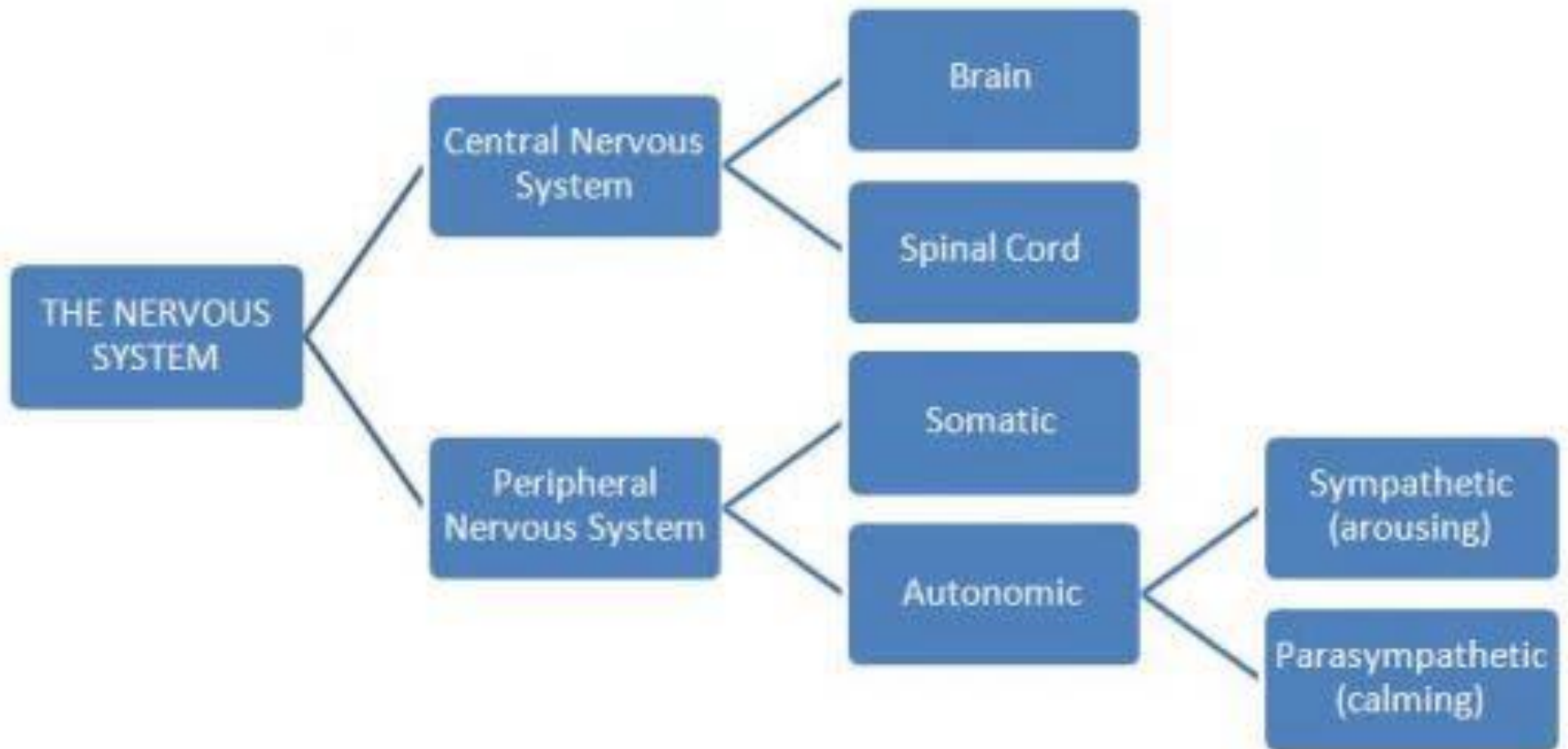


STRUCTURAL ARRANGEMENT OF THE NERVOUS SYSTEM

IVANA HRADILOVÁ SVÍŽENSKÁ

Nervous system

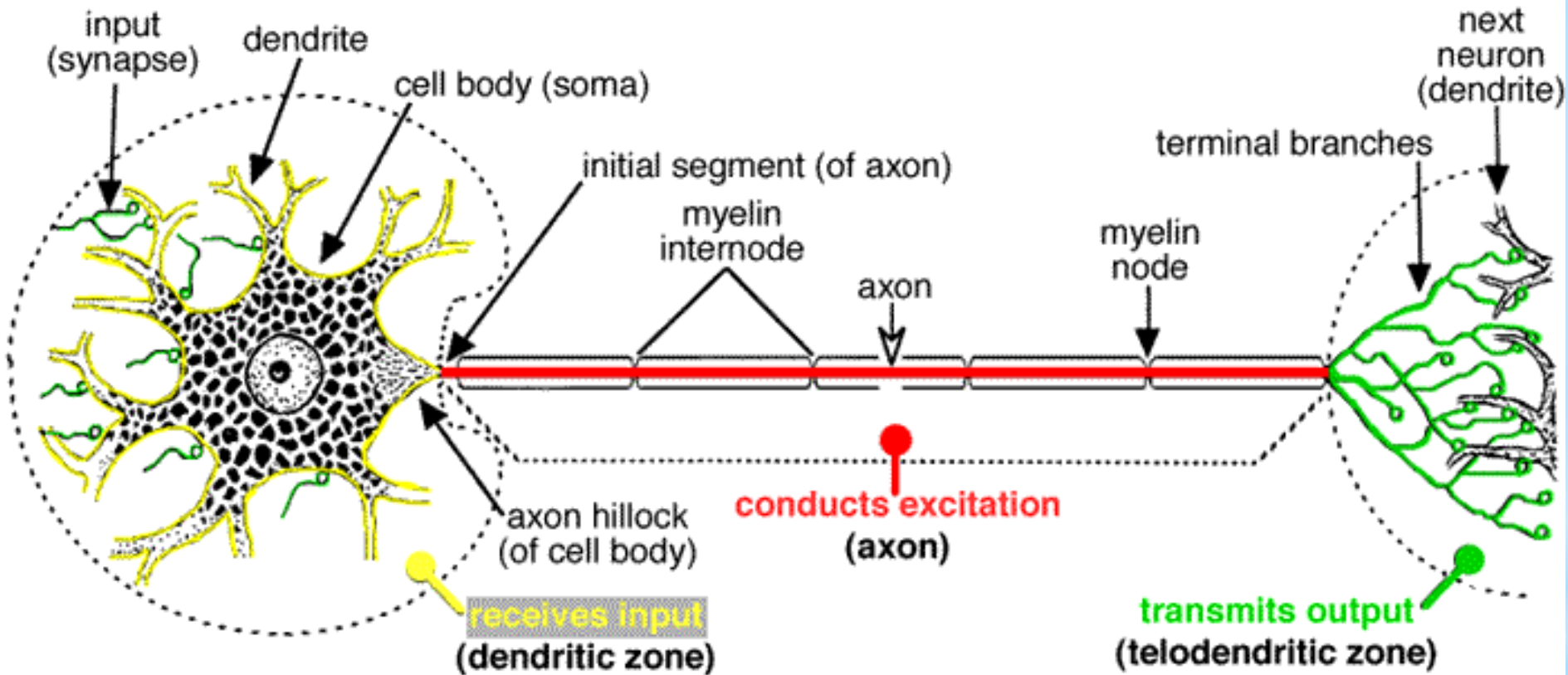
- organ system containing a network of specialized cells (neurons and glia) that coordinate the actions of an organism and transmit signals between different parts of its body



Nervous tissue

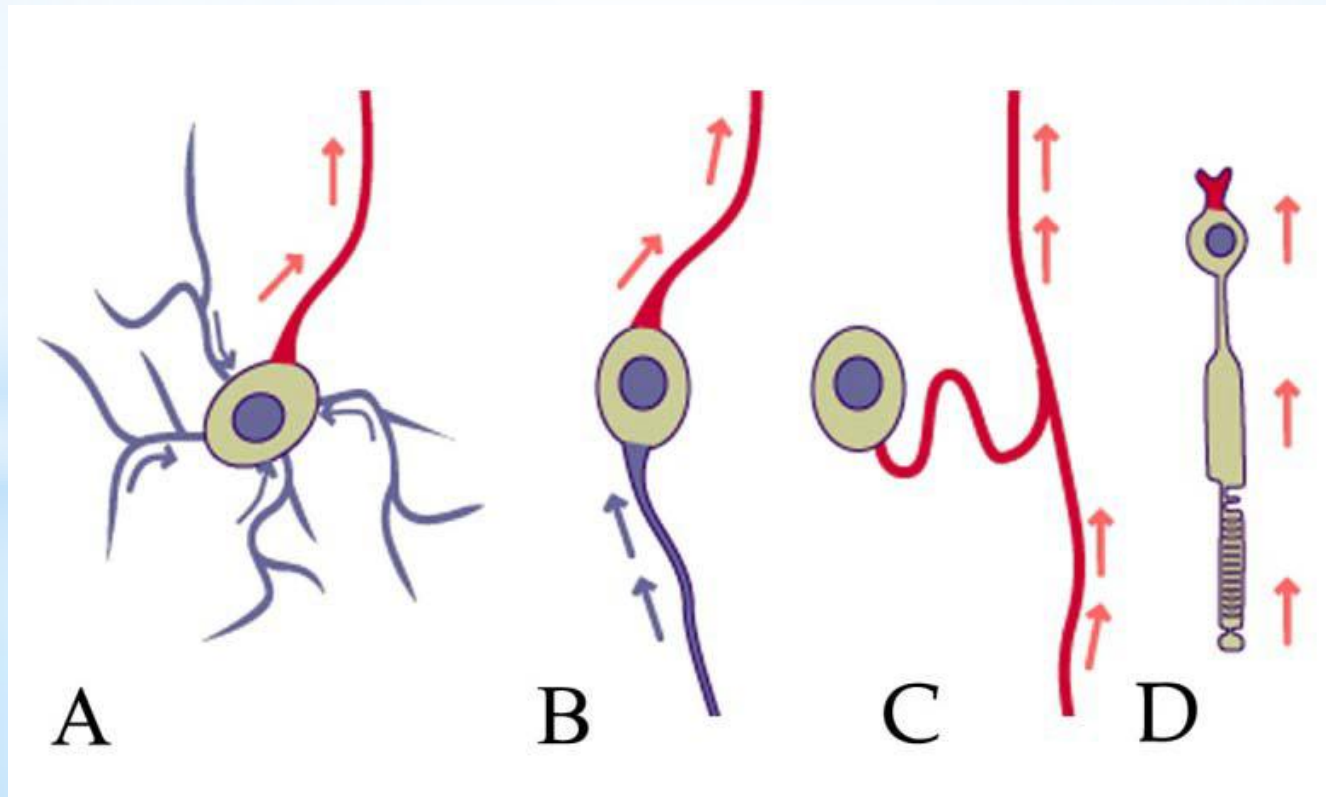
- one of four major classes of vertebrate tissue
- composed of
 - neurons - transmit impulses
 - glial cells - assist propagation of the nerve impulse as well as provide nutrients to the neuron

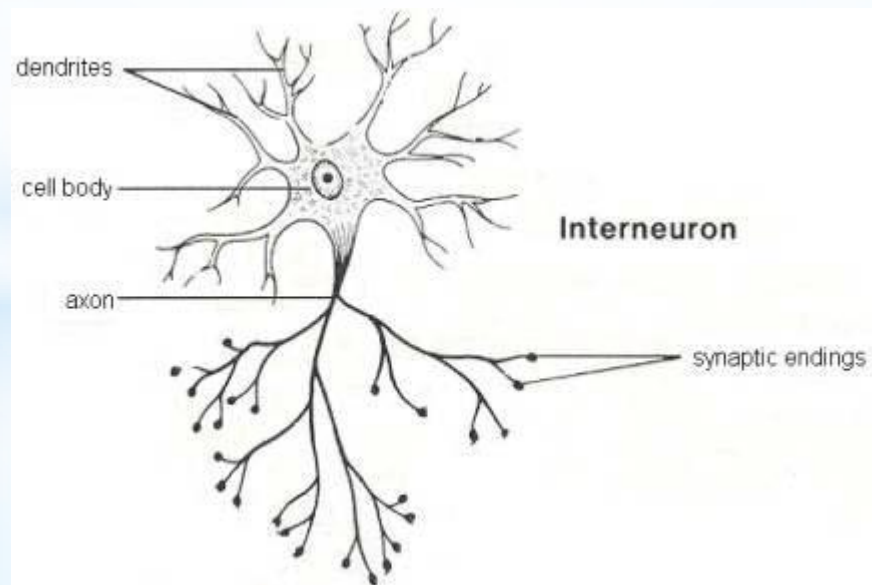
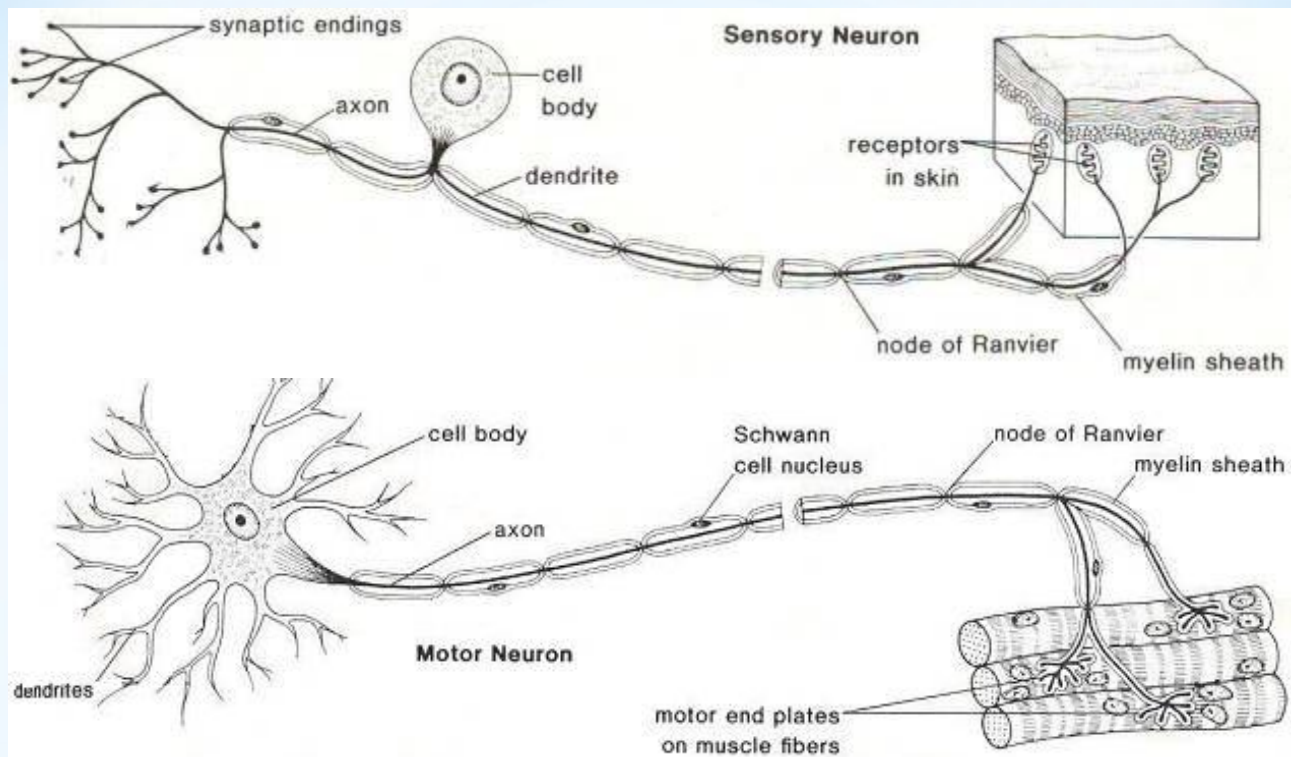
Zones of a neuron



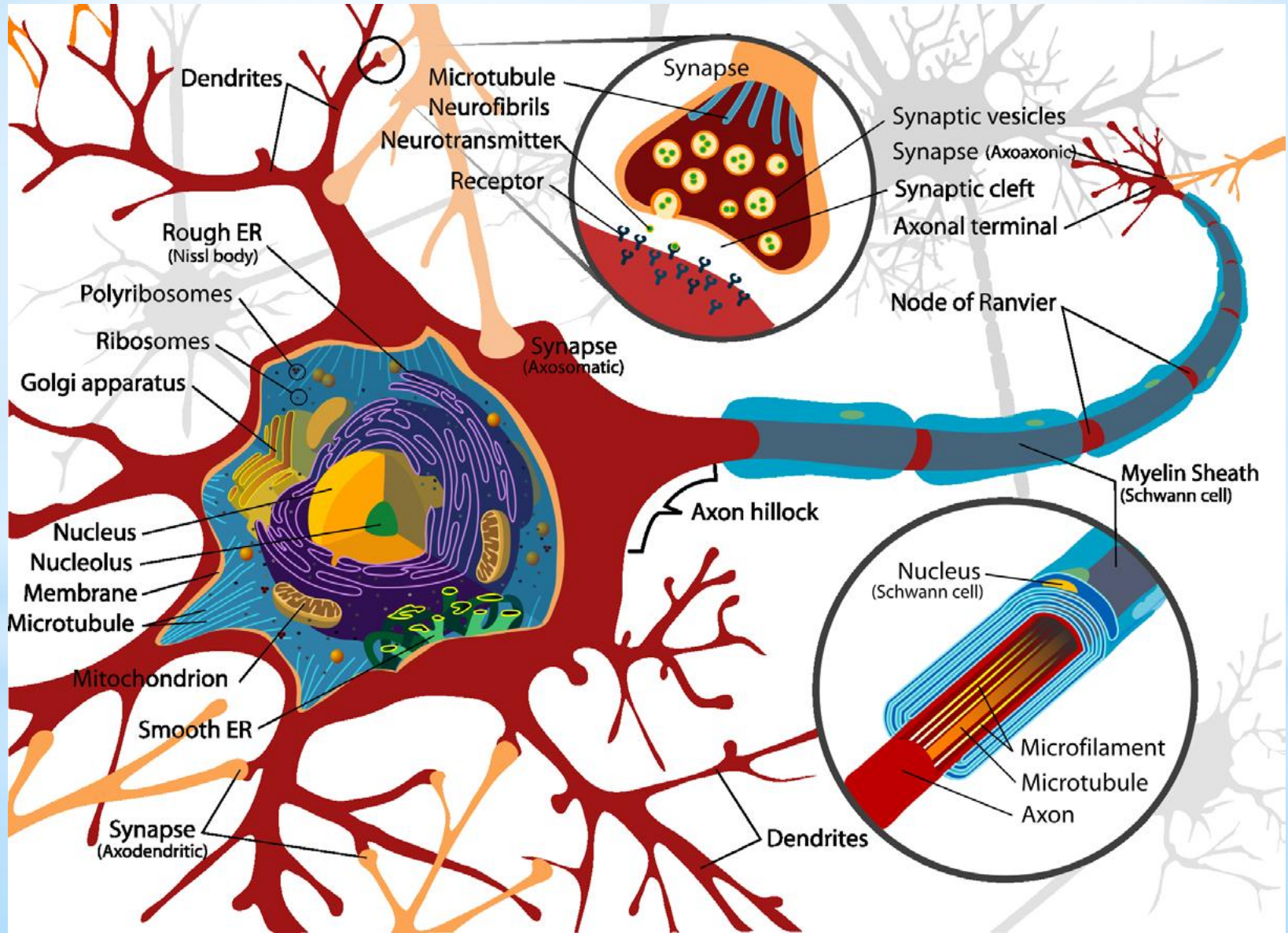
Structural classification of neurons:

- A. multipolar neurons
- B. bipolar neurons
- C. pseudounipolar neurons
- D. unipolar neurons





Neuron



Cytoskeleton

- a complex internal scaffold of protein filaments and tubules and their associated proteins.
1. neurotubules - 20-25 nm in diameter
 2. neurofilaments - 10 nm in diameter
 3. actin microfilaments - 5 nm in diameter

Axoplasmic transport

- a distribution of many substances and organelles through the cytoplasm to and from the neuronal body

axoplasm = cytoplasm of the axon

Axoplasmic transport

- turnover of membranous and skeletal materials
- movement of neurotransmitters to the synapses
- recognition of the surroundings
- not changed during the conduction of nerve impulses

Axoplasmic transport

- Speed

- fast rate >100 mm/day (i.e., hundreds of mm/day)
- slow rate < 10 mm/day

- Direction

- anterograde movement from the cell body to the terminals
fast+ slow
- retrograde movement toward the cell body
fast

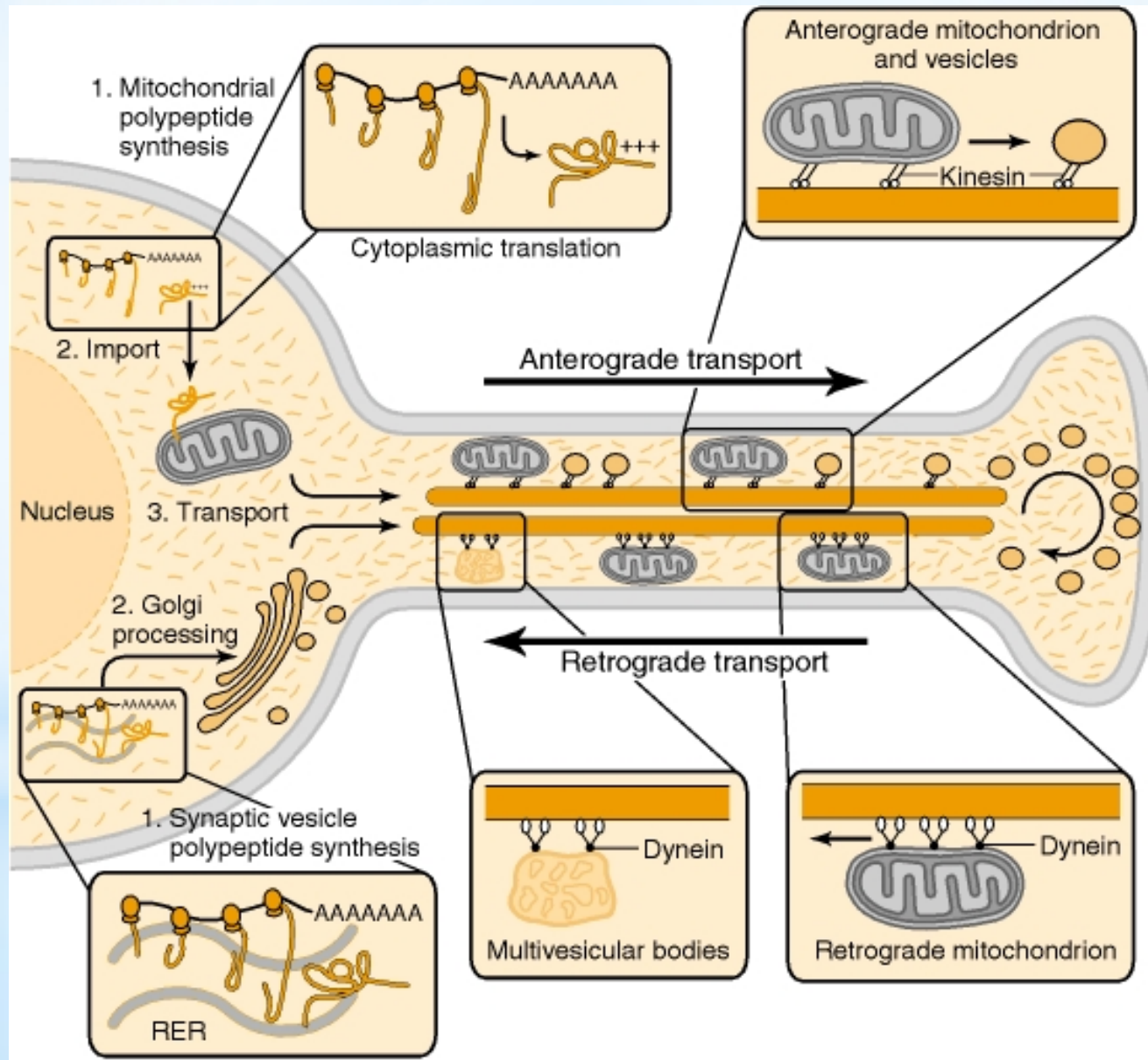
Anterograde transport

- **Rapid** (at a speed of 300-400 mm/day)
 - Synaptic vesicles, transmitters, mitochondria, lipids and proteins of the plasma membrane
- **Slow** (at 5-10 mm/day)
 - skeletal elements, proteins and other substances to renew and maintain the axoplasm, soluble enzymes

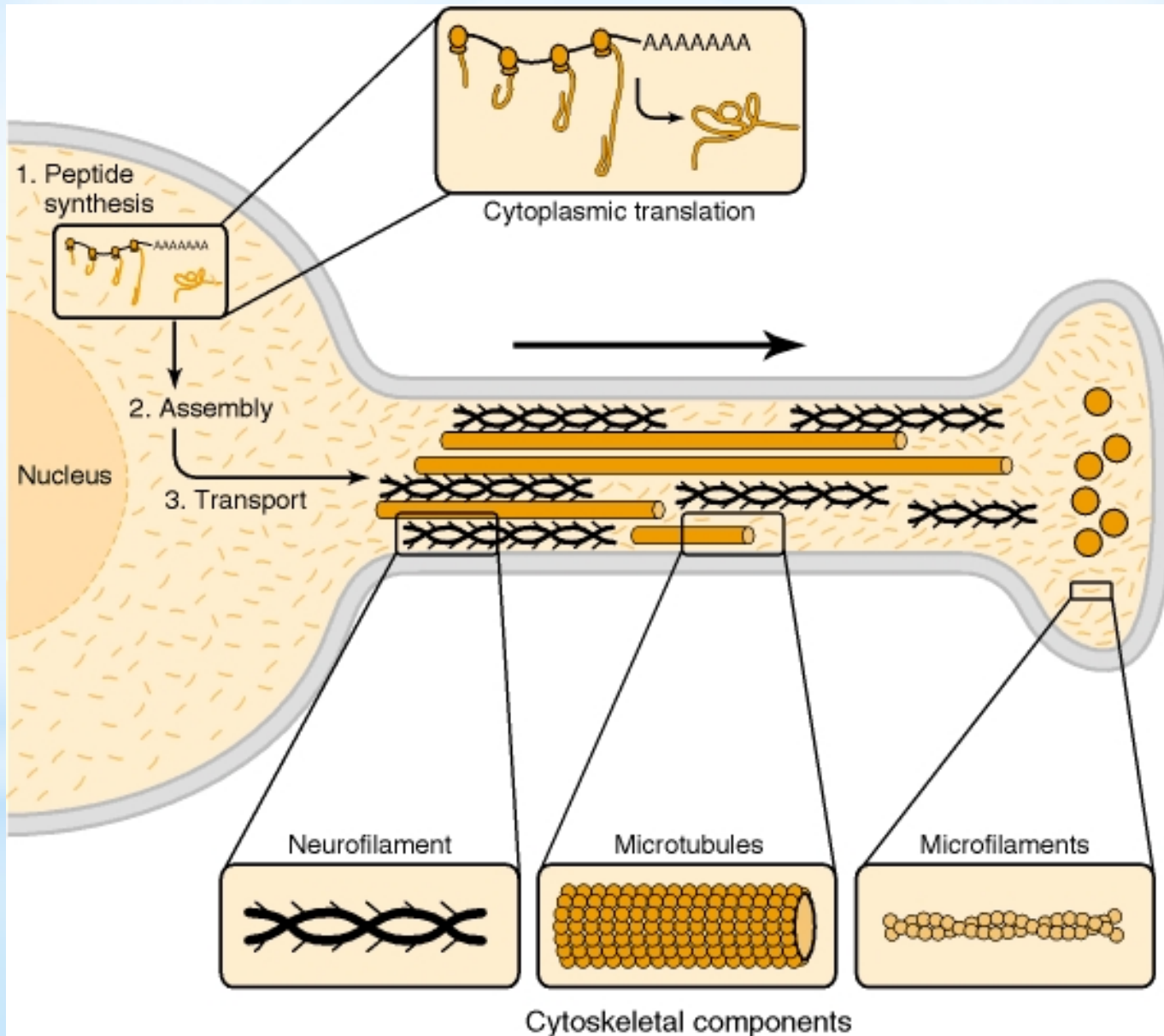
Retrograde transport

- **Rapid** (at a speed of 150-200 mm/day)
 - transport of exhausted organelles and old membrane constituents (e.g. receptors, ...)
 - transport of trophic and other signalling molecules from the periphery to the neuronal body
 - some neurotropic viruses such as poliomyelitis, herpes, and rabies and neurotoxins enter peripheral nerve endings and ascend to infect the cell body via retrograde transport

Fast axonal transport



Slow axonal transport



Glial cells

PNS (neural crest)

- Schwann cells
- satellite glial cells
- enteric glial cells

CNS

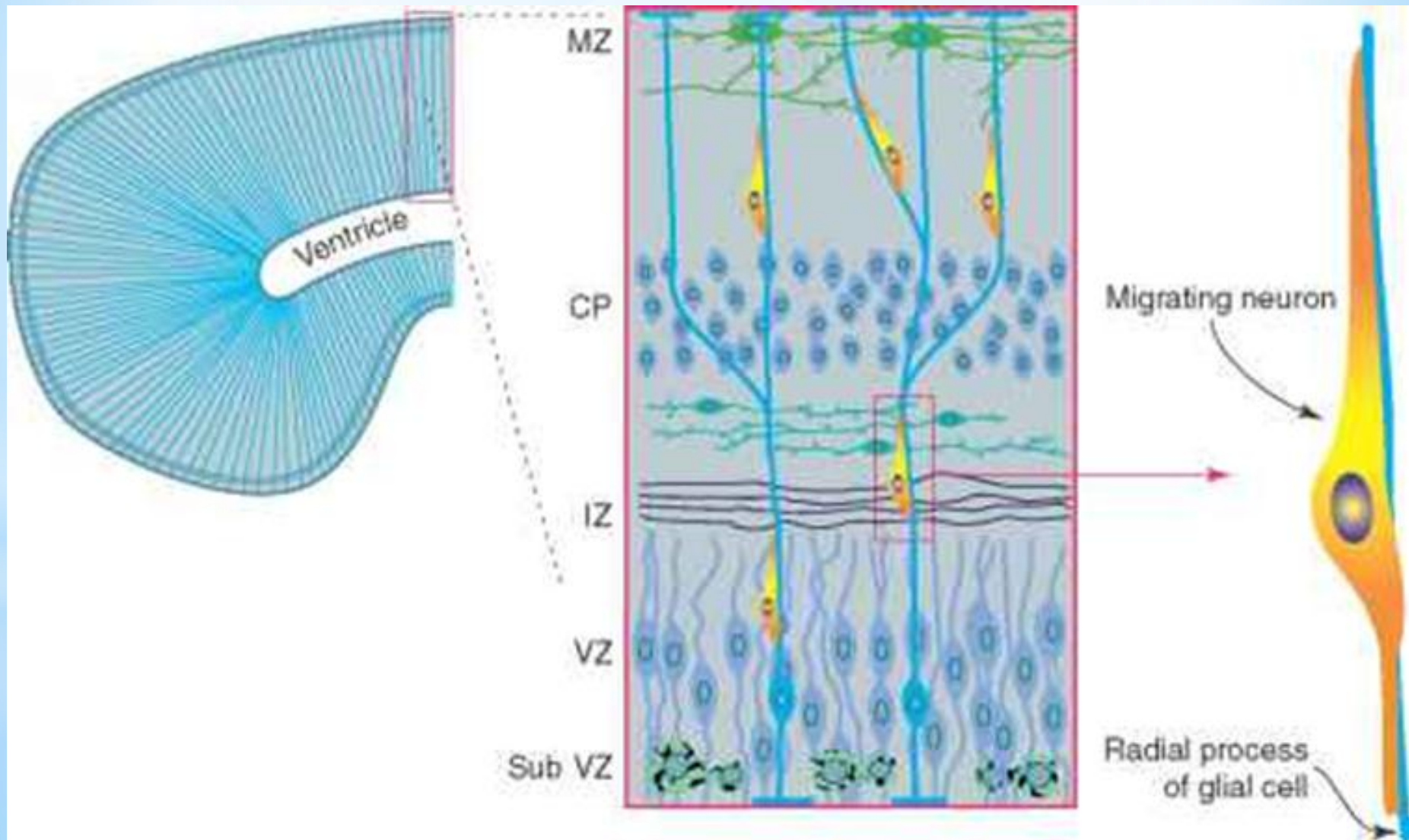
➤ Microglia (mesoderm)

specialized macrophages capable of phagocytosis that protect neurons of the central nervous system

➤ Macroglia (ectoderm)

- Astrocytes
- Oligodendrocytes
- Ependymal cells
- Radial glia

Radial glia



Glia of PNS

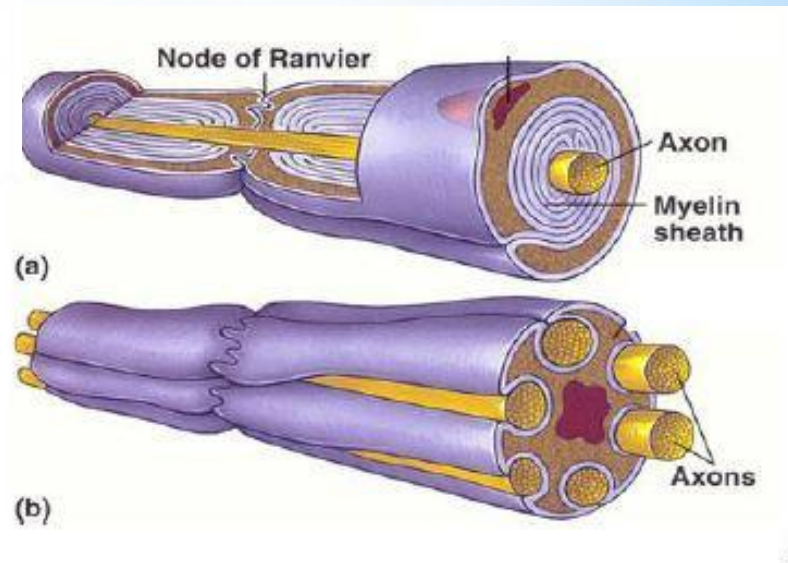
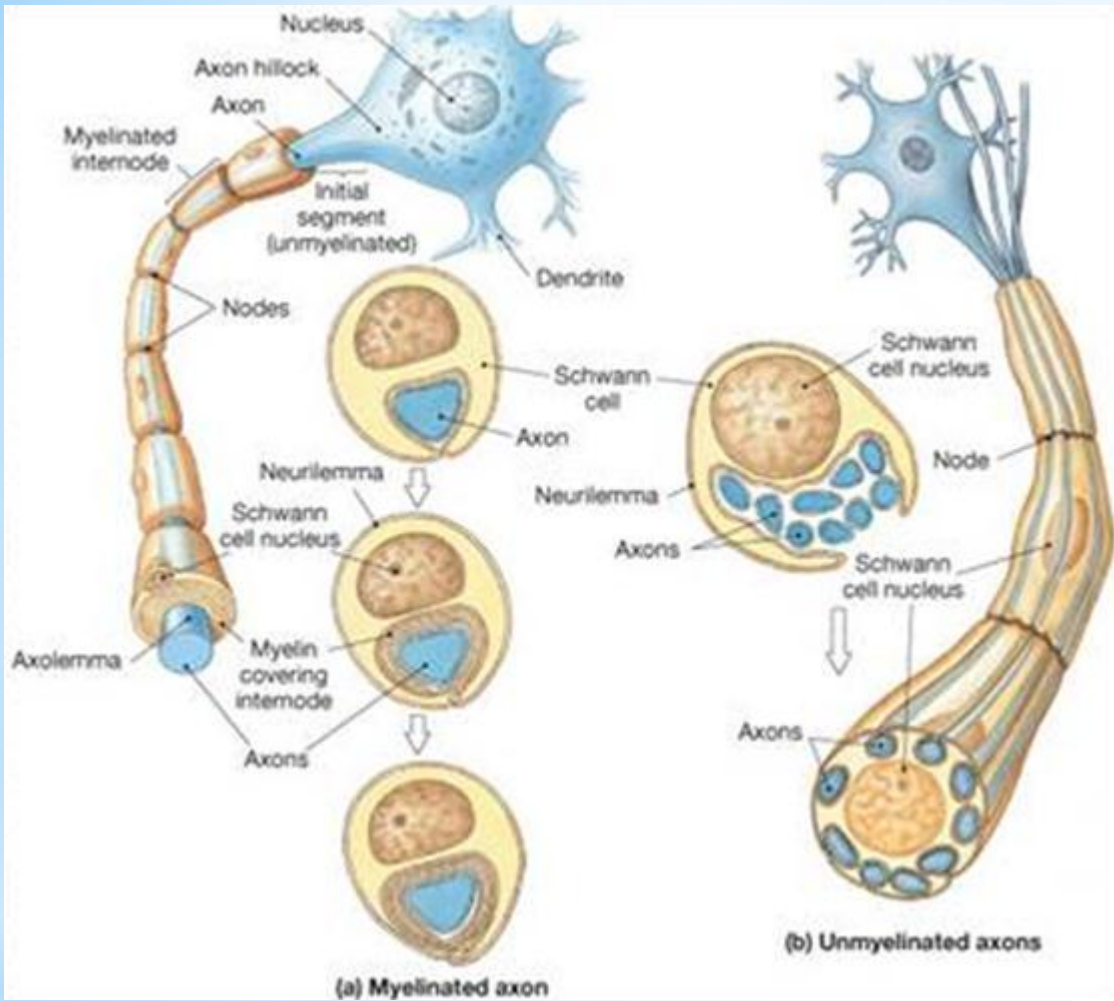
➤ Schwann cells

- conduction of nervous impulses along axons
- nerve development and regeneration
- trophic support for neurons
- production of the nerve ECM
- modulation of neuromuscular synaptic activity
- presentation of antigens to T-cells

Glia of PNS

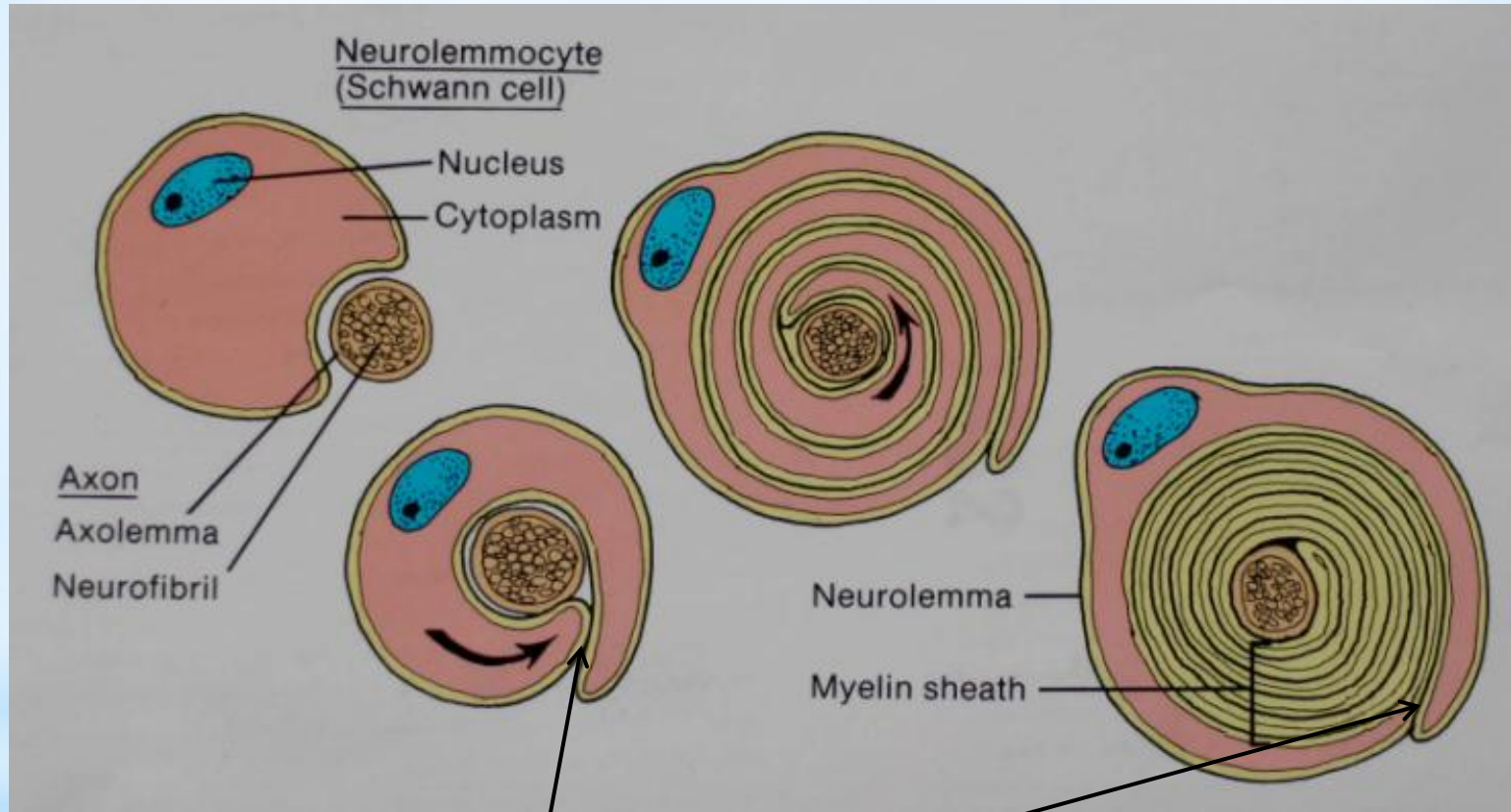
➤ Schwann cells

- myelinating Schwann cells form myelin sheaths around peripheral axons
- non-myelinating Schwann cells
- terminal Schwann cells



Saltatory conduction

Myelination in the PNS



mesaxon

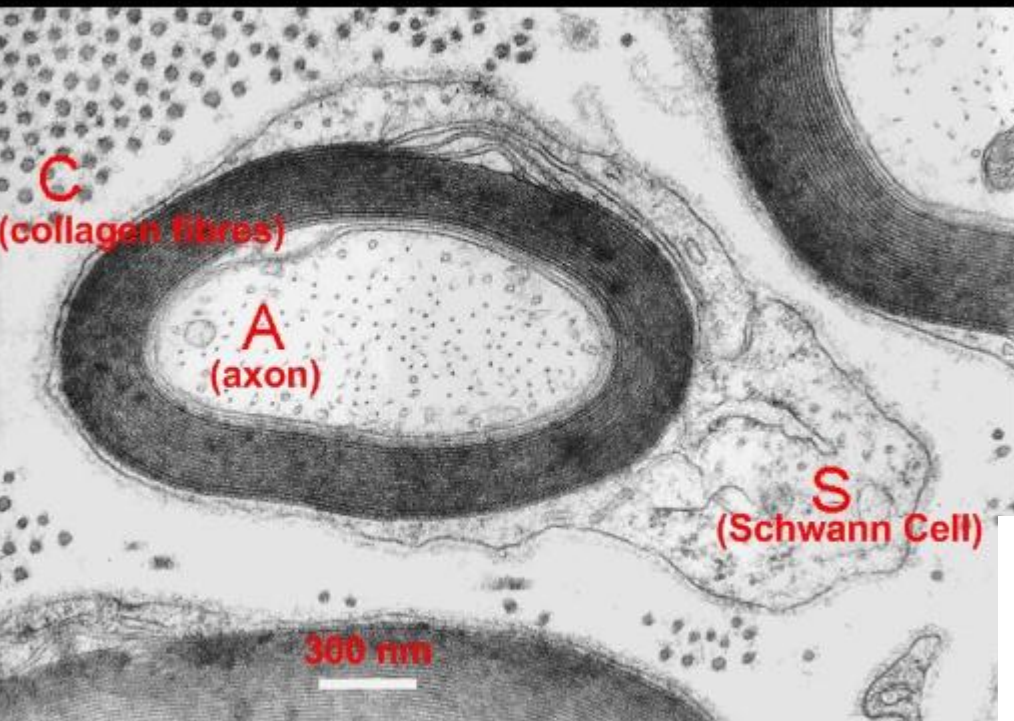
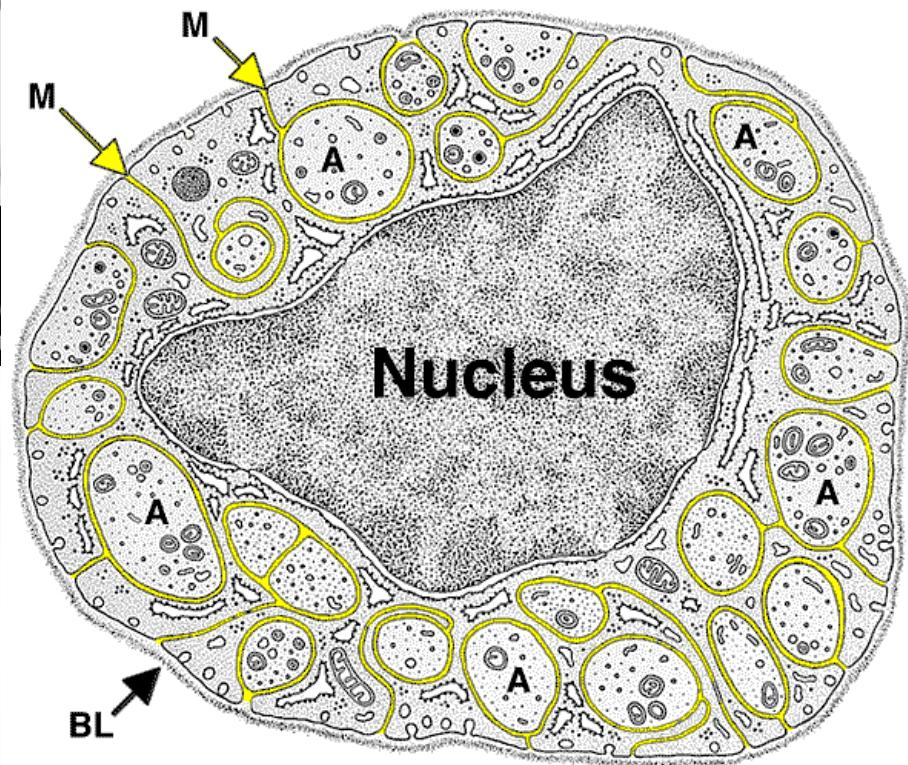
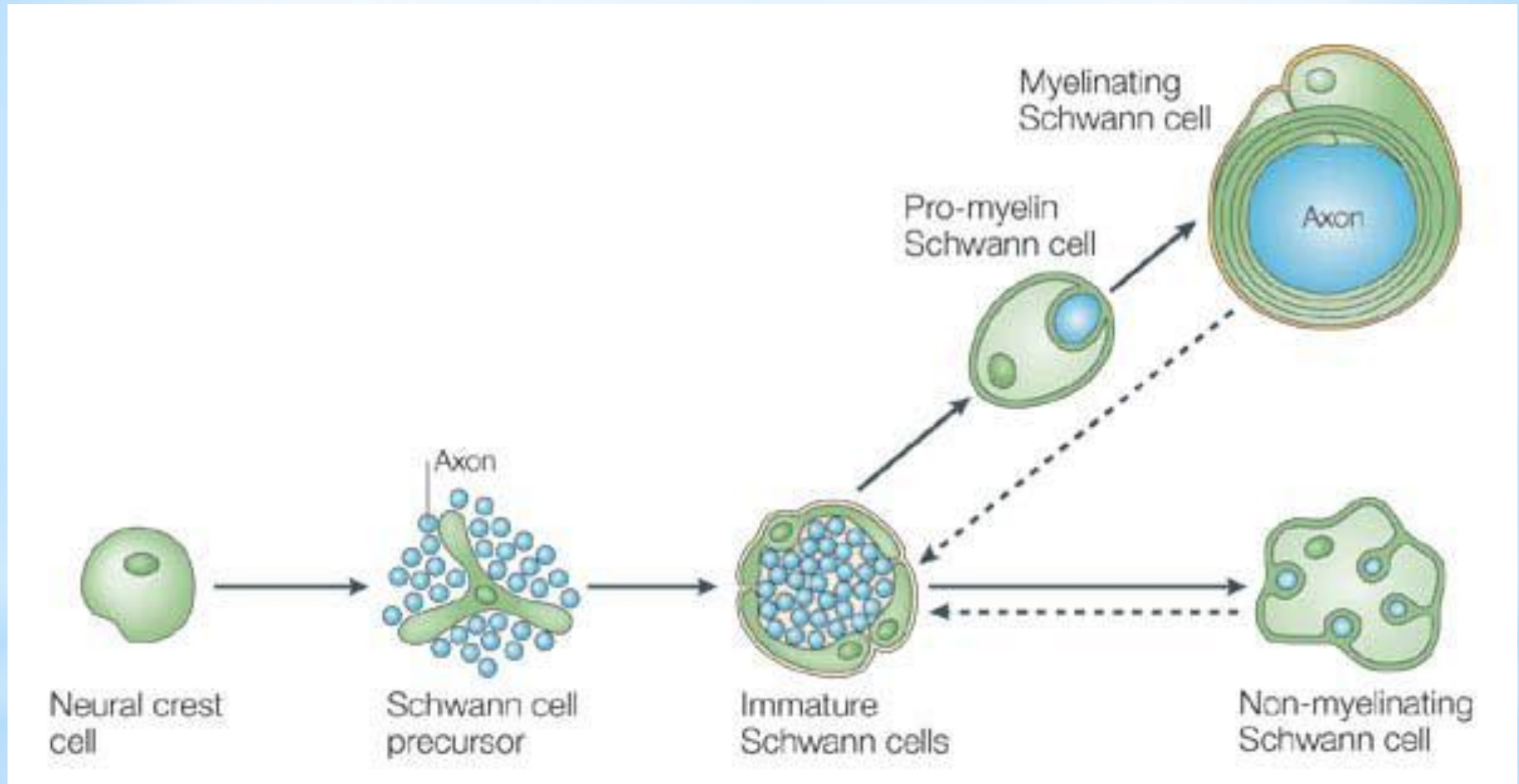


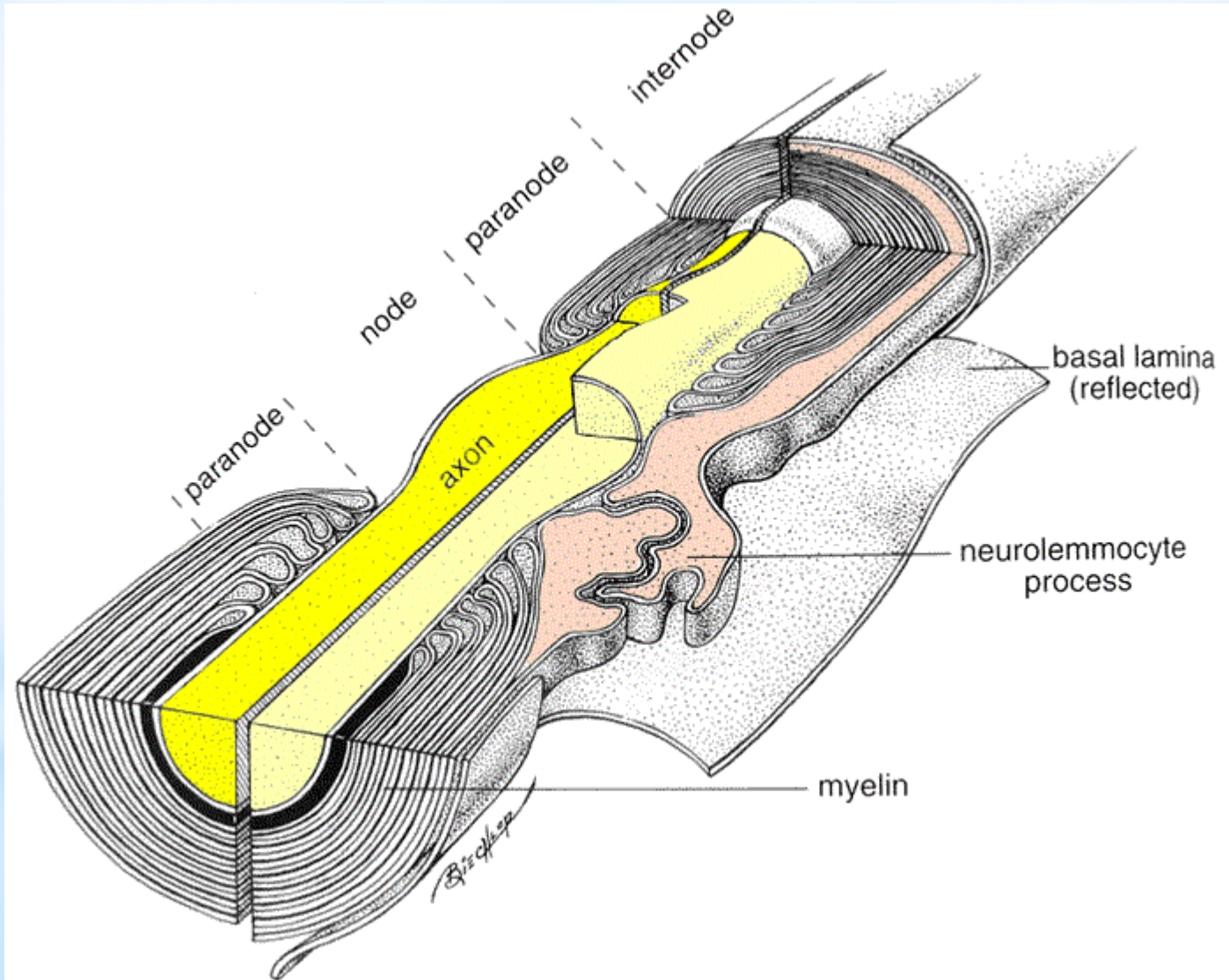
image obtained from Synapse Web
http://synapse-web.org/atlas/5_3.str



Schwann cell development

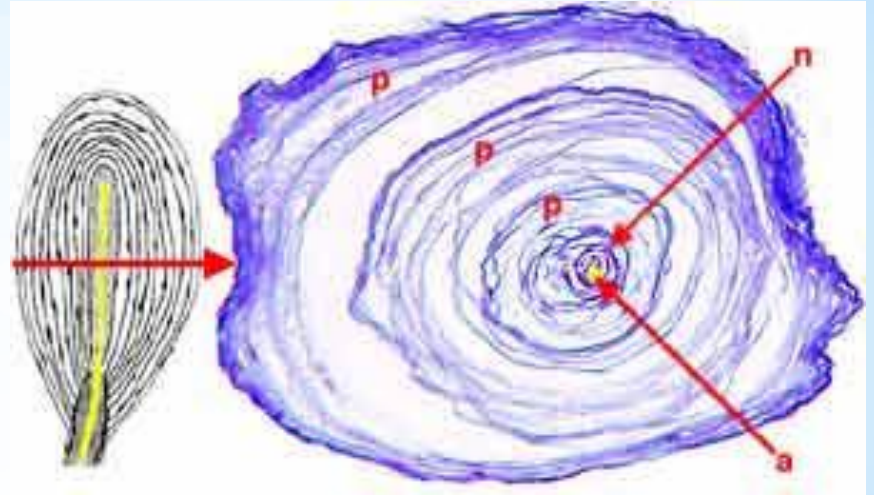


Node of Ranvier

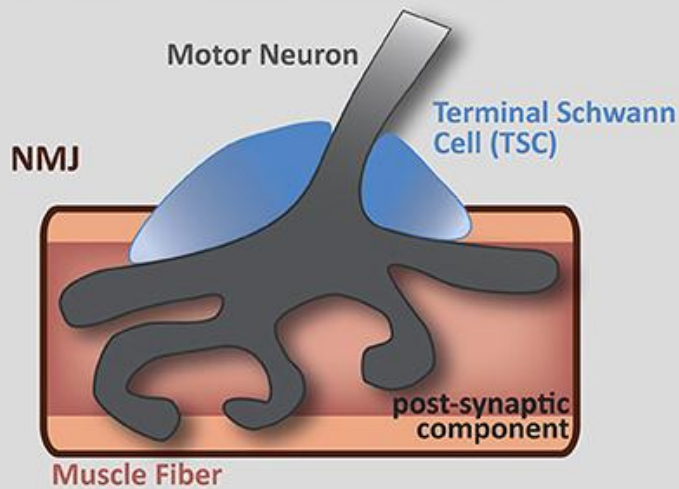


Terminal Schwann cells

Pacinian corpuscle

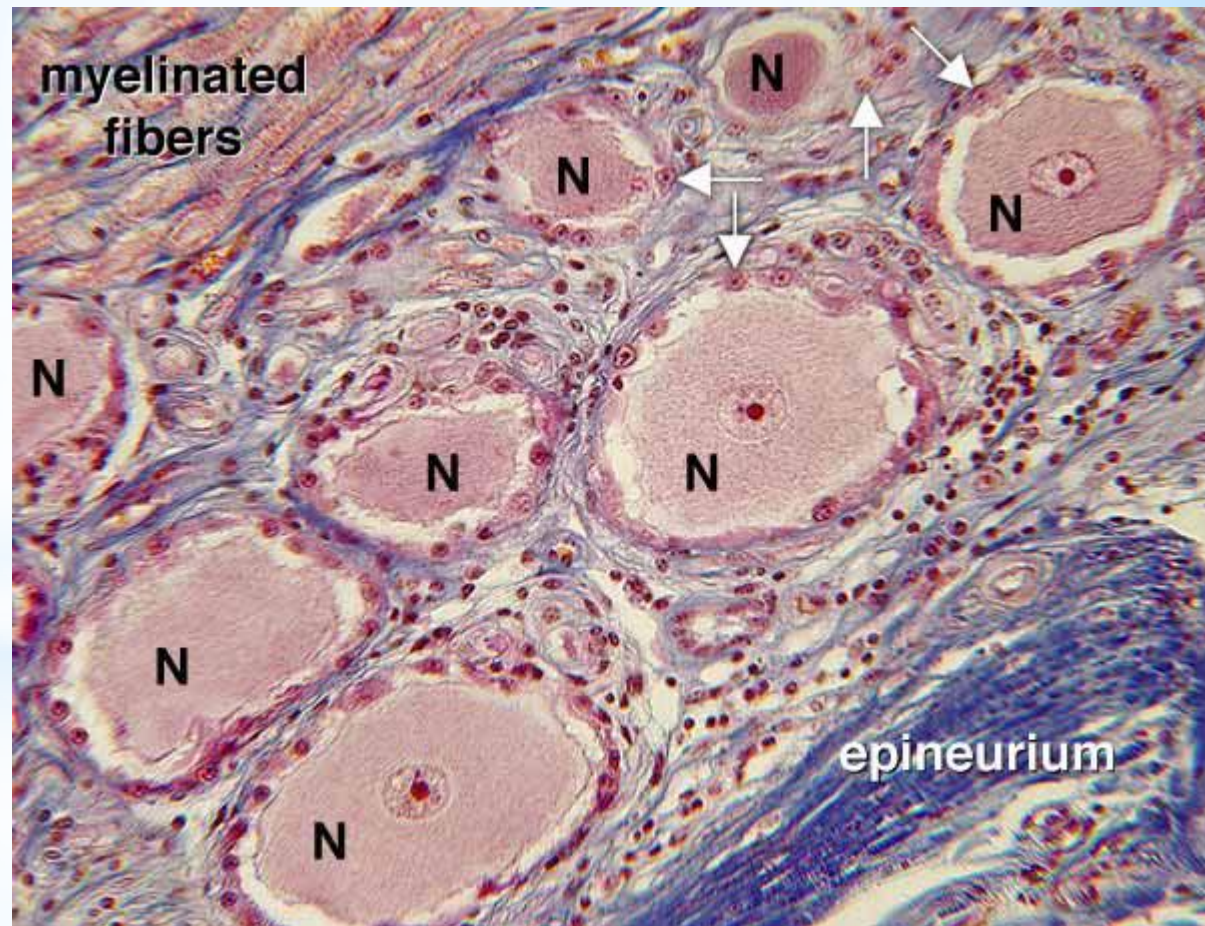
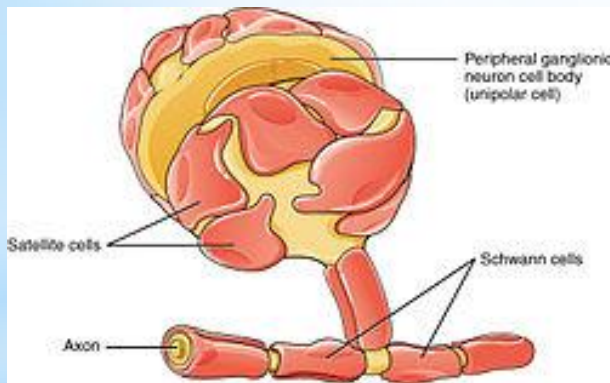


A Healthy Neuromuscular Junction (NMJ)



Glia of PNS

- satellite glial cells - support neurons in the PNS ganglia

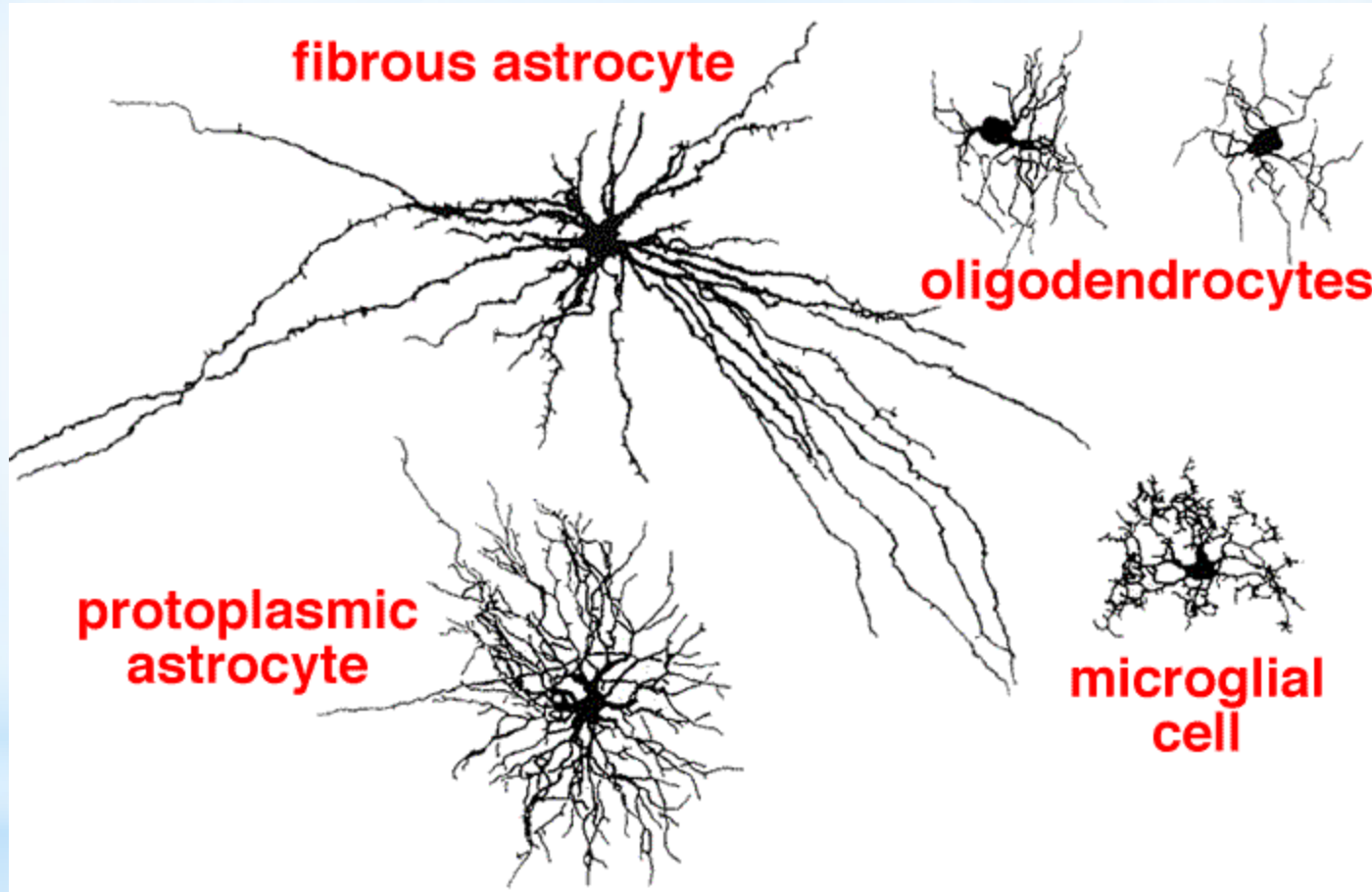


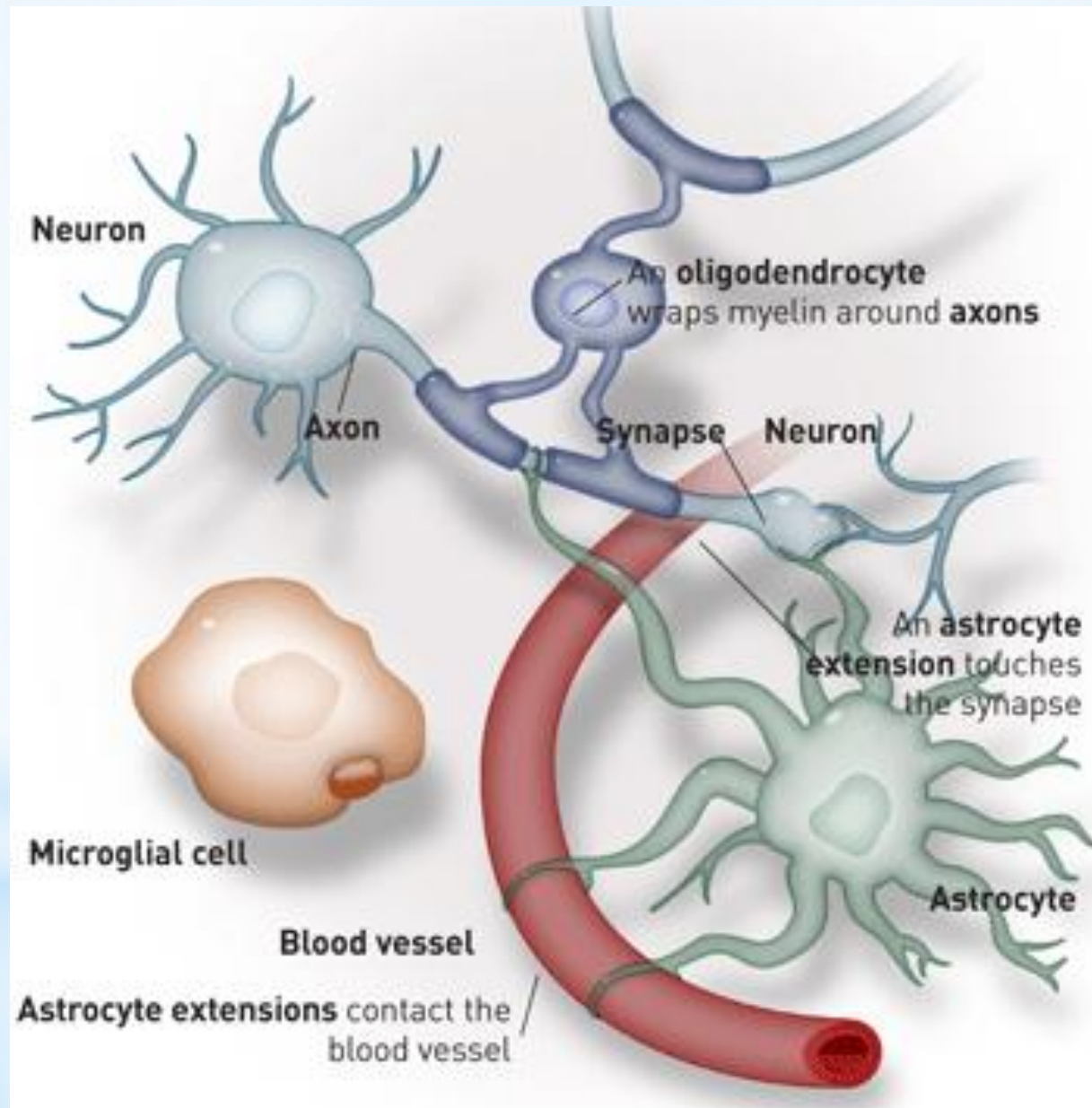
Glia of CNS

- surround neurons and hold them in place
- supply nutrients and oxygen to neurons
- insulate one neuron from another
- destroy pathogens and remove dead neurons
- participate in synaptic transmission
- regulate the clearance of neurotransmitters from the synaptic cleft
- release gliotransmitters such as ATP, which modulate synaptic function

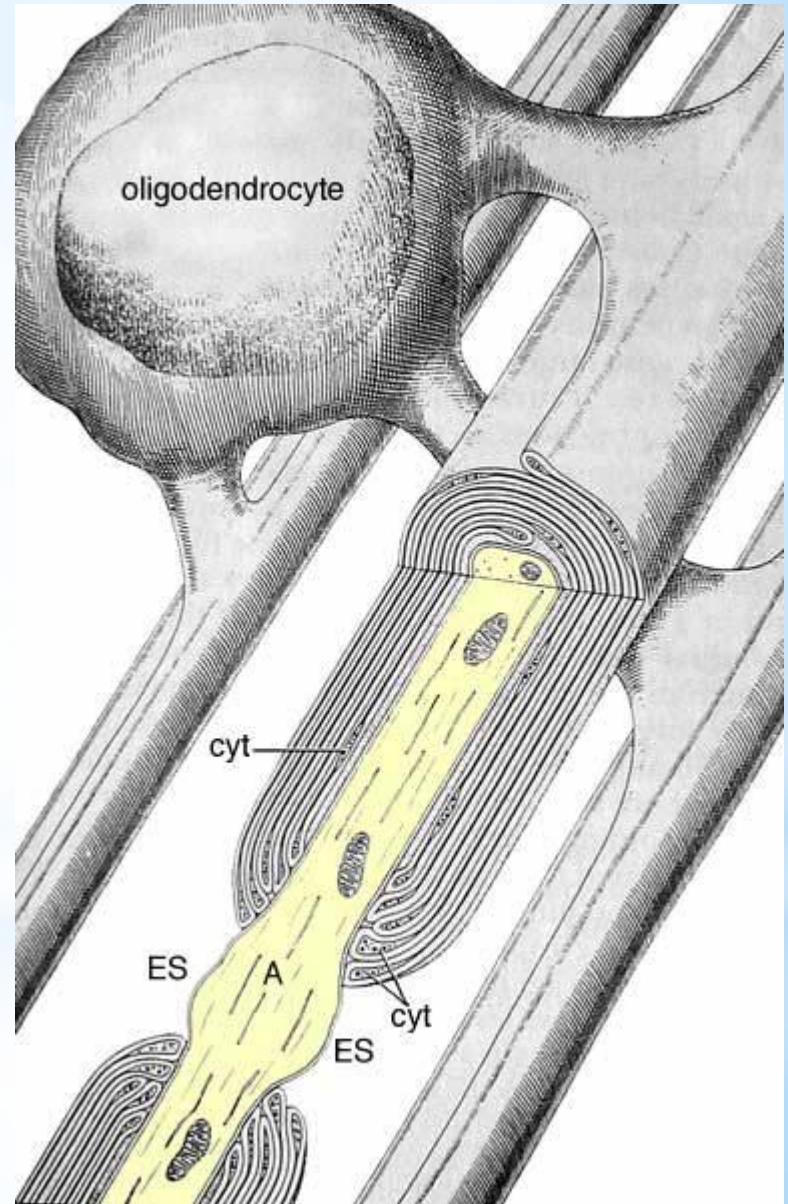
Glia of CNS

- **Astrocytes** - provide a link between the vasculature and neurons
- **Oligodendrocytes** - form the myelin sheath around axons of the CNS
- **Microglia** - phagocyte cells that migrate through the CNS removing foreign matter and degenerated brain tissue
- **Ependymal cells** - line the ventricular system of the CNS, are involved in the secretion of the cerebrospinal fluid and aid in its circulation





Myelin sheath in the CNS



BLOOD - BRAIN BARRIER



BARRIERS OF THE CNS

Intracellular compartment
Extracellular compartment
Compartment of CSF
Intravascular compartment

Meningeal barrier

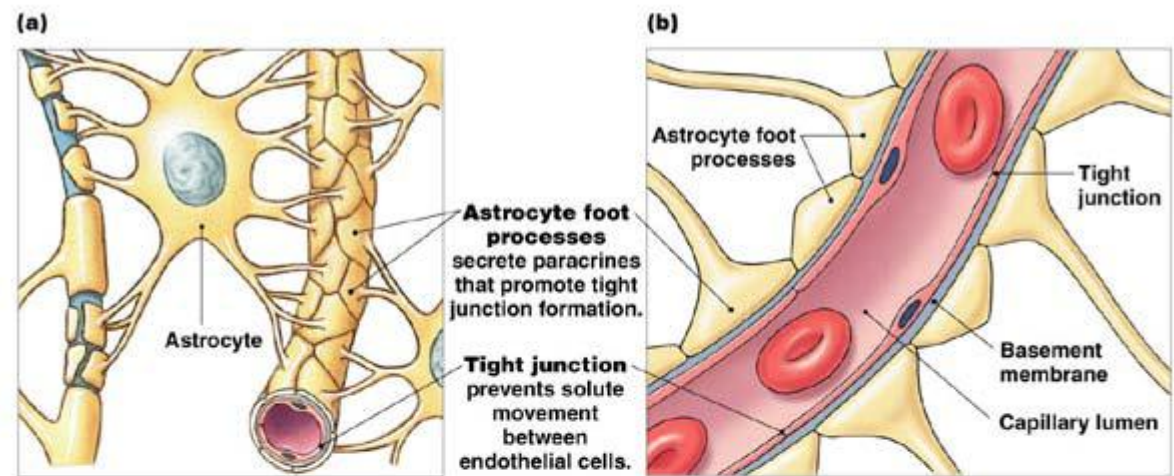
Blood - CSF barrier

Blood - brain barrier

BLOOD - BRAIN BARRIER

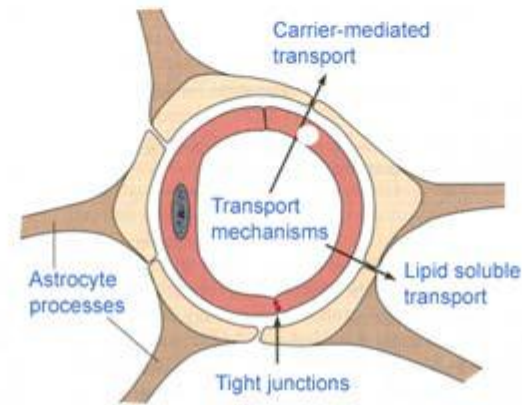
- A barrier separating the circulating blood from the extracellular space of the CNS
- Functions
 - protects the brain from "foreign substances" in the blood that may injure the brain
 - protects the brain from hormones and neurotransmitters in the rest of the body
 - maintains a constant environment for the brain

Structural components of BBB

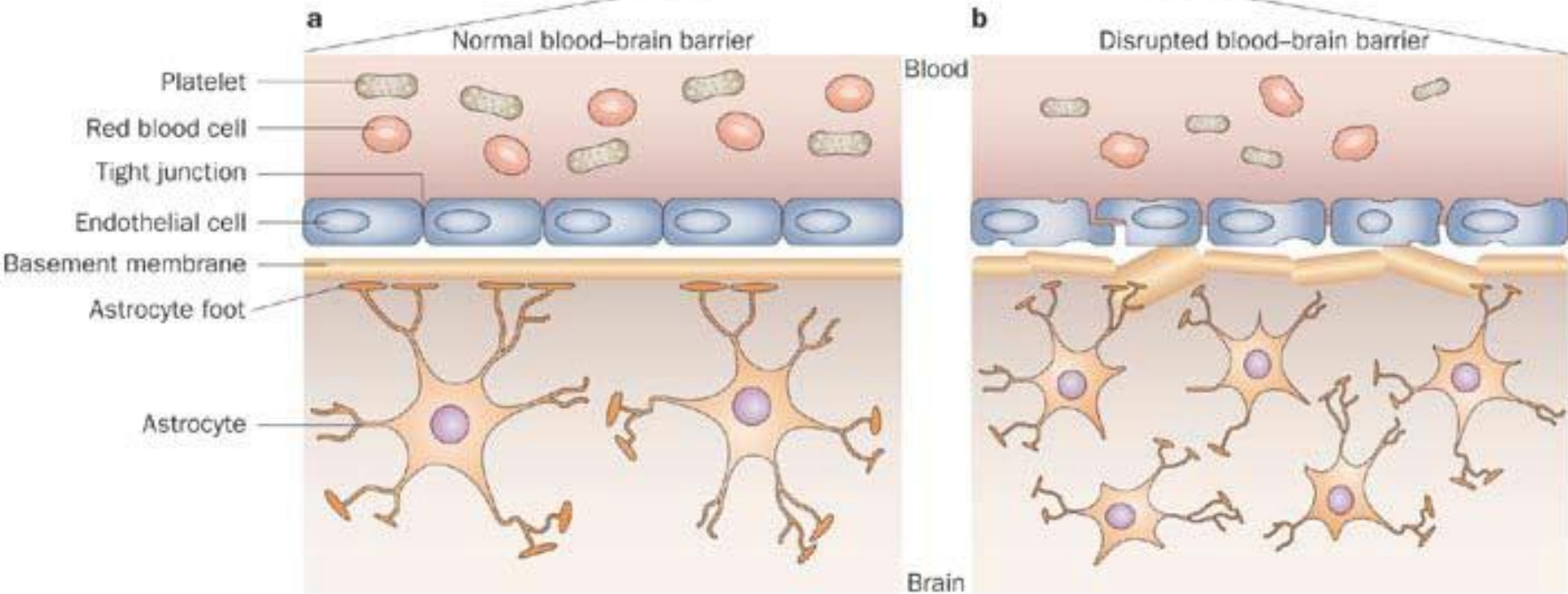
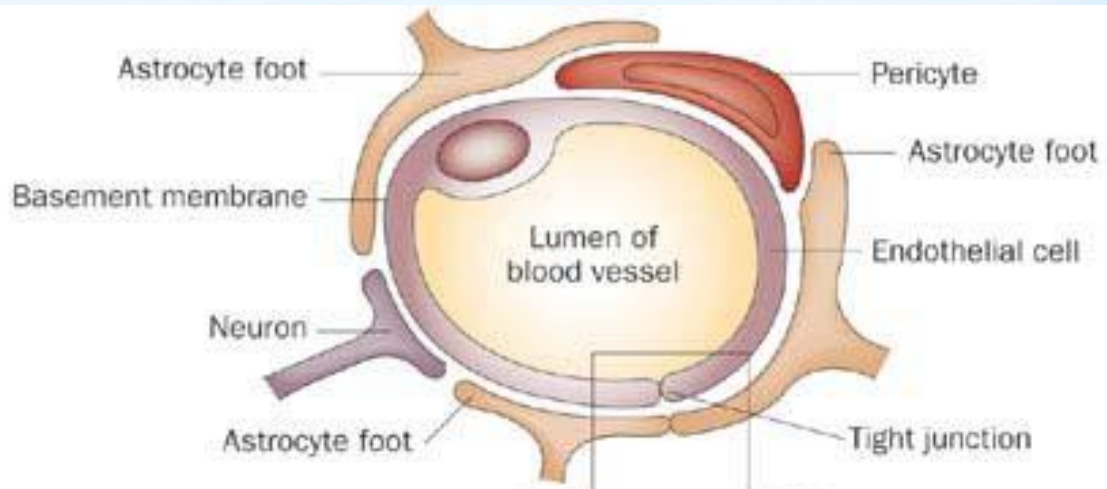


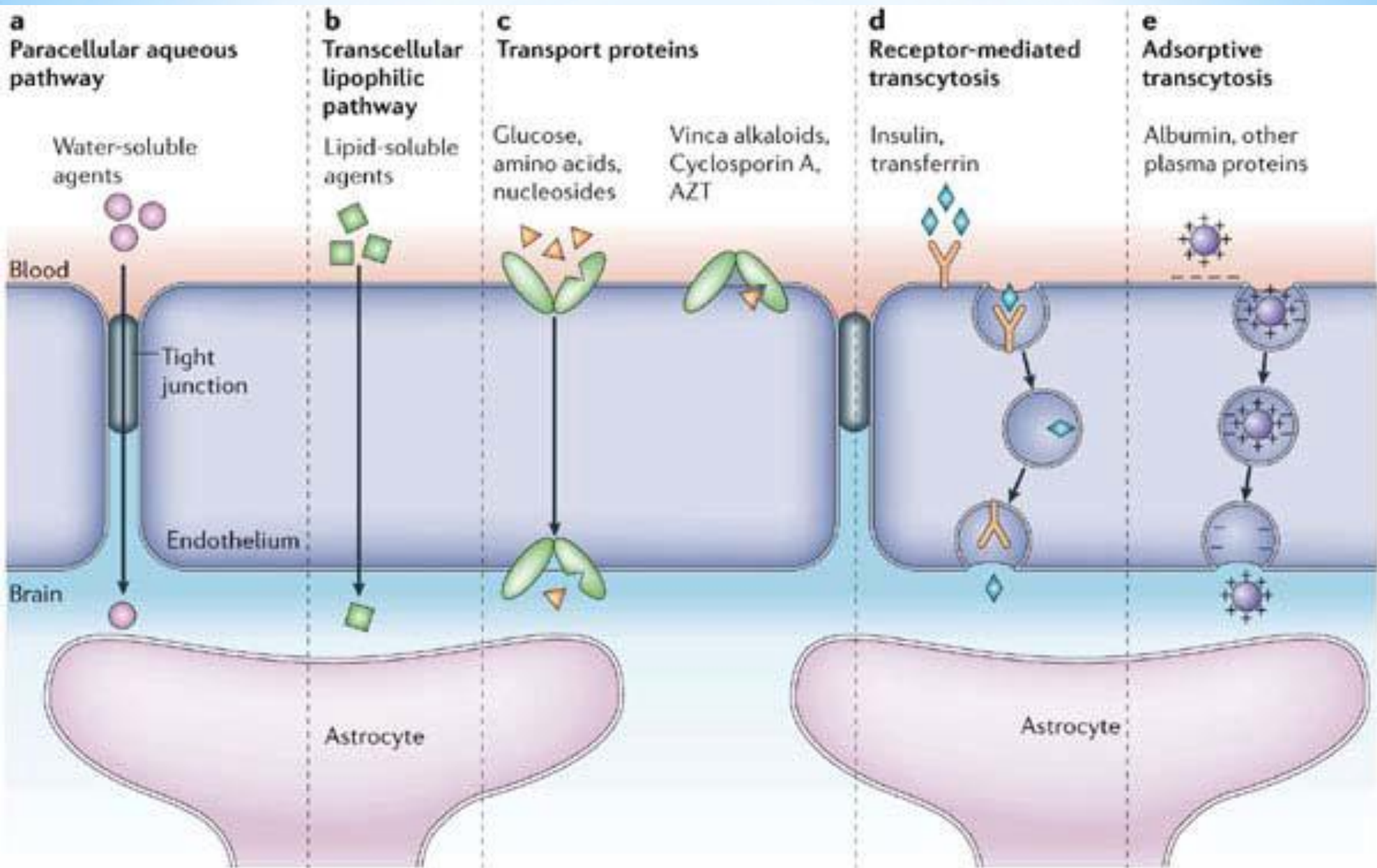
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Fig. 9-6



- Endothelial cells connected by tight junctions
- Foot processes of astrocytes
- Basement membrane



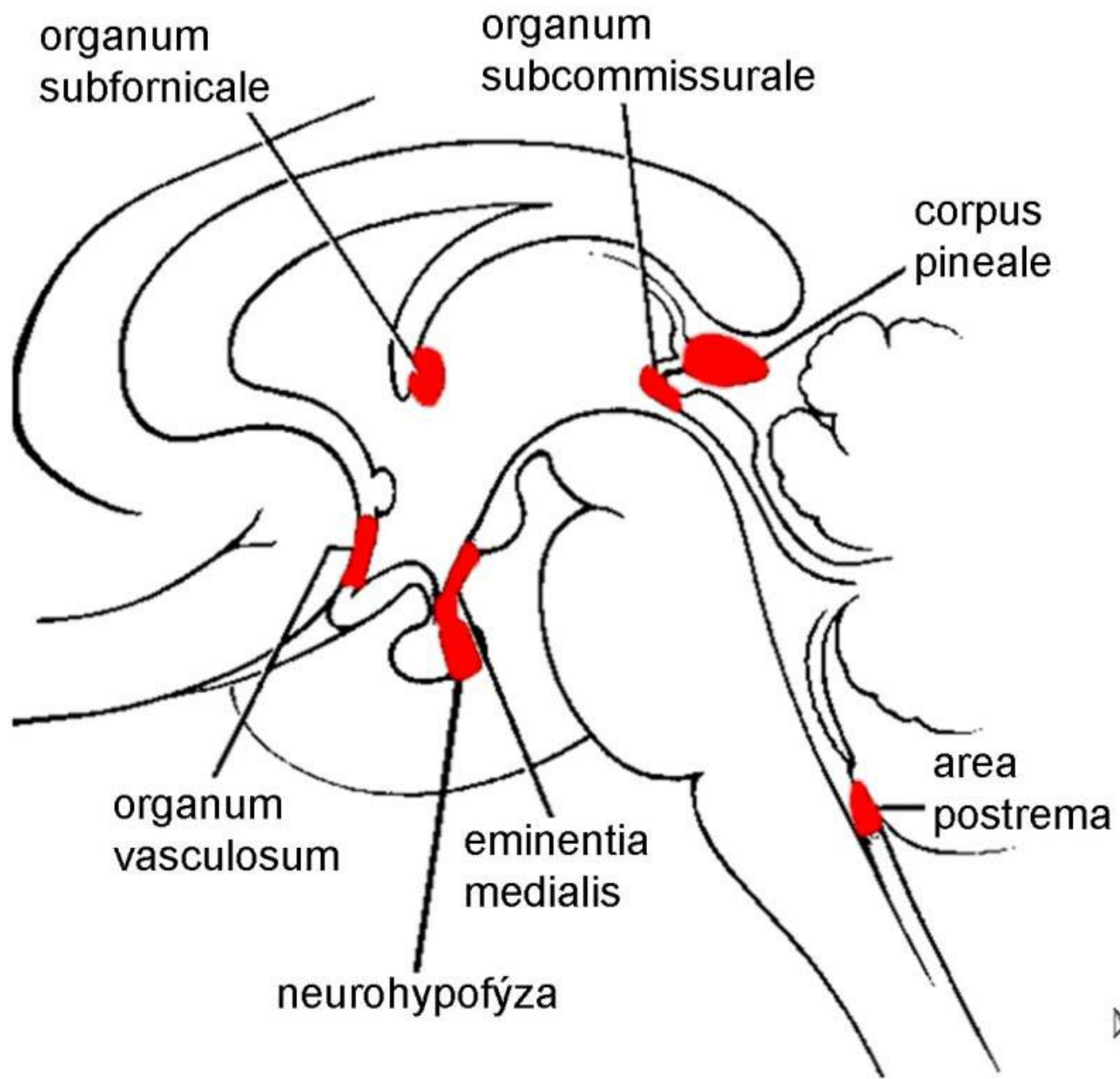


Transport through the BBB

- **simple diffusion** (lipophilic substances)
- **facilitated diffusion** through a protein carrier
energy independent
- **simple diffusion** through an aqueous channel
- **active transport** - energy dependent

Circumventricular organs

- areas of the human brain without the BBB:
 - Pineal body (epiphysis)
 - Neurohypophysis (posterior pituitary) - releases neurohormones (oxytocin and vasopressin) into blood
 - Median eminence: regulates anterior pituitary through release of releasing and inhibiting hormones
 - Subcommissural organ: glycoprotein SCO-spondin
 - Subfornical organ: important for the regulation of body fluids
 - Vascular organ of lamina terminalis: responsible for osmosensory balance
 - Area postrema: "vomiting center"



Liquor cerebrospinalis (CSF)

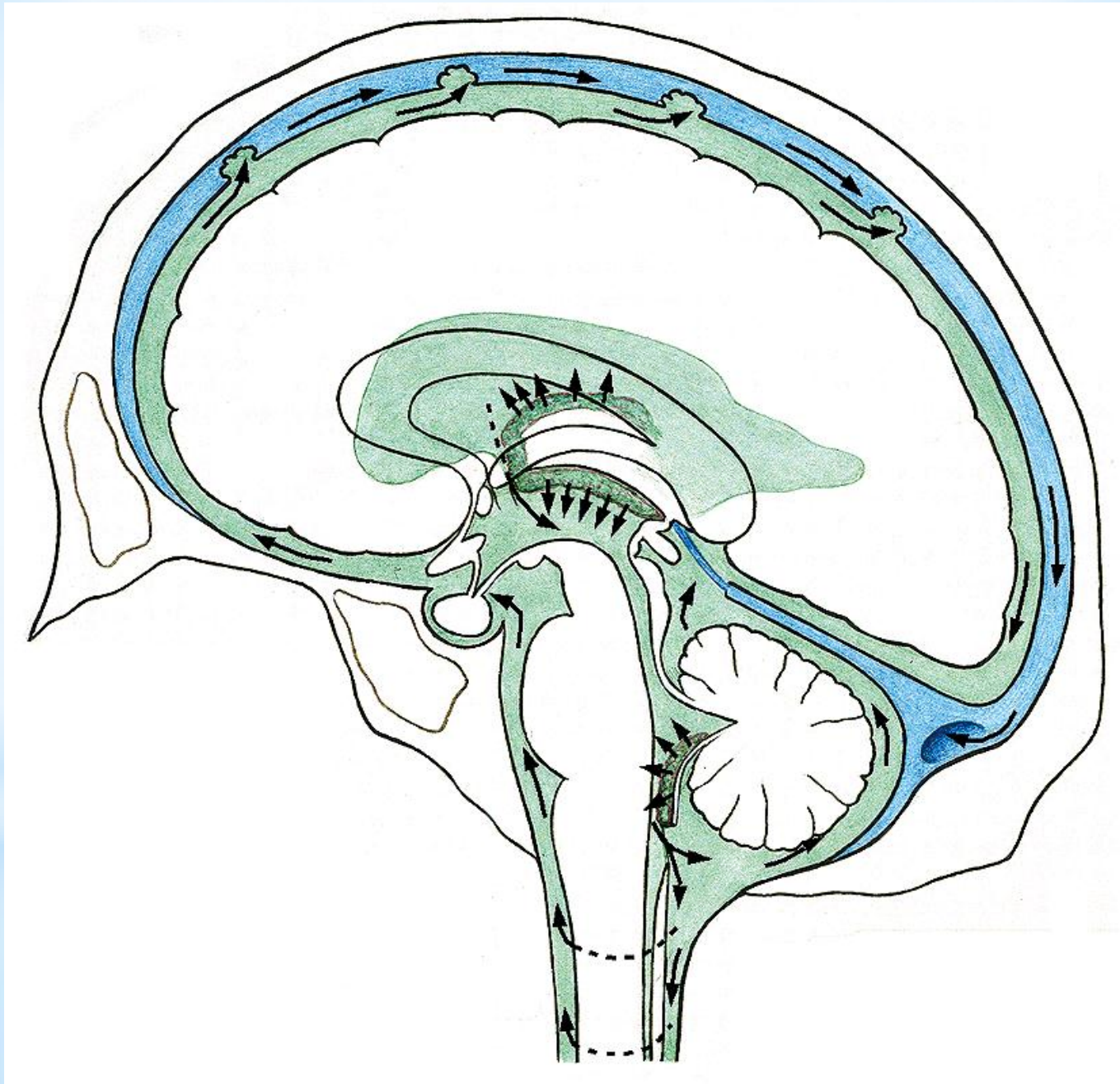
Clear, colorless fluid, 150 mL, secreted at the rate of 500-800 mL daily

Produced by the choroid plexuses of ventricles

Protects the brain, prevents the weight of the brain from compressing the nerves and vessels against the cranium

Removes the harmful substances from the CNS to venous blood

Has immune functions



Illustrations were copied and lecture was prepared from:

Noback CH.R. et al: The Human Nervous System: Structure and Function. Humana Press, Totowa, New Jersey, Sixth ed.

Neuroscience Online, the Open-Access Neuroscience Electronic Textbook

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