

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

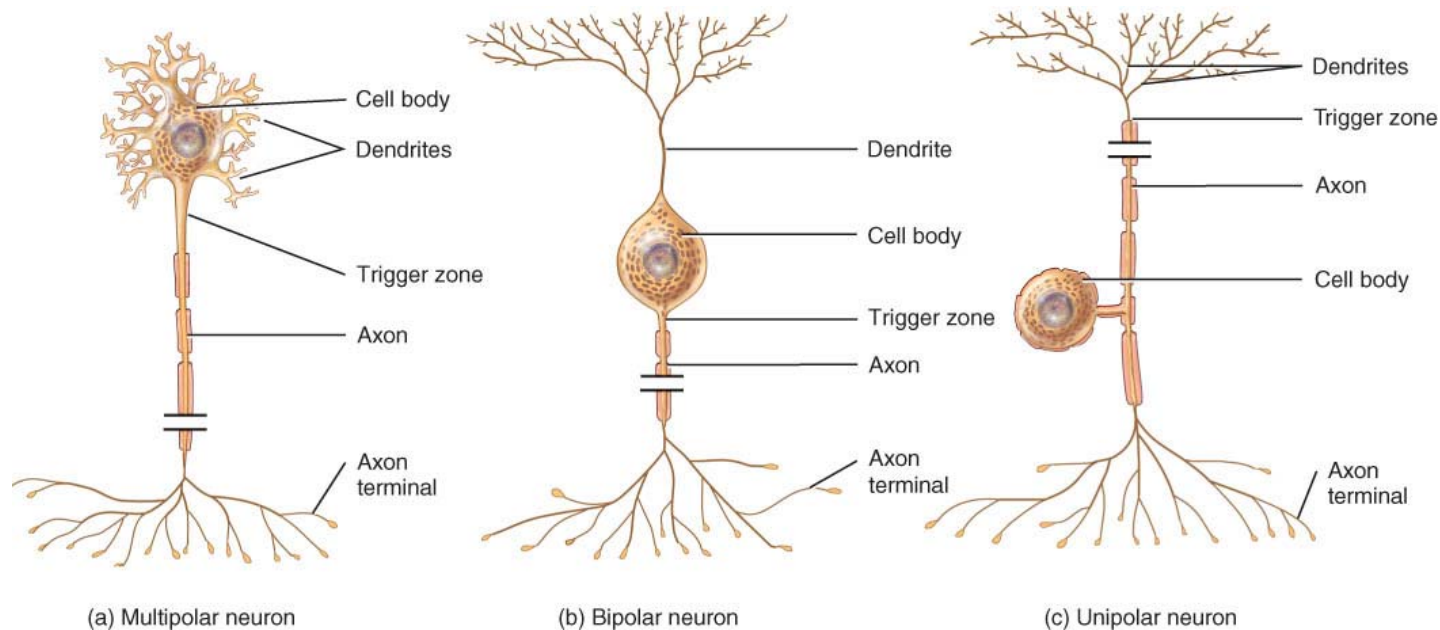
- Functional unit of nervous system
- Have capacity to produce action potentials
 - electrical excitability
- Cell body
- Cell processes = dendrites & axons



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

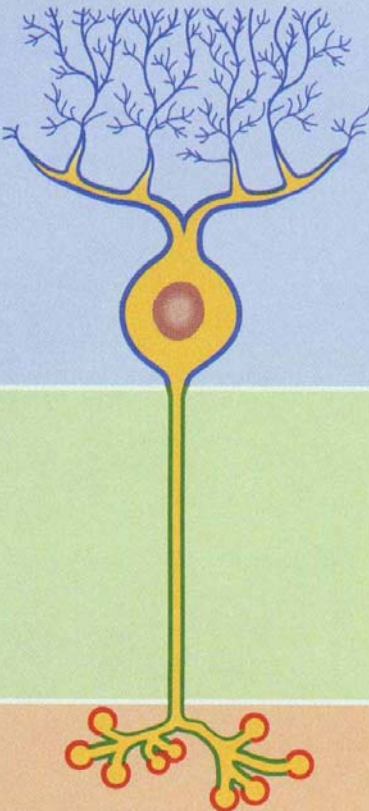





- Based on number of processes found on cell body
 - multipolar = several dendrites & one axon
 - most common cell type
 - bipolar neurons = one main dendrite & one axon
 - found in retina, inner ear & olfactory
 - unipolar neurons = one process only(develops from a bipolar)
 - are always sensory neurons

Functional Classification of Neurons

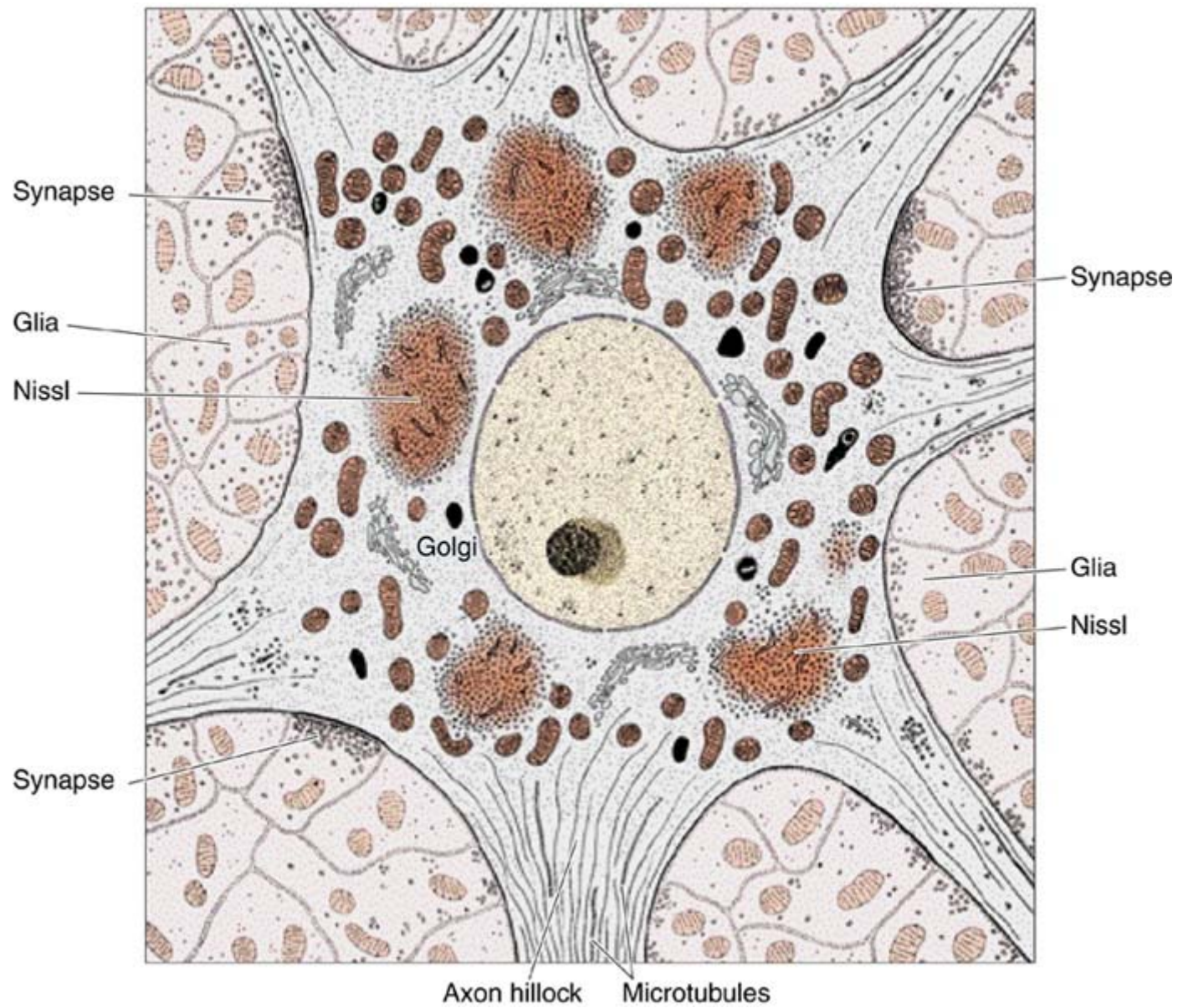
- Sensory (afferent) neurons
 - transport sensory information from skin, muscles, joints, sense organs & viscera to CNS
- Motor (efferent) neurons
 - send motor nerve impulses to muscles & glands
- Interneurons (association) neurons
 - connect sensory to motor neurons
 - 90% of neurons in the body

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.
<ul style="list-style-type: none">  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 (4-5 μ m) or large (150 μ m) 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.

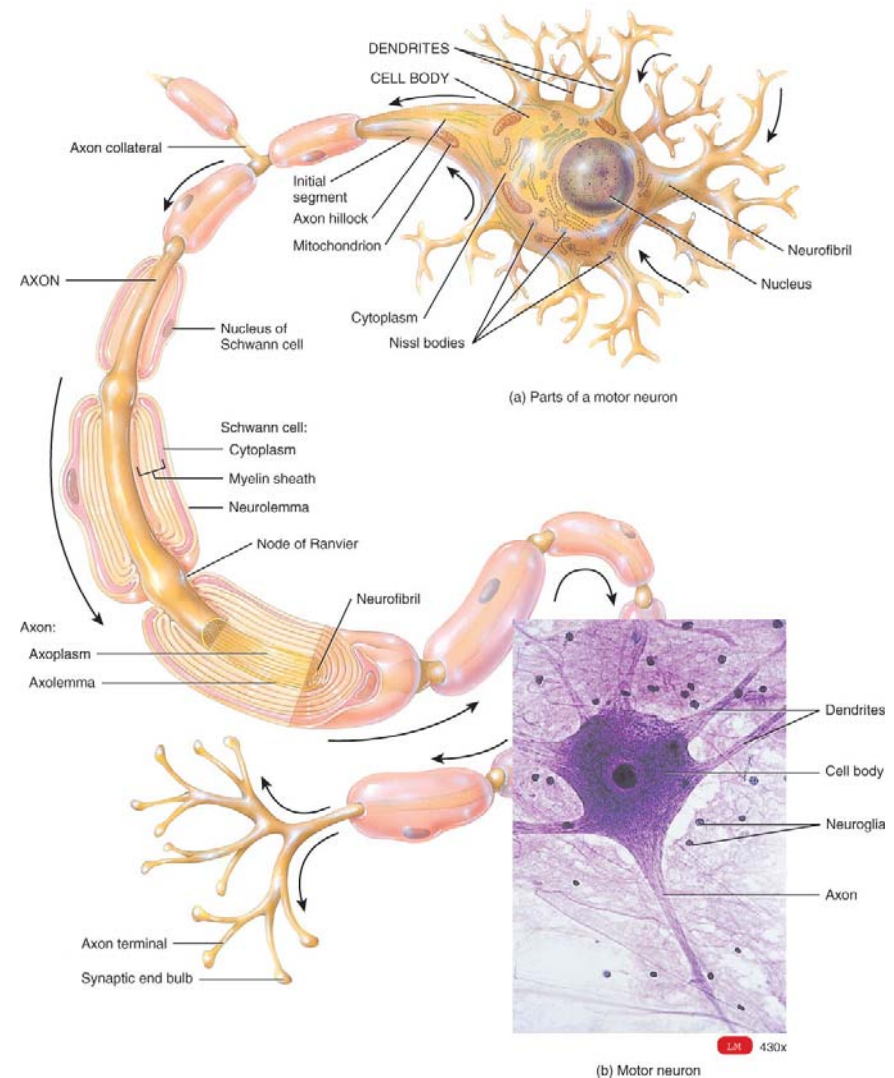


Neuronal processes

- 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).

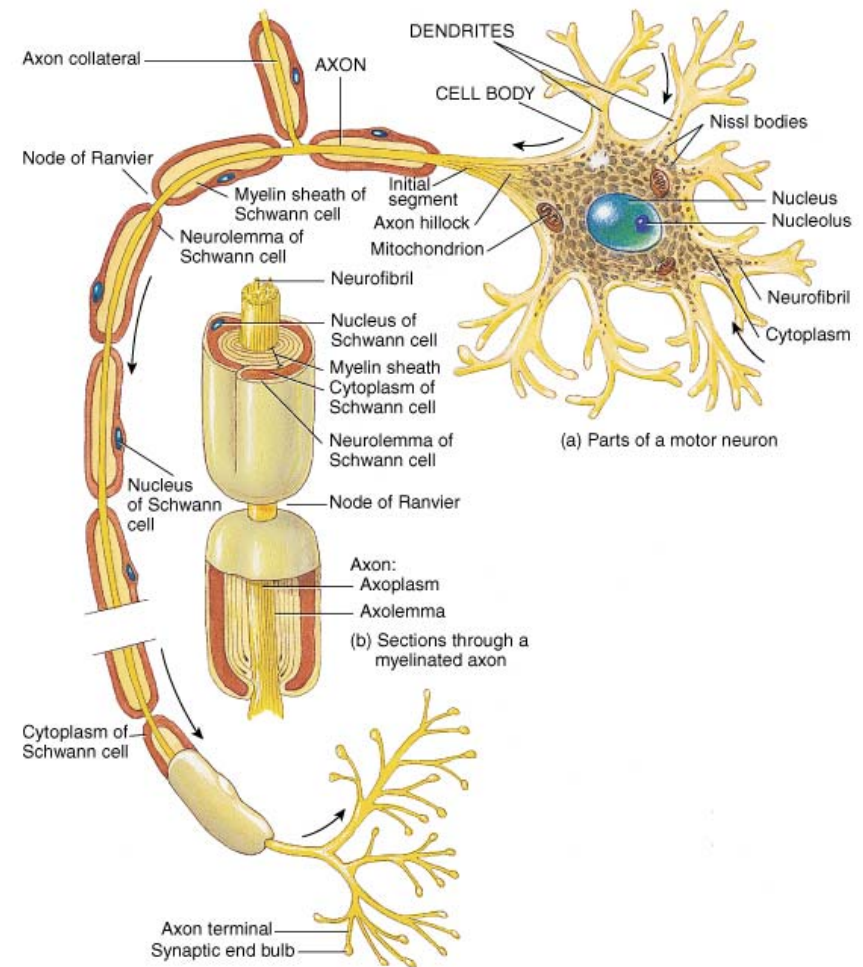
Dendrites

- 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



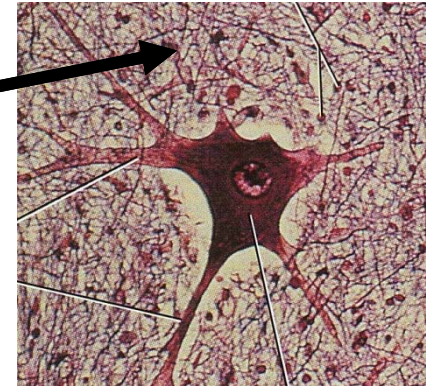
Axons

- 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**



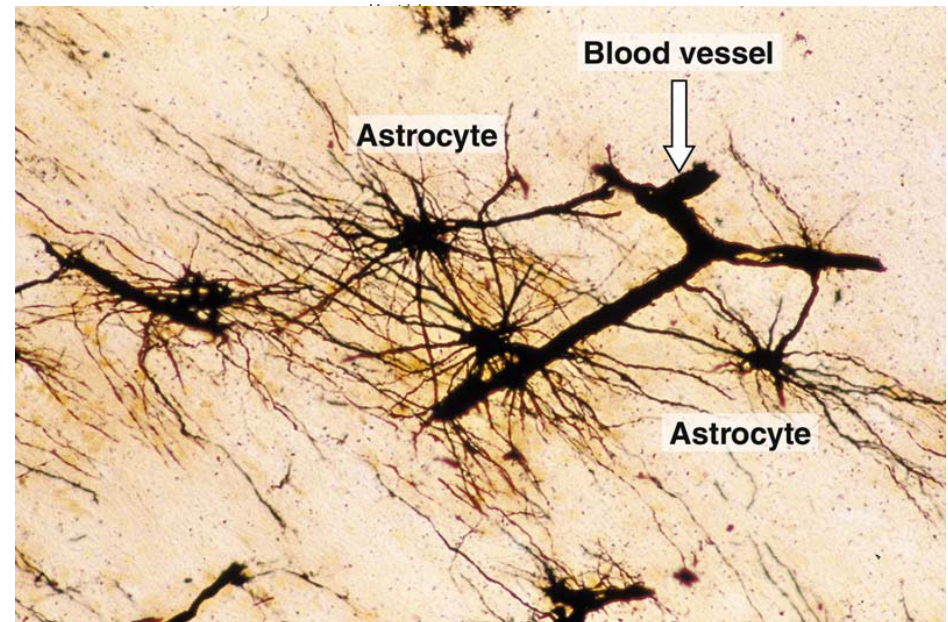
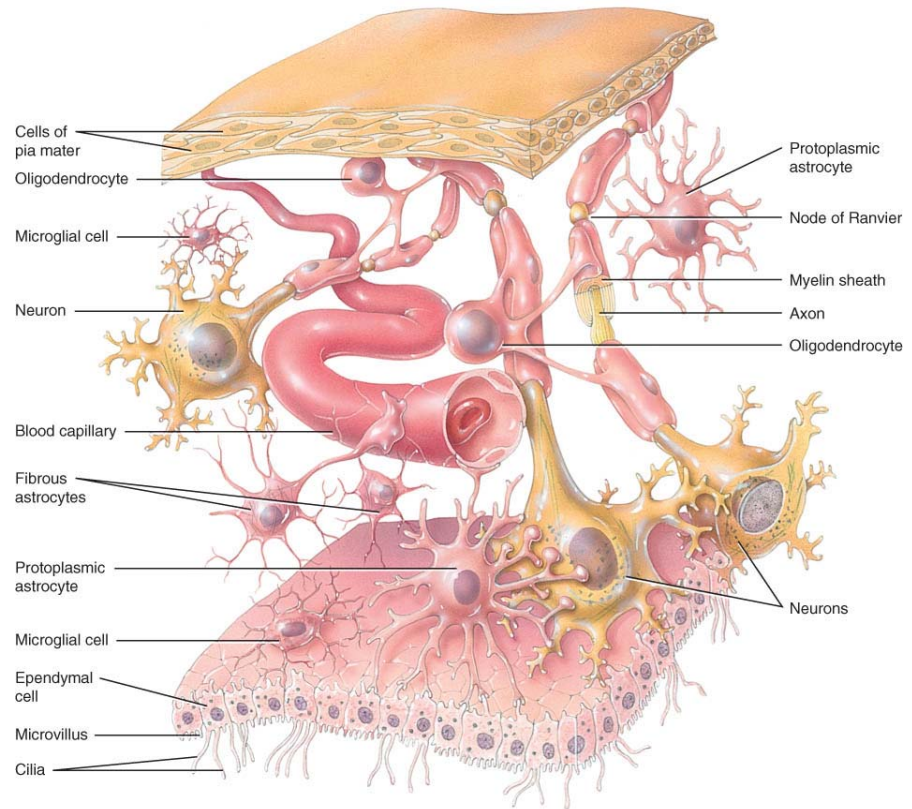
Neuroglial Cells

- 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

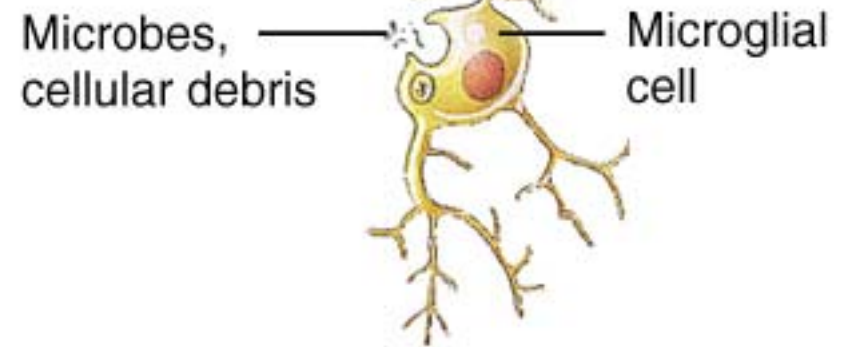
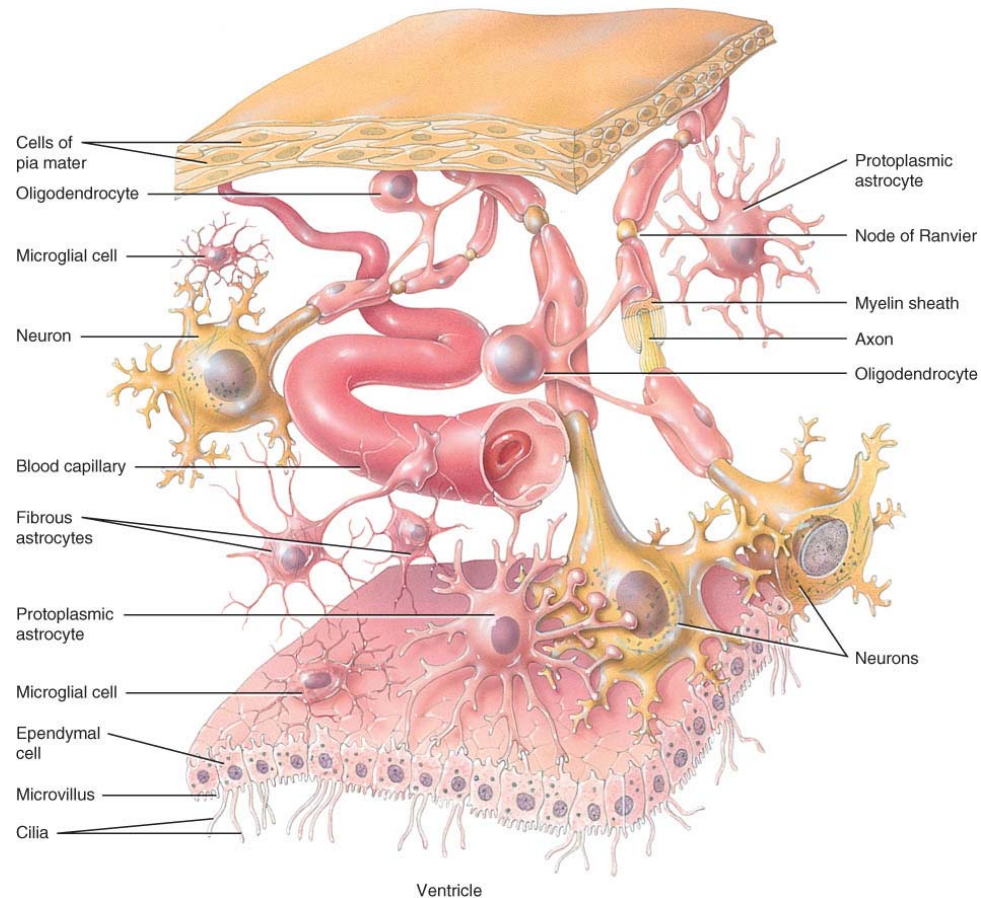


Astrocytes

- 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

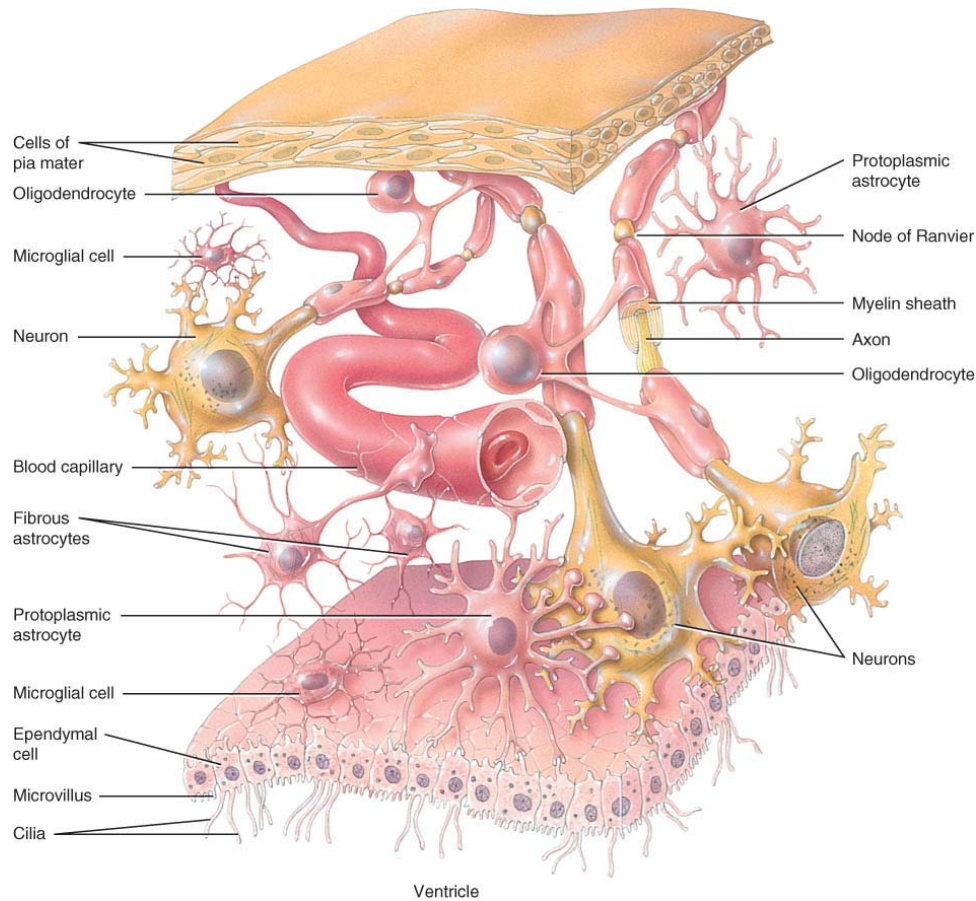


Microglia

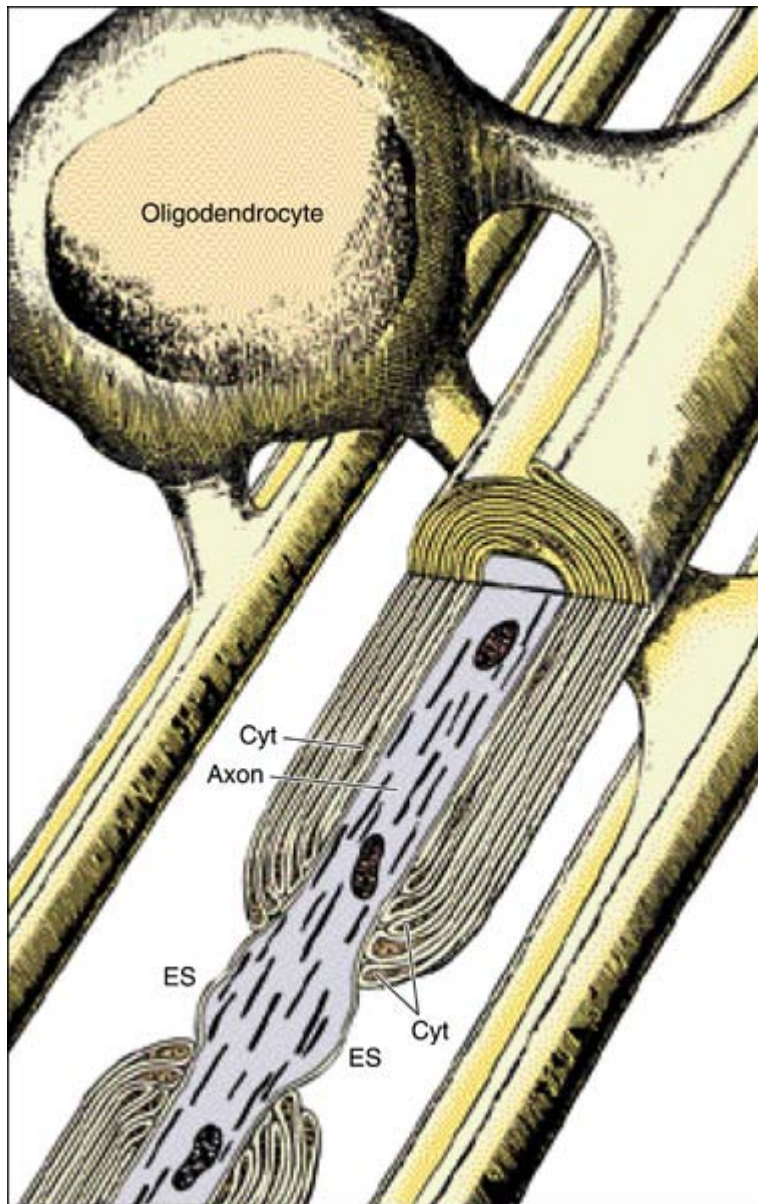


- Small cells found near blood vessels
- Phagocytic role -- clear away dead cells
- Derived from cells that also gave rise to macrophages & monocytes

Ependymal cells



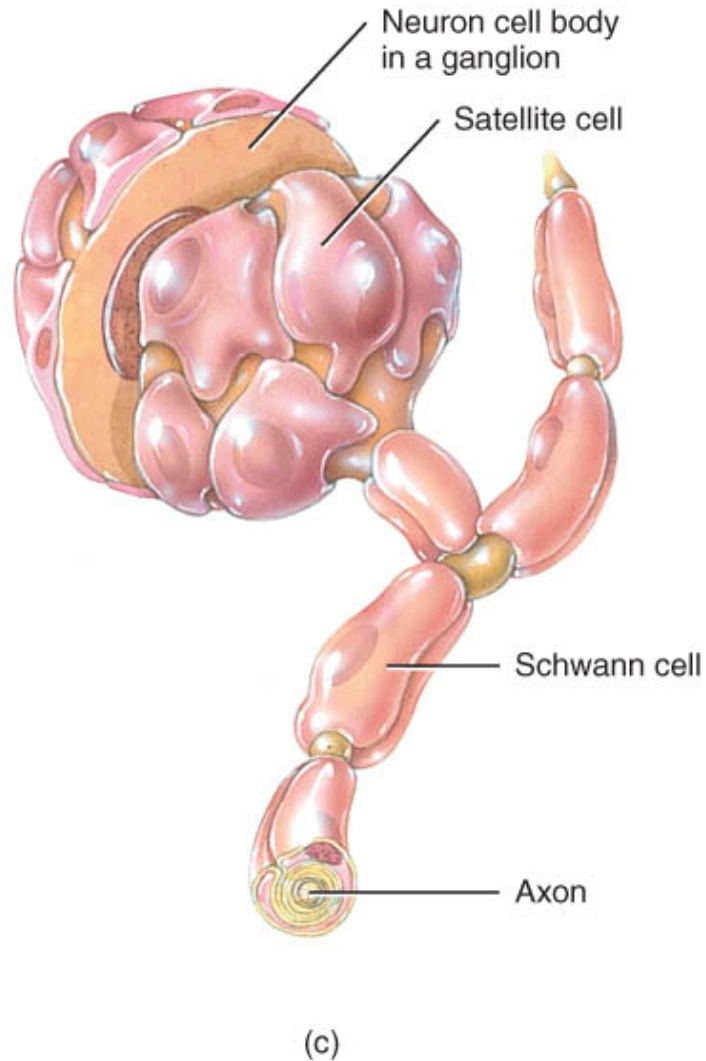
- Form epithelial membrane, lining cerebral cavities & central canal
- Cuboidal or low columnar
- Have cilia and microvilli
- Produce cerebrospinal fluid (CSF)



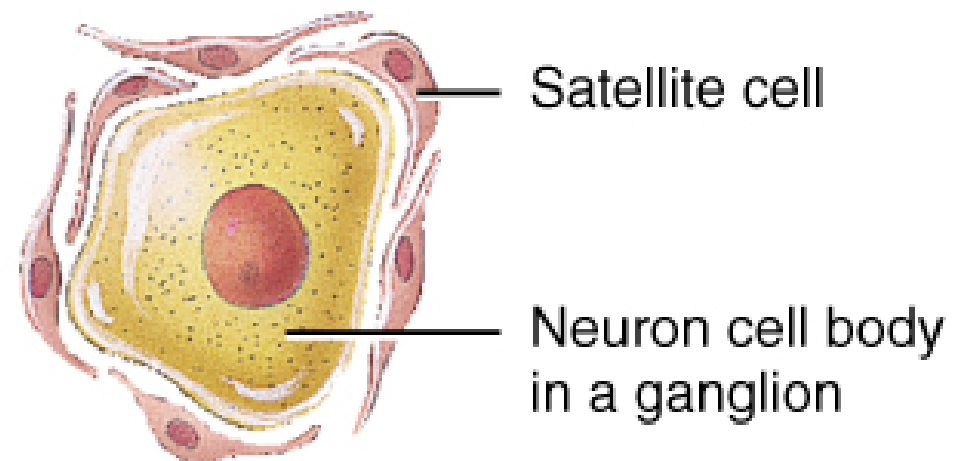
Oligodendrocytes

- 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

Satellite Cells



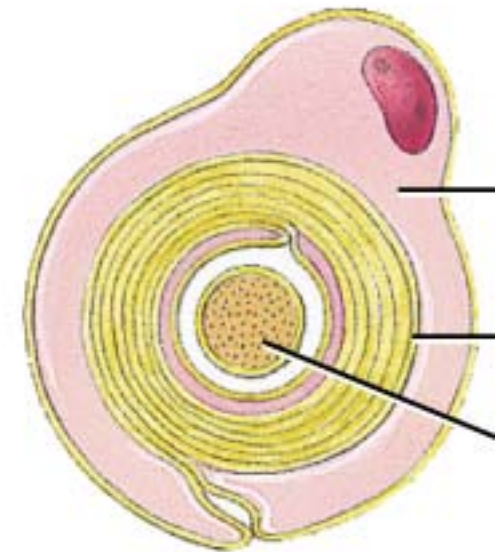
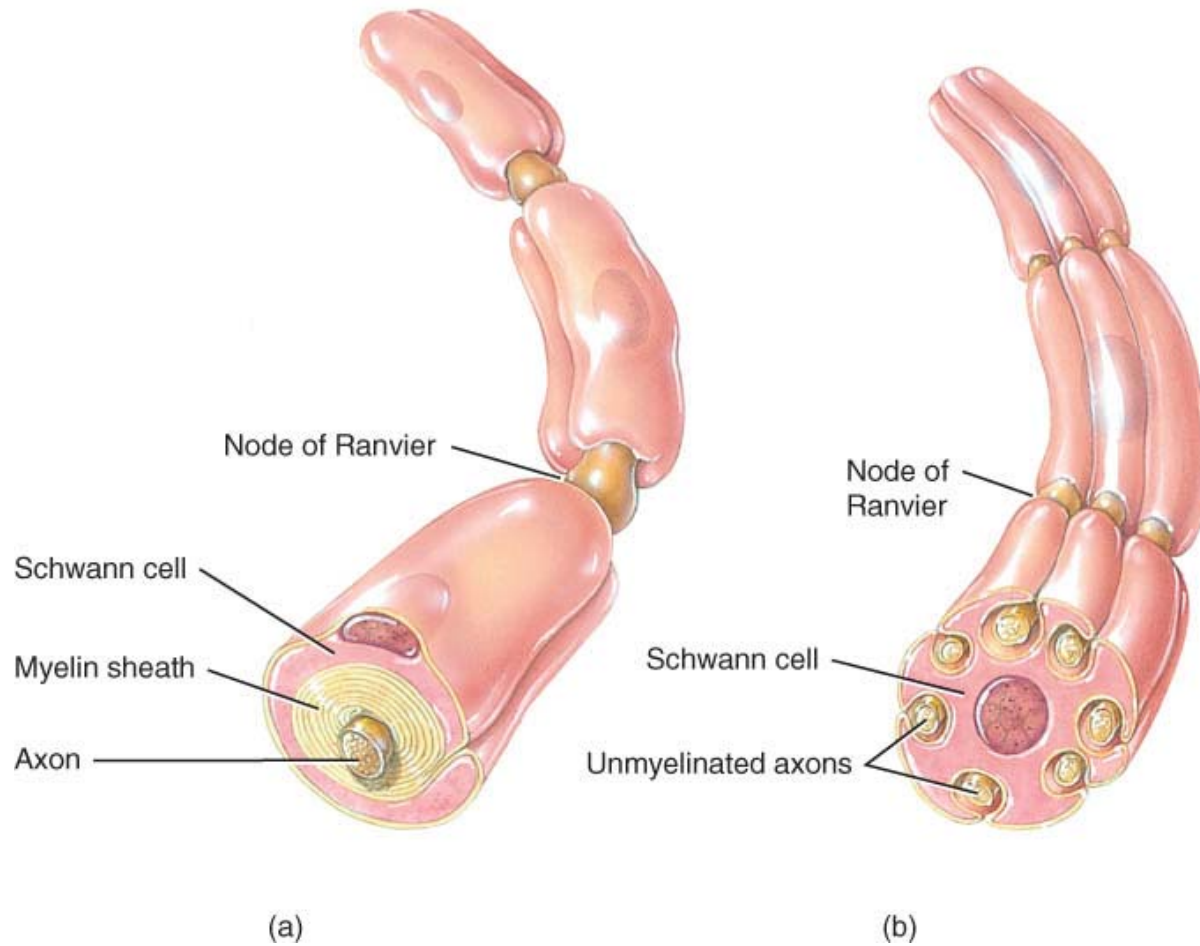
- Flat cells surrounding neuronal cell bodies in peripheral ganglia
- Support neurons in the PNS ganglia



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.

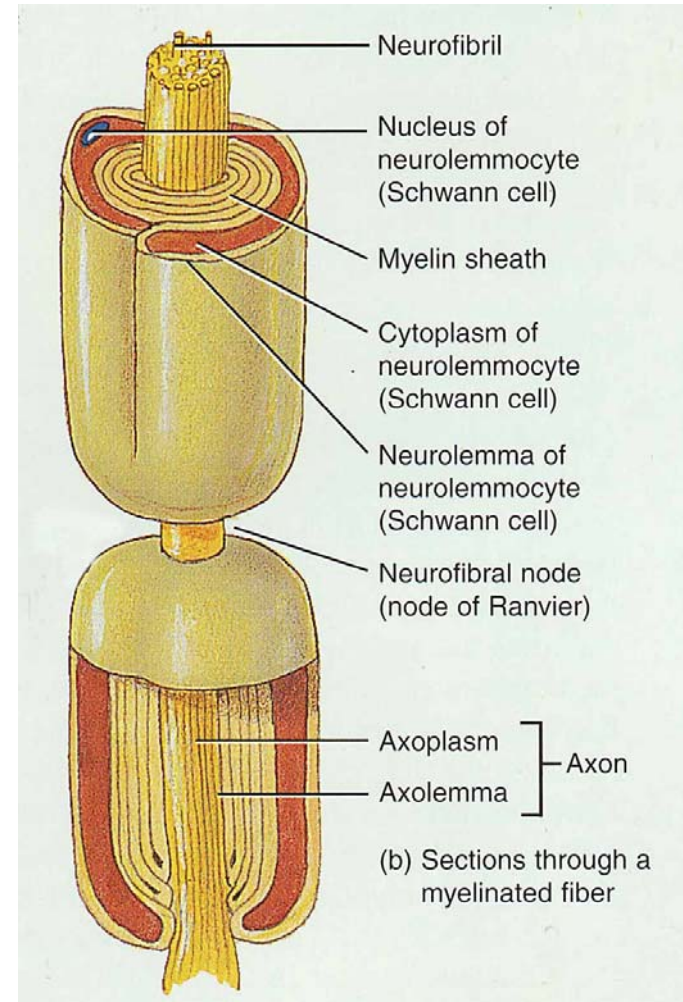
Schwann Cell

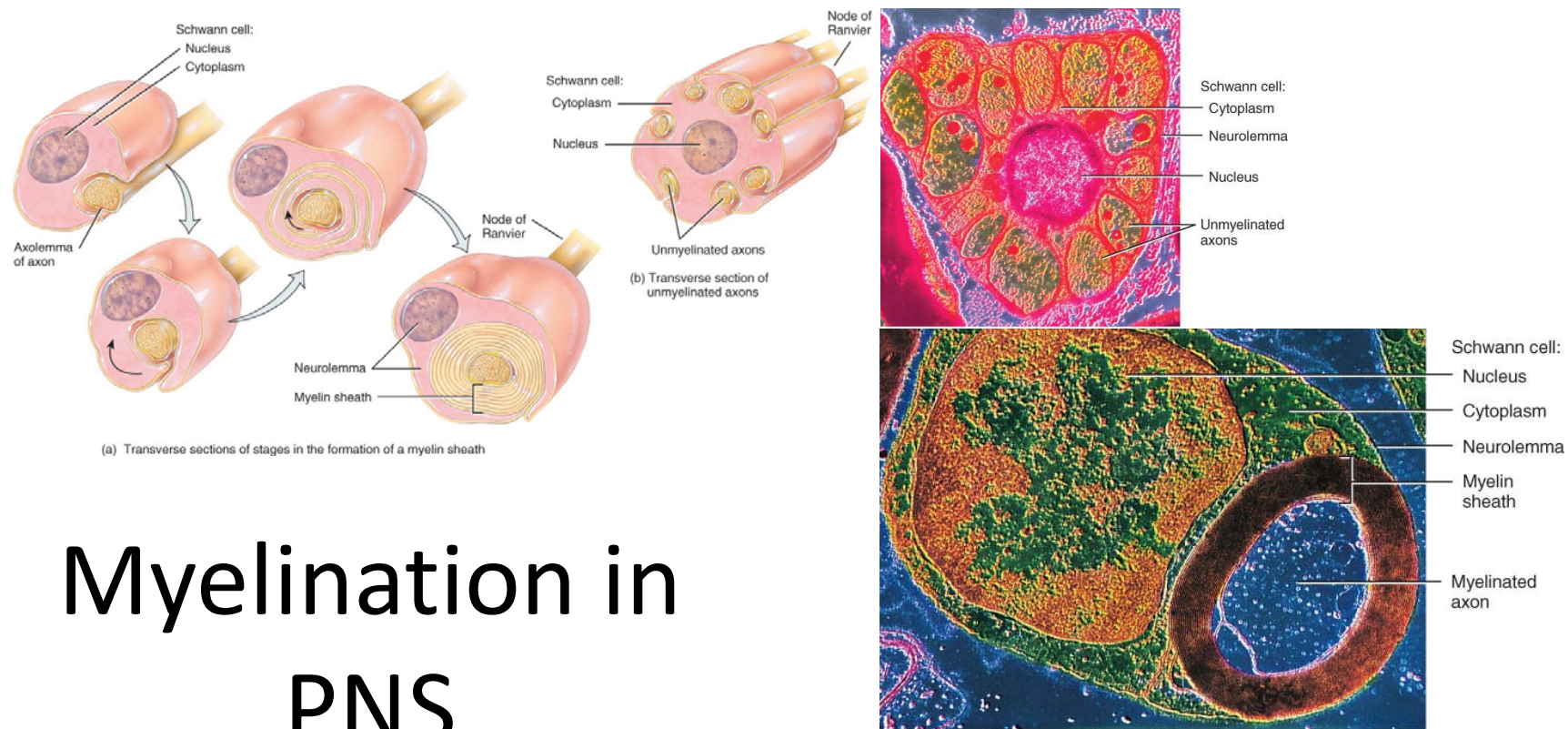


- Cells encircling PNS axons
- Each cell produces part of the myelin sheath surrounding an axon in the PNS

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



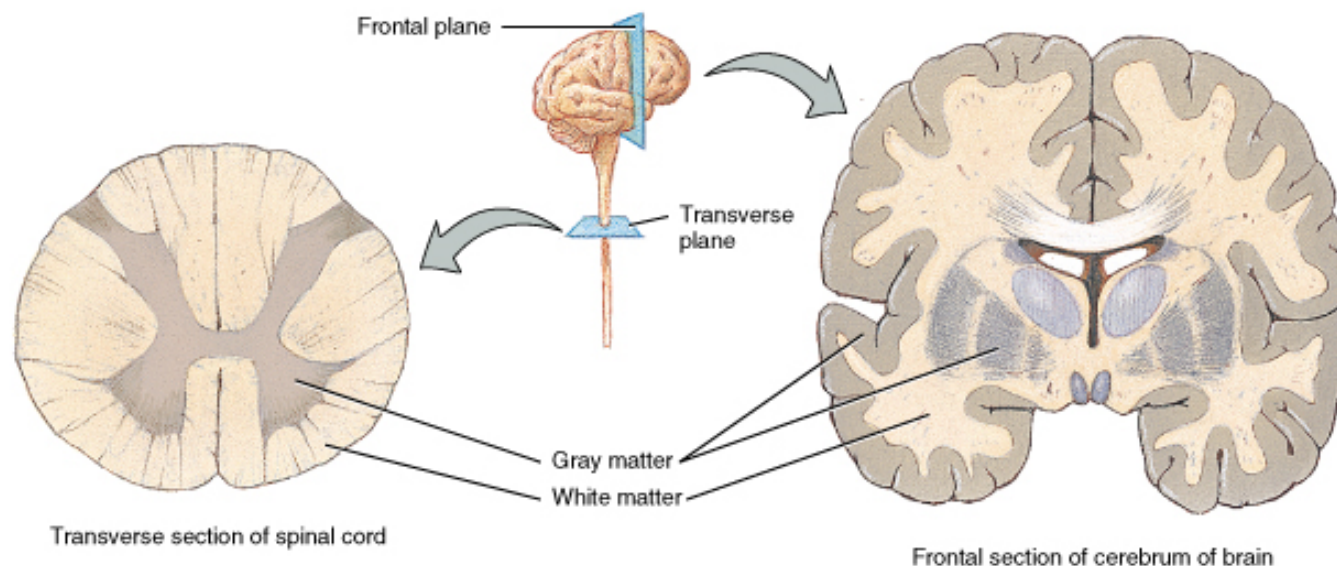


Myelination in PNS

- 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

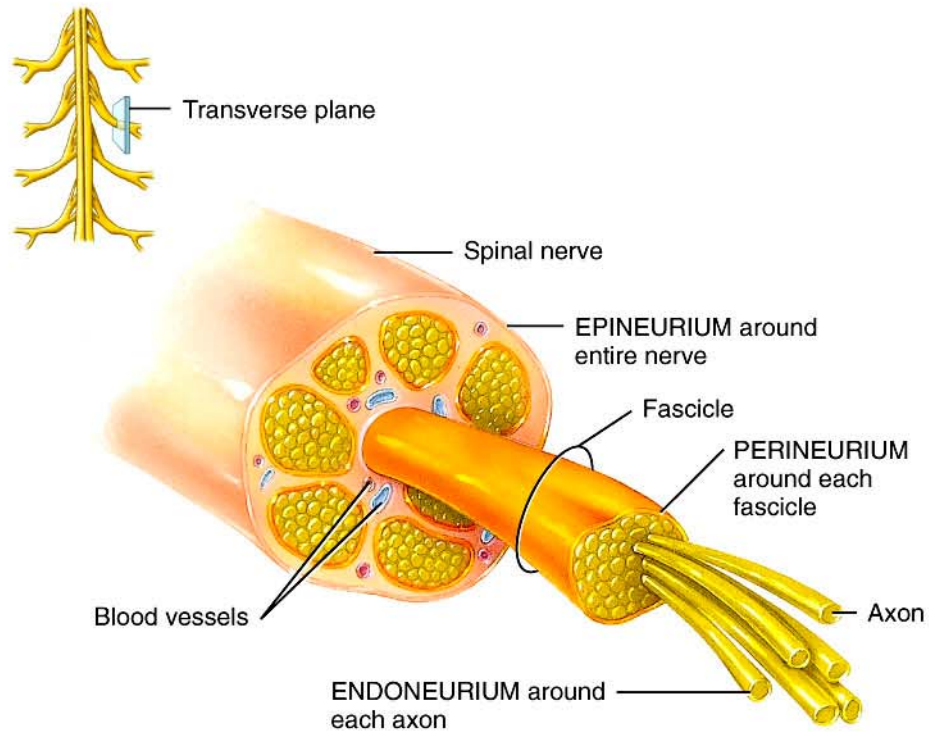


Spinal Nerves

Connective tissue coverings of spinal nerves:

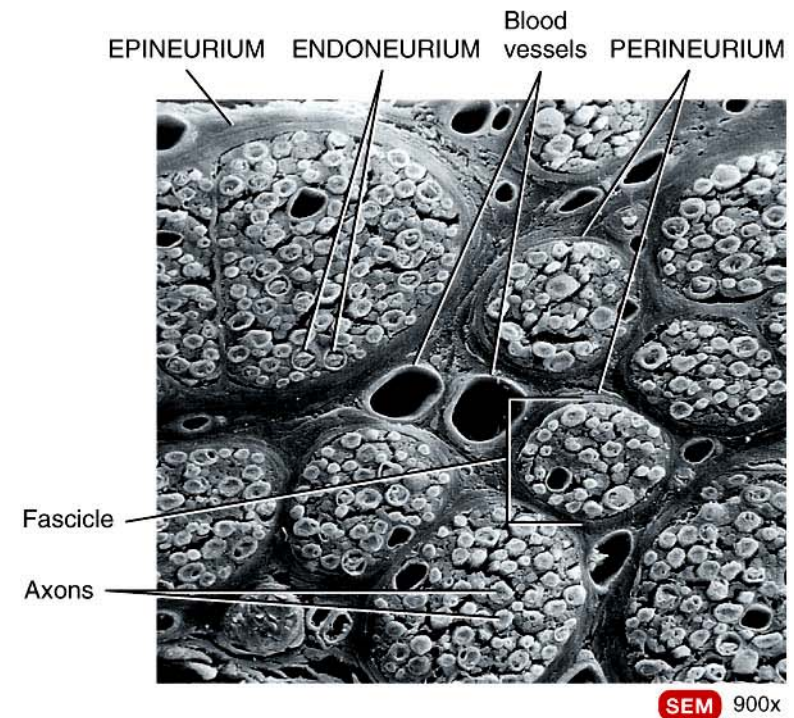
- Epineurium
- Perineurium
 - Fascicles
- Endoneurium

Spinal Nerves



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

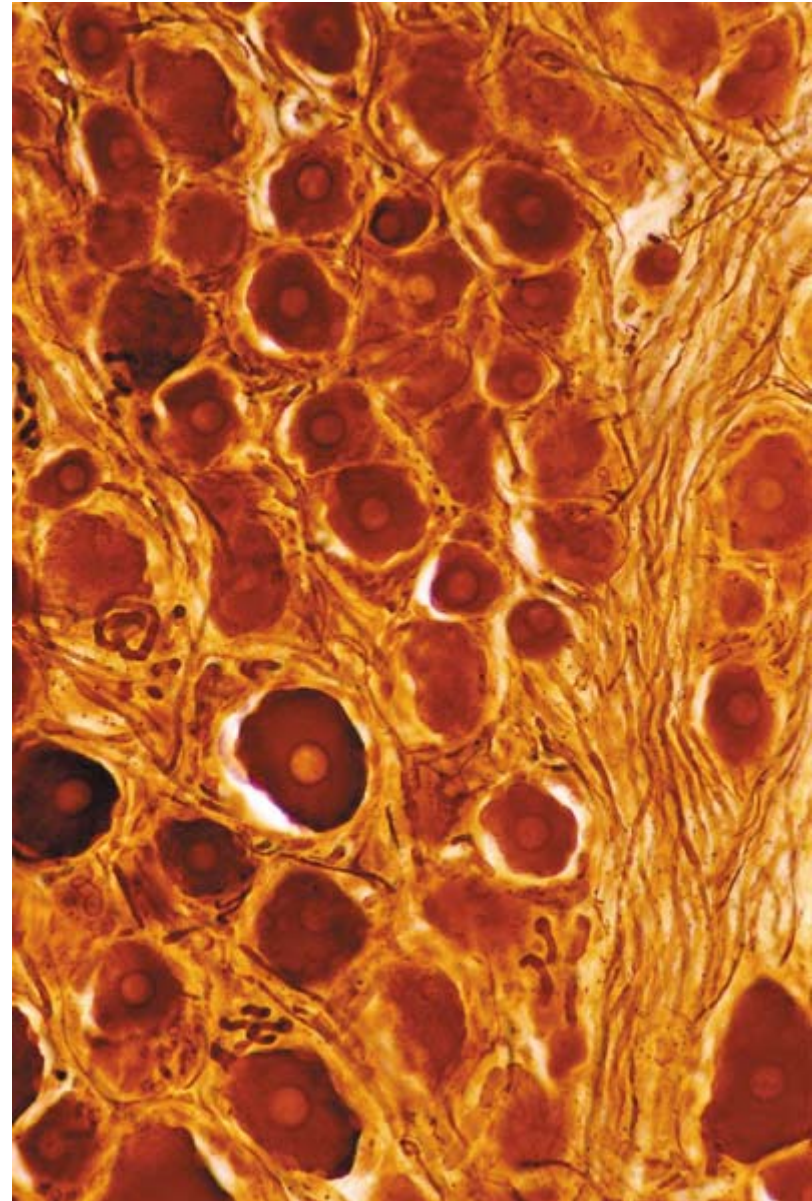
Figure 13.05 Tortora - PAP 12/e
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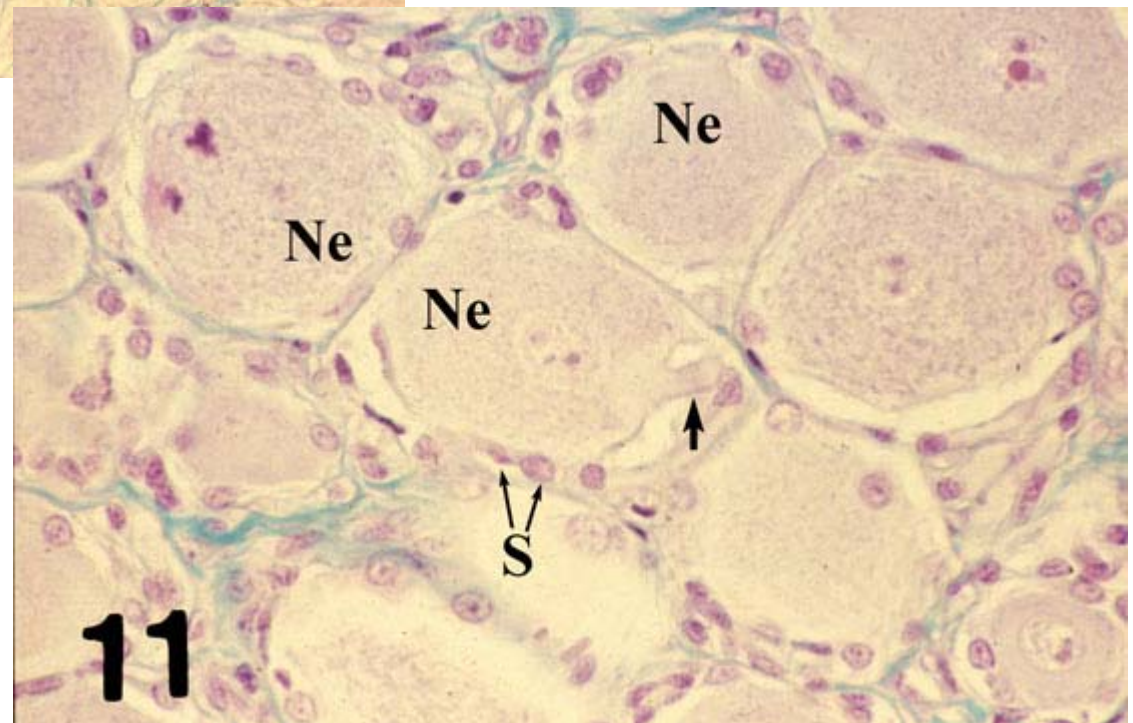
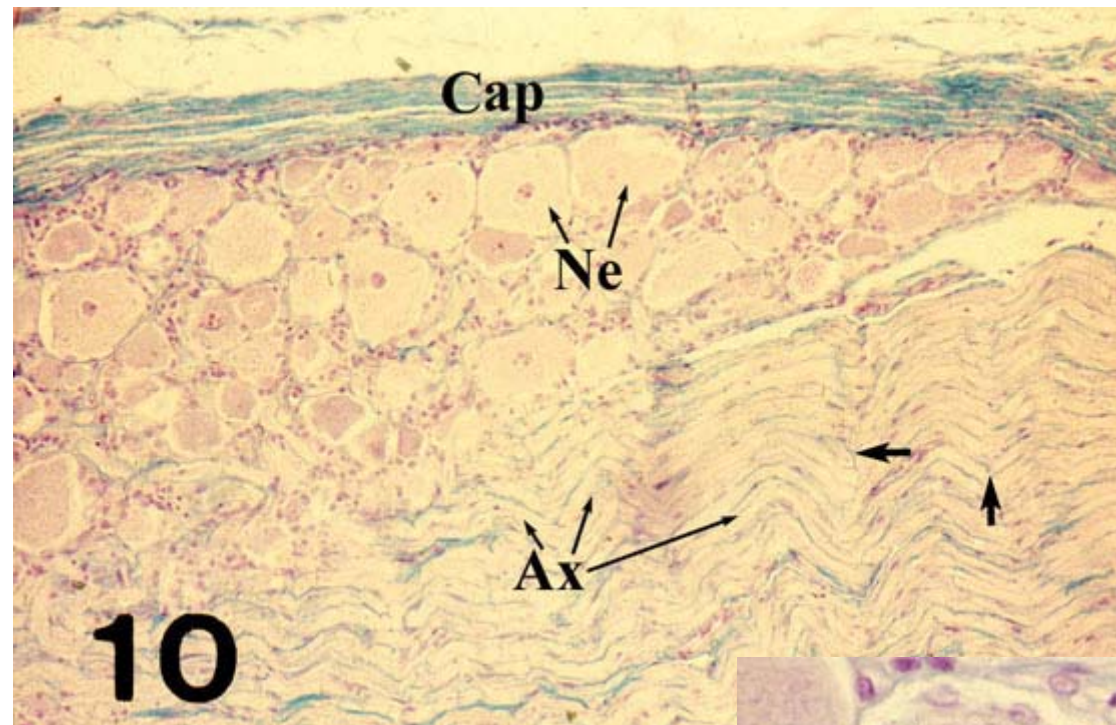


(b) Transverse section of 12 nerve fascicles

Ganglia

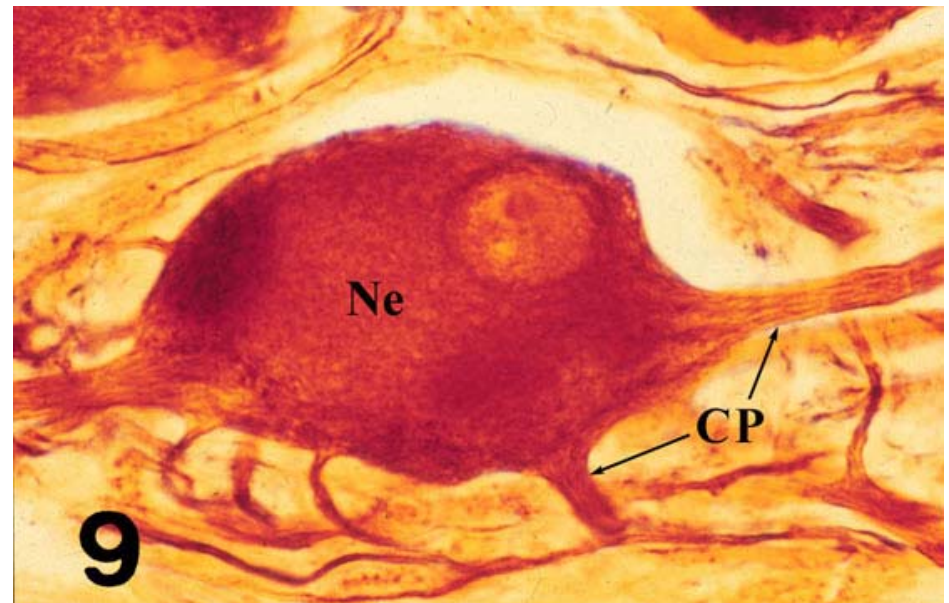
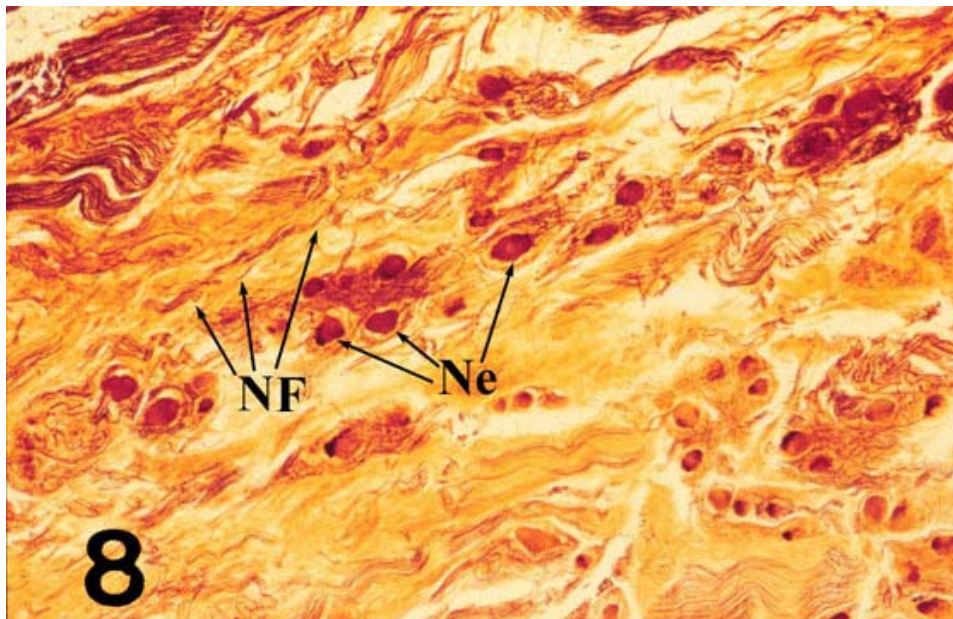
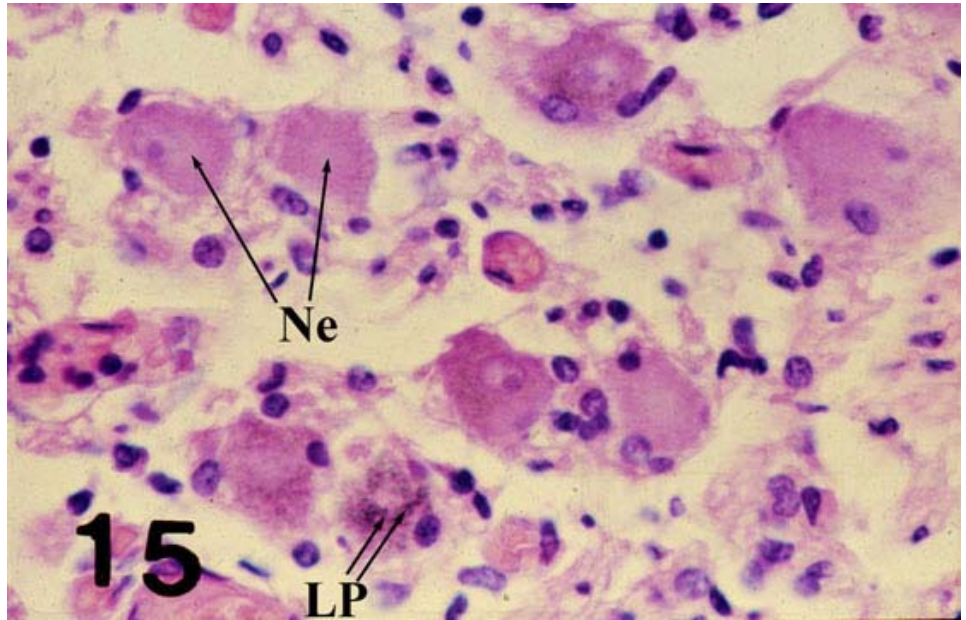
- Dorsal root (sensory) ganglia
 - Nuclei are large, prominent and central
 - Neurons arranged in rows
 - Two population of neurons based on size
 - Large 100 μm diameter
 - Small 10-15 μm diameter
 - Satellite (nurse) cells and well-developed capsule
 - Fixation causes perikaryon to shrink away from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





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

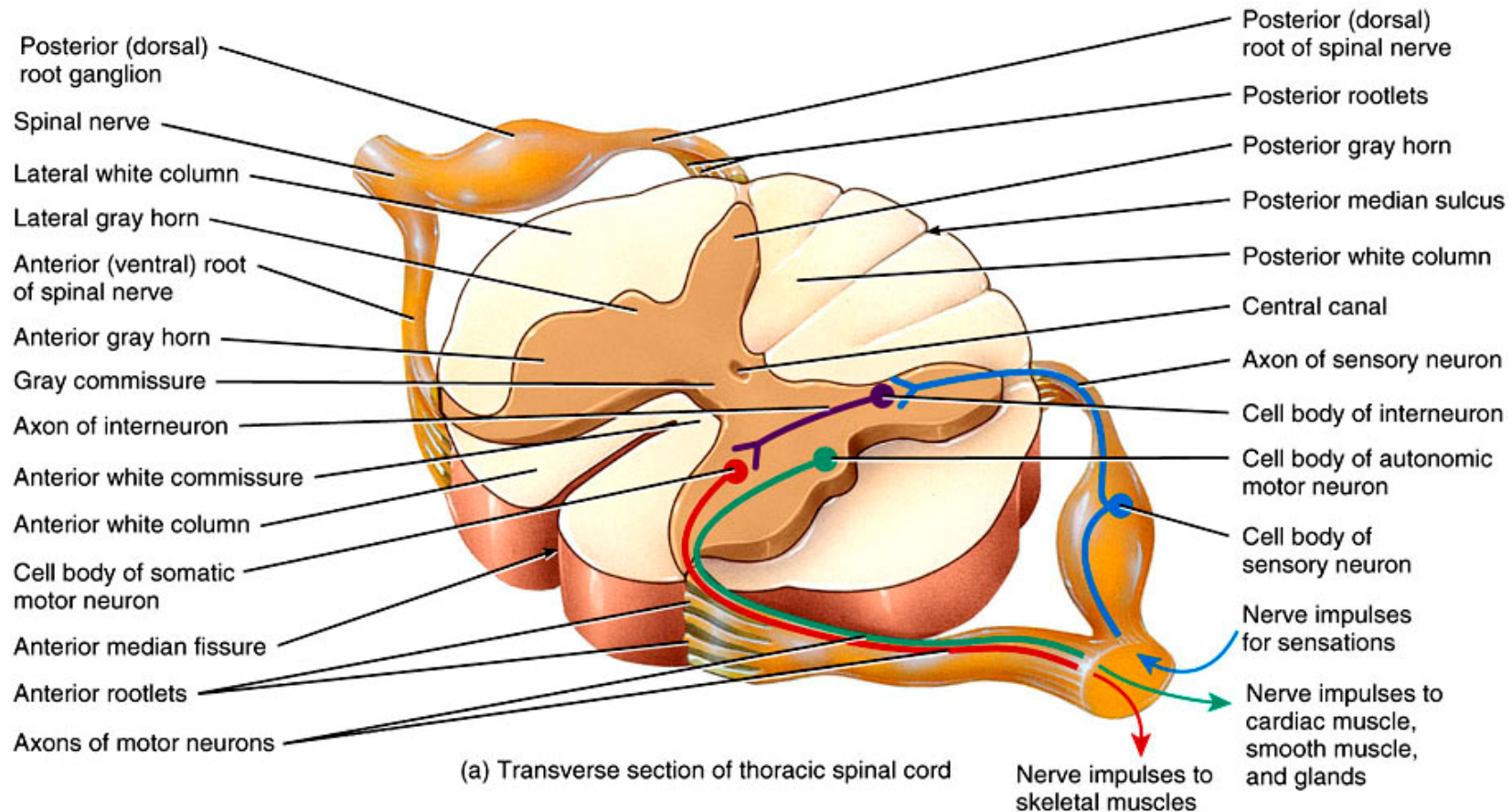


Figure 13.03 Tortora - PAP 12/e

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Internal Anatomy of Spinal Cord

