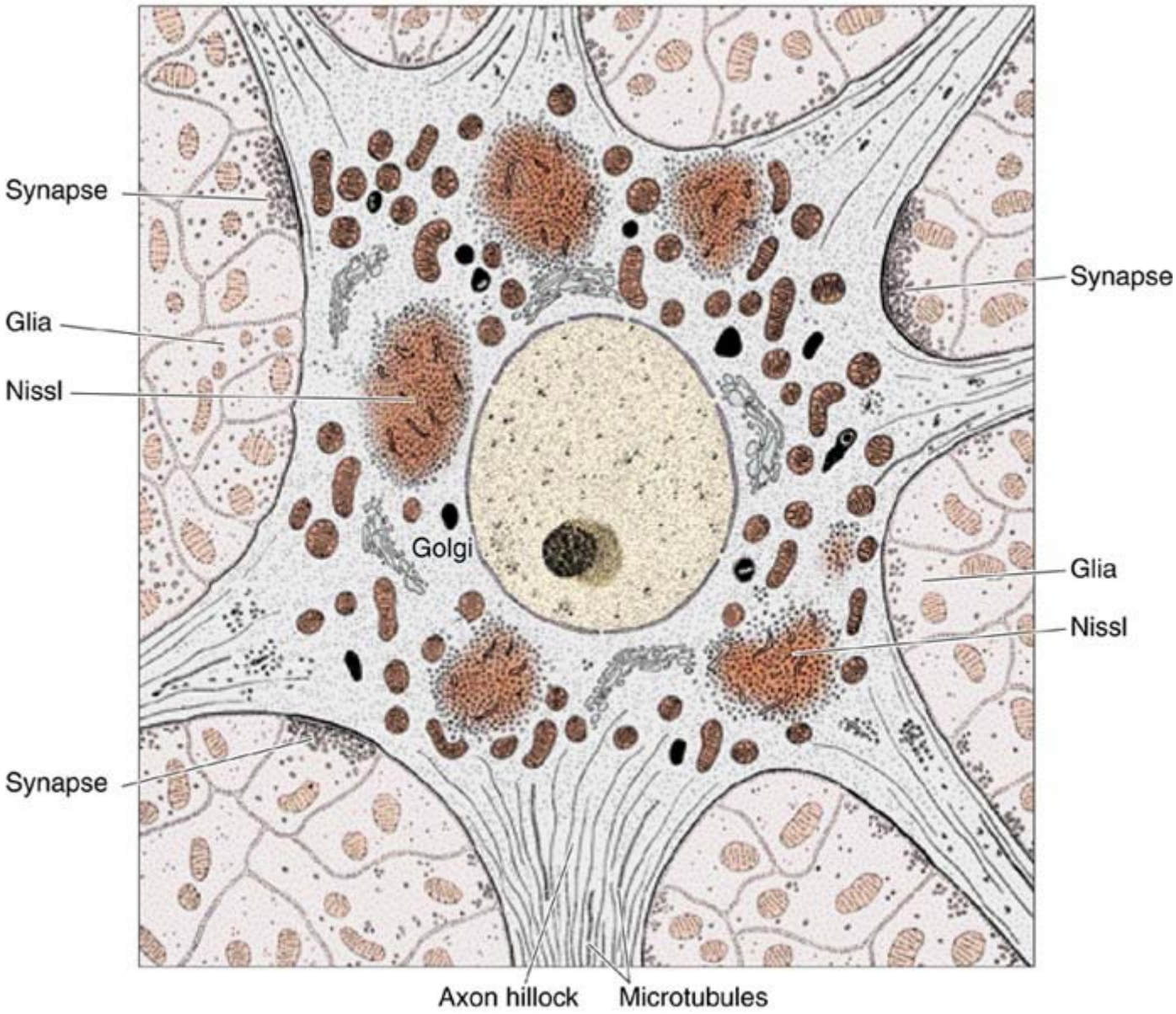
- All motor and interneurons are multipolar neurons.

- All unipolar and dipolar neurons are sensory neurons.

- the cell body is the trophic center because it has all the organelles.

- the cell body in the brainstem is very large.

- neurofilaments are intermediate filaments.

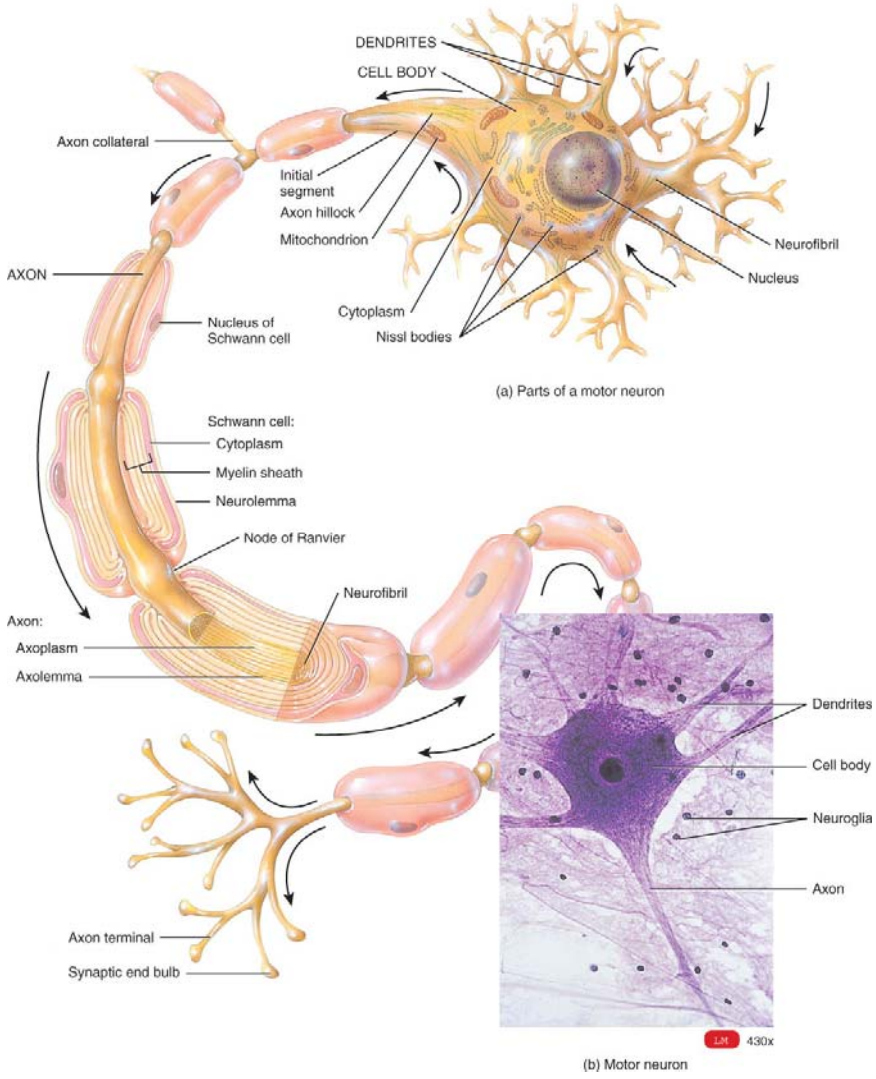

Synapse
Glia
Nissl
Golgi
Synapse
Glia
Nissl
Synapse
Axon hillock
Microtubules

Neuronal processes

- The *dendrites* are the receiving or input portions of a neuron.
- The *axon* conducts nerve impulses from the neuron to the dendrites or cell body of another neuron or to an effector organ of the body (muscle or gland).

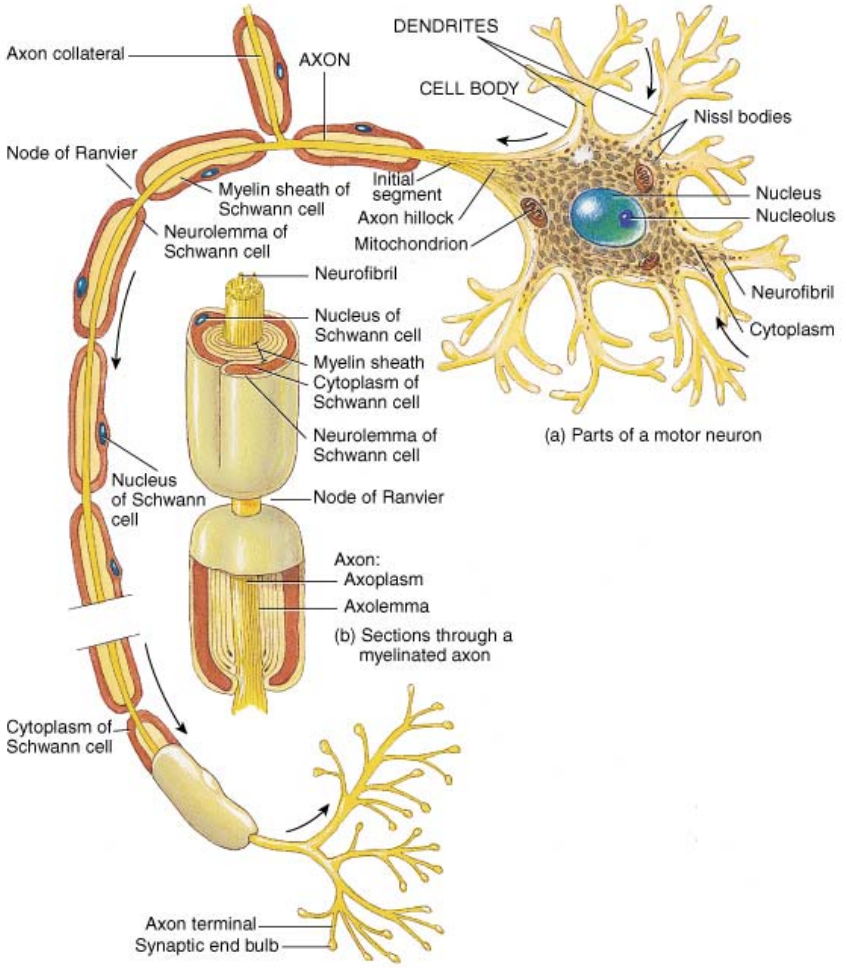
Dendrites

- Extend from cell body
- In proximal portion, continues cytoplasmic character of perikaryon
- Usually irregular contour and spines (microvilli-like projections)
- Usually multiple
- Rarely myelinated, usually unsheathed
- Ramifies by branching at acute angles
- If cell body is in CNS then dendrites remain in CNS
- Conducts impulses towards the cell body



Axons

- Conduct impulses away from cell body
- Long, thin cylindrical process of cell
- One per neuron
- Do not contain ribosomes
  - Dependence on perikaryon
    - If axon is severed, its peripheral parts degenerate and die
- Arises at axon hillock Impulses arise from initial segment (trigger zone)
- Branches to form collaterals at obtuse angles
- end in fine processes called axon terminals
- Swollen tips called synaptic end bulbs contain vesicles filled with neurotransmitters
- Terms: Axolemma and axoplasm



sheet # 2 :

- an axon have a lot of collaterals that copy the same information to many different areas.

- the beginning of it is called " axon hillock " , which connects the axon with cell body.

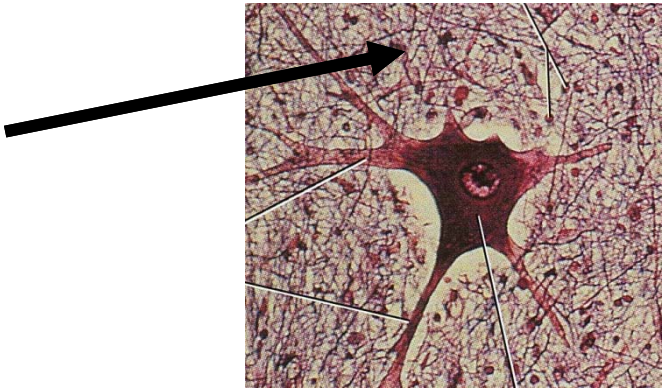
- dendrites is like cytoplasmic structures in cell body.

- we can find " nissl bodies " in the beginning of dendrites, on the other side in axon hillock there is no organelles and that's how we can differentiate between them in microscopic slides.

- axolemma : cell membrane
axoplasm : cytoplasm
.. within the axon itself.

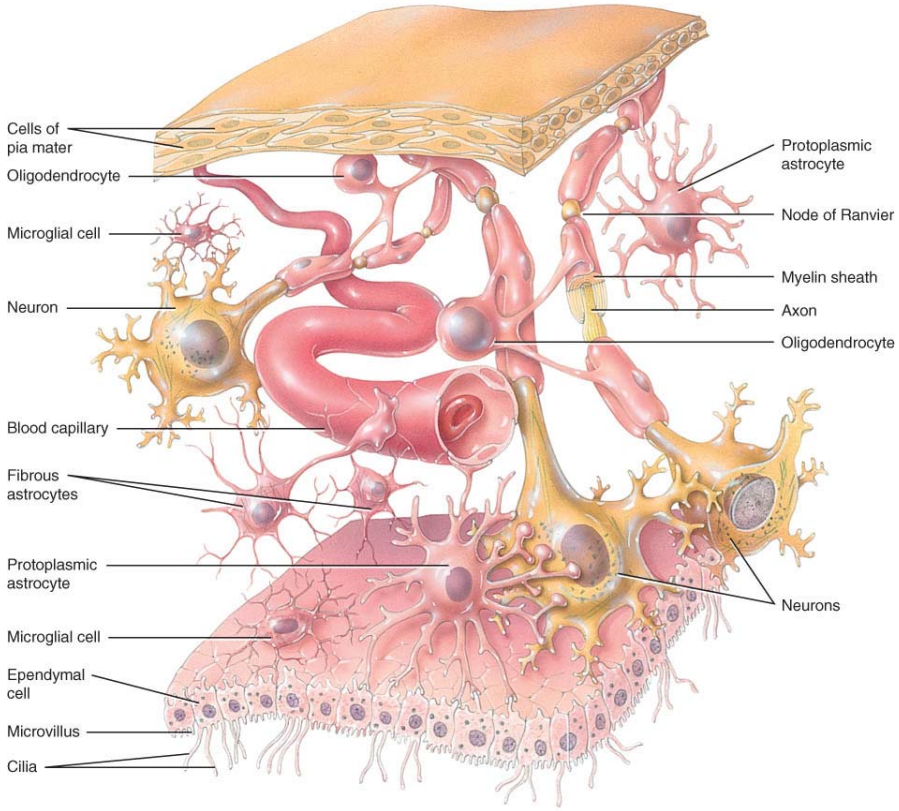
Neuroglial Cells

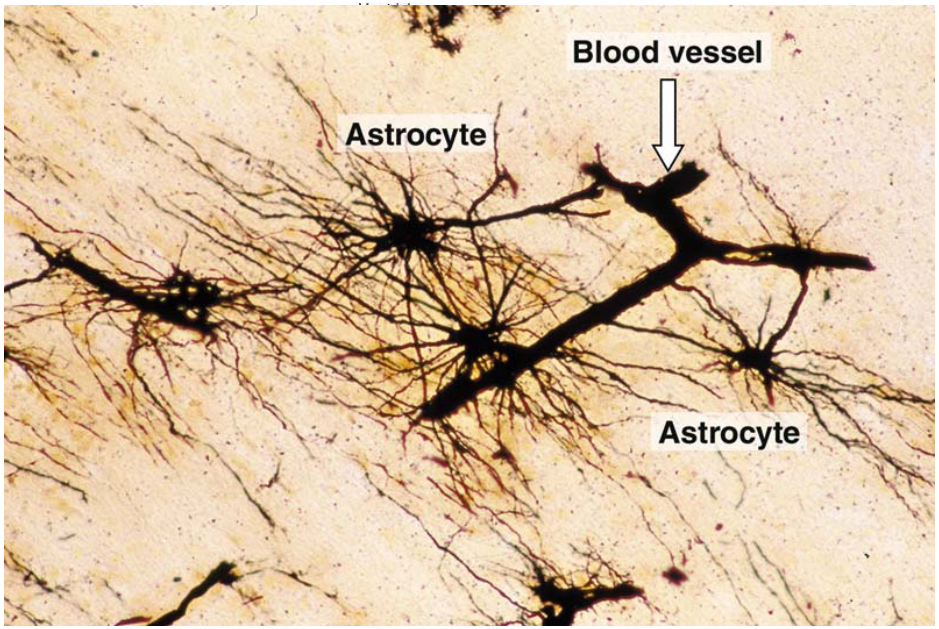
- Half of the volume of the CNS
- Smaller cells than neurons
- 50X more numerous
- Cells can divide
  - rapid mitosis in tumor formation (gliomas)
- 4 cell types in CNS
  - astrocytes, oligodendrocytes, microglia & ependymal
- 2 cell types in PNS
  - schwann and satellite cells



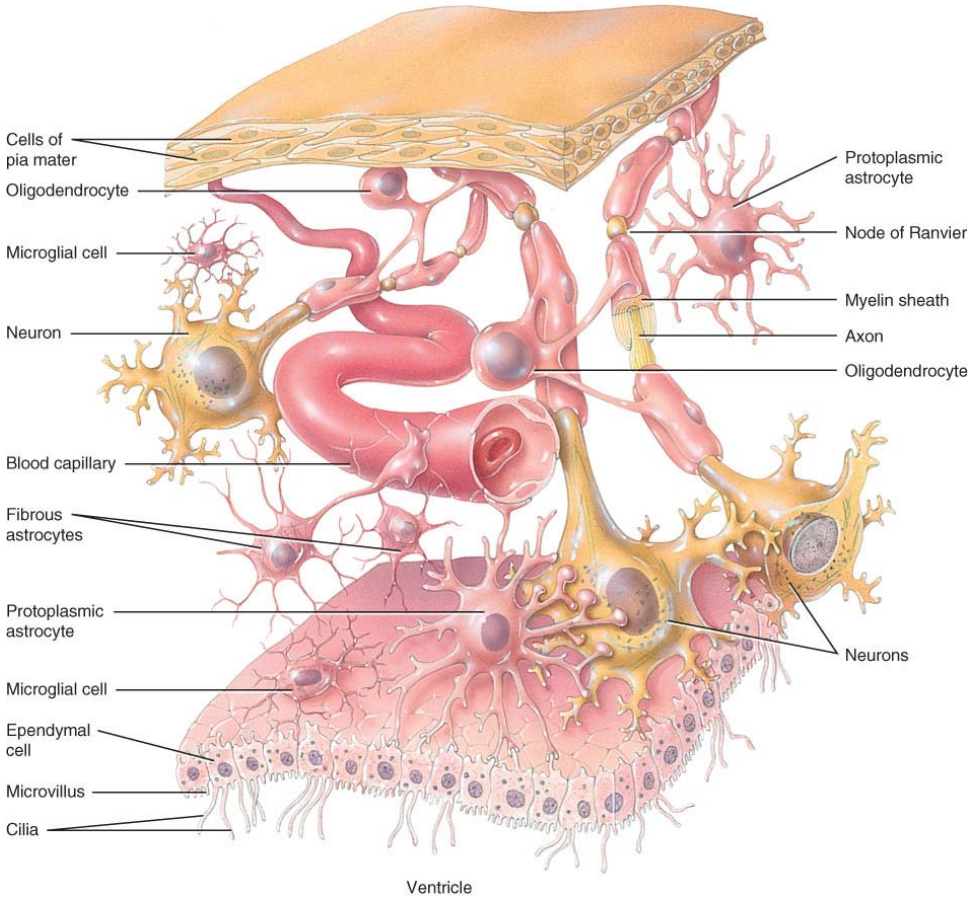
Astrocytes

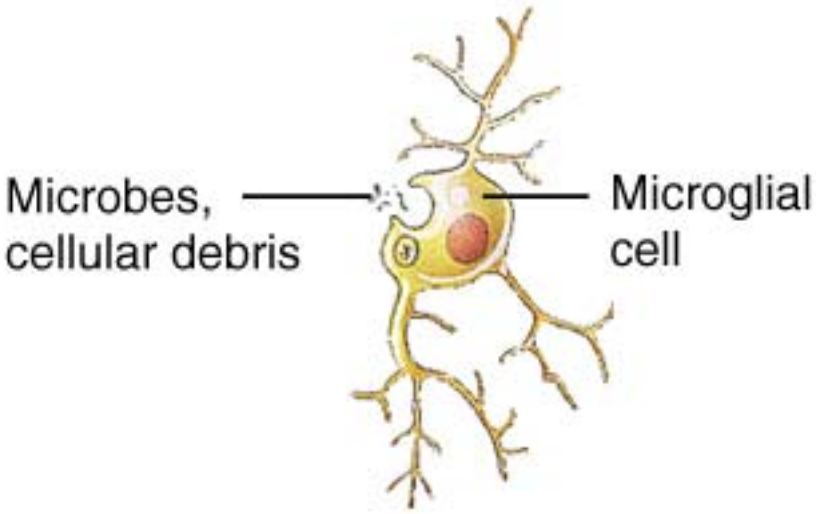
- Most abundant glia cells
- Star-shaped cells
- Types
  - Fibrous
    - white matter
    - Few, long processes
  - Protoplasmic-
    - gray matter
    - Many, short processes
- Connected to each other with gap junction
- Activity
  - Form blood-brain barrier by covering blood capillaries
  - Metabolize neurotransmitters
  - Regulate K+ balance
  - Provide structural support





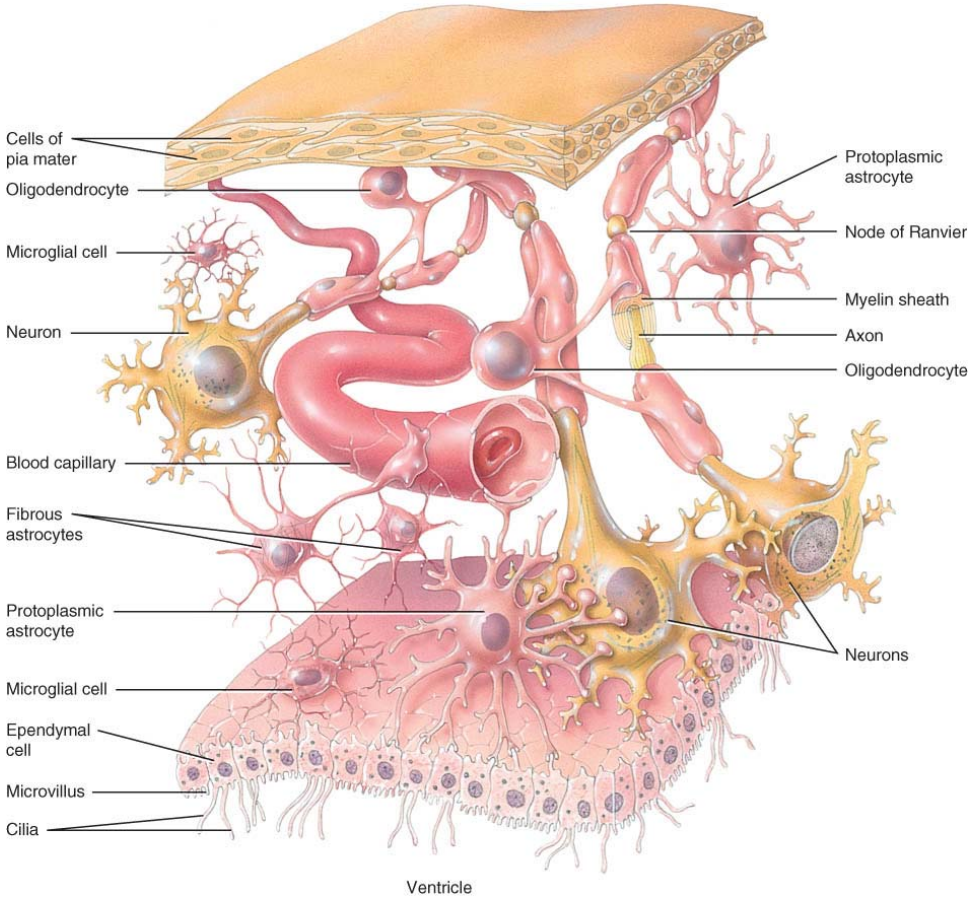
Microglia



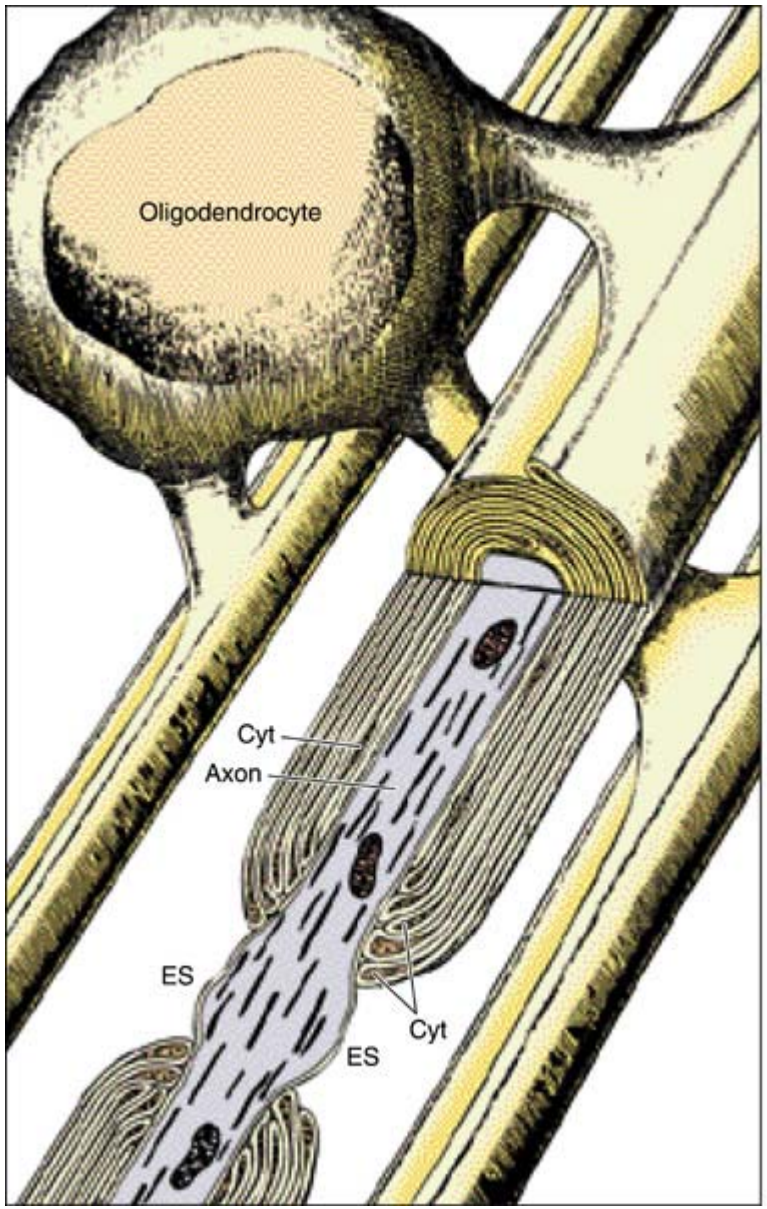


- Small cells found near blood vessels
- Phagocytic role -- clear away dead cells
- Derived from cells that also gave rise to macrophages & monocytes

Ependymal cells



- Form epithelial membrane, lining cerebral cavities & central canal
- Cuboidal or low columnar
- Have cilia and microvilli
- Produce cerebrospinal fluid (CSF)



Oligodendrocytes

- Mostly available in white matter
- Each forms myelin sheath around more than one axons in CNS
- Analogous to Schwann cells of PNS
- Under microscope
  - Round condensed nucleus
  - Clear or pale cytoplasm

sheet # 3 :

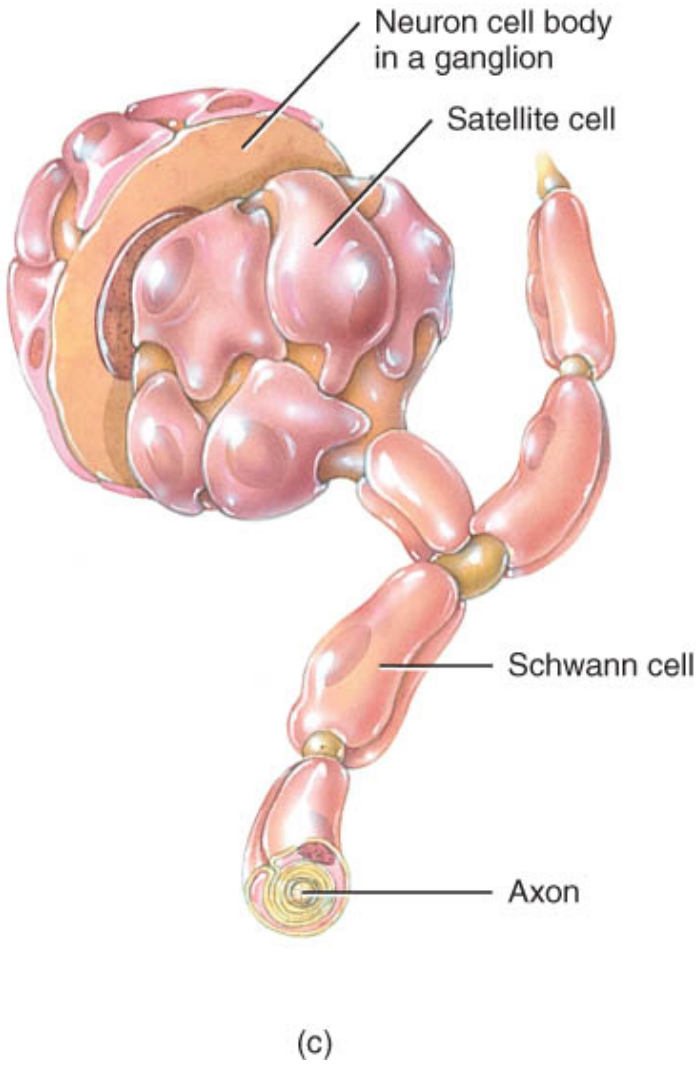
- oligodendrocyte is a large cell in CNS, very important in making myelin sheath because it has fatty tissue in it's membrane.

- it has branches that go to specific area on neuron and wraps around it to make a lot of layers (segment of myelin sheath) .

- it can make one or more than one segment for one or more than one neuron.

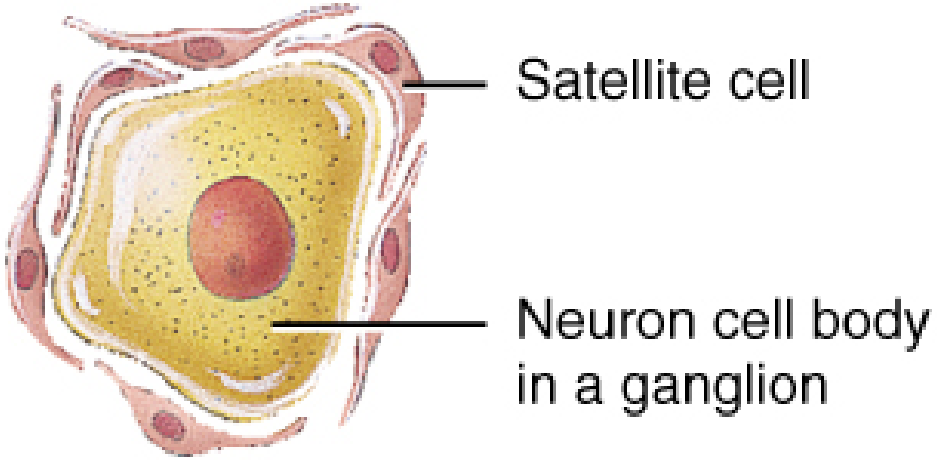
- ependymal cells lines the ventricles and the choroid plexuses

** choroid plexus is a complex network of capillaries and it's function is to produce cerebrospinal fluid (CSF).



Satellite Cells

- Flat cells surrounding neuronal cell bodies in peripheral ganglia
- Support neurons in the PNS ganglia



sheet # 4 :

- we already know that the cell body of sensory neurons are found in ganglions outside CNS , these ganglions are covered by satellite cells.

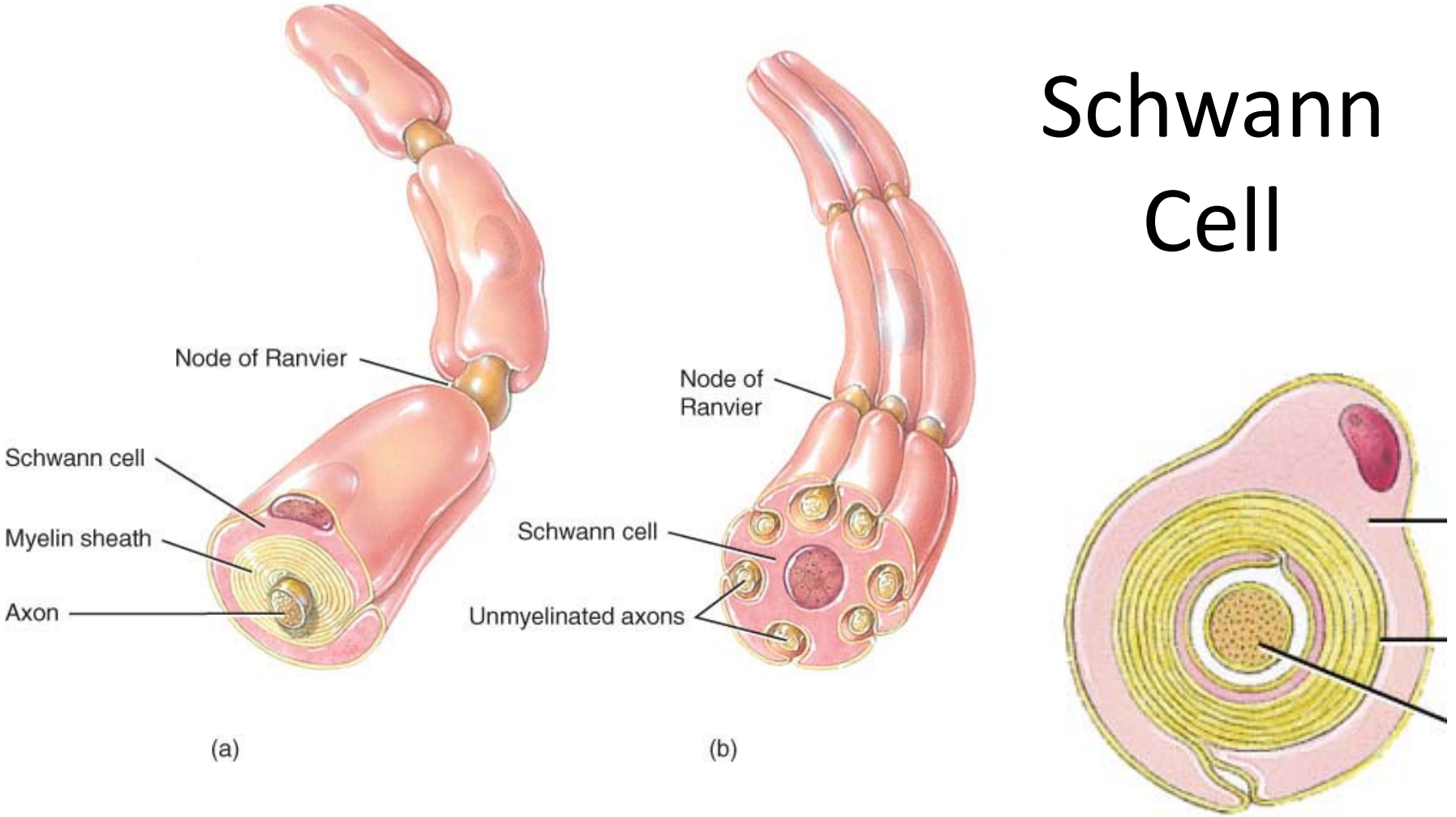
- satellite cells are small, they make a layer around the nucleus of the sensory neurons in dorsal root ganglion ,also in autonomic ganglia (motor neurons postsynaptic autonomic neurons) .

- shwann cells can work like astrocytes by providing support only without producing myelin sheath.

Myelination

- A multilayered lipid and protein covering called the *myelin sheath* and produced by Schwann cells and oligodendrocytes surrounds the axons of most neurons
- The sheath electrically insulates the axon and increases the speed of nerve impulse conduction.

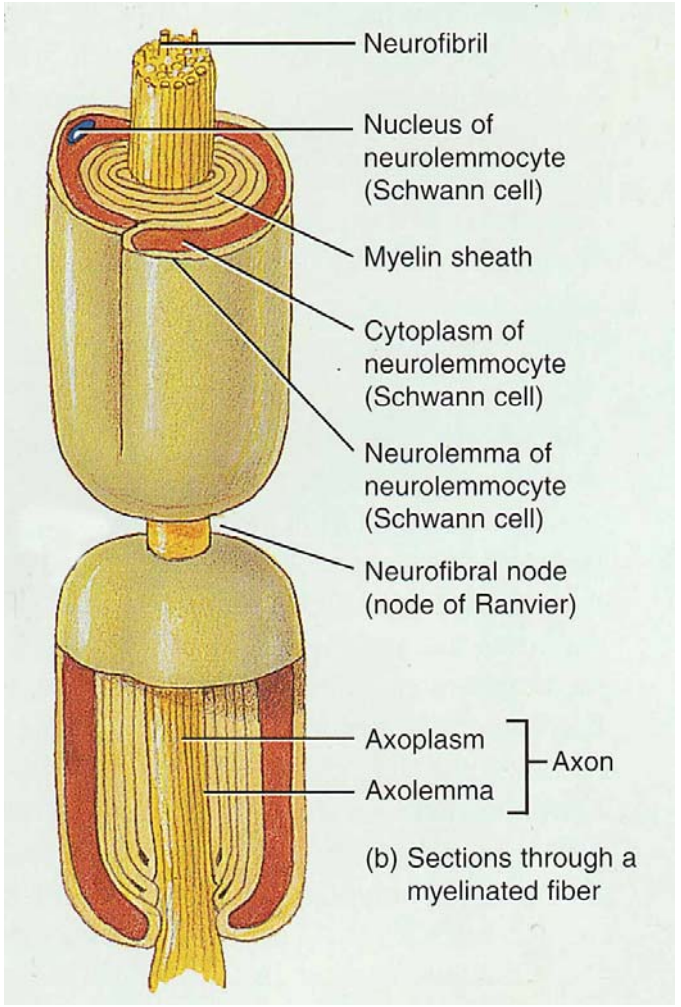
Schwann Cell

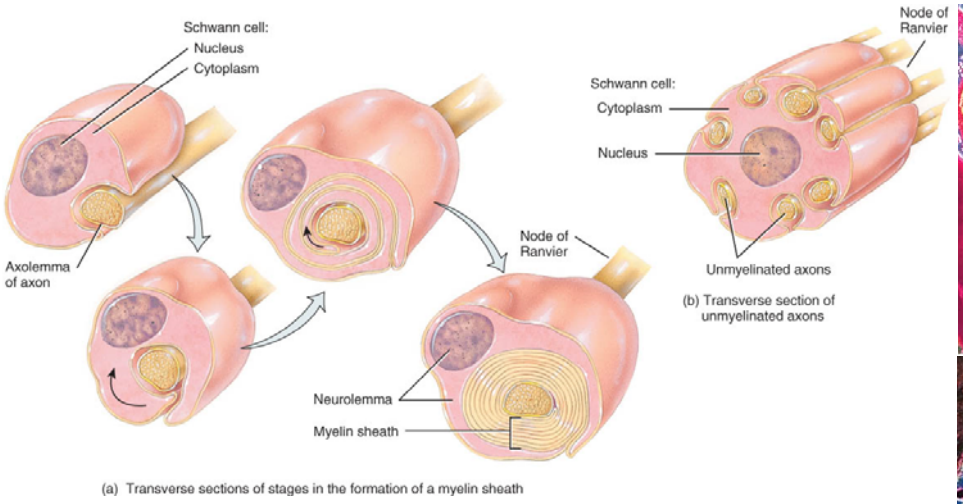


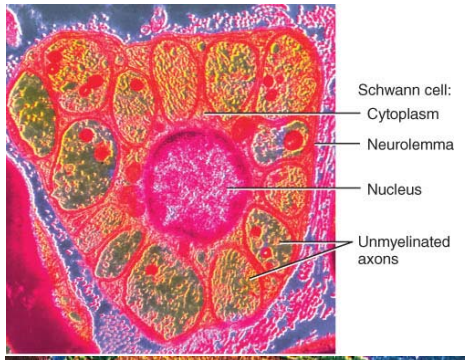
- Cells encircling PNS axons
- Each cell produces part of the myelin sheath surrounding an axon in the PNS

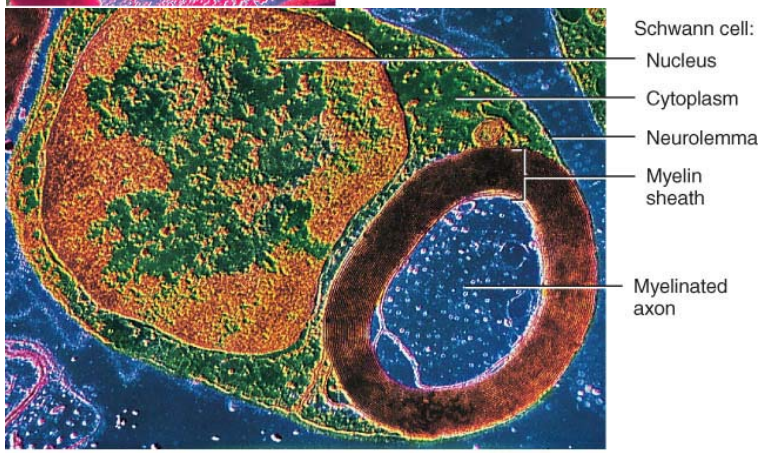
Axon Coverings in PNS

- All axons surrounded by a lipid & protein covering (myelin sheath) produced by Schwann cells
- Neurilemma the most superficial part of Schwann cell covering the myelin sheath
  - gaps called nodes of Ranvier
- Myelinated fibers appear white
  - jelly-roll like wrappings made of lipoprotein = myelin
  - acts as electrical insulator
  - speeds conduction of nerve impulses
- Unmyelinated fibers
  - slow, small diameter fibers
  - only surrounded by neurilemma but no myelin sheath wrapping







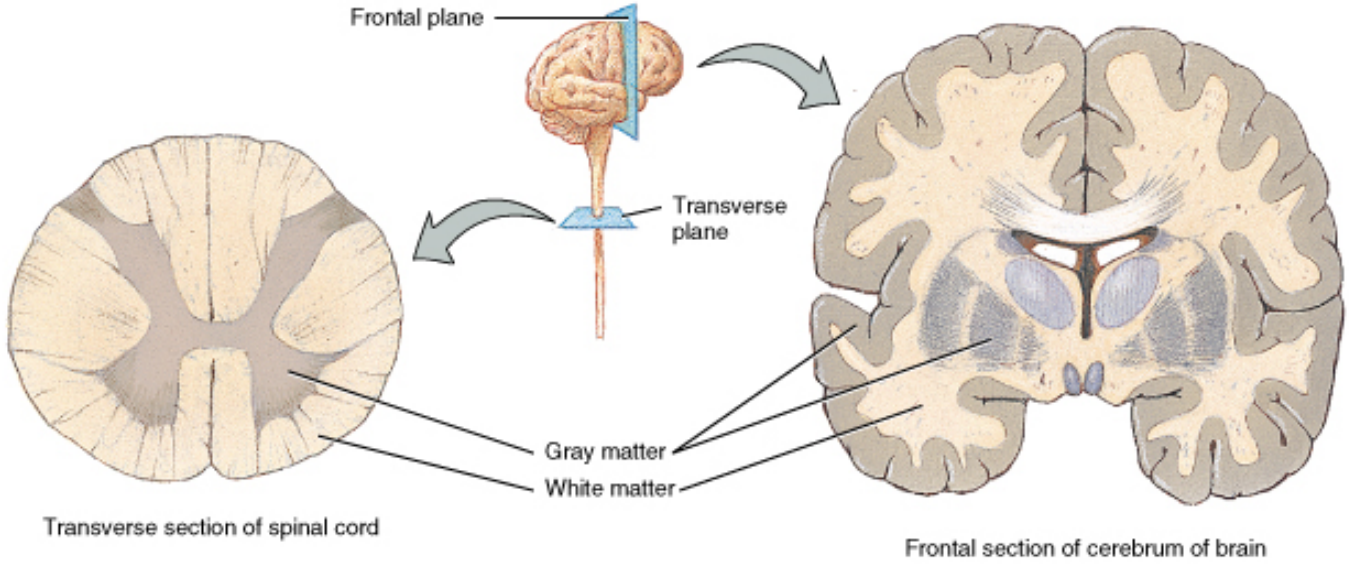


Myelination in PNS

- Schwann cells myelinate (wrap around) axons in the PNS during fetal development
- Schwann cell cytoplasm & nucleus forms outermost layer of neurolemma with inner portion being the myelin sheath
- Tube guides growing axons that are repairing themselves

Myelination in the CNS

- Oligodendrocytes myelinate axons in the CNS
- Broad, flat cell processes wrap about CNS axons, but the cell bodies do not surround the axons
- No neurilemma is formed
- Little regrowth after injury is possible due to the lack of a distinct tube or neurilemma

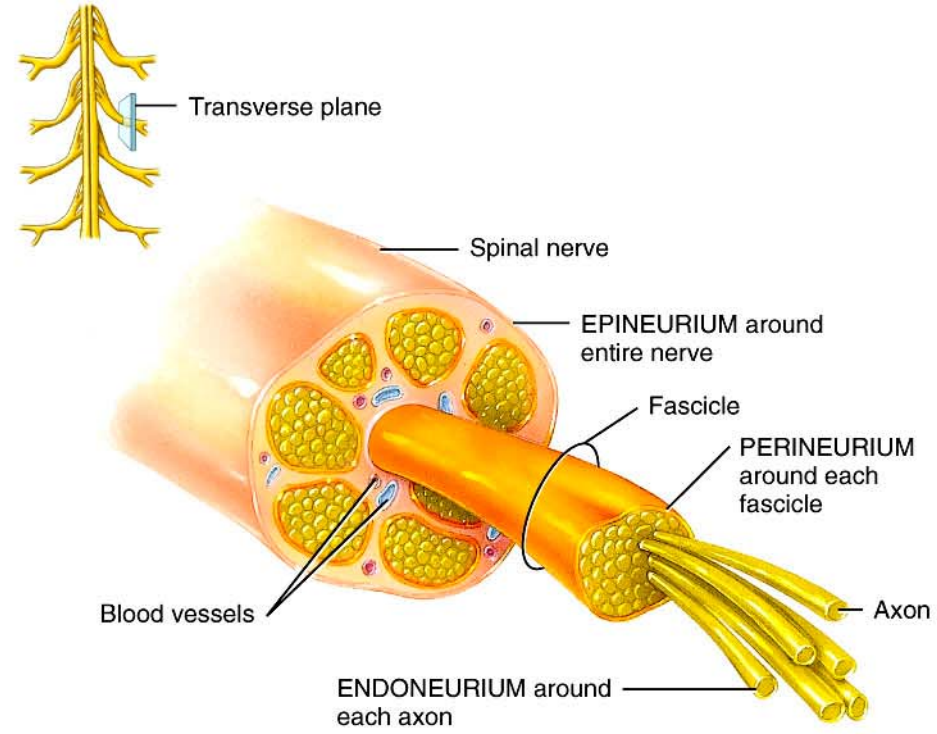


Spinal Nerves

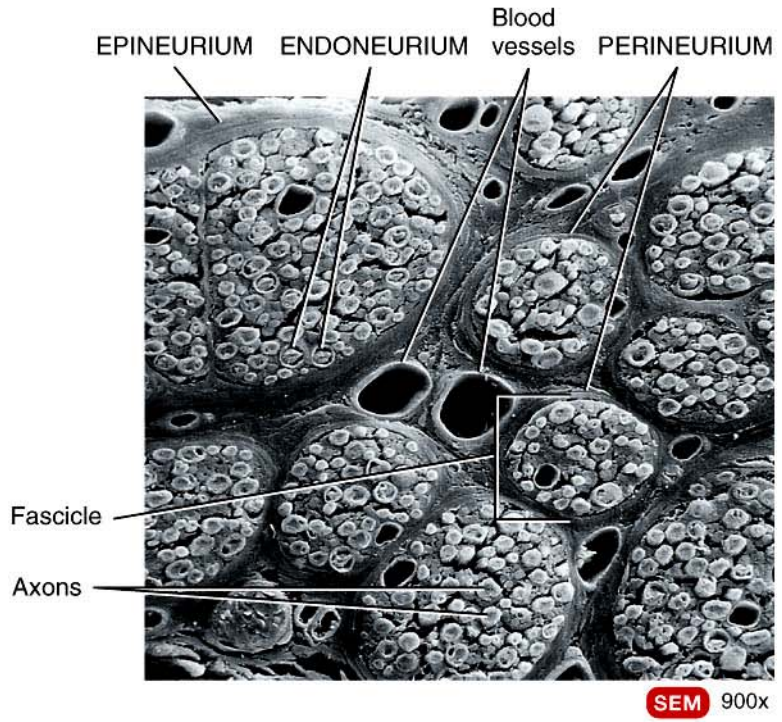
Connective tissue coverings of spinal nerves:

- Epineurium
- Perineurium
  - Fascicles
- Endoneurium

Spinal Nerves



(a) Transverse section showing the coverings of a spinal nerve



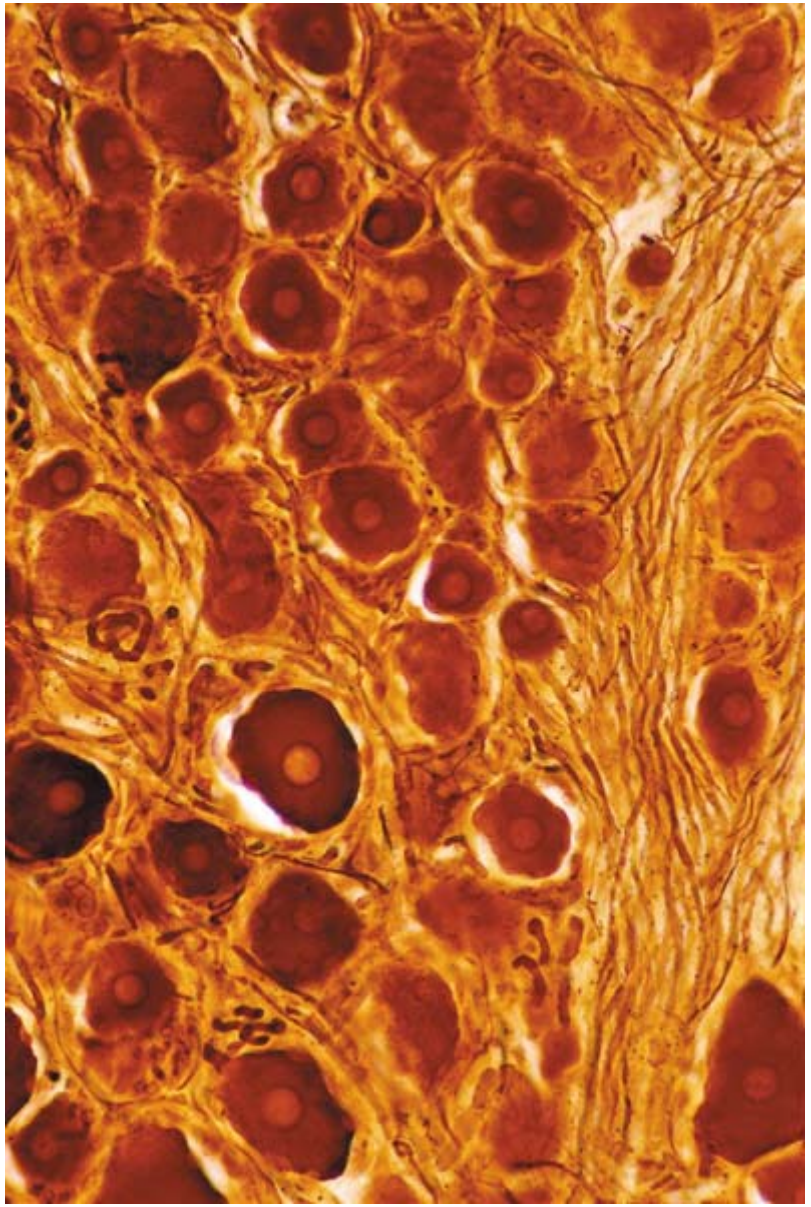
(b) Transverse section of 12 nerve fascicles

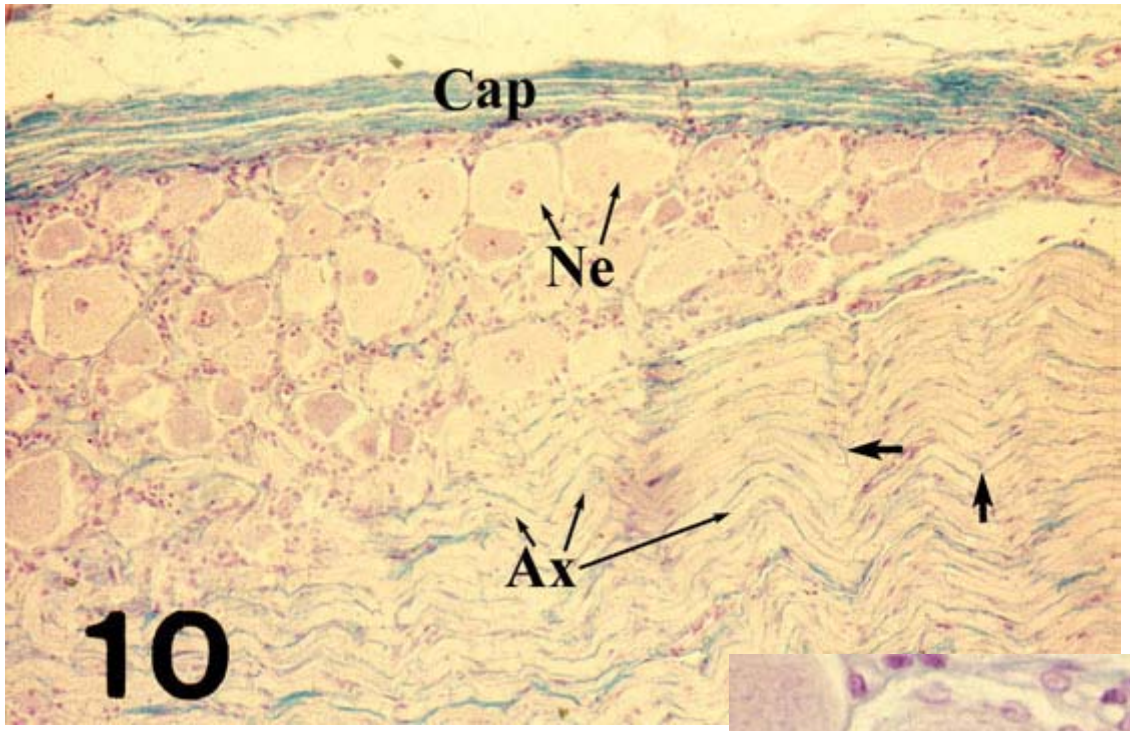
Figure 13.05 Tortora - PAP 12/e

** epineurium is an extension from dura matter.

Ganglia

- Dorsal root (sensory) ganglia
  - Nuclei are large, prominent and central
  - Neurons arranged in rows
  - Two population of neurons based on size
    - Large 100 µm diameter
    - Small 10-15 µm diameter
  - Satellite (nurse) cells and well-developed capsule
  - Fixation causes perikaryon to shrink away from capsule

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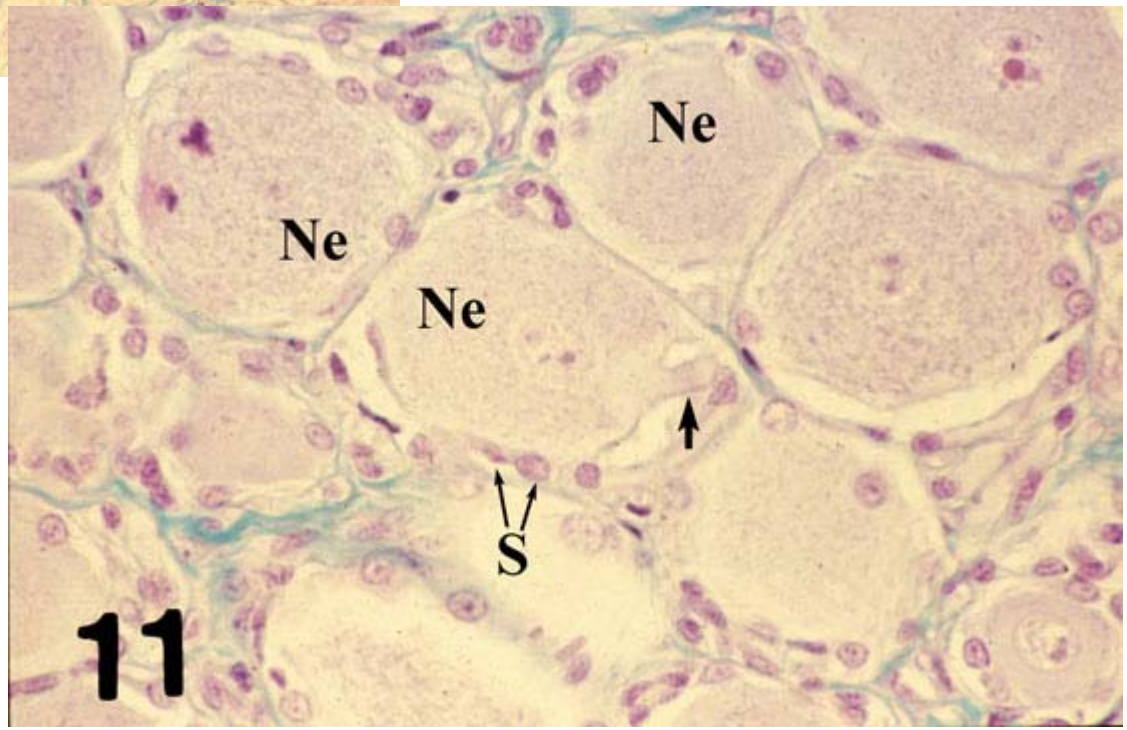
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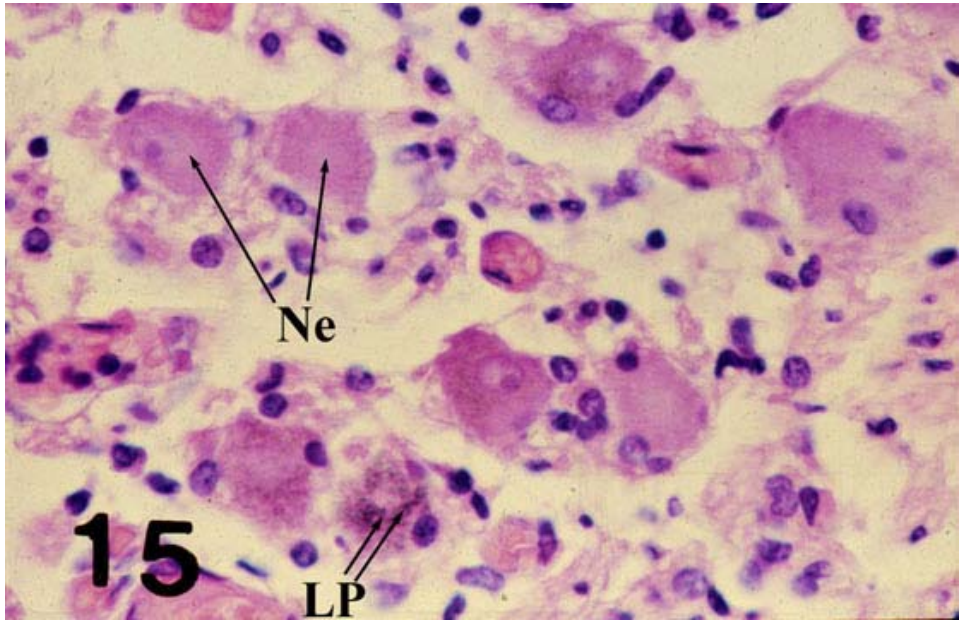
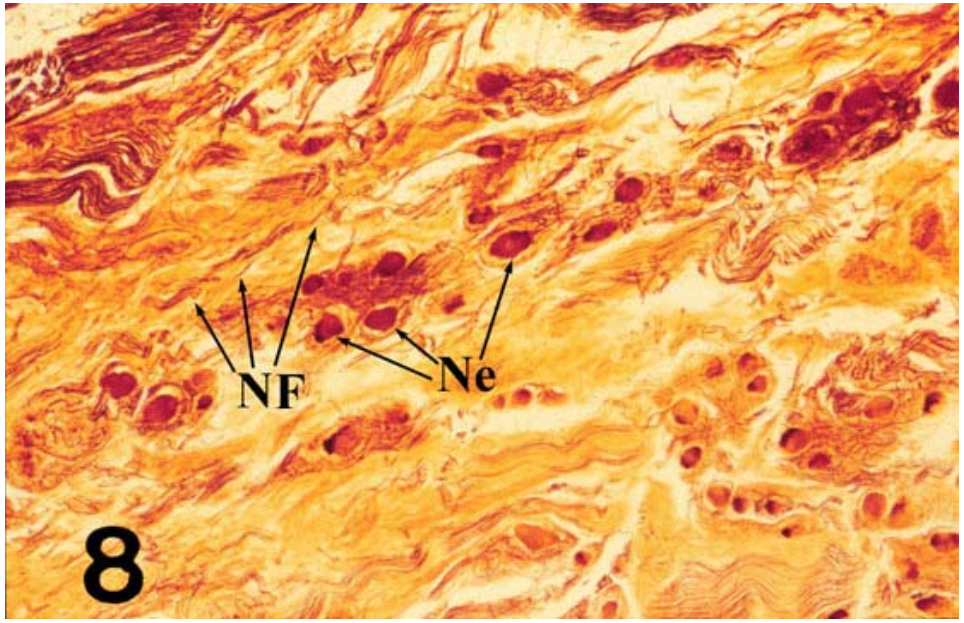
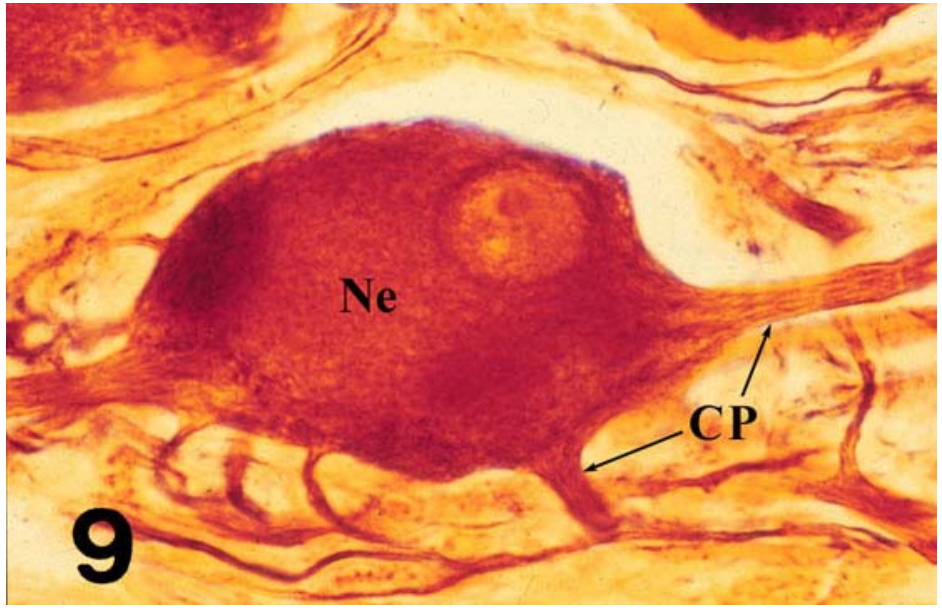
Ganglia

- Autonomic ganglia
  - Nuclei are eccentric
  - No neuronal clusters
  - One size neuron-small
  - Poorly defined capsule, fewer satellite cells
  - Lipofuscin granules
  - Multipolar







Spinal Cord

- Anterior median fissure
- Posterior median sulcus
- Gray and white commissures
- Central canal
- Anterior, posterior & lateral gray horns
  - Anterior horns contain motor neurons
  - Posterior horns receive sensory fibers from neurons in the spinal ganglia
- Anterior, posterior & lateral white columns

Internal Anatomy of Spinal Cord

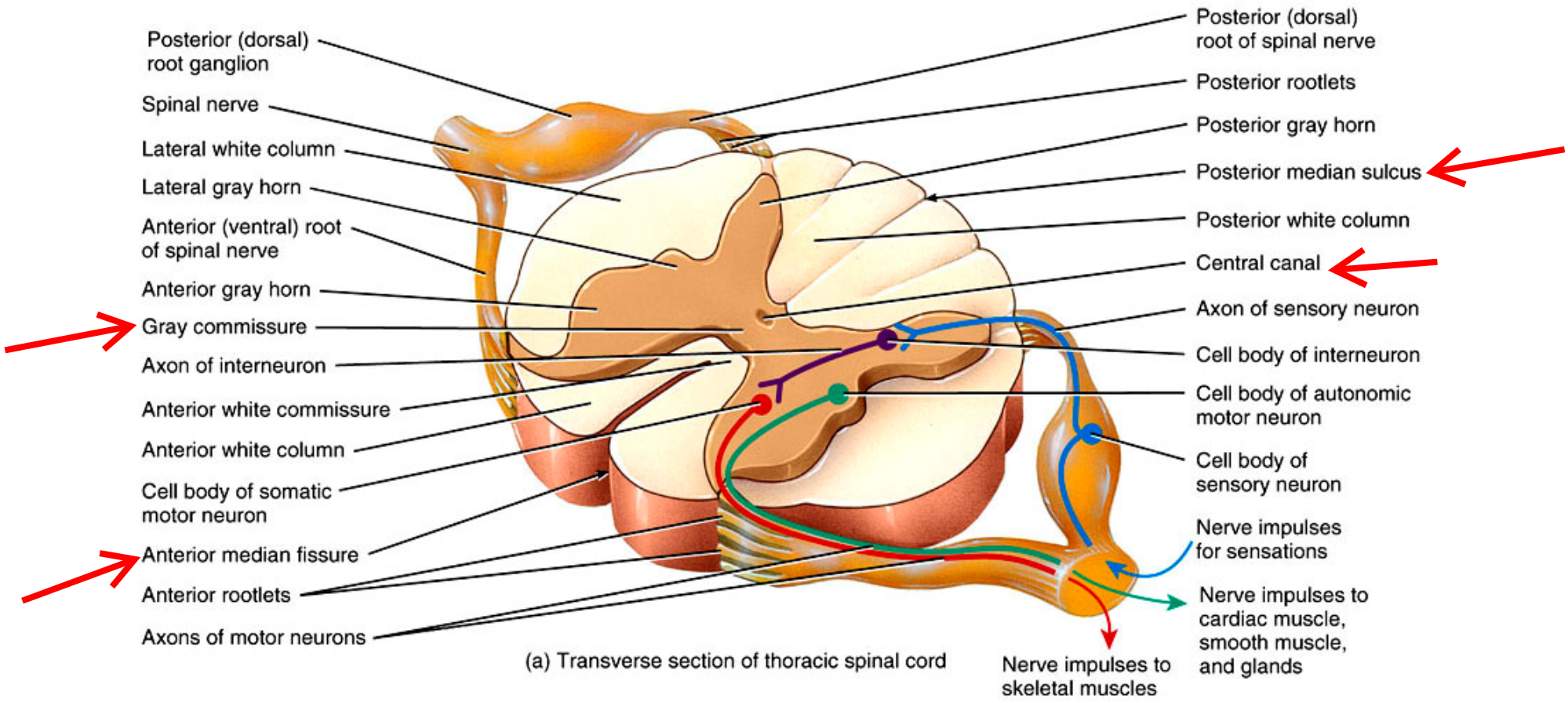
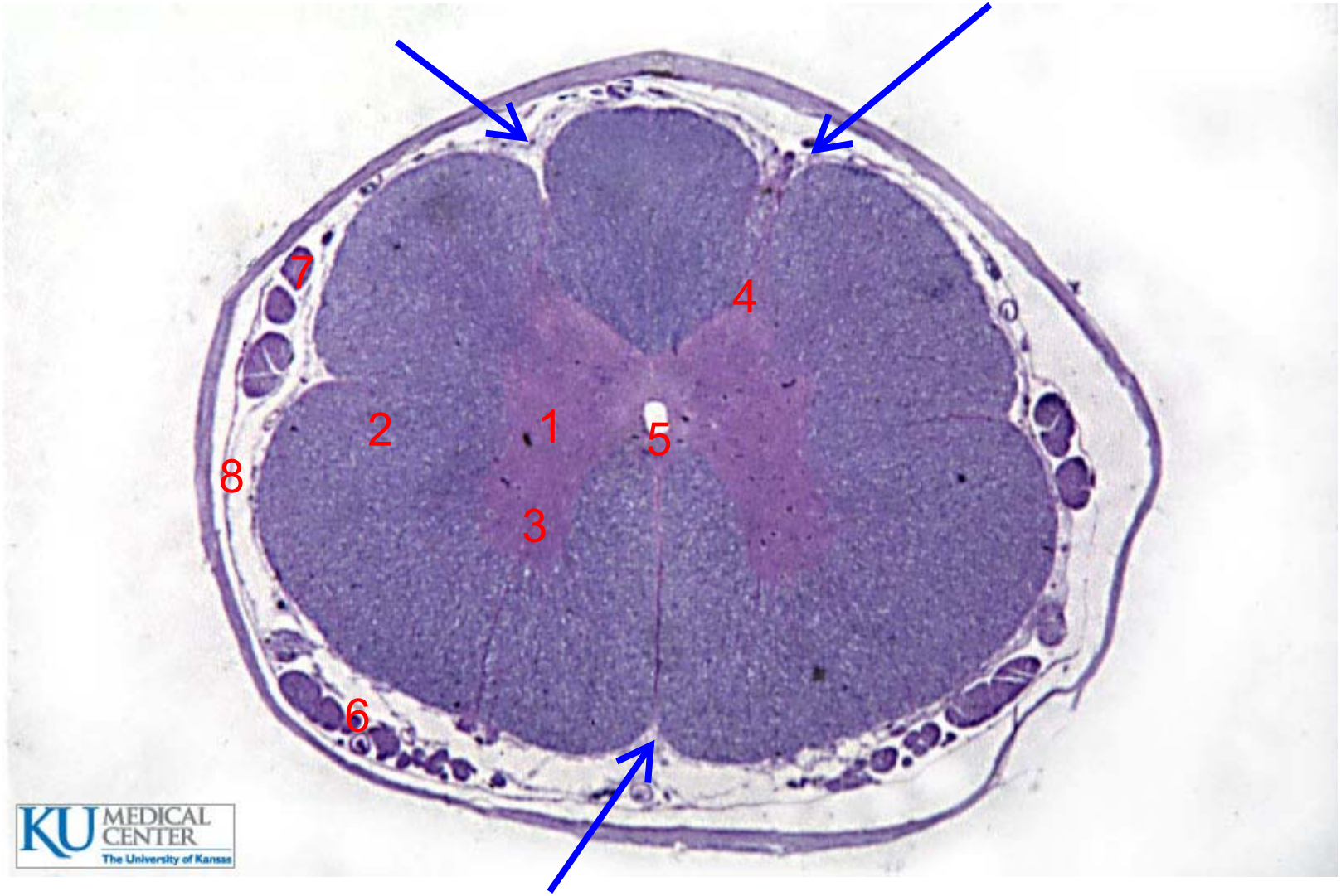


Figure 13.03 Tortora - PAP 12/e

** ventral root have axons of motor neurons while dorsal root have axons of sensory neurons .

Internal Anatomy of Spinal Cord



Sheet # 5 :

1 : gray matter
2 : white matter
3 : ventral horn
4 : dorsal horn
5 : central canal
6 : parts from ventral roots
7 : parts from dorsal roots
8 : meninges

- dorsal horn have 2 spinal arteries while ventral horn have one spinal artery and that's how we can distinguish between ventral and dorsal horns
(see blue arrows in the last picture) .

- right and left gray matter are connected by gray commissure .