Introduction to the Nervous System

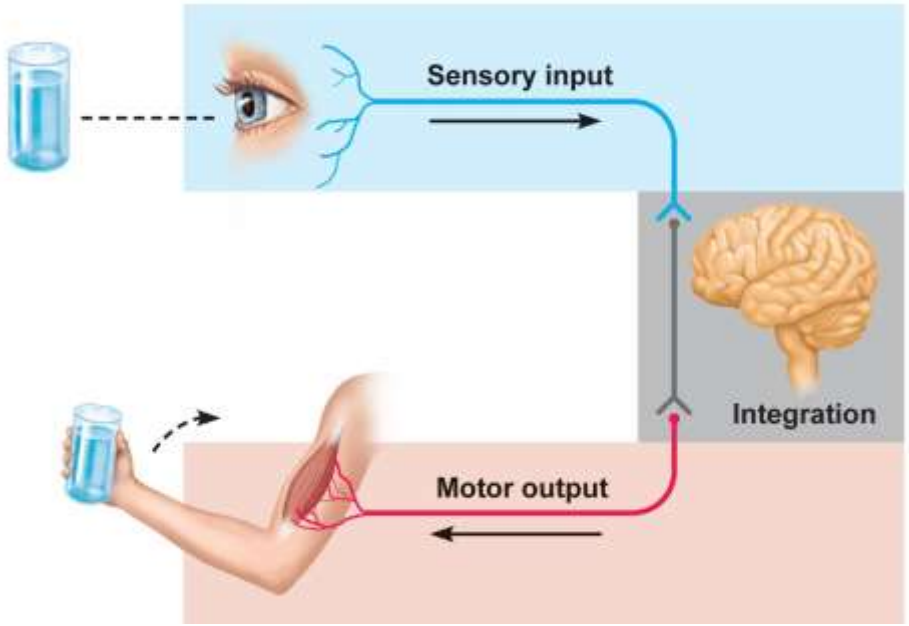
Biology 260

M. Iyengar

Overview of the Nervous System

- The master control and communication system
  - Uses electrical and chemical signals
  - Voluntary and Involuntary communication

Three (3) overlapping functions:

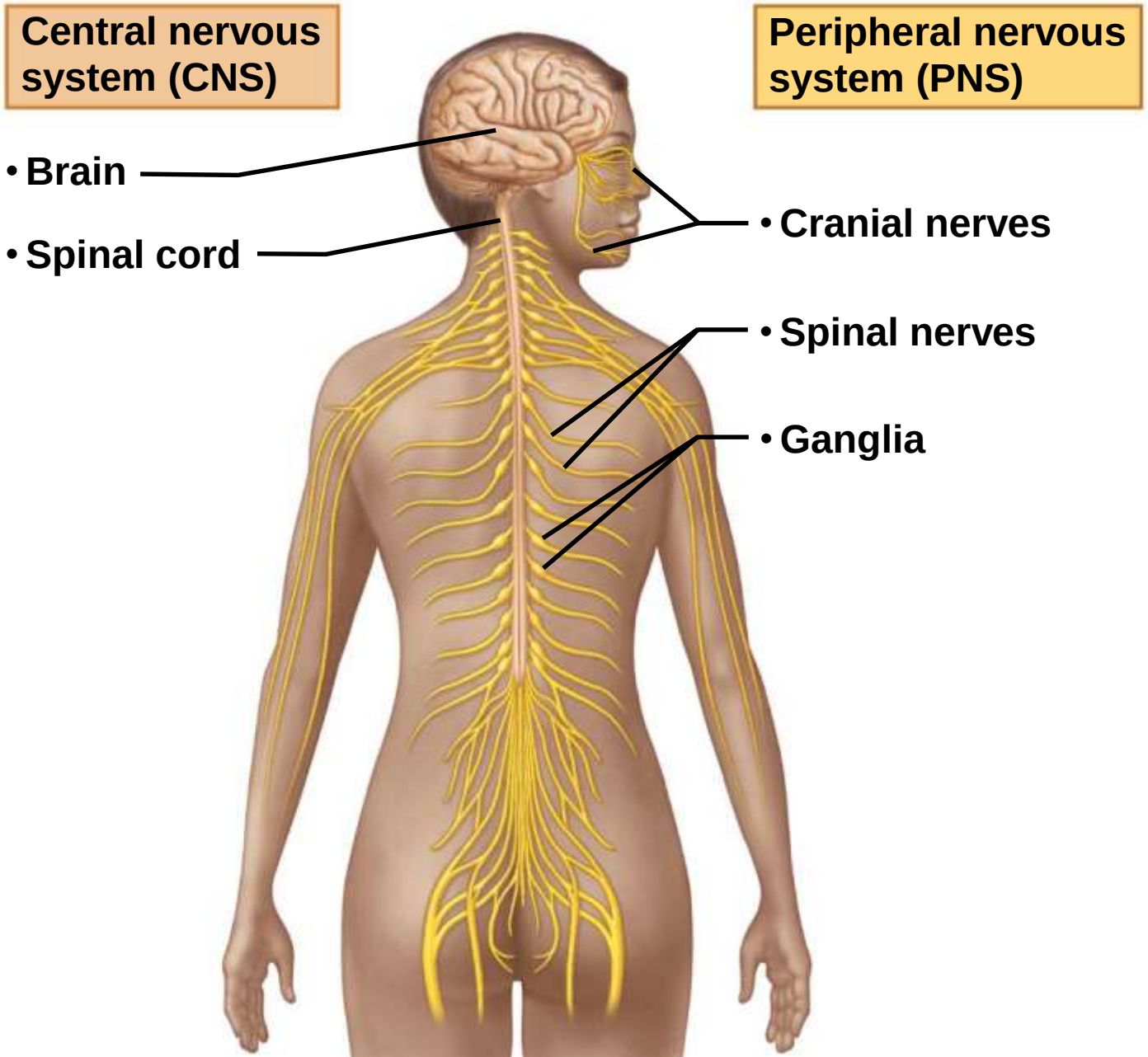


1) **Sensory**

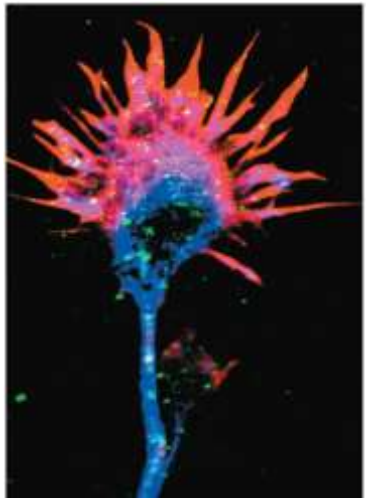
2) **Integration**

3) **Motor**

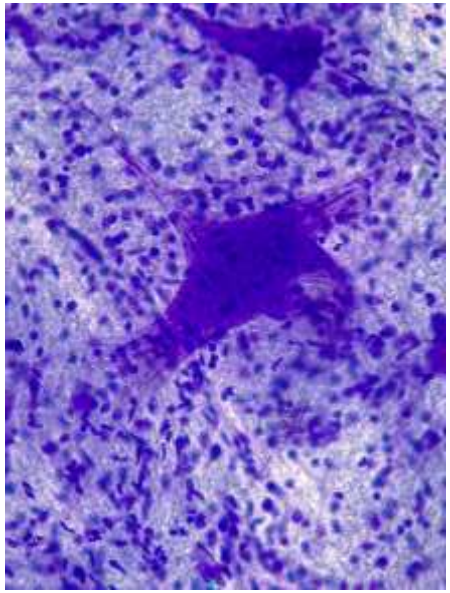
Overview of the Nervous System



Histology of the Nervous System



1. **Neurons** (**nerve cells**): excitable cells that transmit electrical signals
   - Do not divide
   - Require a lot of oxygen and glucose to function
   - respond to stimuli (Excitability)
   - spread electrical signals (Conductivity)
   - release neurotransmitters (Secretion)



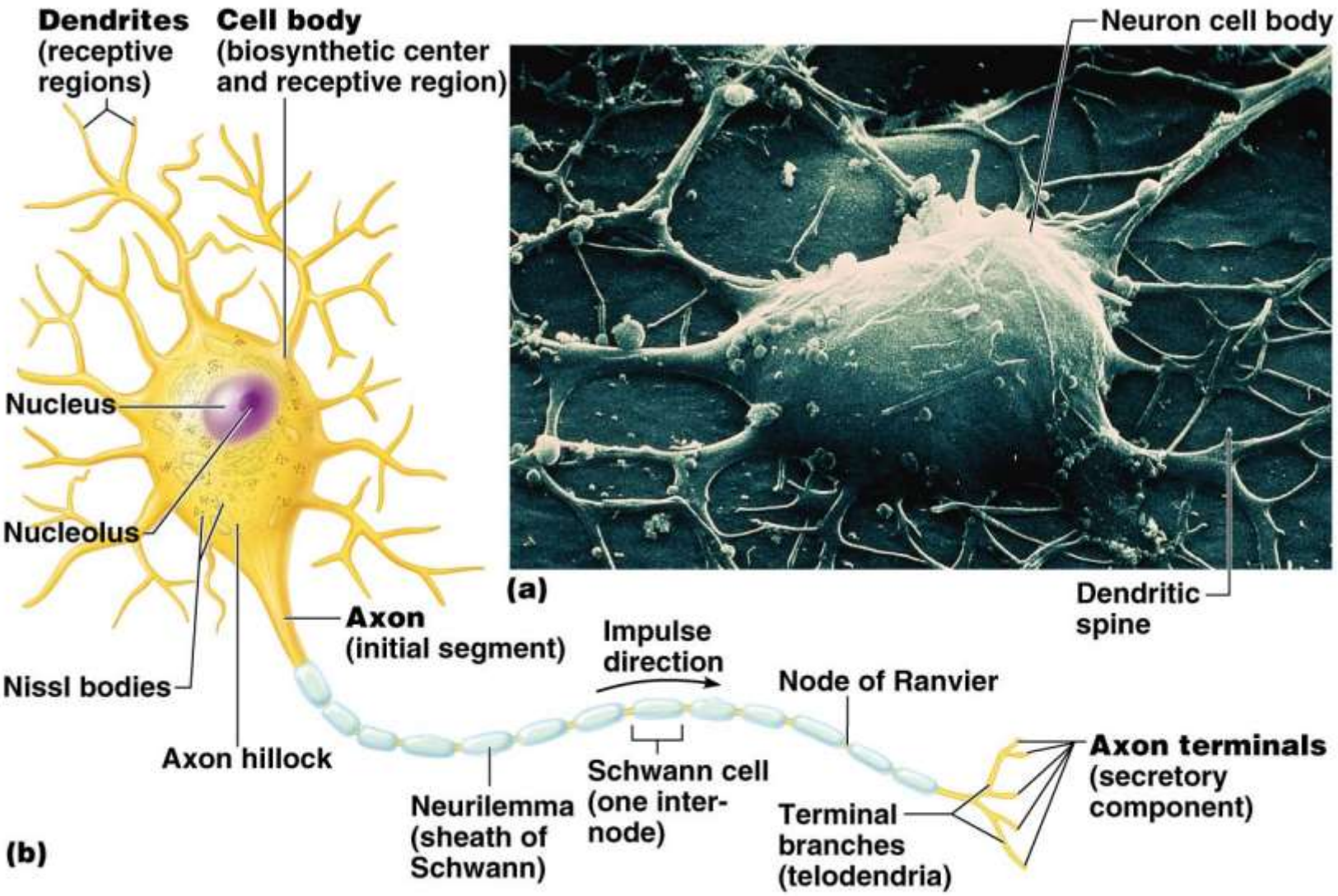
2. **Neuroglia** (**glial cells**): surround, attach, and support neurons.
   - Continue to divide
   - Have different functions

Neuron Anatomy

- **Cell body** (soma or perikaryon)**:**
  - Single nucleus surrounded by cytoplasm & organelles
  - Metabolic center
    - Synthesizes proteins, membranes, neurotransmitters
    - What organelles would be here?

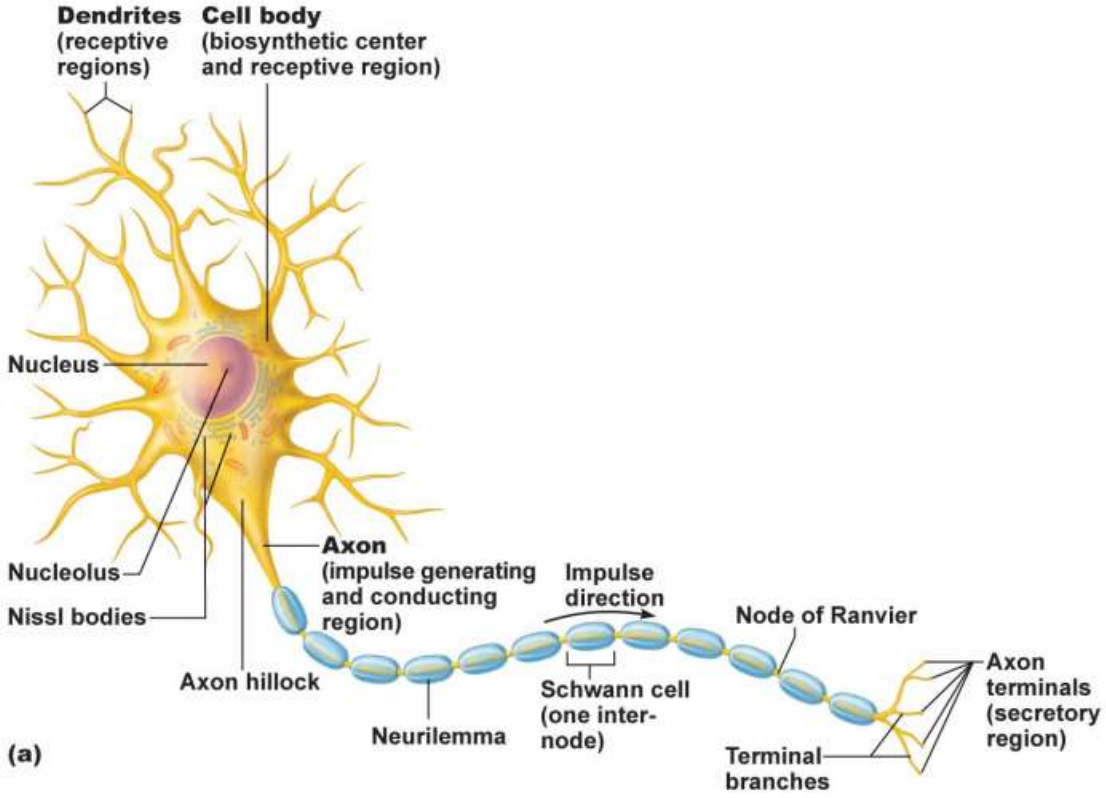
- **Neuron processes:**
  - Arm-like extensions from cell body
  - **Two types:**
    1. Dendrites
    2. Axon

Neuron Anatomy



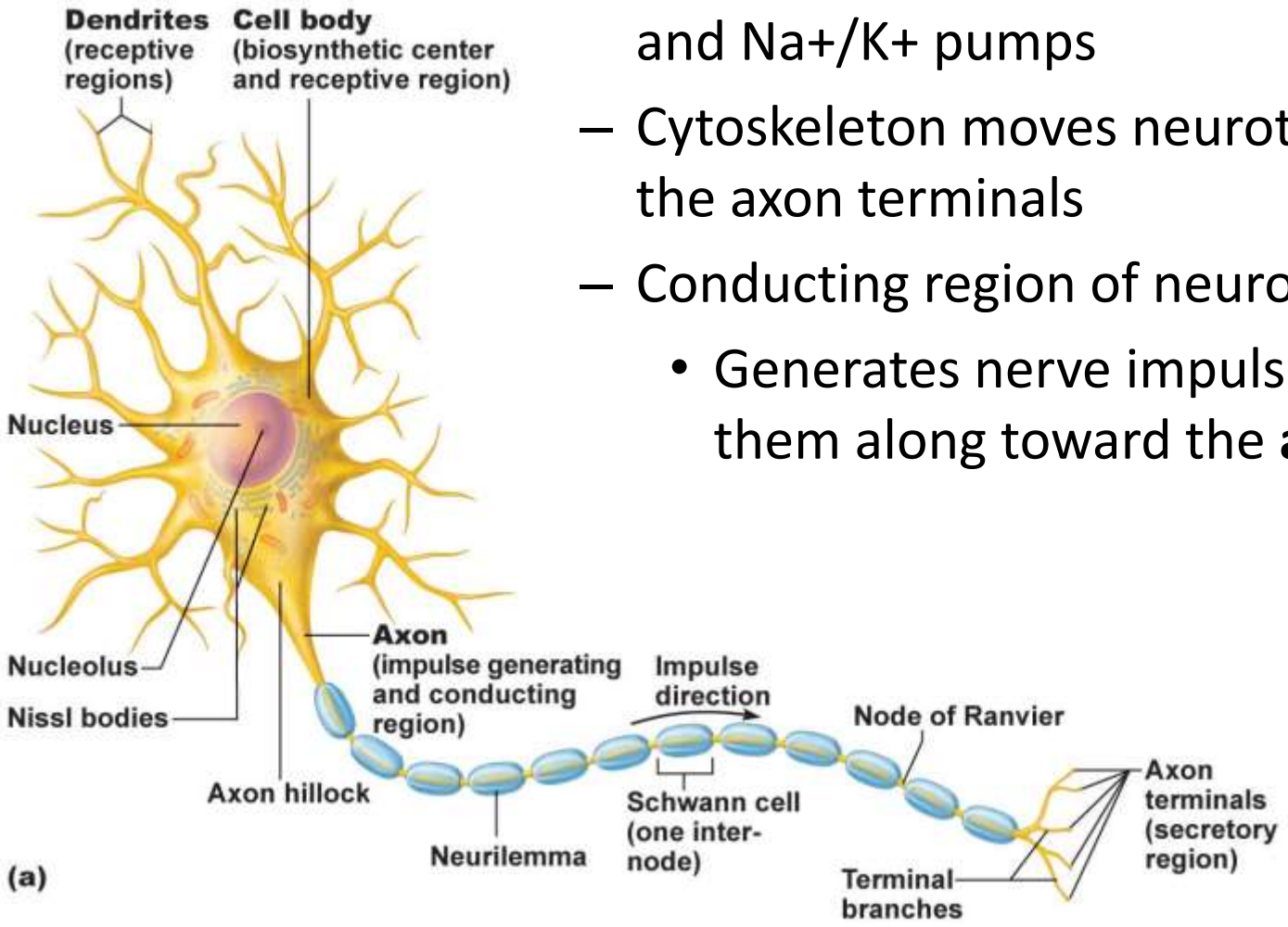
Dendrites

- Branch from the cell body
- Contain all organelles found in cell body
- Receive stimulus & send electrical signals toward the axon



Axon

- Arises from the funnel-shaped area of the cell body = **axon hillock**
- Can be short or long
- Plasma membrane contains ion channels and Na+/K+ pumps
- Cytoskeleton moves neurotransmitters to the axon terminals
- Conducting region of neuron
  - Generates nerve impulses and transmits them along toward the **axon terminus**

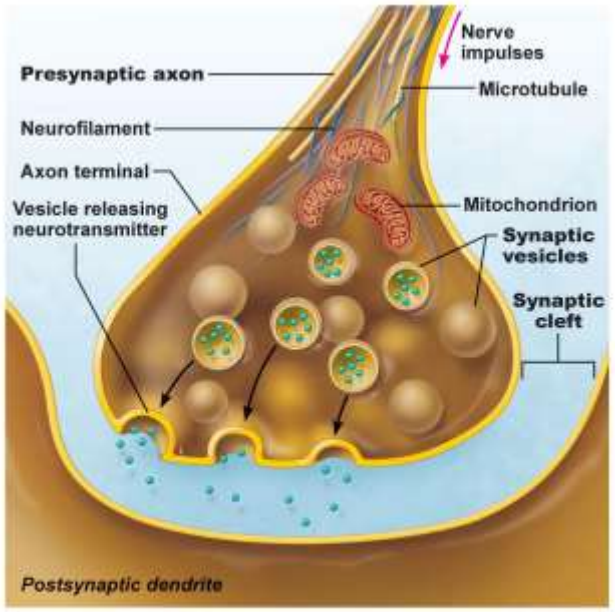


Axon Terminus

- The axon branches at the distal end
  - Each leads to a **synapse**
    - Transfers nerve impulse
      - From one neuron → another neuron
      - From one neuron → an effector cell (muscle, gland)

Types of synapses:

1. **Chemical synapse** – release neurotransmitters
2. **Electrical synapse** – *gap junctions* between cells



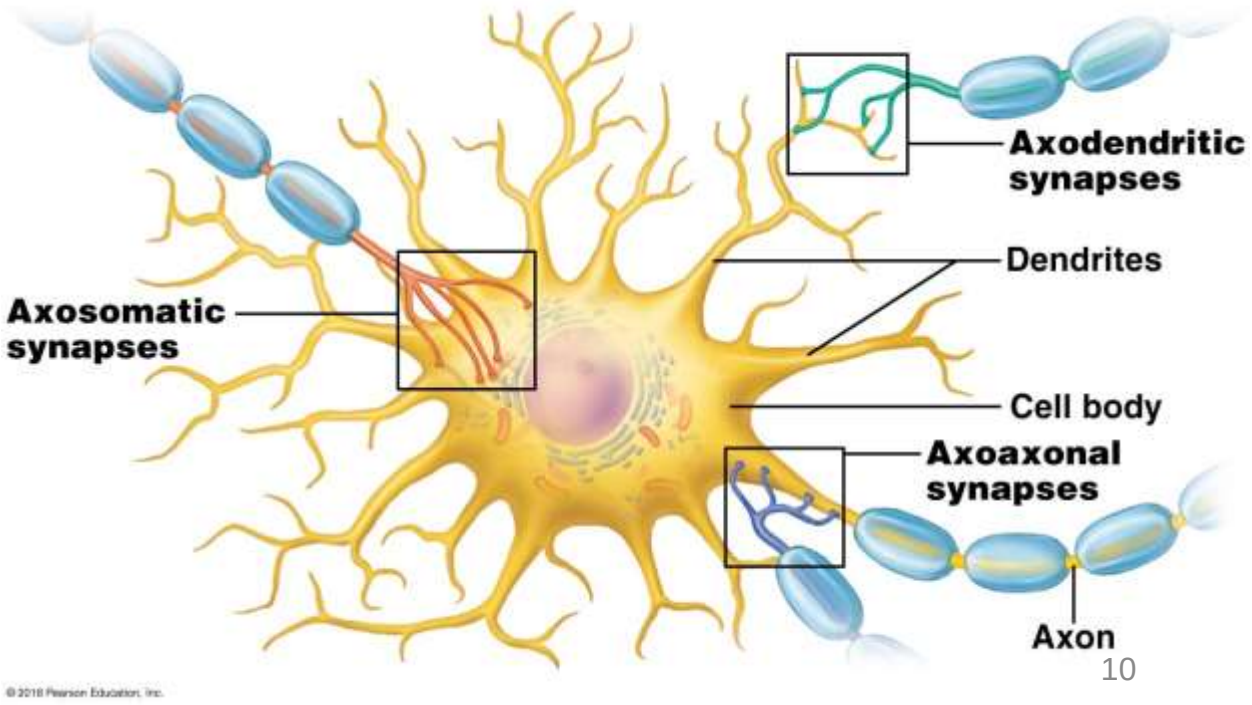
(b) Enlarged view of the synapse

Types of synaptic connections

1. **Axodendritic synapse**:

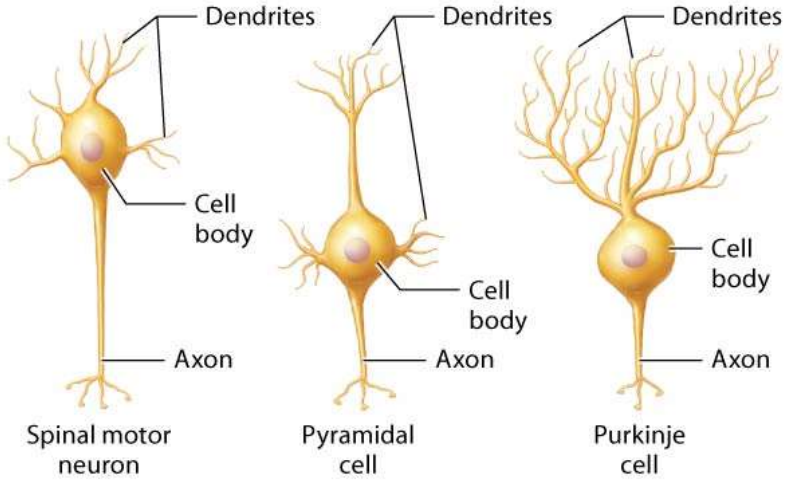
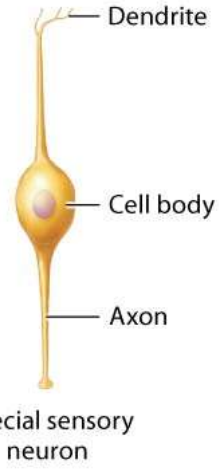
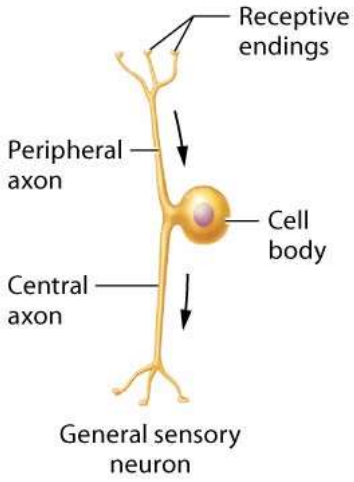
2. **Axosomatic synapse**:

   – Less common connections:
   - Axoaxonal
   - Dendrodendritic
   - Somatodendritic



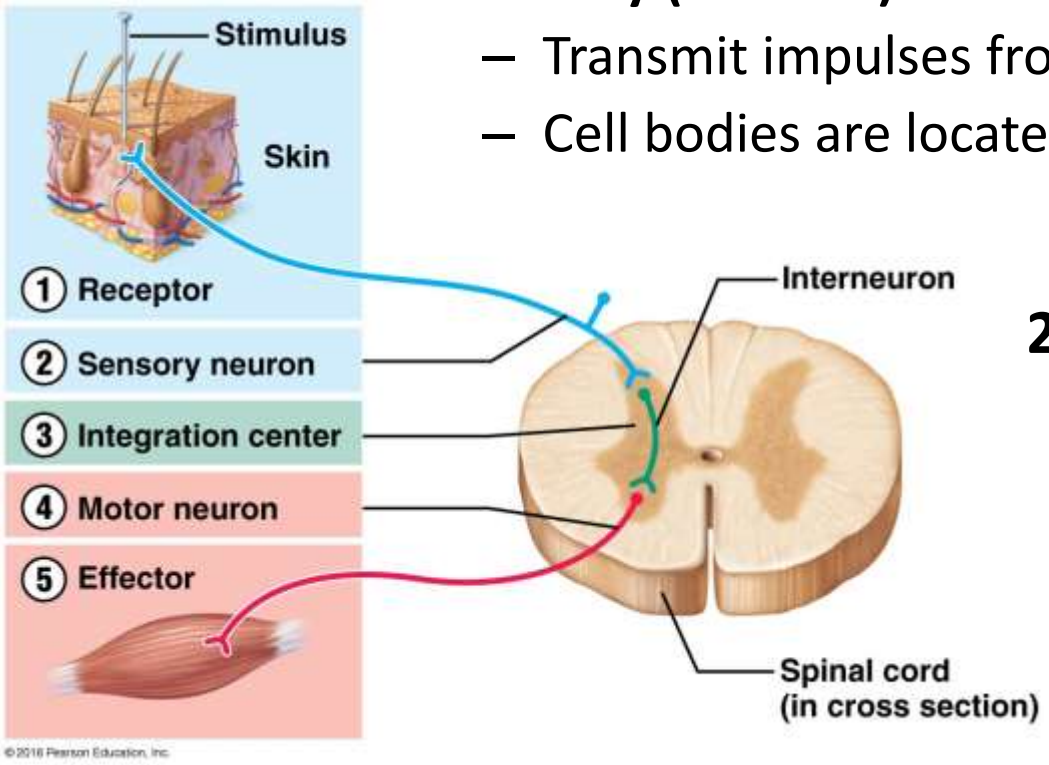
Neuron Classification

Table 11.1 Neuron Classification

Structural Class	Multipolar Neurons	Bipolar Neurons	Pseudounipolar Neurons
Structural Features	One axon with two or more dendrites; typically have highly branched dendritic tree	One axon and one dendrite	Single short process that splits into two axons (no dendrites)
			
Typical Functional Class	Motor (efferent) neurons, interneurons	Sensory (afferent) neurons	Sensory (afferent) neurons
Location	Most neurons in the CNS, motor neurons in the PNS	Special sense organs in the PNS, such as the retina and olfactory epithelium	Sensory neurons in the PNS associated with touch, pain, and vibration sensations

Functional Classification of Neurons

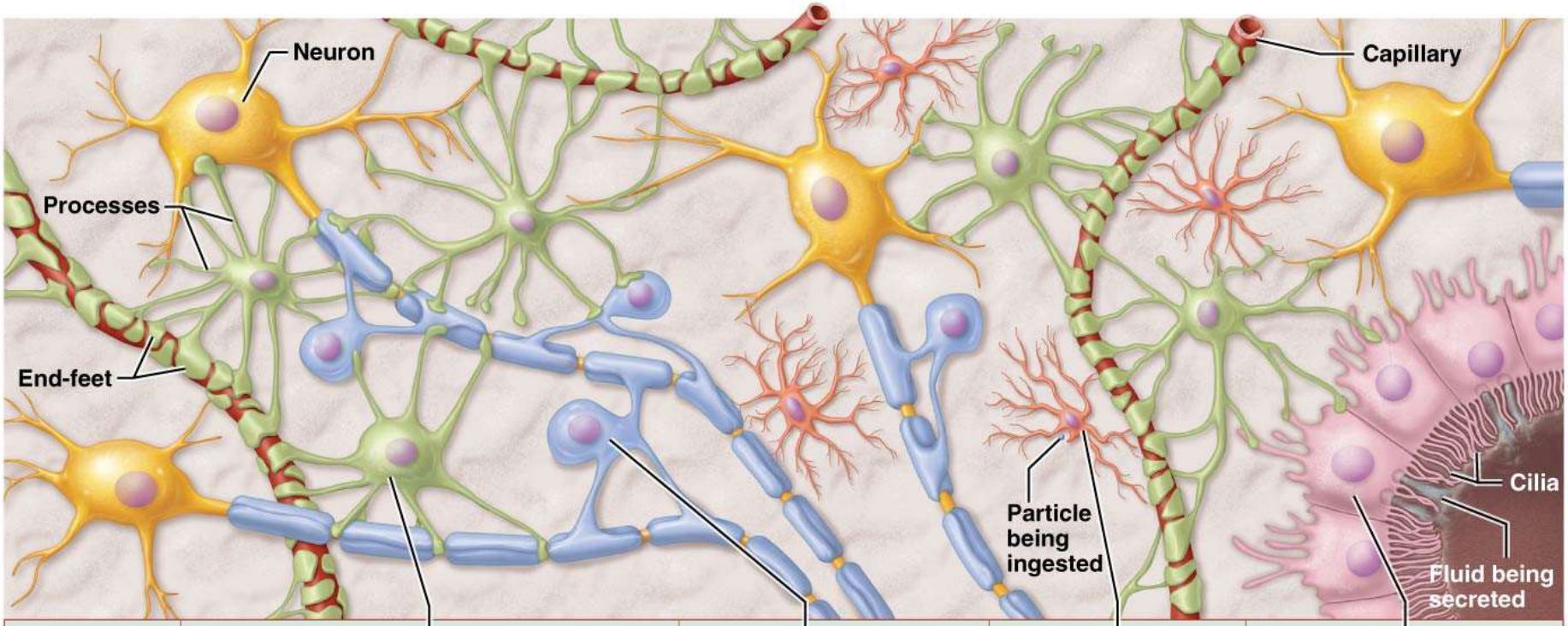
1. **Sensory (afferent)**:
   - Transmit impulses from sensory receptors toward CNS
   - Cell bodies are located in PNS ganglia



2. **Interneurons**: 99% of all the body's neurons
   - Process, store, retrieve, and integrate information
   - Always in CNS, shuttle signals through CNS pathways

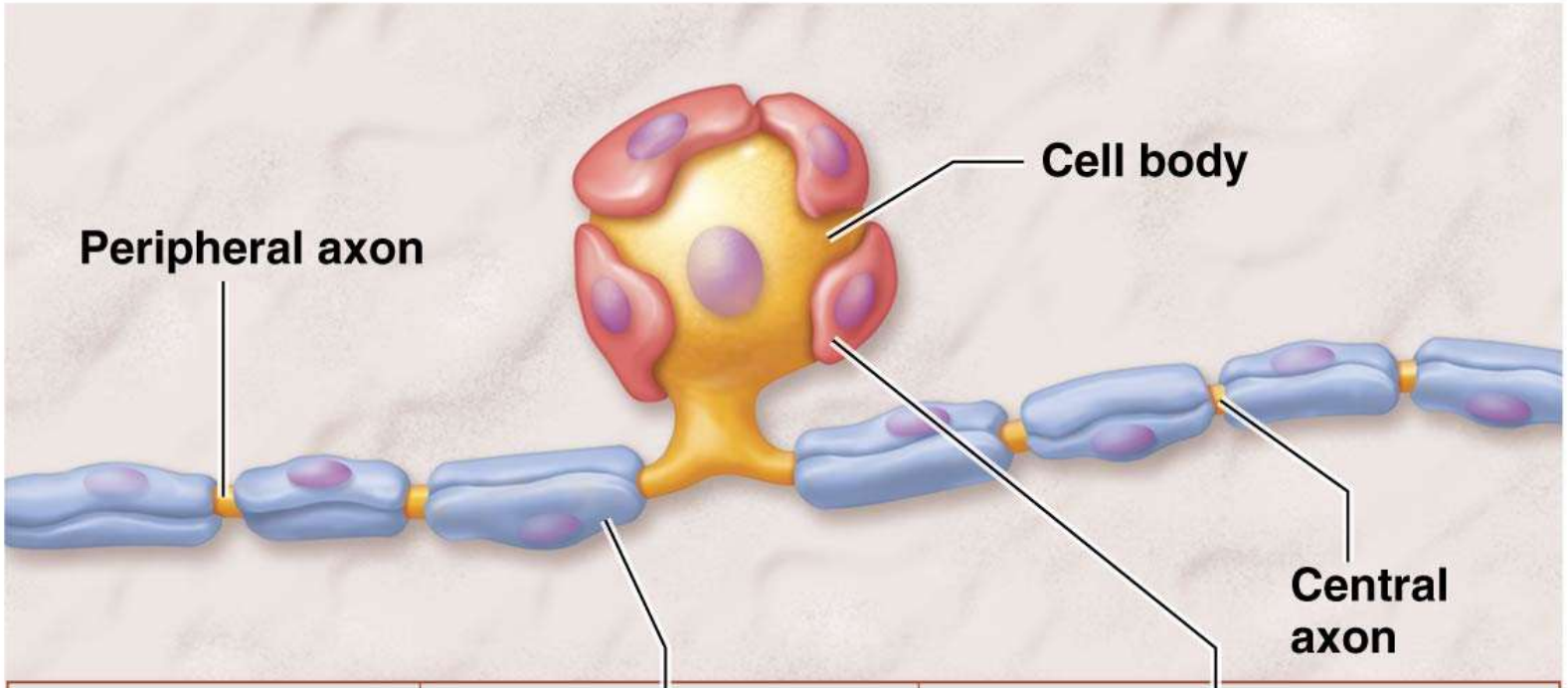
3. **Motor (efferent)**:
   - Carry impulses from CNS to effectors, like muscle or glands.
   - Cell bodies are located in CNS (except some autonomic neurons)

Neuroglia cells of the CNS



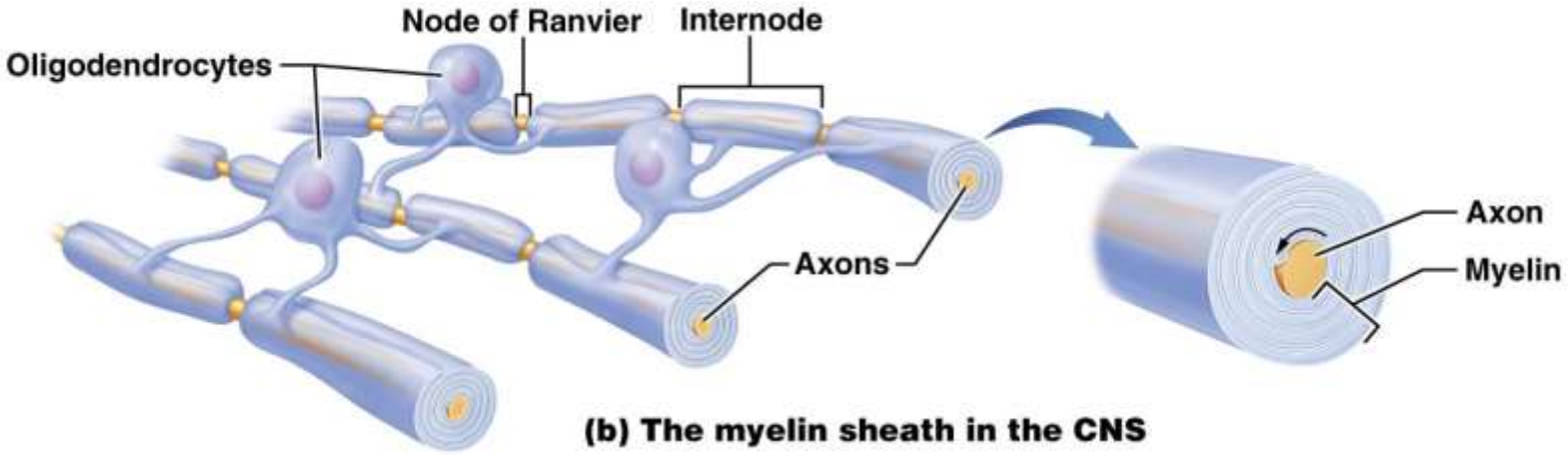
NEUROGLIAL CELL TYPE	ASTROCYTE	OLIGODENDROCYTE	MICROGLIAL CELL	EPENDYMAL CELL
FUNCTION	• Anchor neurons and blood vessels • Regulate the extracellular environment • Facilitate the formation of the blood-brain barrier • Repair damaged tissue	• Myelinate certain axons in the CNS	• Act as phagocytes	• Line cavities • Cilia circulate fluid around brain and spinal cord • Some secrete this fluid

Neuroglia cells of the PNS

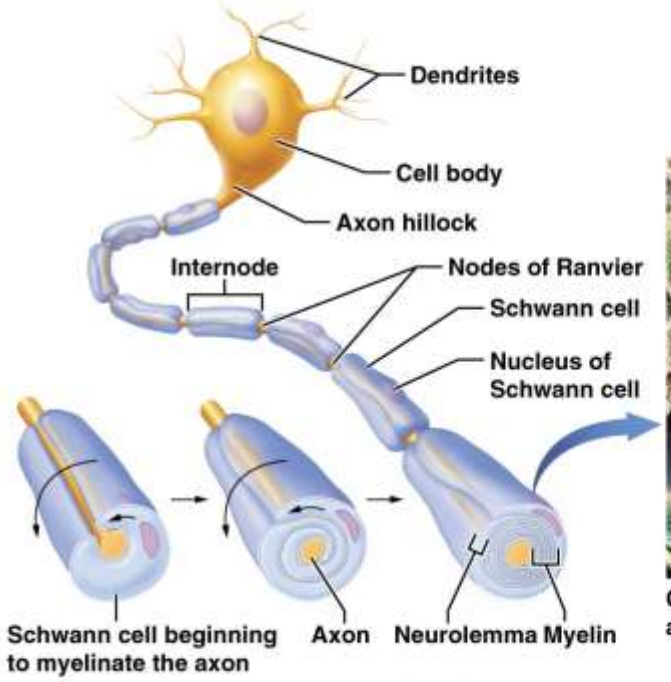


NEUROGLIAL CELL TYPE	SCHWANN CELL	SATELLITE CELL
FUNCTION	• Myelinate certain axons in the PNS	• Surround and support cell bodies

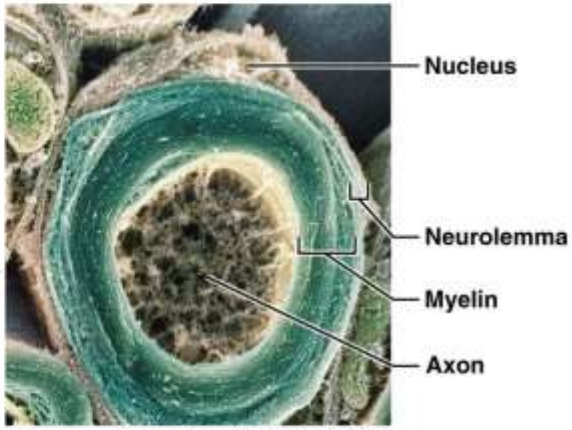
Myelin sheath in the CNS vs PNS



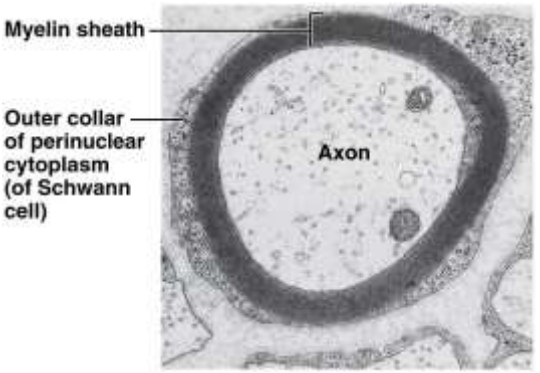
(b) The myelin sheath in the CNS



(a) The myelin sheath and myelination in the PNS



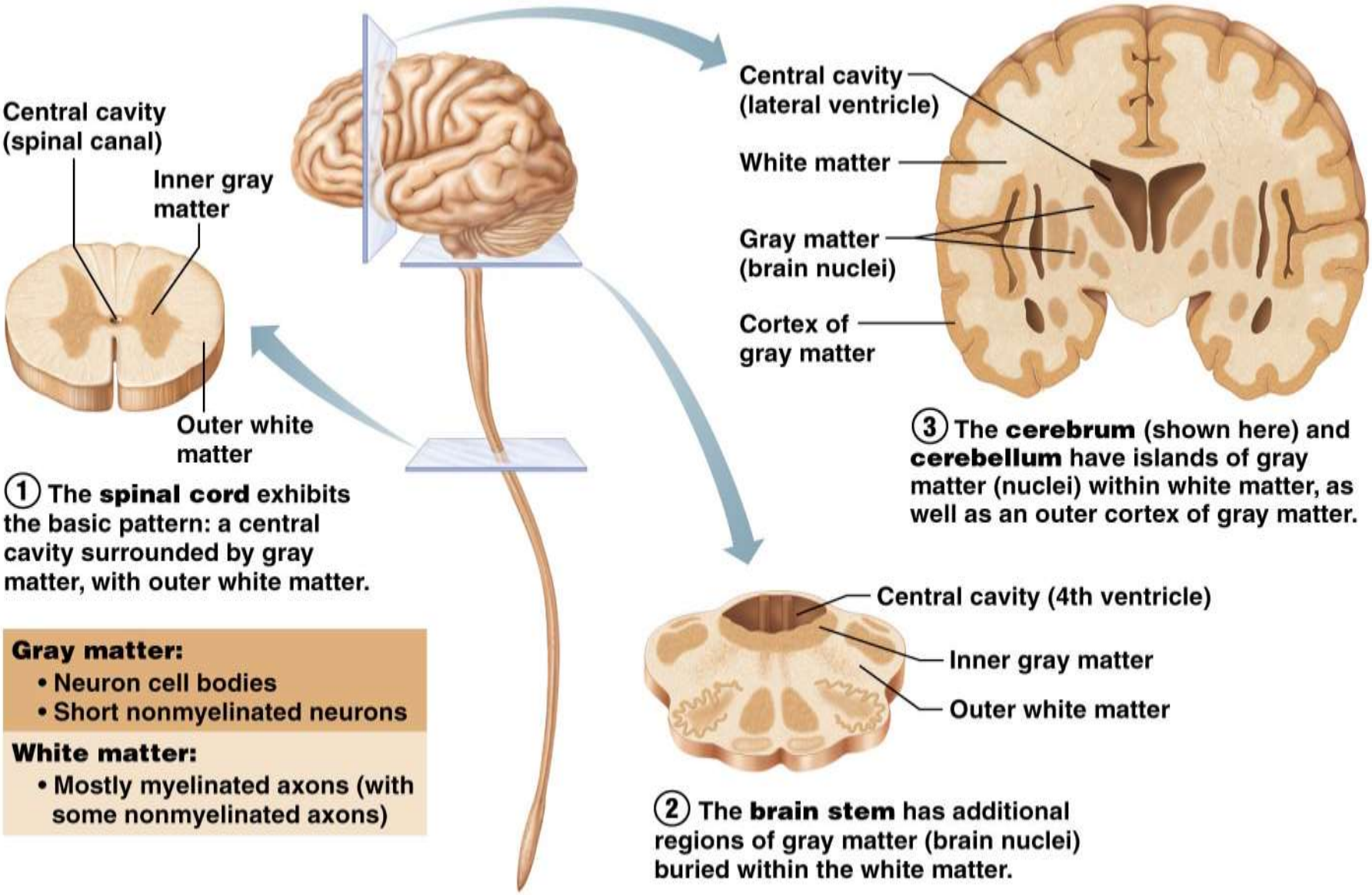
Cross-section of a myelin sheath SEM (30,700×)



Nervous Tissue Collections

Feature	CNS	PNS
Neuroglial that makes the **myelin sheath** =	**O**ligodendrocytes	**S**chwann Cells
	Think CO-PS	
Collection of **axons** =	Nerve tracts	Peripheral nerves
Collection of **cell bodies** =	Nuclei (singular = nucleus)	Ganglia (singular = ganglion)

Nervous Tissue Collections of the CNS



① The **spinal cord** exhibits the basic pattern: a central cavity surrounded by gray matter, with outer white matter.

Gray matter:
- Neuron cell bodies
- Short nonmyelinated neurons

White matter:
- Mostly myelinated axons (with some nonmyelinated axons)

② The **brain stem** has additional regions of gray matter (brain nuclei) buried within the white matter.

③ The **cerebrum** (shown here) and **cerebellum** have islands of gray matter (nuclei) within white matter, as well as an outer cortex of gray matter.

Check your understanding

- What neuroglial cells are associated with the brain and spinal cord? Peripheral nerves?
- What are the three types of neurons found in the body?
  - Draw each and then explain what functional category it would belong to.

- Nervous system disorders
  - **Multiple sclerosis (MS):** Degradation of the myelin sheath
    - Which part of neuron is myelinated? Why should this part be insulated with myelin?
    - What might result in the body if the myelin sheath deteriorates?