Nervous tissue

Nervous tissue

- Neurons

- Glial cells

CNS: oligodendrocytes, astrocytes, ependymal cells, microglia

PNS: satellite cells, Schwann´s cells

Synapse
Myelin sheat

Nervous tissue

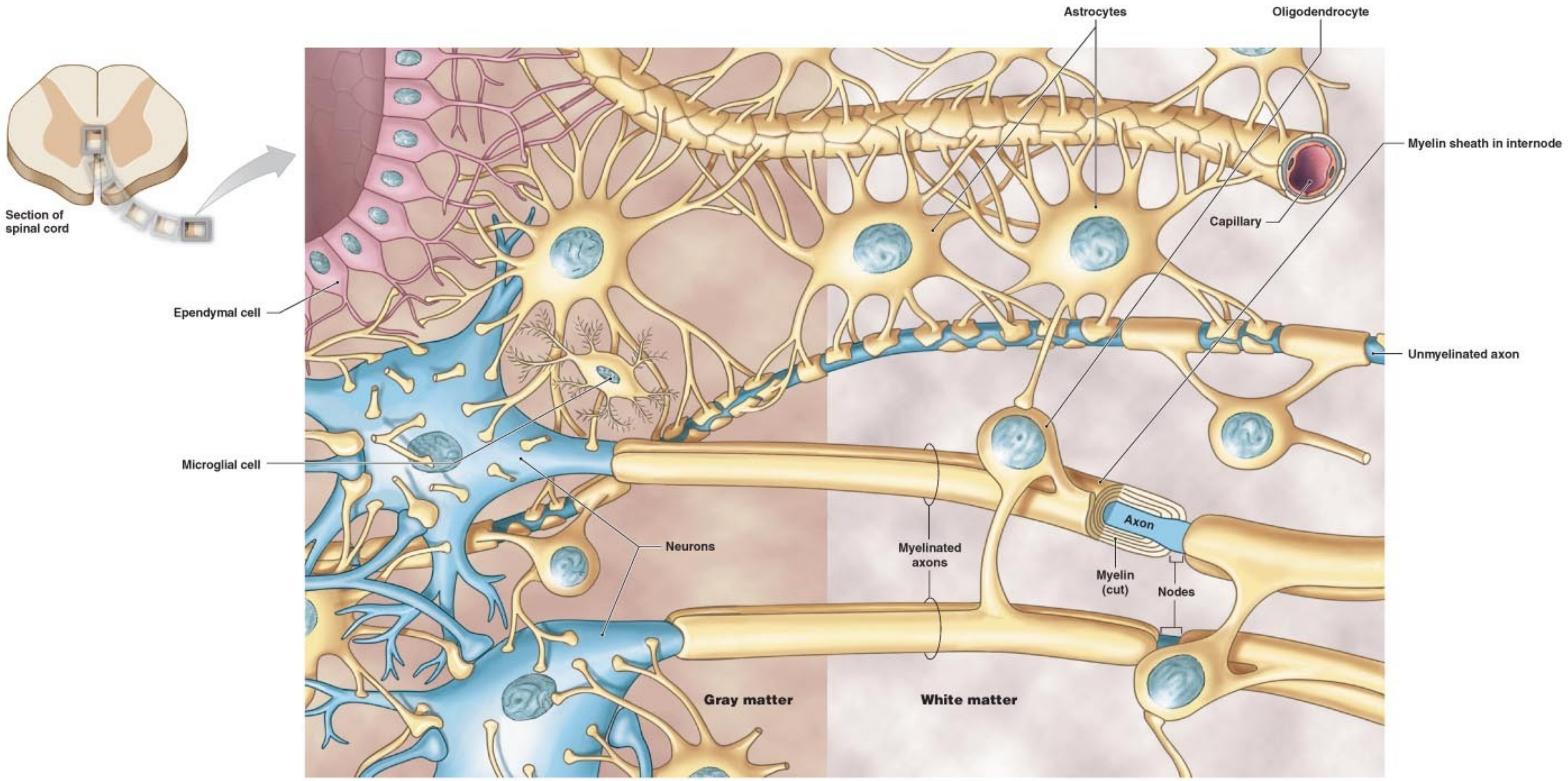
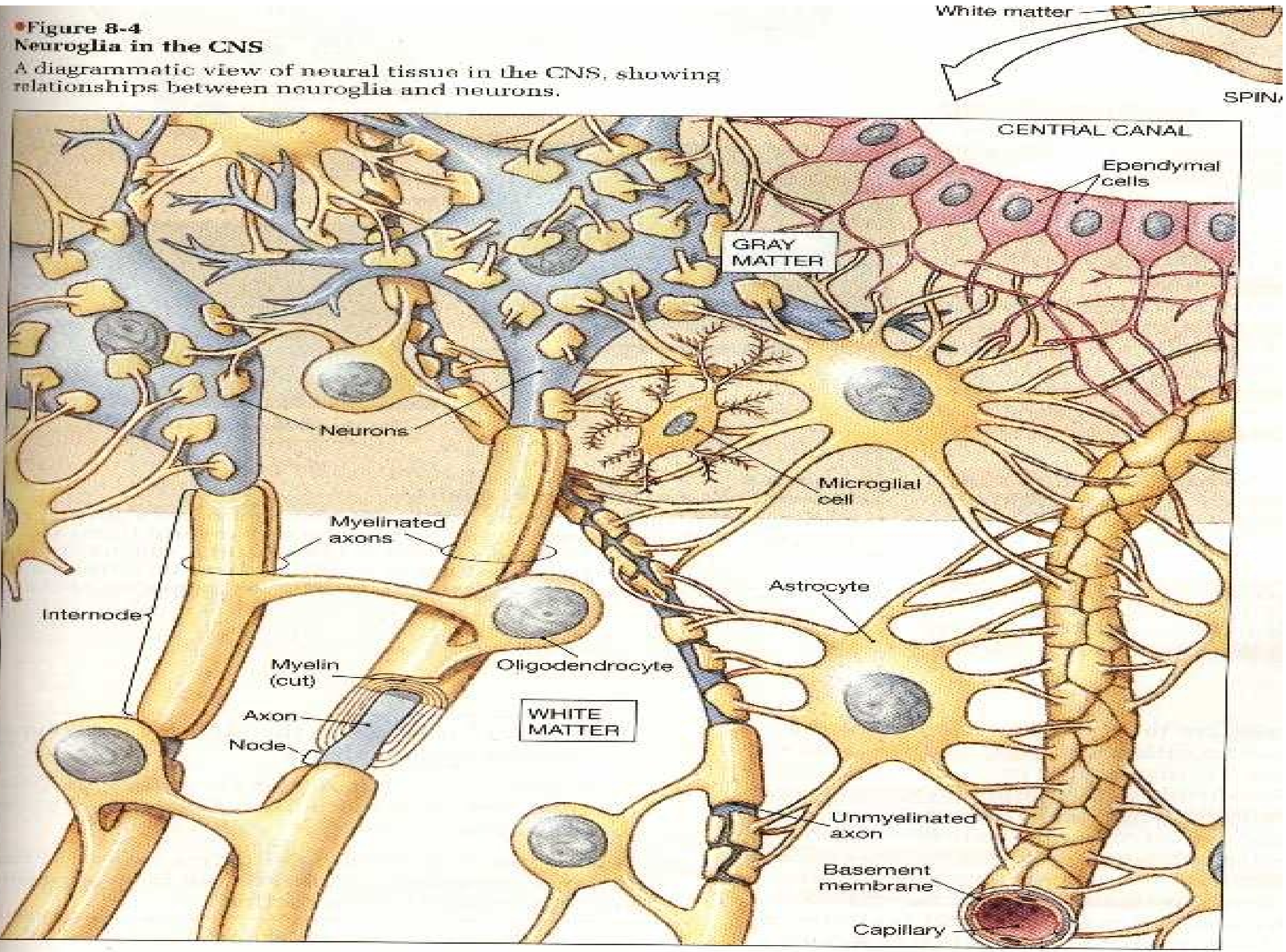


Figure 8-4
Neuroglia in the CNS
A diagrammatic view of neural tissue in the CNS, showing relationships between neuroglia and neurons.



Neuron

- Nerve cells are very variable in appearance, shape and size

- cell body - called soma or **perikarion**

- processes extending from the nerve cell to communicate with other cells

there are two types of processes:

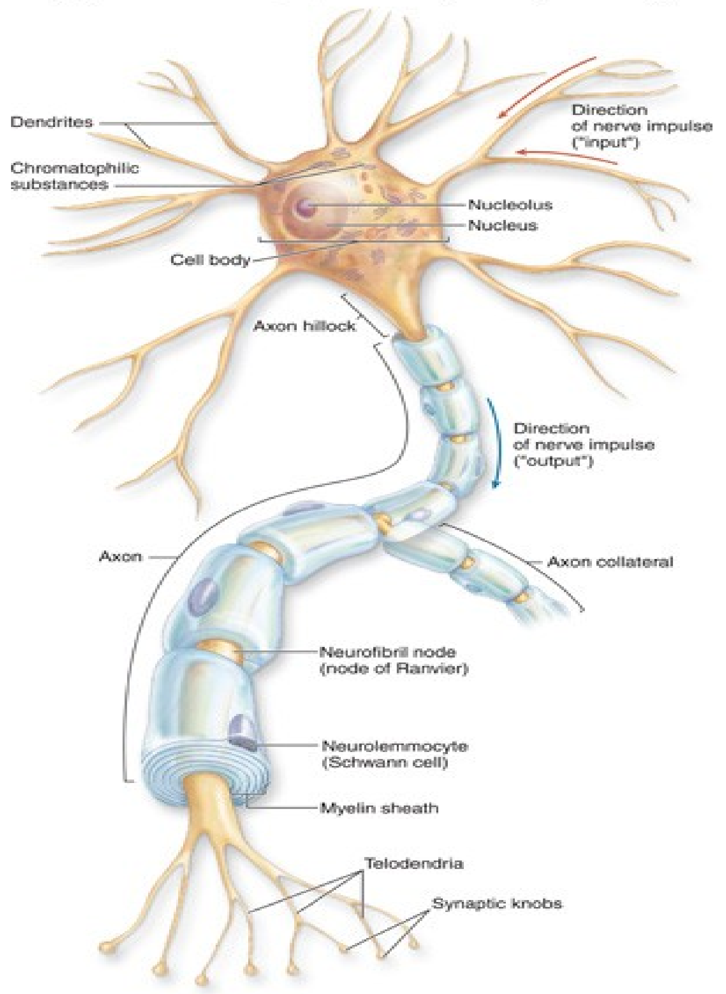
dendrites (receive impulses)

axons (neurits) (transmit impulses)

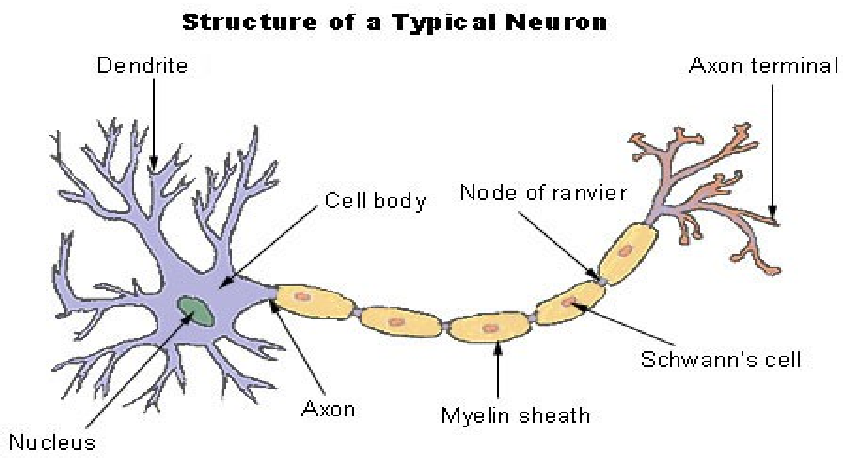
All nerve cells have one axon, which is usually the longest process that extends from the cell and one or more (hundreds) dendrites(shorter and thicker than the axon)

Synapse - the junction where a nerve cell communicates with another nerve cell or an effector cell (eg. muscle fibre), can be chemical and electric

Neurotransmitter – substance at the terminal part of the axon with chemical synapses releases substances which acts on the membrane of the other cell

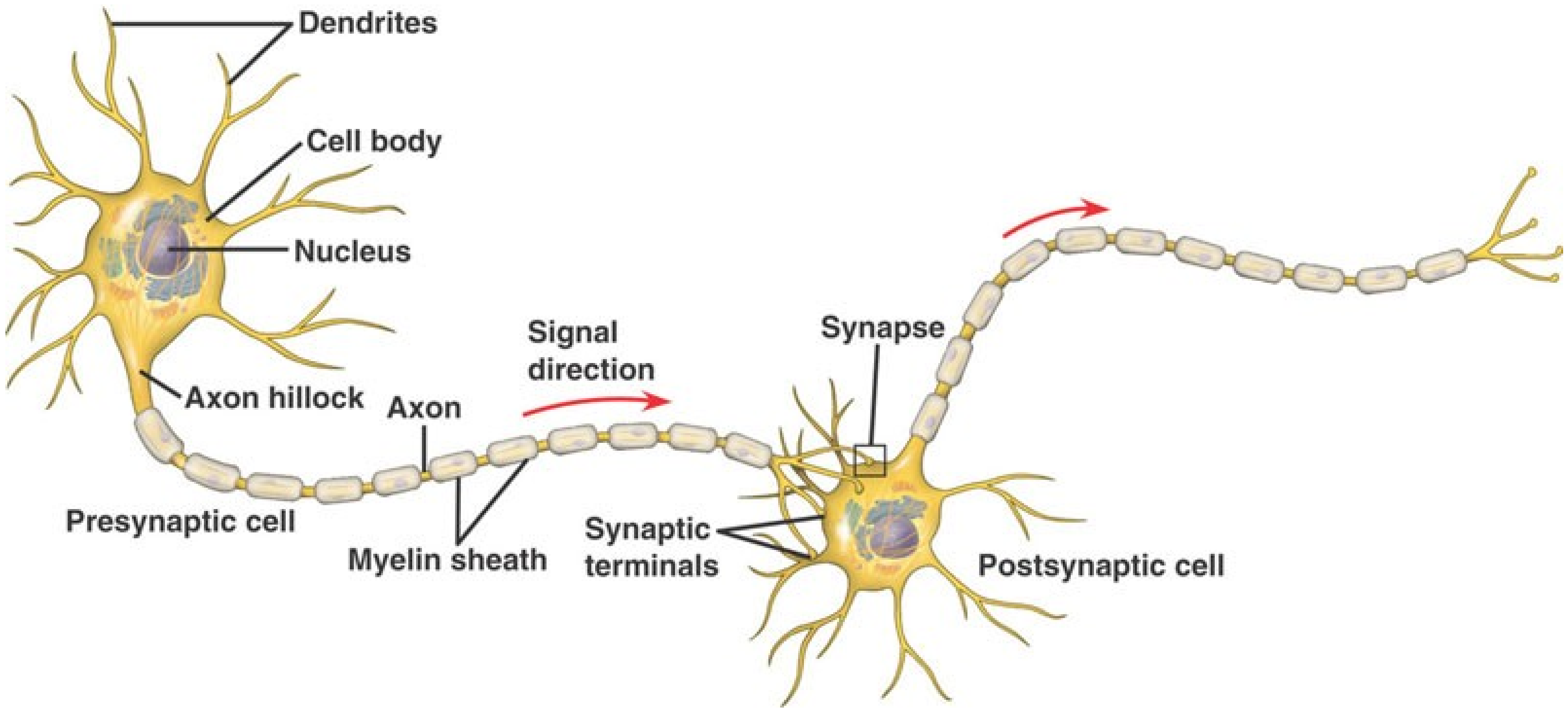


(a)



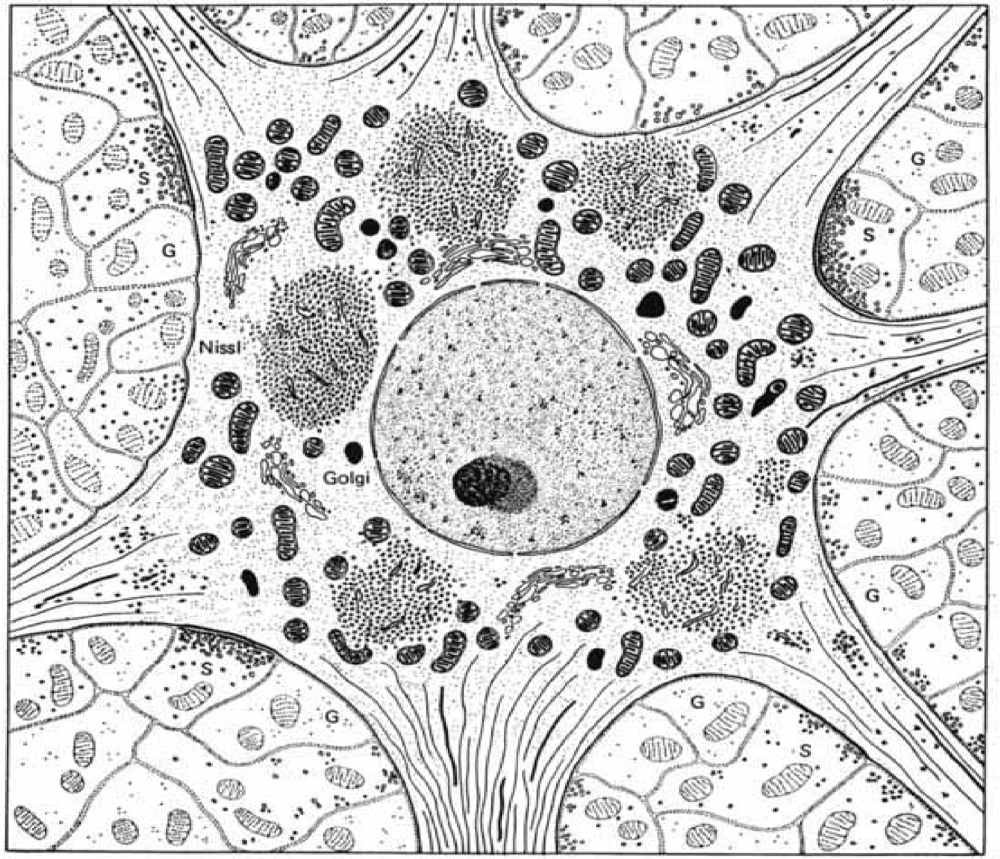
Main parts of neuron

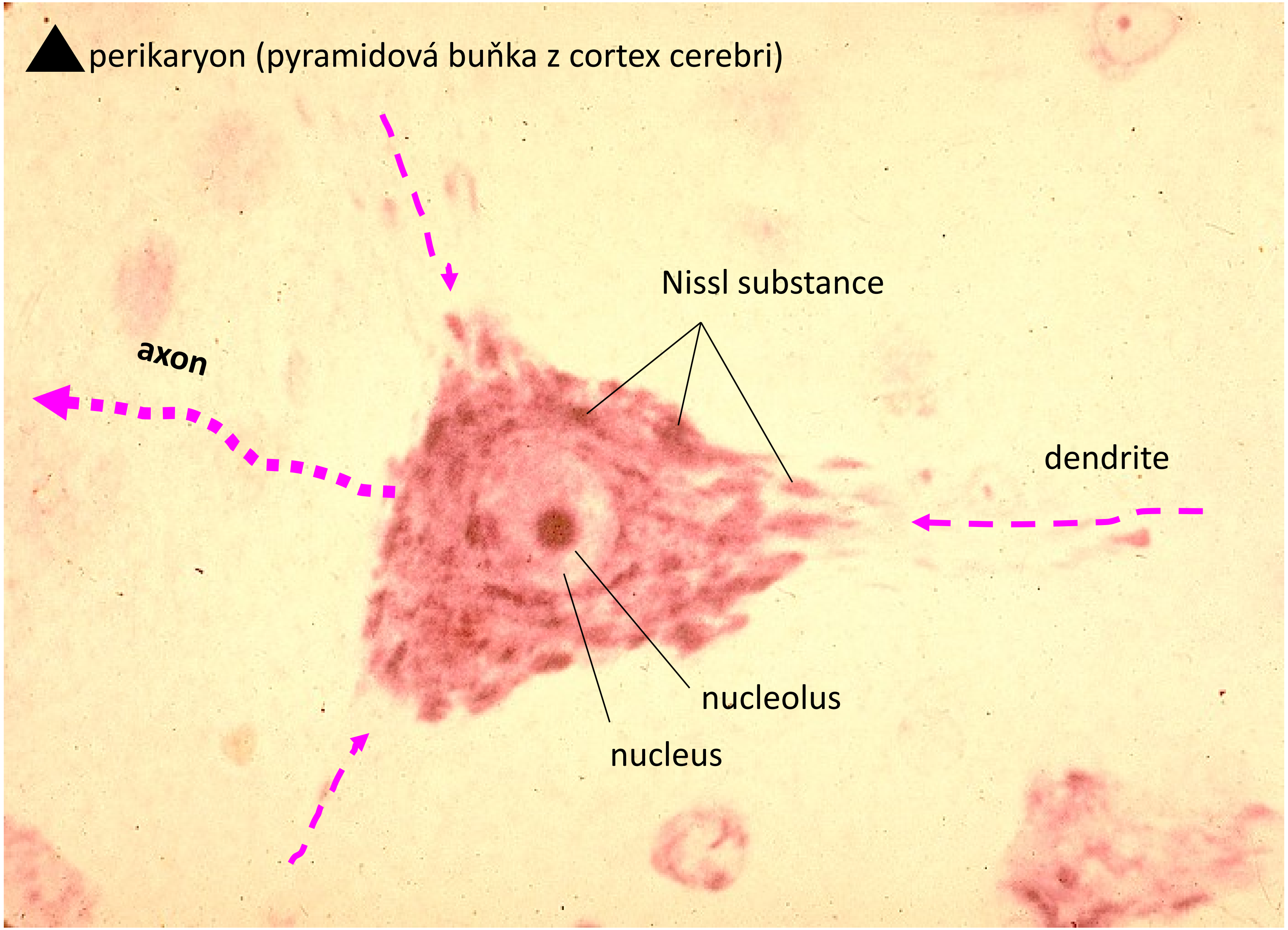
- Dendrites
- Cell body
- Axon (neurit)
- Axon terminal



Perikaryon

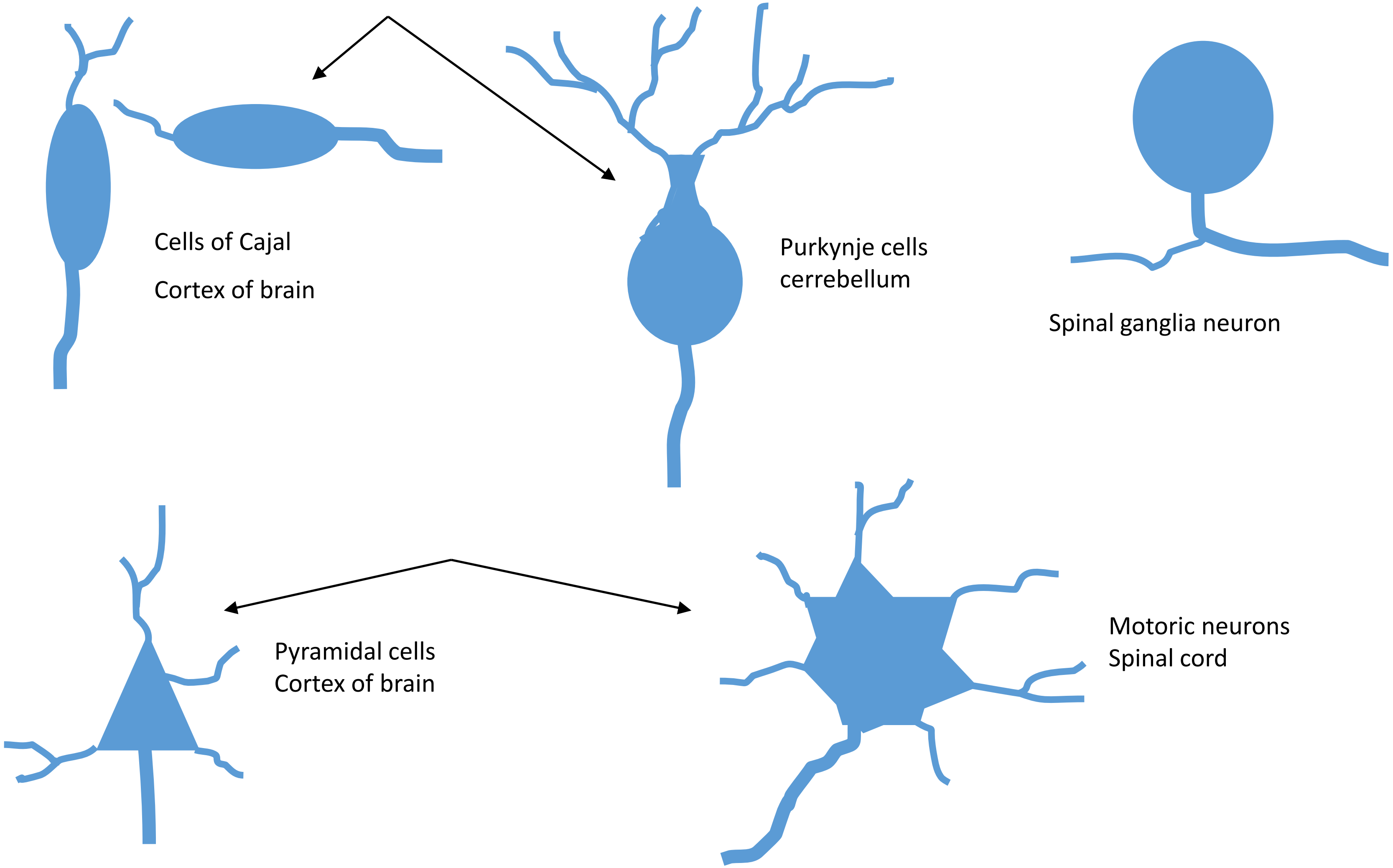
- <u>Cell body – PERIKARION:</u> contains nucleus and most cytoplasm with organelles:
- nucleus – round or oval, very light, with prominent nucleolus
- rough ER (called Nissl´ substance) – involved in synthesis of proteins (neurotransmitters)
- other usual organelles (mitochondria, Golgi apparatus, lysosomes)
- neurofibrils – neurofilaments and neurotubules
- pigment lipofuscin





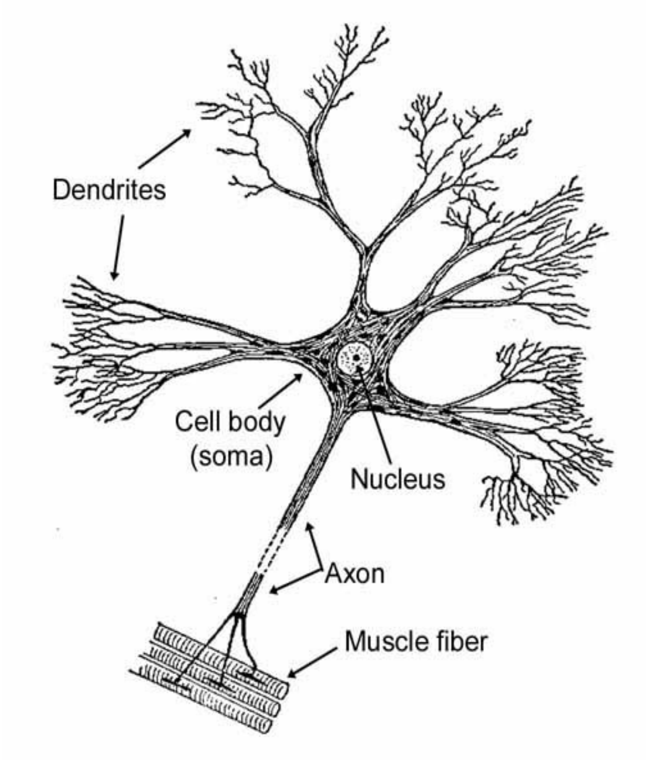
perikaryon (pyramidová buňka z cortex cerebri)
Nissl substance
axon
dendrite
nucleolus
nucleus

Perikaryon


Cells of Cajal
Cortex of brain
Purkynje cells
cerrebellum
Spinal ganglia neuron
Pyramidal cells
Cortex of brain
Motoric neurons
Spinal cord

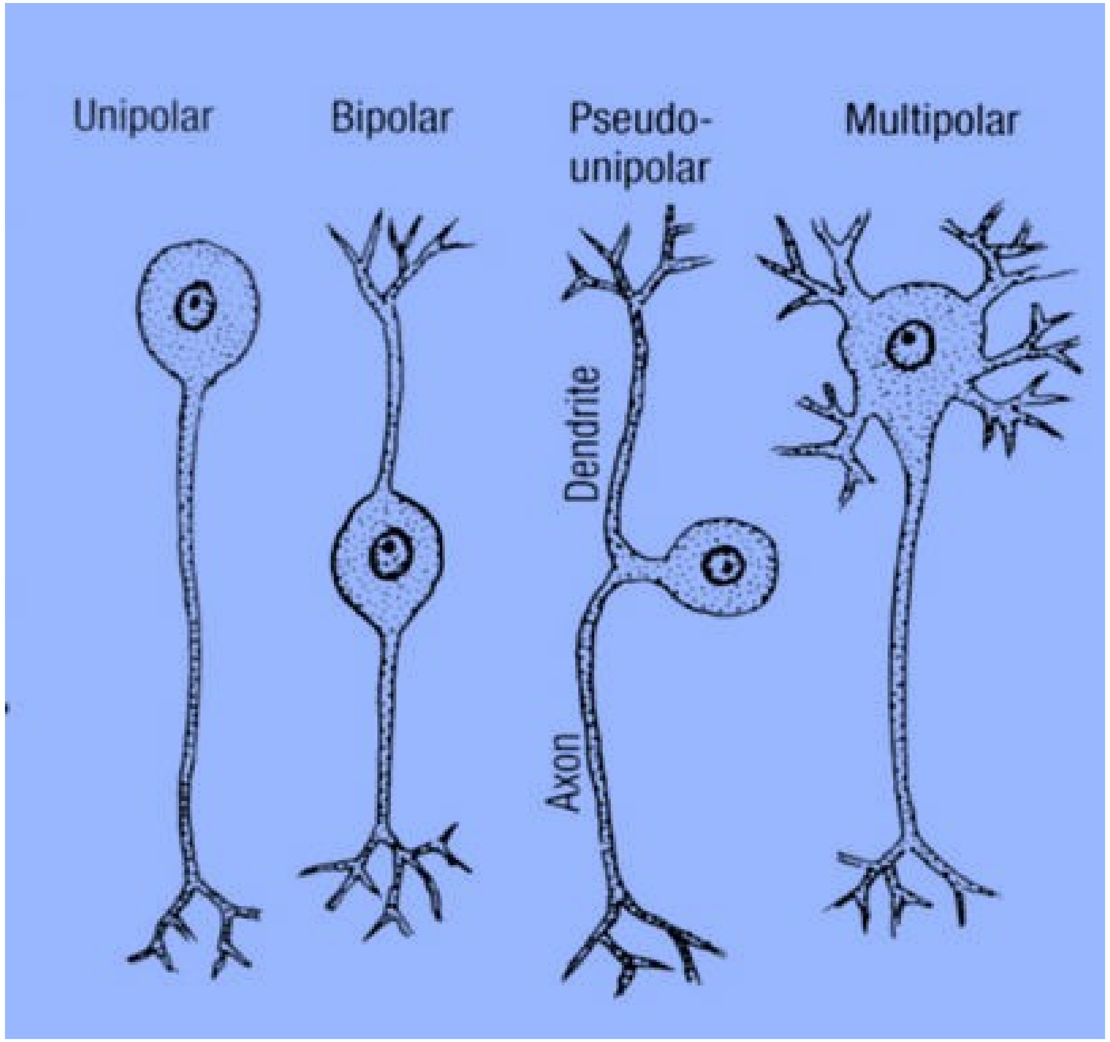
Dendrites

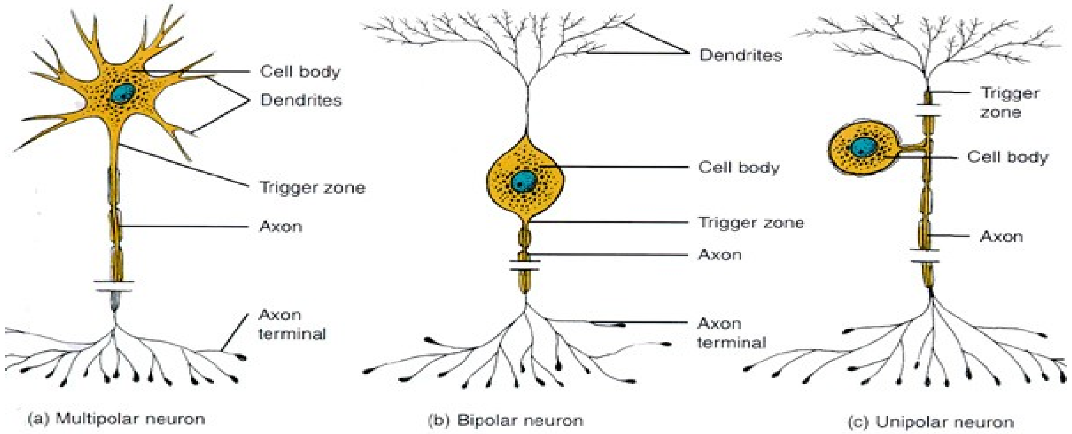
- DENDRITES – input structure – receive signals; number of dendrites: one – several hundreds
- short, branched processes with structure similar to perikarion (cytoplasm + organelles + neurofibrils)
- incoming signals summate to initiate action potential highly branched tree structure

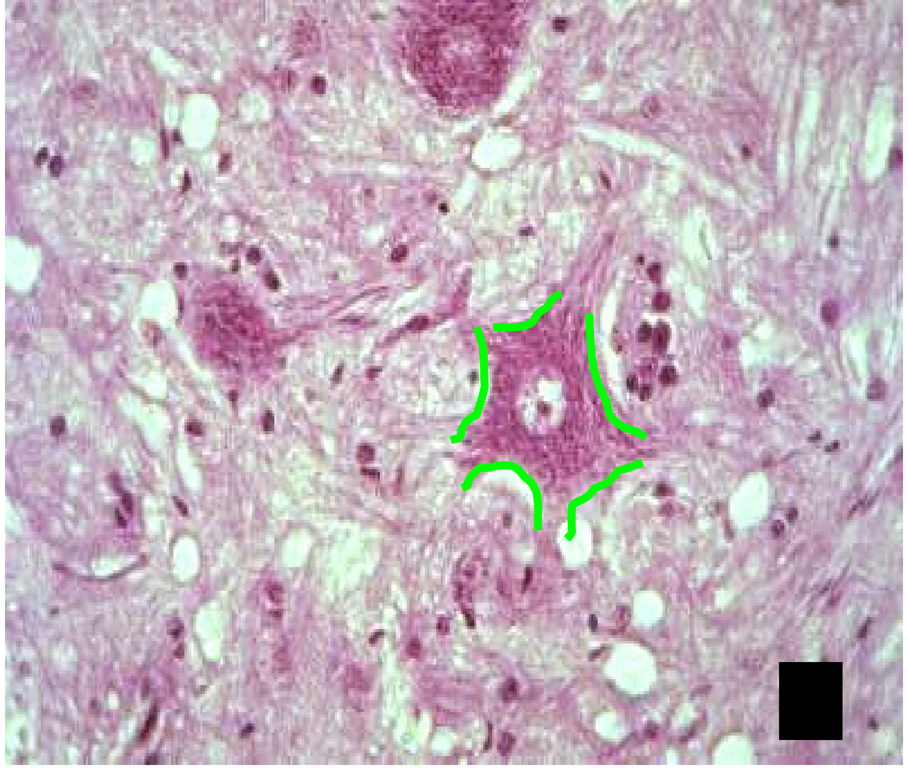


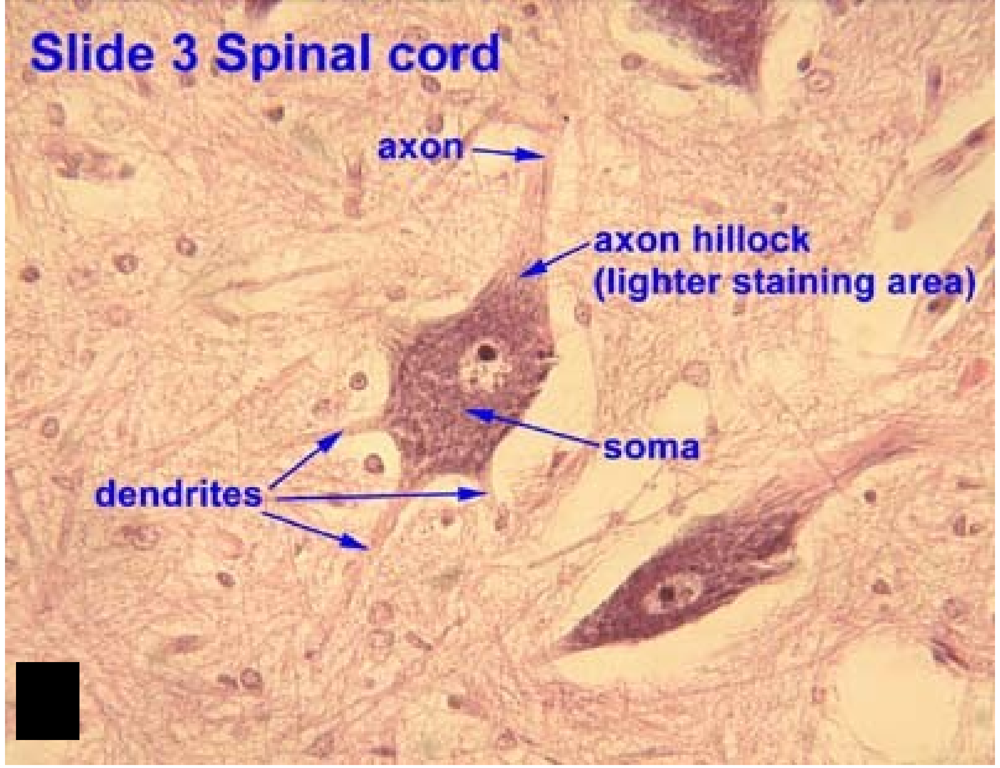
Classification of neurons according to number of processes (dendrites):

1. Multipolar neuron – several dendrites extend from body found in brain & spinal cord
2. Bipolar neuron – one dendrite and one axon (in retina of eye)
3. Unipolar neuron – one process only, link to axon (sensory neurons)
4. Pseudounipolar neuron – one short process divides later into dendrite and axon (spinal ganglia)



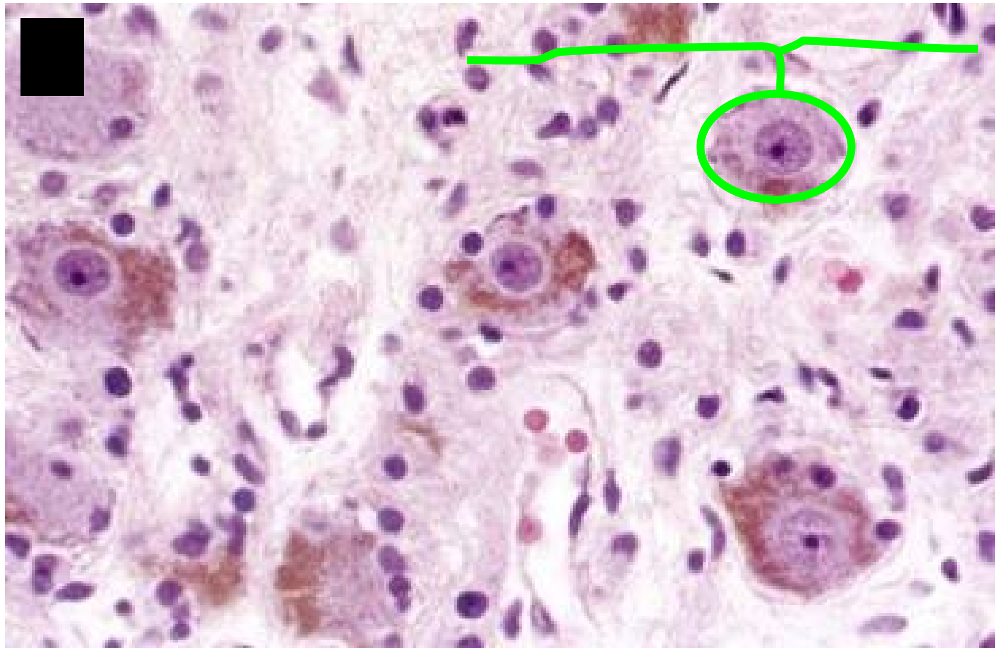






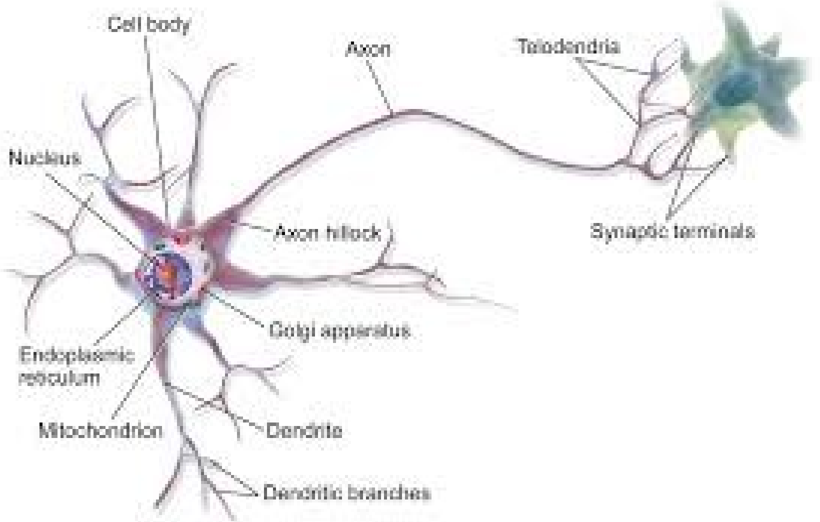
1, 2 – multipolar. neurons: Nissl bodies

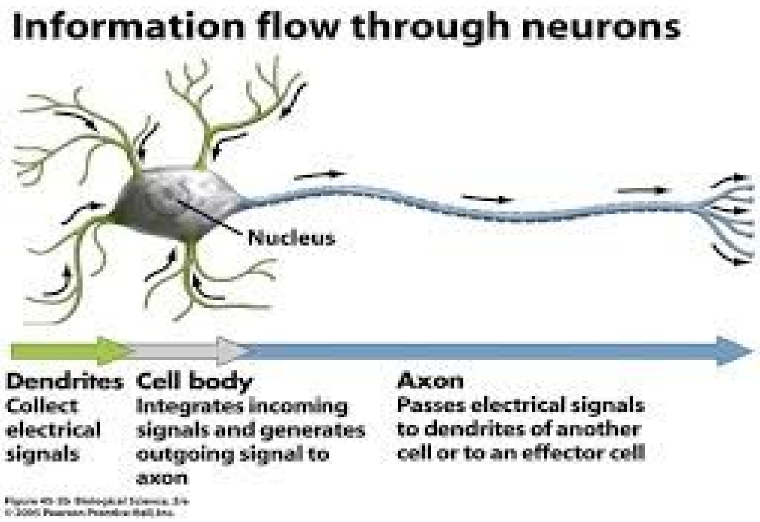
3 – pseudounipolar neurons:lipofuscin



AXON – only one

- no protein synthesis here
- Trigger zone - where nerve impulses arise
- Axon hillock – the cone-shaped base of the axon, its cytoplasm is free of rER (Nissl substance)
- Axons terminal - end with fine branching with „terminal boutons“ – mitochondria and synaptic vesicles containing neurotransmitters
- Axon hillock and terminal are not covered with oligodendrocytes (in CNS) or Schwann cells (in PNS)
- Serves for impulses transmission and for axonal transport of neurotransmitters and nutrients





Classification of neurons according to length of axon:

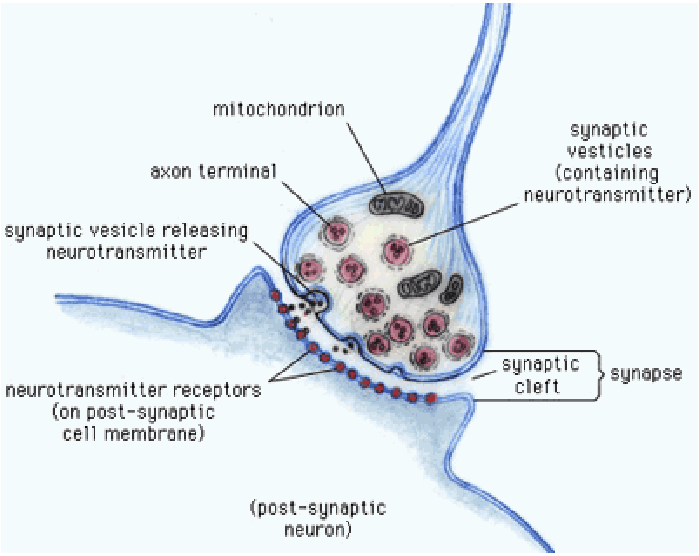
1. Golgi type I – long axon (up to 1 m) – somatic motor neurons
2. Golgi type II - short axon (in µm)

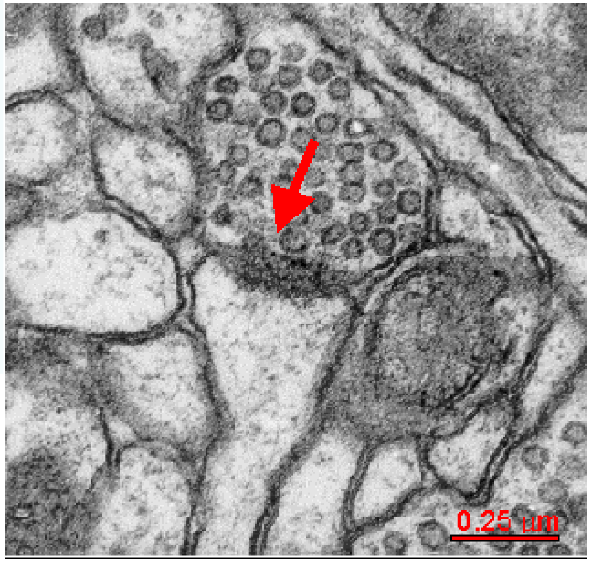
Classification of neurons according to function:

1. sensitive neurons – (afferent) conduct informations from receptors to CNS
2. motor neurons – (efferent) conduct infirmations from CNS to effector cells: somatomotor to skeletal muscle and visceromotor to smooth muscle cells, cardiomyocytes or glandular cells
3. interneurons (97 %)

Synapses

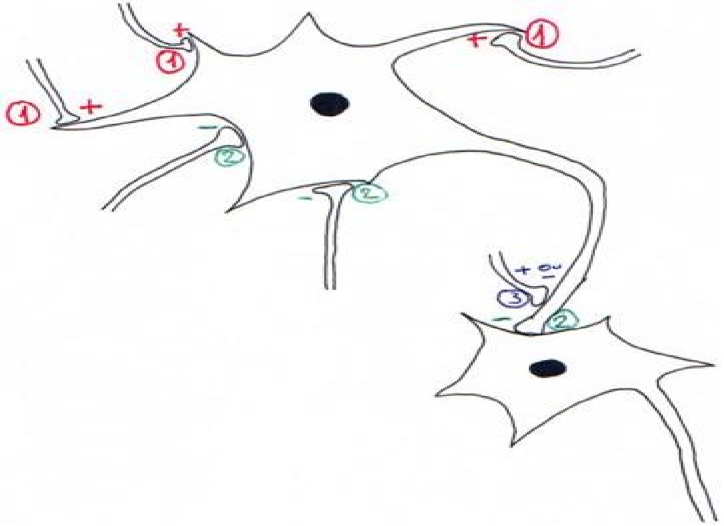
- NEURON – NEURON
- Presynaptic neuron - conducts signal to a synapse // synaptic vesicles with neurotransmiter
- Synaptic cleft (20-30 nm thick)
- Postsynaptic neuron - conducts signal from a synapse // receptors on cell membrane





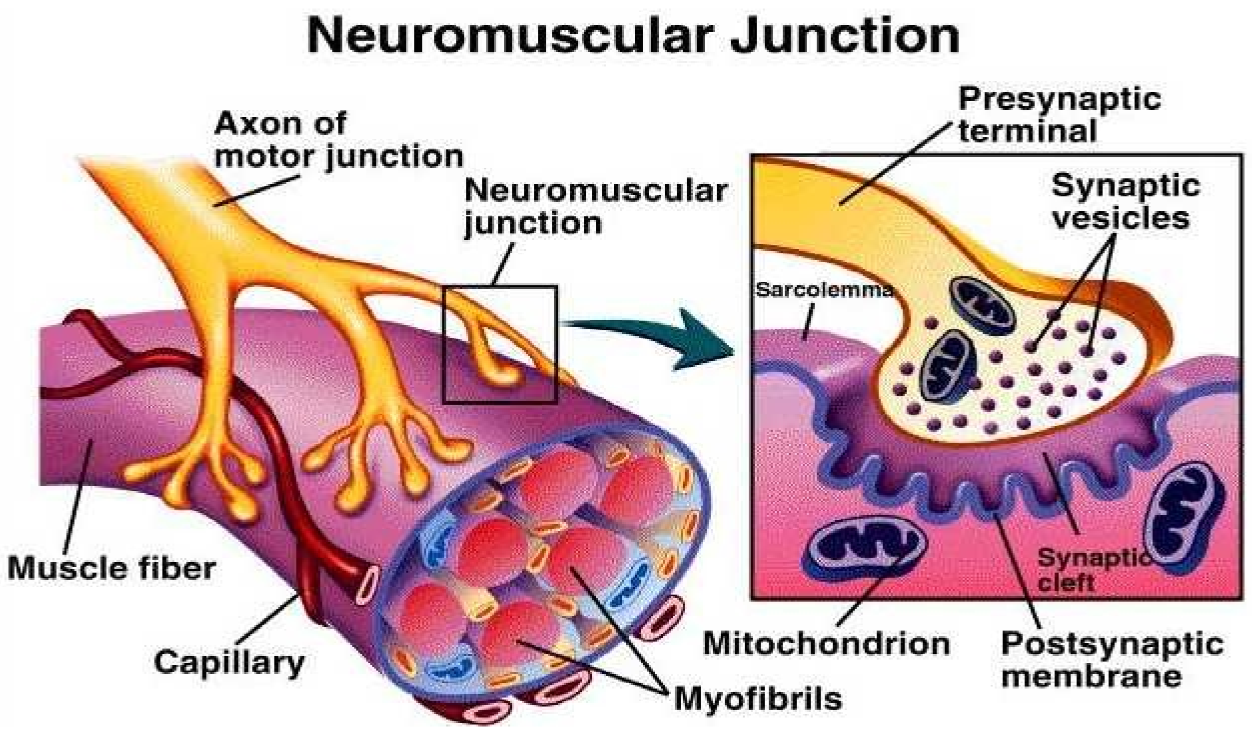
- Axodendritic (1)
- Axosomatic (2)
- Axoaxonal (3)

Dendrodendritic synapses



- **NEURON – EFFECTOR CELL**

Effector cells – muscle cells (in smooth muscle = **neuromuscular spindle**, in skeletal muscle = **motor-end-plate**), cardiomyocytes, glandular cells



Chemical Synapses

- Presynaptic cell releases neurotransmitters from synaptic vesicles
- Act on the postsynaptic cell (help initiate AP)
- Neurotransmitters can excite or inhibit
- Neurotransmitters (acetylcholine, serotonin, norepinepherine and epinephrin, dopamine, GABA, …)
- Neurotransmiter must be removed to prevent continual firing of neurons
- Enzymatically - acetylcholineresterase
- Many pharmaceuticals and drugs modulate this effect
- Cocaine block removal of dopamine

Electrical Synapses

- Without synaptic vesicles; synaptic cleft – only 2 nm thick
- Depolarizating wave continues from presynaptic to postsynaptic membrane
- Morphologically (in electron microscope) it looks like communicatin intercellular connection: gap junction (nexus)

SUPPORT CELLS

- essential to the function and survival of nerve cells
- CNS and PNS each have their own specific types of support cells

Support cells in the CNS:

- general term for support cells in the CNS is **glia** or **neuroglia**
- here are four types of neuroglial cells.

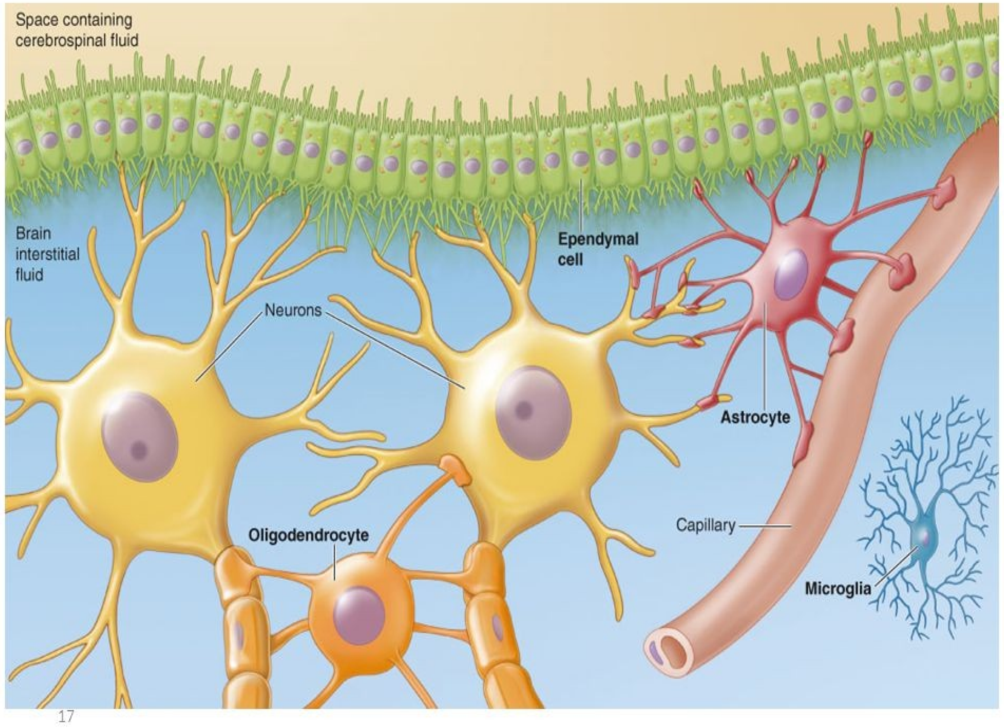
  Oligodendrocytes - myelin-secreting cells of the CNS

  Astrocytes - provide physical and metabolic support for nerve cells

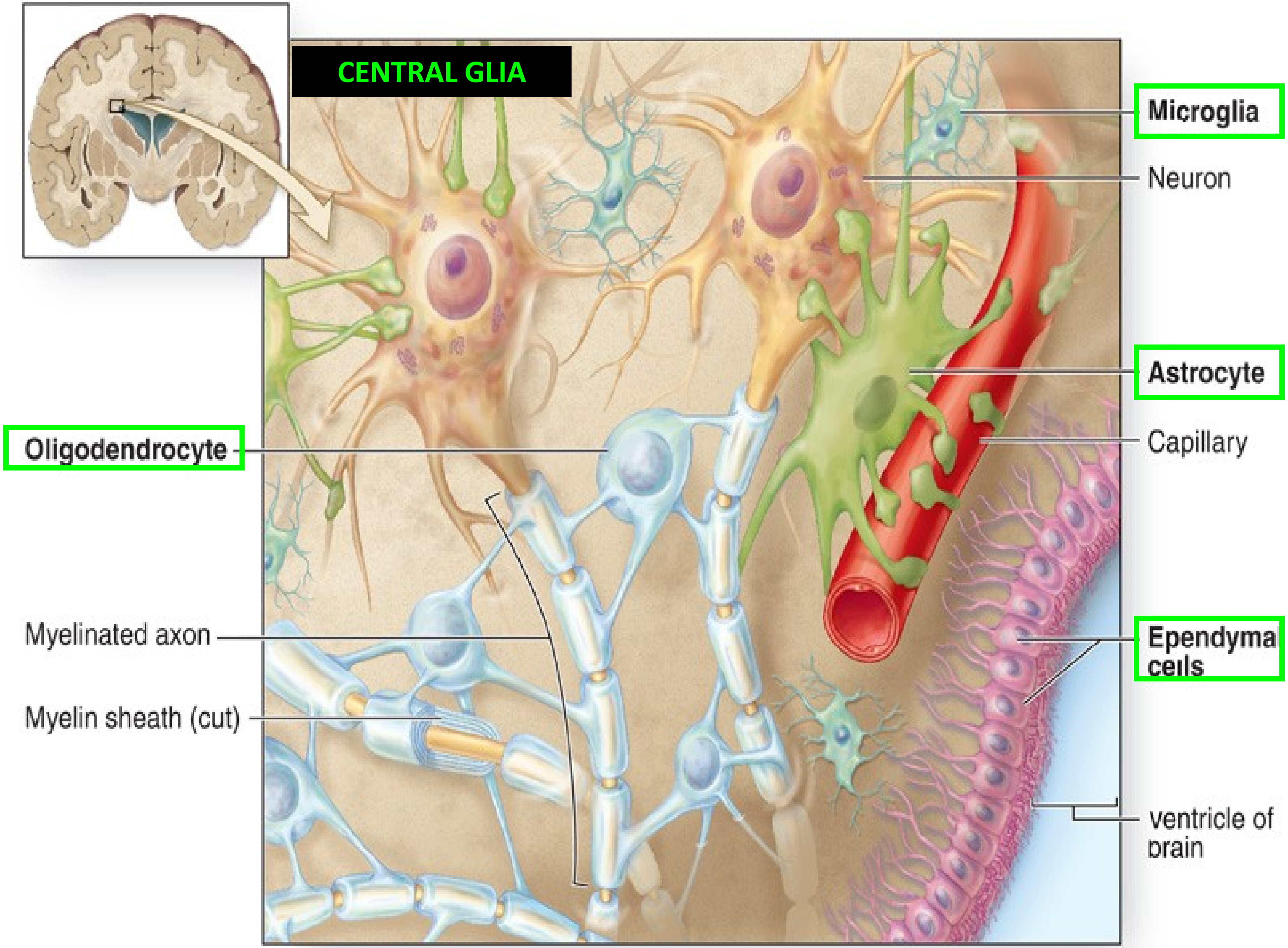
  Microglia (microglial cells) - phagocytes of CNS

  Ependyma (ependymal cells) - lining brain cavities and central canal in spinal cord

GLIAL CELLS



CENTRAL GLIA



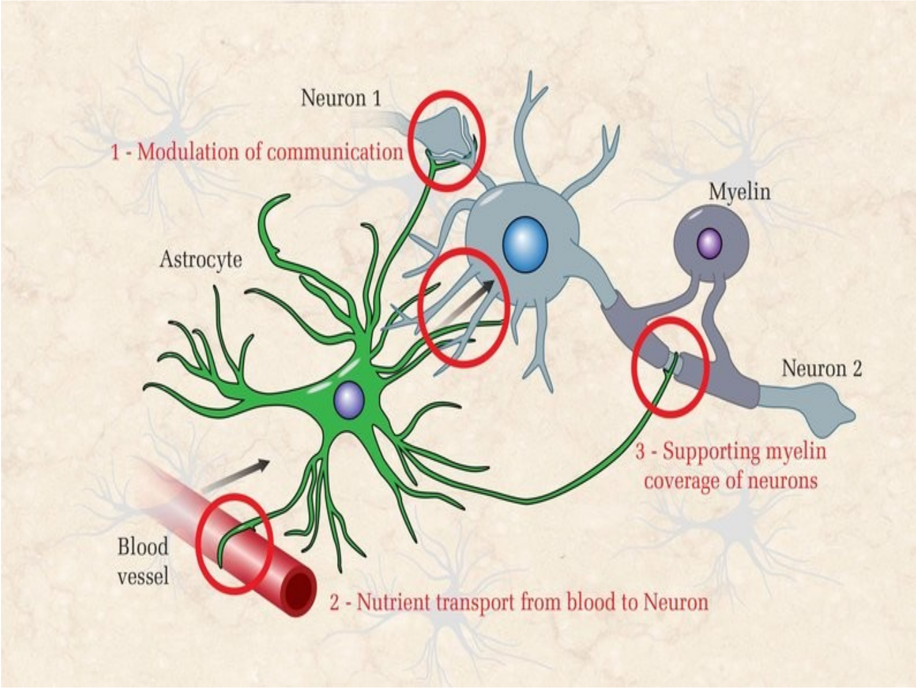
Astrocytes

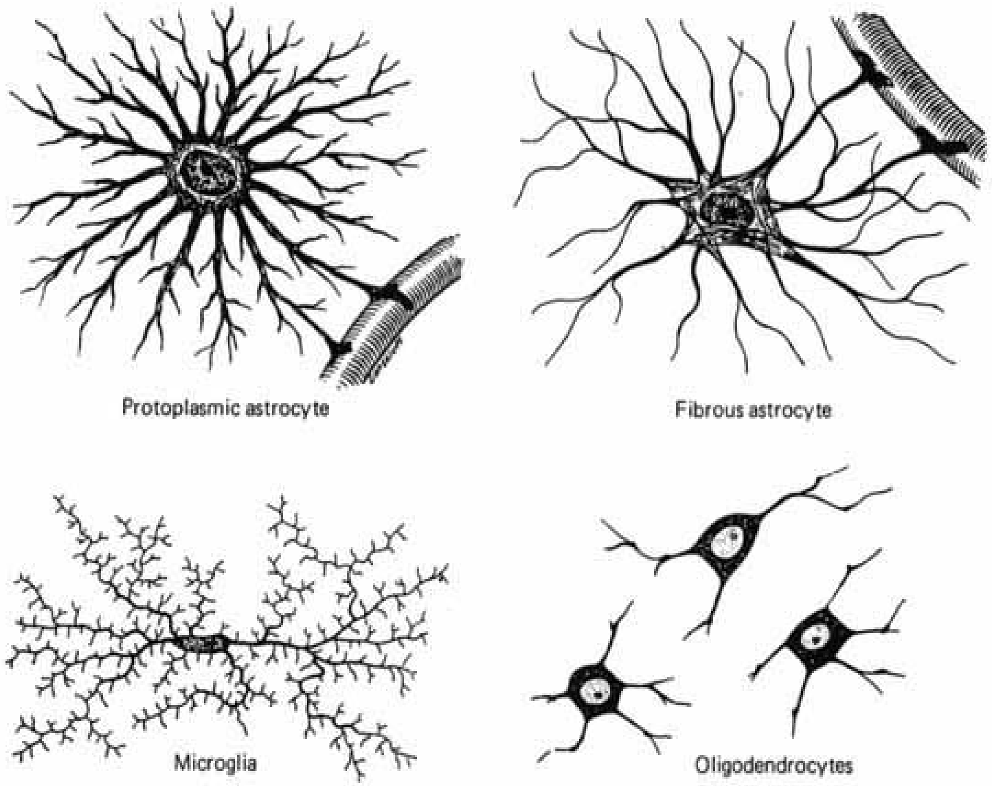
the largest of the neuroglial cells with processes that extend between neurons and blood vessels

- ends of the processes expand to form end feet, which cover large areas of the outer surface of the blood vessel or axolemma
- play a role in the movement of metabolites and wastes to and from neurons
- may be involved in regulating the tight junctions in the capillaries that form the blood-brain barrier
- cover the bare areas of neurons, at nodes of Ranvier and synapses
- two kinds of astrocytes are identified

  protoplasmic

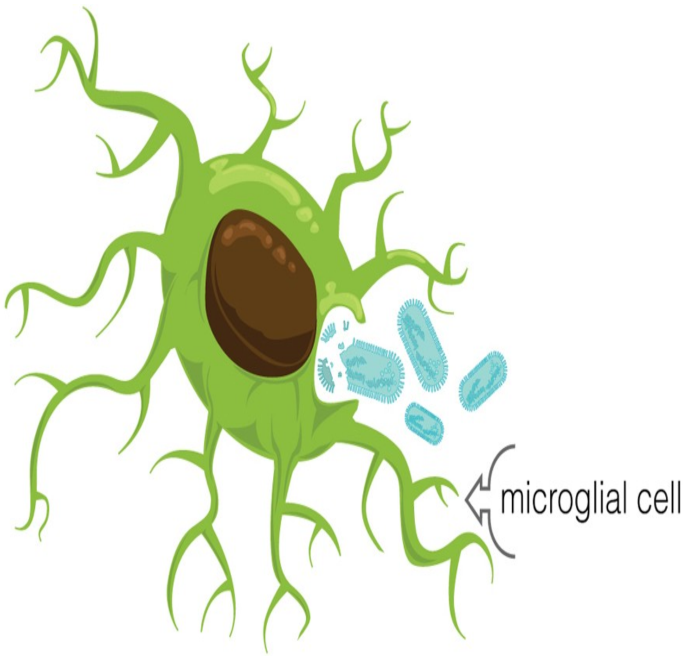
  fibrous astrocytes, contain prominent bundles of intermediate filaments, but the filaments are more numerous in fibrous astrocytes. (fibrous astrocytes are more prevalent in white matter, protoplasmic ones in grey matter)




Protoplasmic astrocyte
Fibrous astrocyte
Microglia
Oligodendrocytes

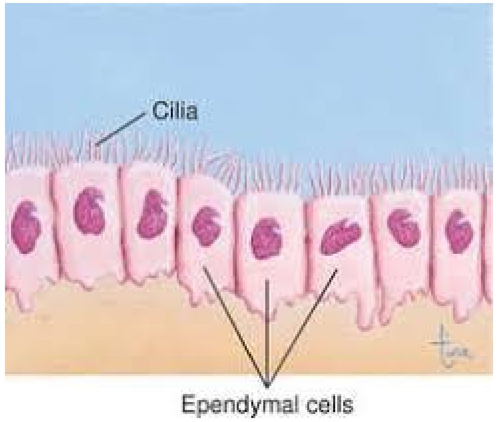
Microglia

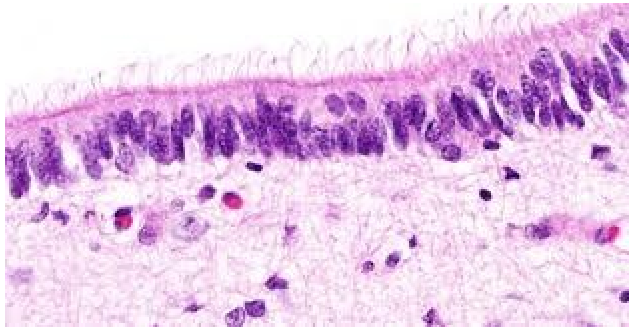
- the smallest of the glial cells, with short twisted processes
- are the phagocytes of the CNS, considered part of the mononuclear phagocytic system
- are believed to originate in bone marrow and enter the CNS from the blood
- In the adult CNS only in small numbers, but proliferate and become actively phagocytic in disease and injury.



Ependymal cells

- cuboidal to columnar cells in one layer lining the fluid-filled
- brain ventricles and central canal (canalis centralis) in spinal cord
- is involved in cerebrospinal fluid production in som regions (choroid plexus)

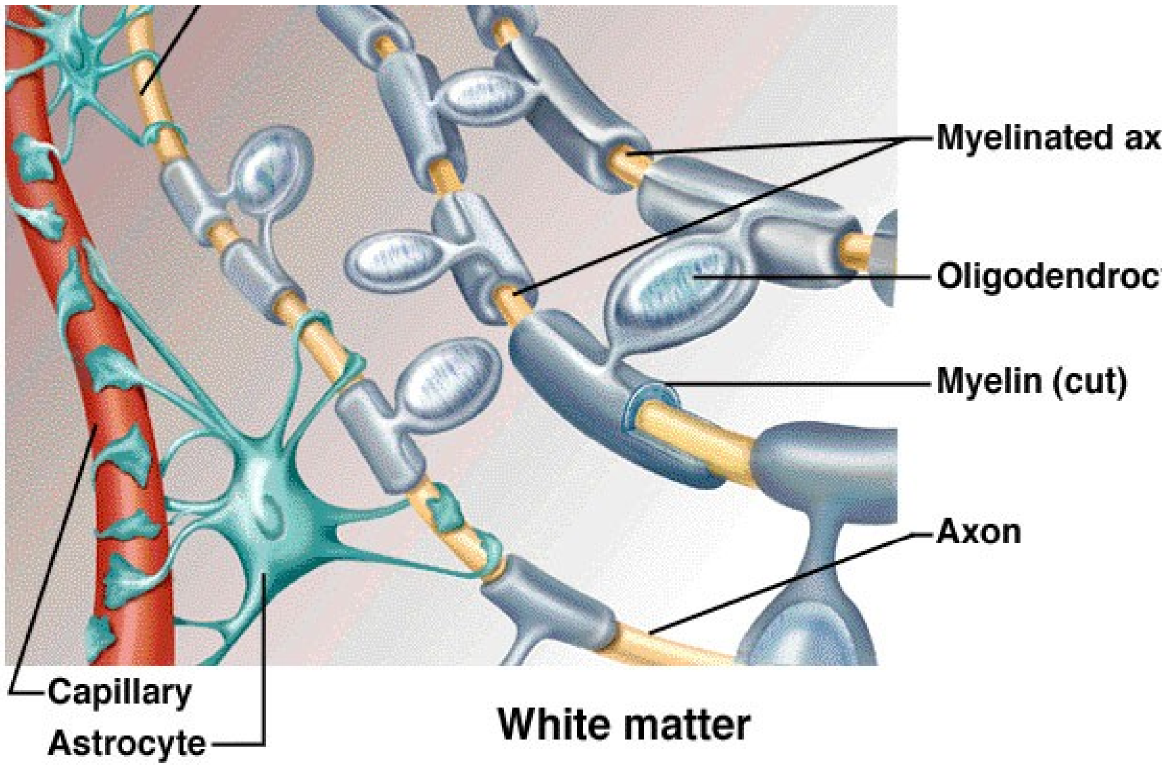




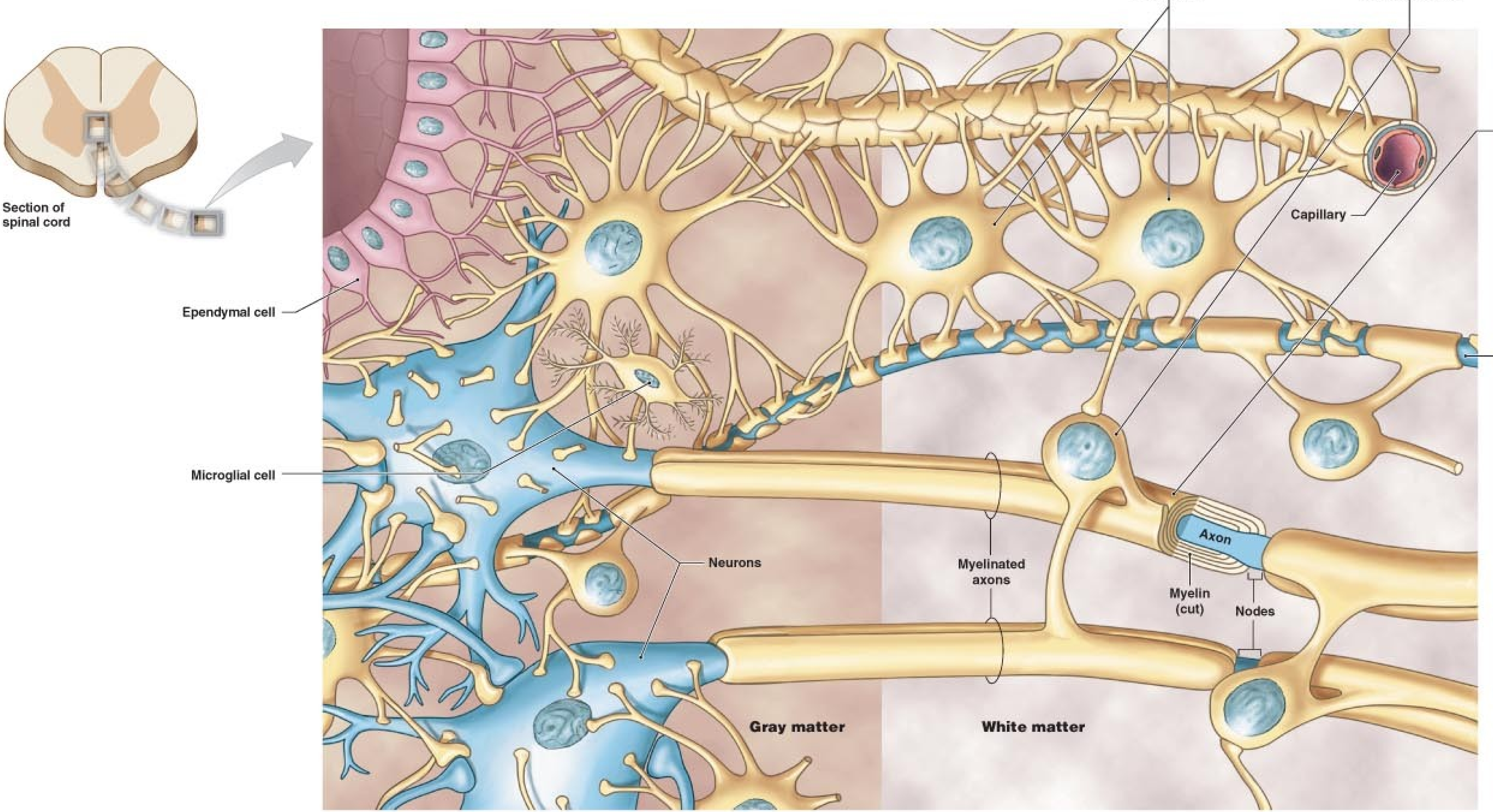
Oligodendrocytes

- have few processes, found in rows between axons

- the myelin sheath around axons is formed by concentric layers of oligodendrocytes plasma membrane -each oligodendrocyte gives off several tongue-like processes that contacts axon, where each process wraps itself around a portion of the axon, forming an internodal segment of myelin !!!
- one oligodendrocyte may **myelinate one axon or several**, in the CNS, nodes of Ranvier (between myelinated regions) are larger than those of the PNS,and the larger amount of exposed axolemma makes saltatory conduction more efficient



Unmyelinated axons in the CNS are truly bare, that is they are not embedded in any glial cell process. (In contrast to the situation in the PNS, described below.)


Section of spinal cord
Ependymal cell
Microglial cell
Neurons
Capillary
Myelinated axons
Axon
Myelin (cut)
Nodes
Gray matter
White matter

Support cells in the PNS:

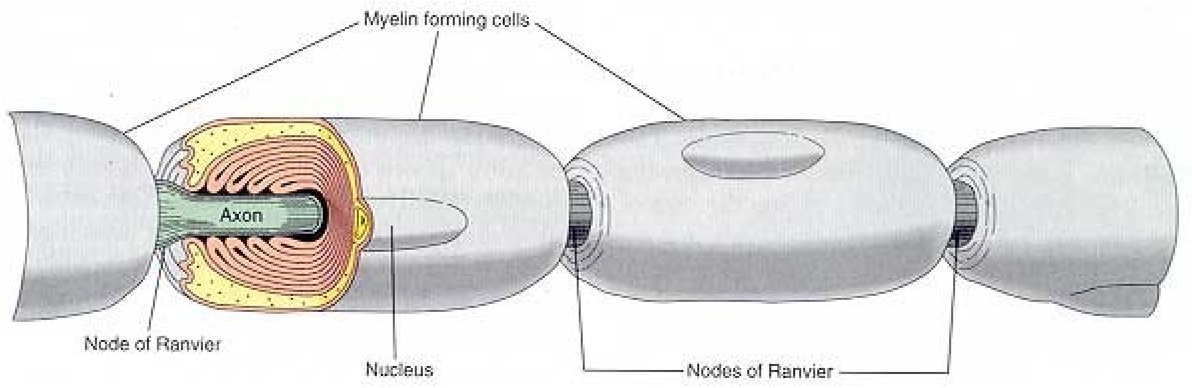
- support cells of the PNS : satellite cells and Schwann cells

Satellite cells

- surround the cell bodies of the neurons in ganglia
- small cuboidal cells form a complete layer around the nerve cell body, but only their nuclei are visible in routine preparations
- controll microenvironment around the nerve cell body, providing electrical insulation and a pathway for metabolic exchange
- **nutrition and isolation of neurons in ganglia**

Schwann cells

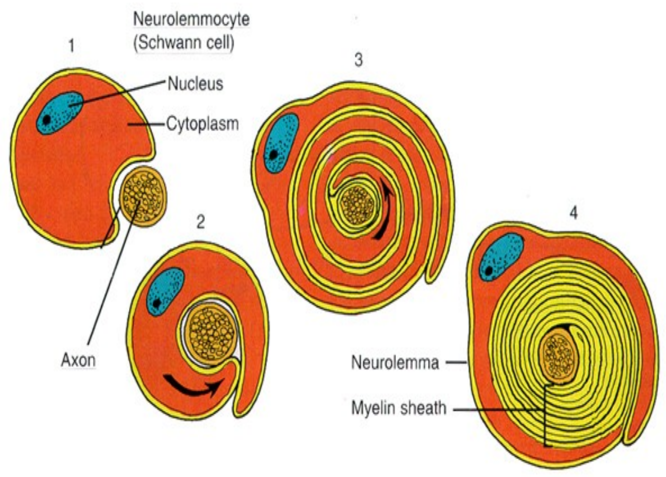
- responsible for **the myelination of axons in the PNS**
(Schwann cell wraps itself, jelly roll-fashion, in a spiral around a short segment of an axon. During the wrapping, cytoplasm is squeezed out of the Schwann cell and the leaflets of plasma membrance of the concentric layers of the Schwann cell fuse, forming the layers of the myelin sheath. An axon's myelin sheath is segmented because it is formed by numerous Schwann cells arrayed in sequence along the axon. The junction where two Schwann cells meet has no myelin and is called the node of Ranvier (the areas covered by Schwann cells being the internodal regions).



Sheaths of axons:

Schwann sheath (neurilemma) – Schwann cells surround the axon (gray fibers)

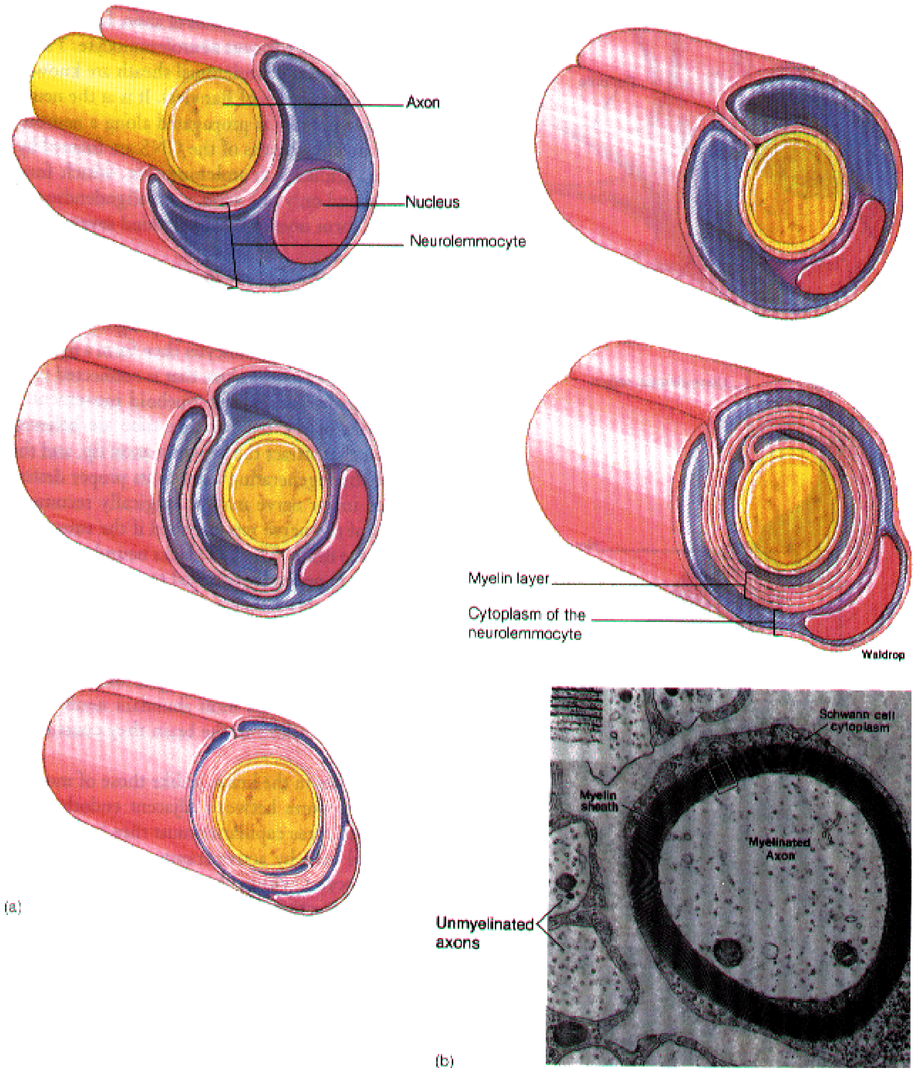
Myelin sheath – lipoprotein product of Schwann cells in PNS and oligodendrocytes in CNS
- electrically insulates axon - inreases speed of nerve impulse
- wraps around one axon many times and has a lamellar appearance



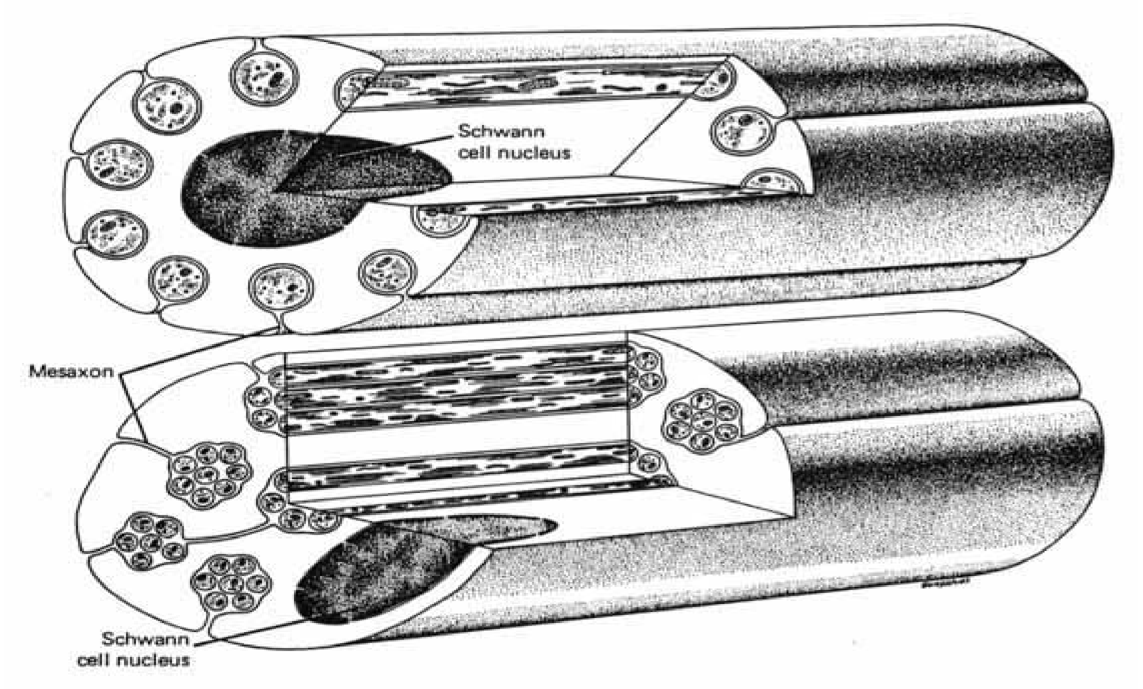
Many axons are wrapped in a lipid-rich covering called **myelin**. This myelin sheath insulates the axon from the surrounding extracellular component and increases the rate of electrical conduction. The myelin sheath is discontinuous at intervals called the **nodes of Ranvier**. The area covered with myelin is called **internodal area (internodium)**. In myelinated axons, the voltage reversal (that is, the impulse propagation) can occur only at the nodes, and the impulse "jumps" from node to node. This is called **saltatory conduction**. In unmyelinated axons, the impulse is conducted more slowly, moving as a wave of voltage reversal along the axon.

The lack of Schwann cell cytoplasm in the concentric rings of the myelin sheath is what makes it lipid-rich. Schwann cell cytoplasm is however found in several locations. There is an inner collar of Schwann cell cytoplasm between the axon and the myelin, and an outer collar around the myelin. The outer collar is also called the sheath of Schwann or neurilemma, and contains the nucleus and most of the organelles of the Schwann cell. The node of Ranvier is also covered with Schwann cell cytoplasm, and this is the area where the plasma membranes of adjacent Schwann cells meet. (These adjacent plasma membranes are not tightly apposed at the node, so that extracellular fluid has free acess to the neuronal plasma membrane.) Finally, small islands of Schwann cell cytoplasm persist within successive layers of the myelin sheath, these islands are called Schmidt-Lanterman clefts.

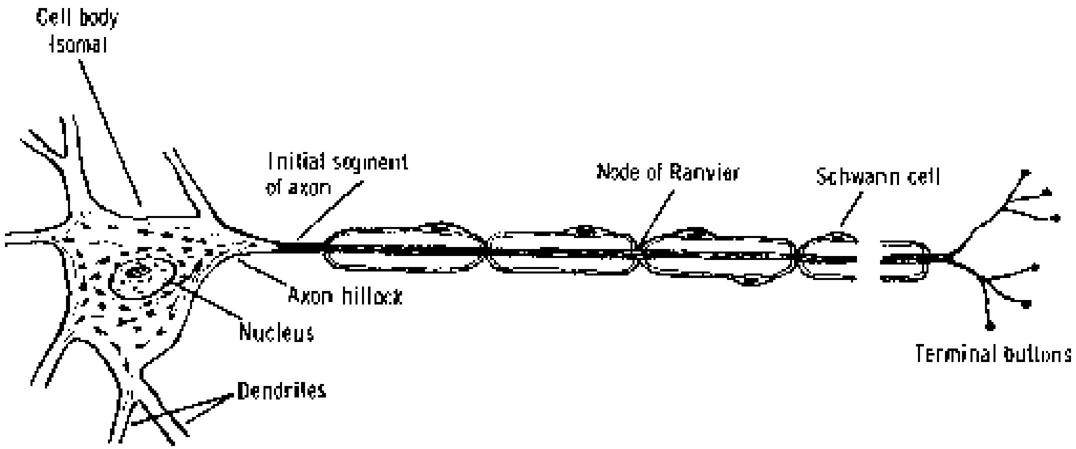
Myelination (development of myelin sheath):

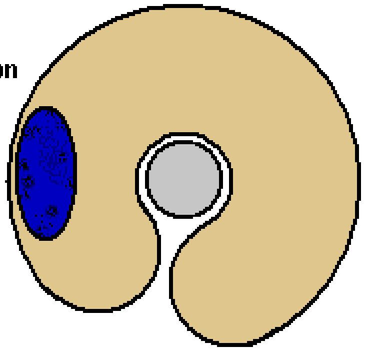


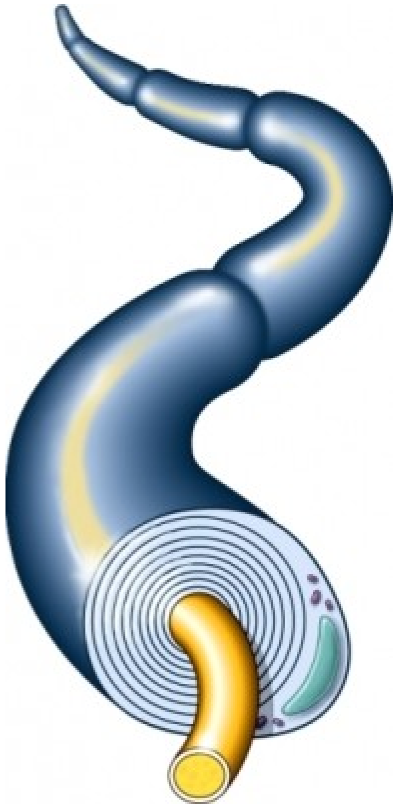
Not all nerve fibres is the PNS are covered with myelin, some axons are unmyelinated. In contrast to the situation in the CNS, unmyelinated fibres in the PNS are not completely bare, but are enveloped in Schwann cell cytoplasm. The Schwann cells are elongated in parallel to the long axis of the axons, which fit into grooves on the surface of the Schwann cell. One axon or a group of axons may be enclosed in a single groove. Schwann cells may have only one or up to twenty grooves. Single grooves are more common in the autonomic nervous system.

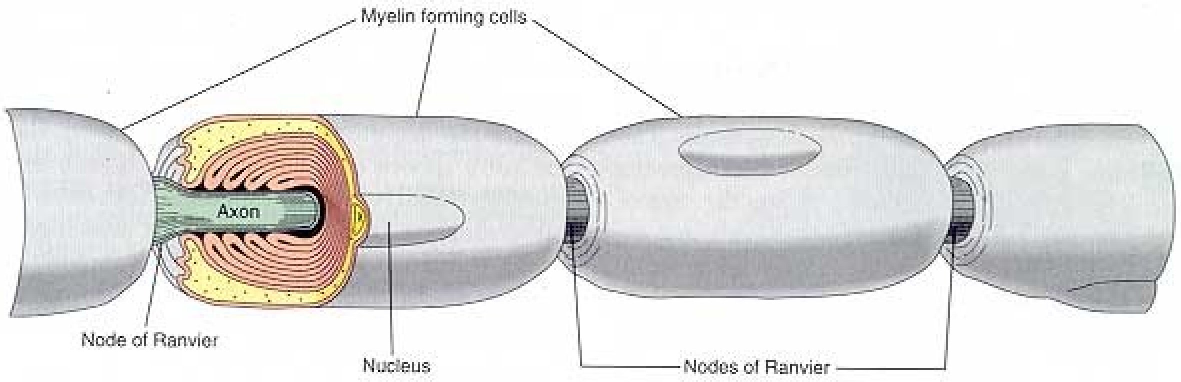


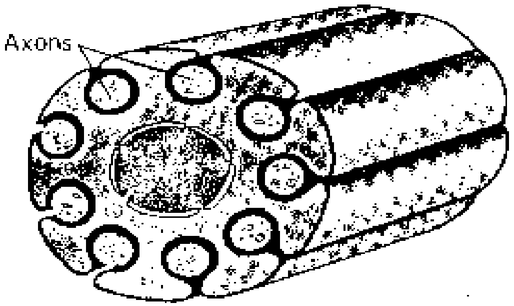
PERIFERNÍ GLIE: SCHWANNOVY BUŇKY

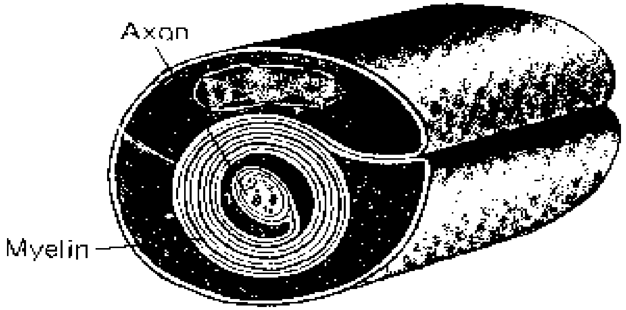


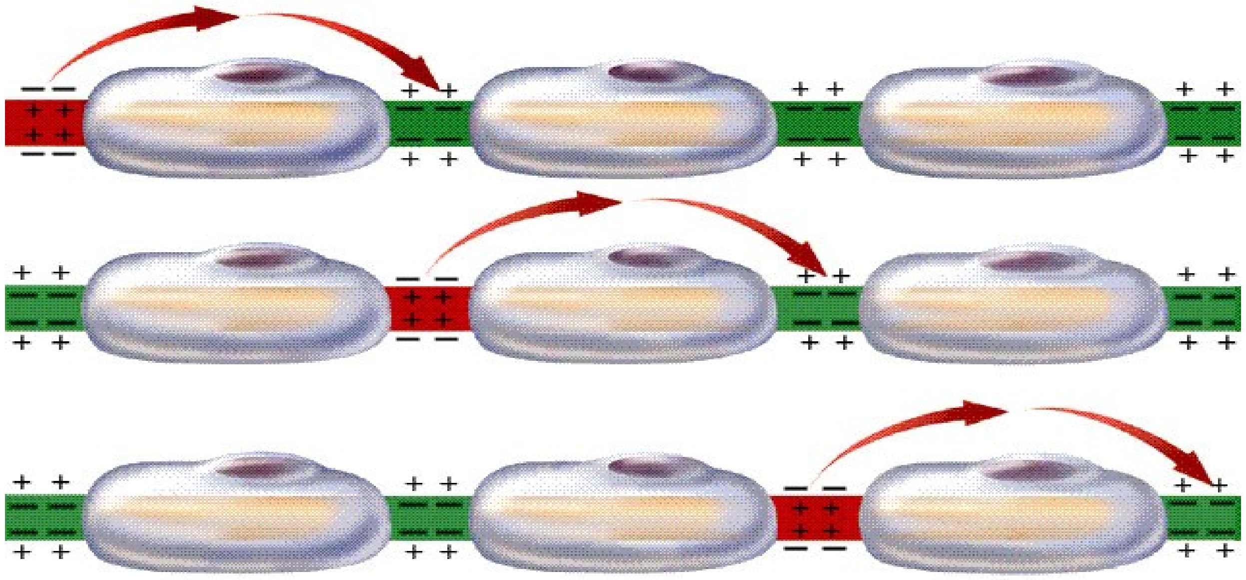


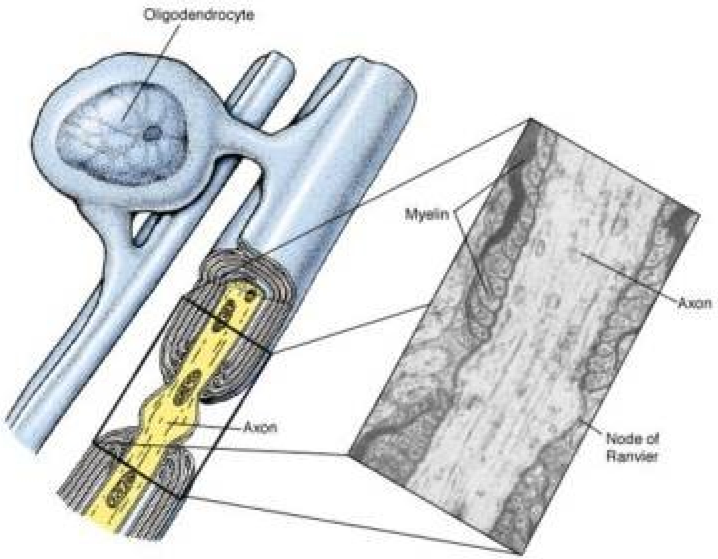


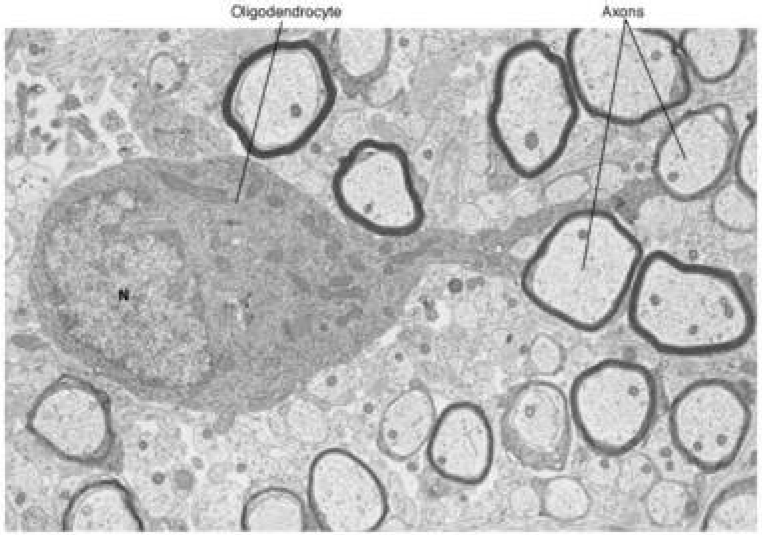




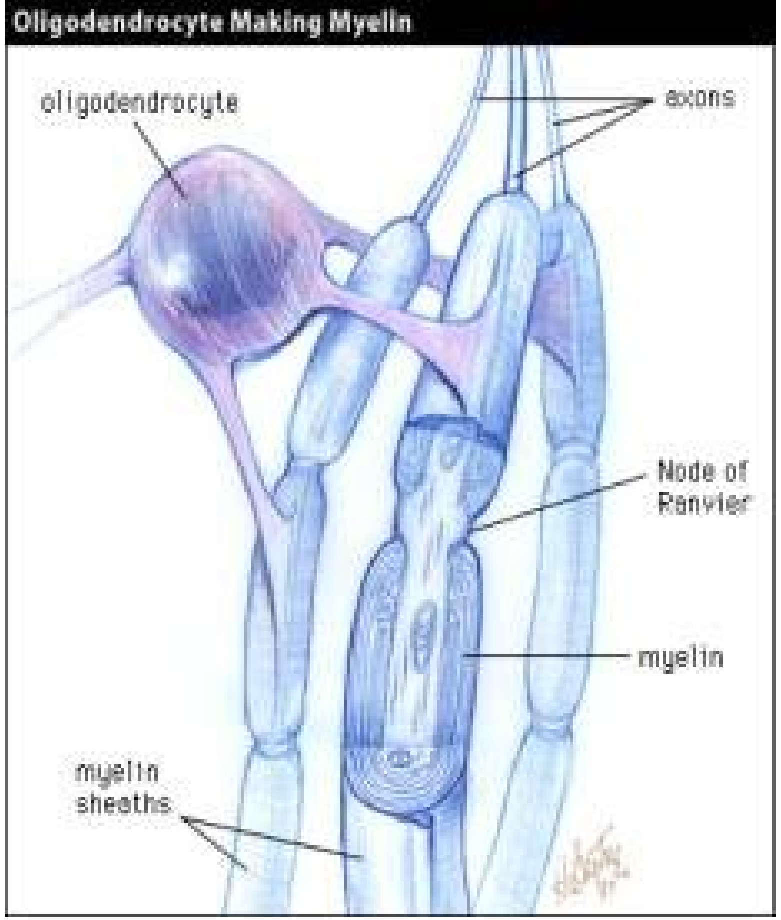


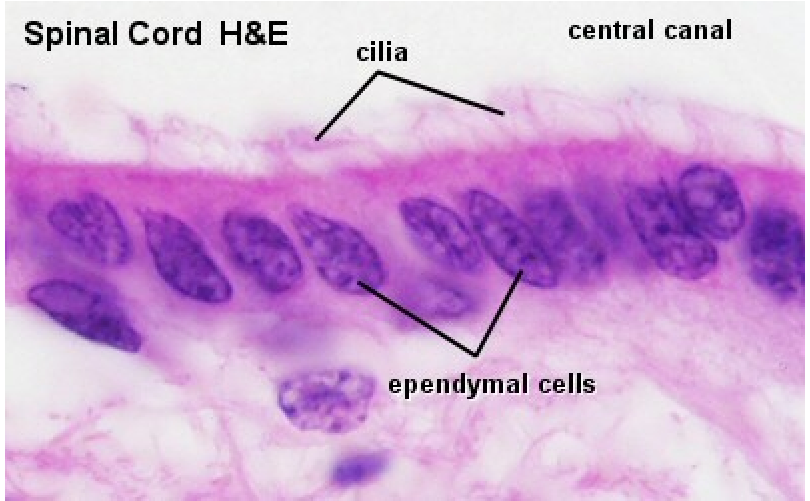



Oligodendrocyte
Myelin
Axon
Axon
Node of Ranvier

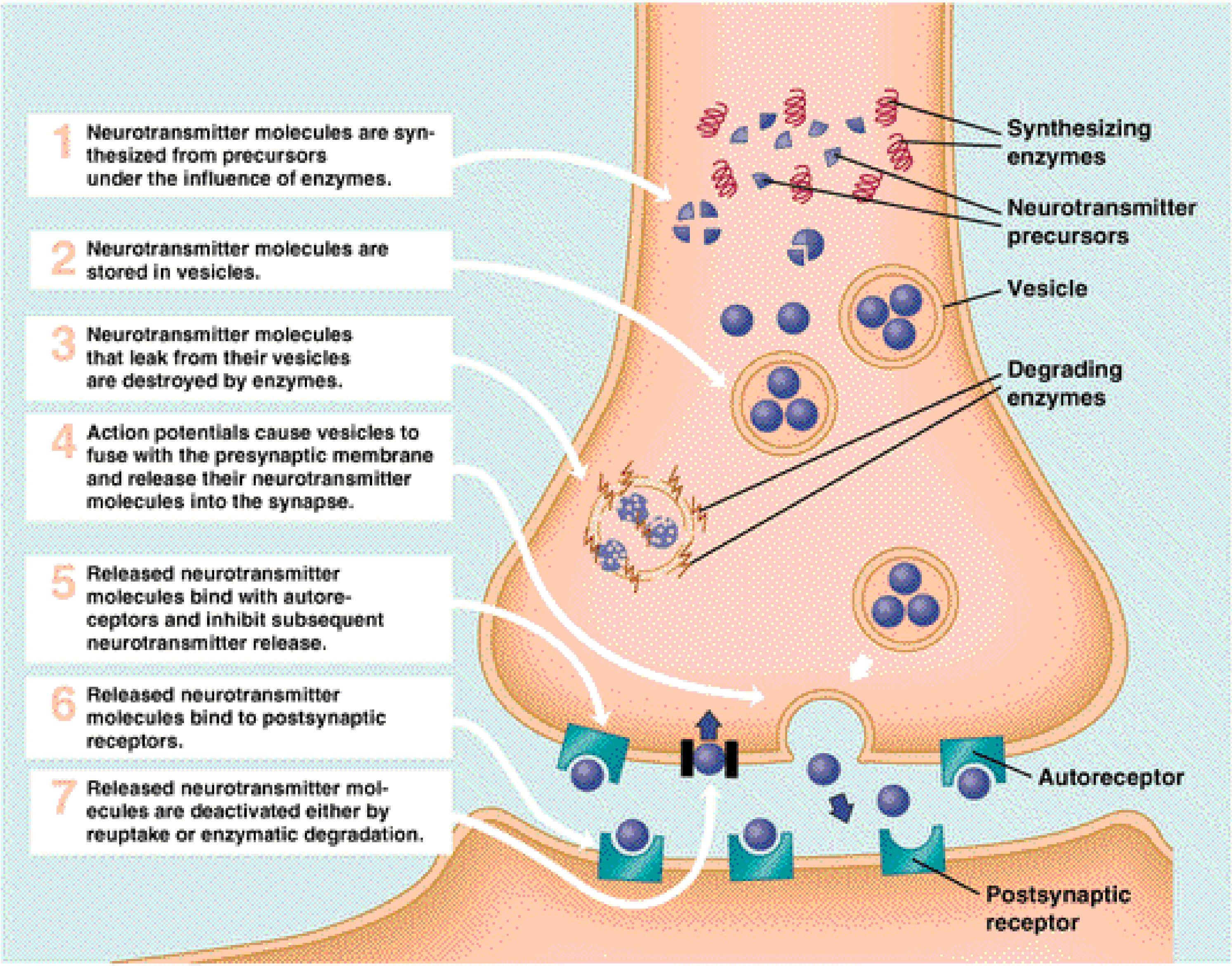

Oligodendrocyte
Axons
N


node of
Ranvier

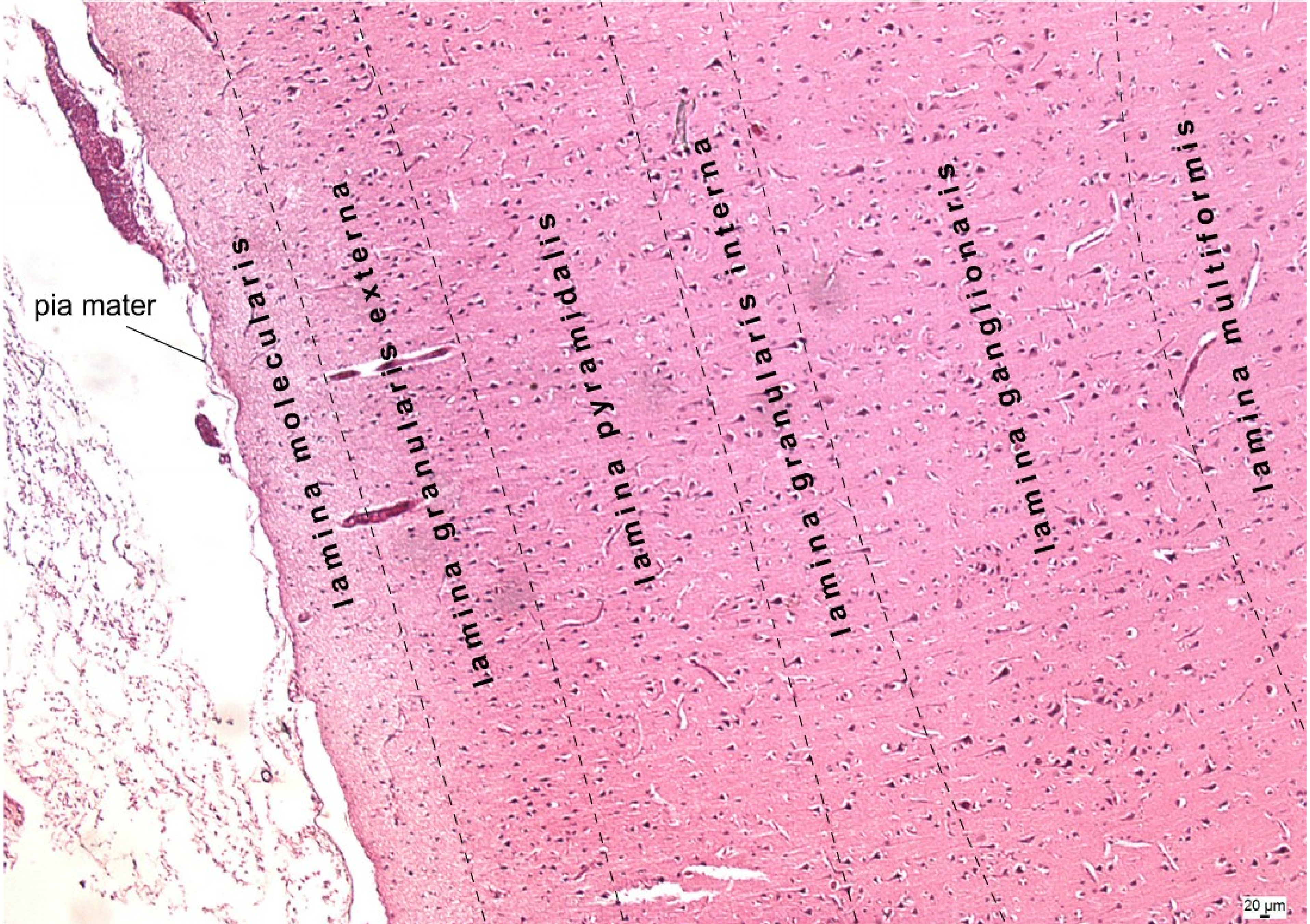

Oligodendrocyte Making Myelin
oligodendrocyte
axons
Node of
Ranvier
myelin
myelin
sheaths


Spinal Cord H&E
cilia
central canal
ependymal cells

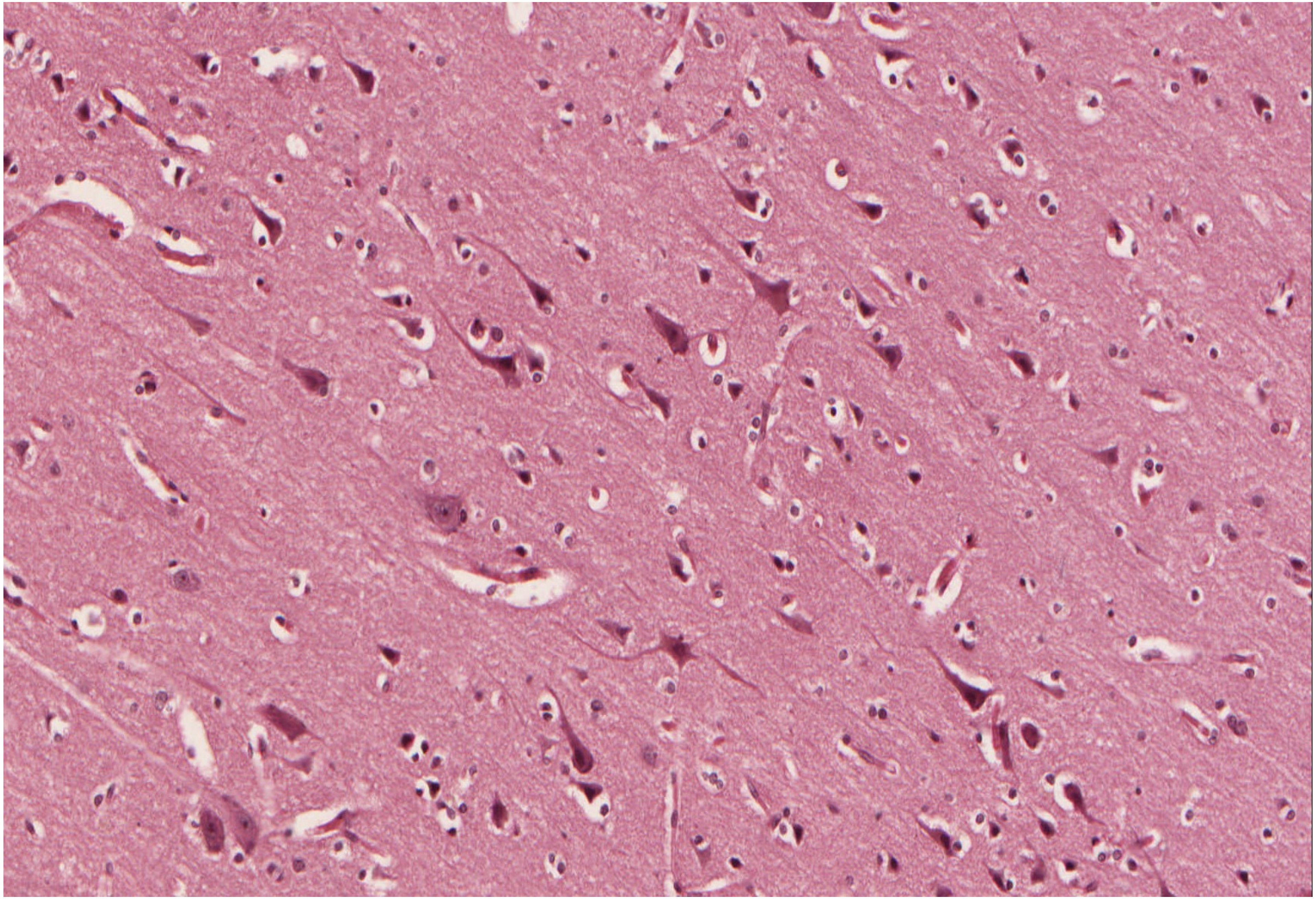
► Seven Processes in Neurotransmitter Action



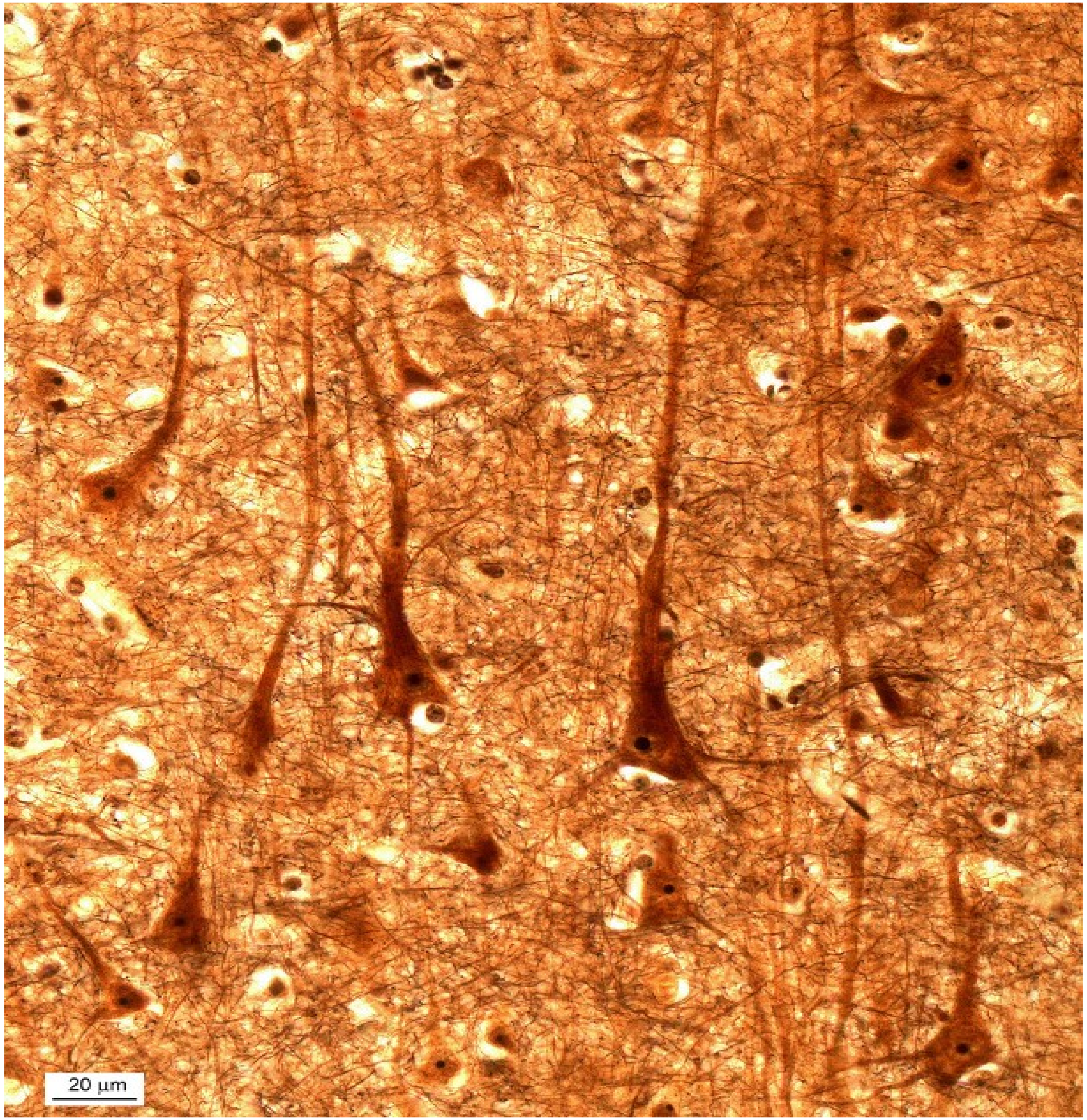
Cortex cerebri



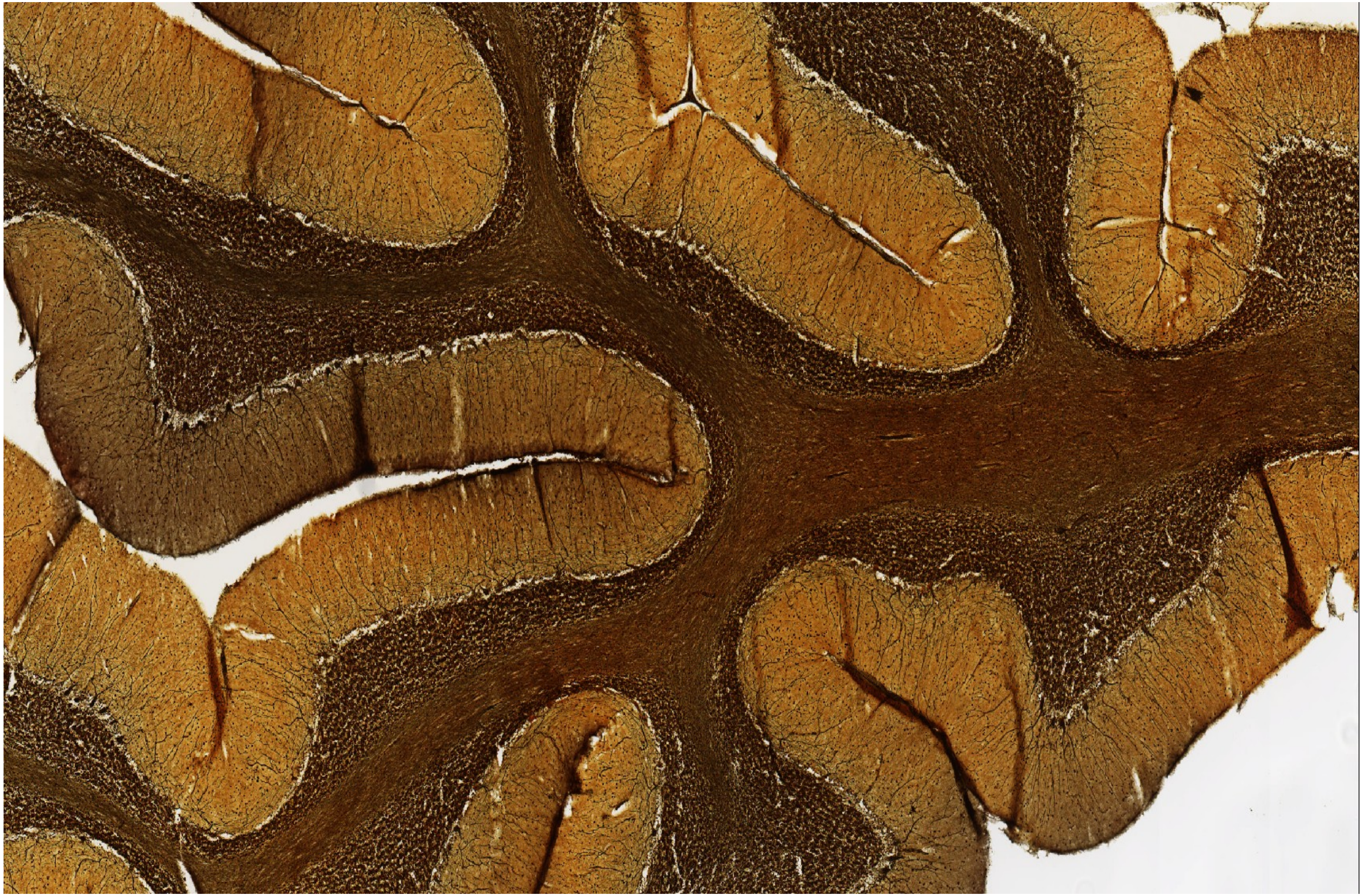
Cortex cerebri – Pyramidal cells – multipolar neurons



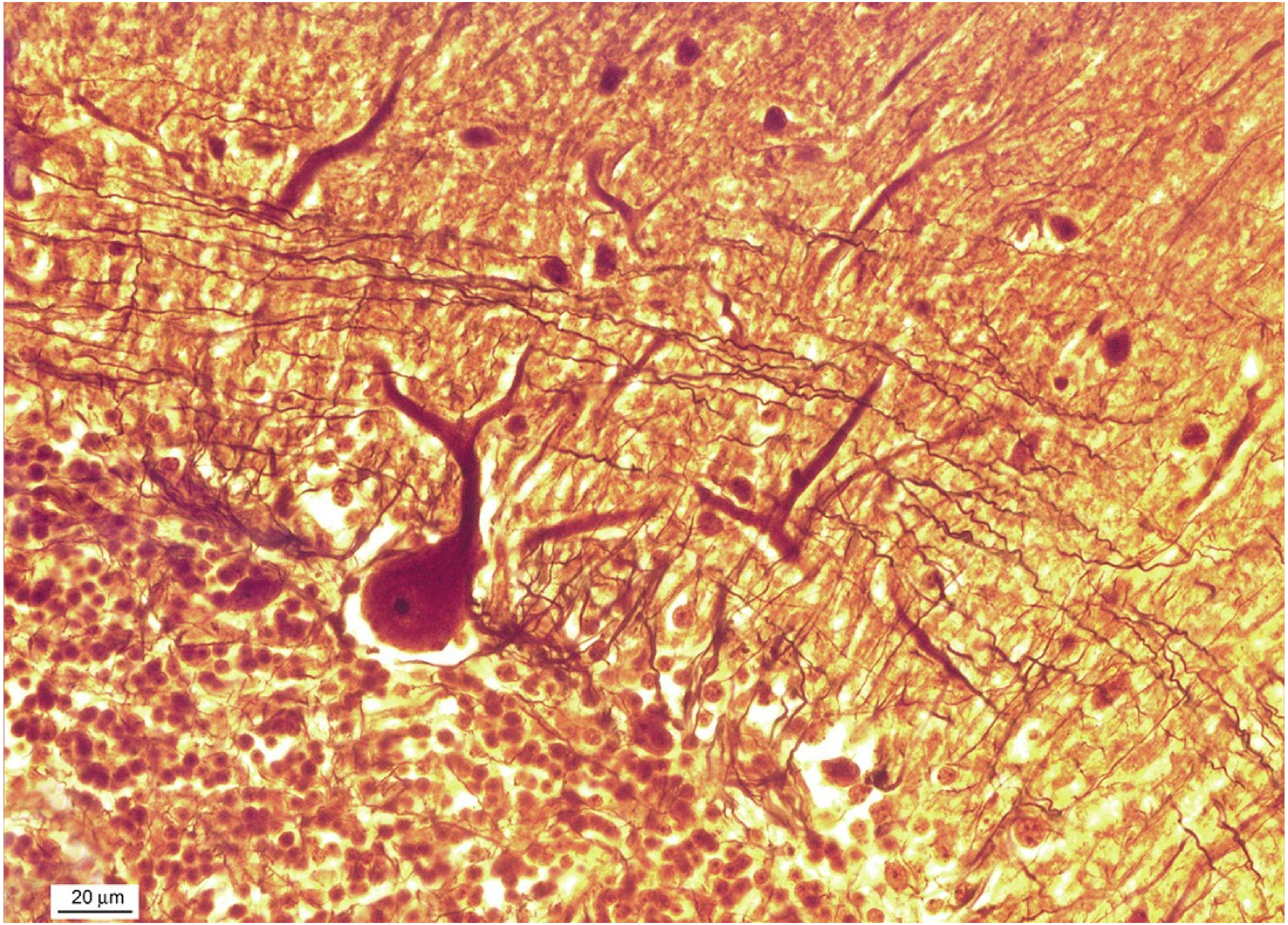
Cortex cerebri – Pyramidal cells – multipolar neurons



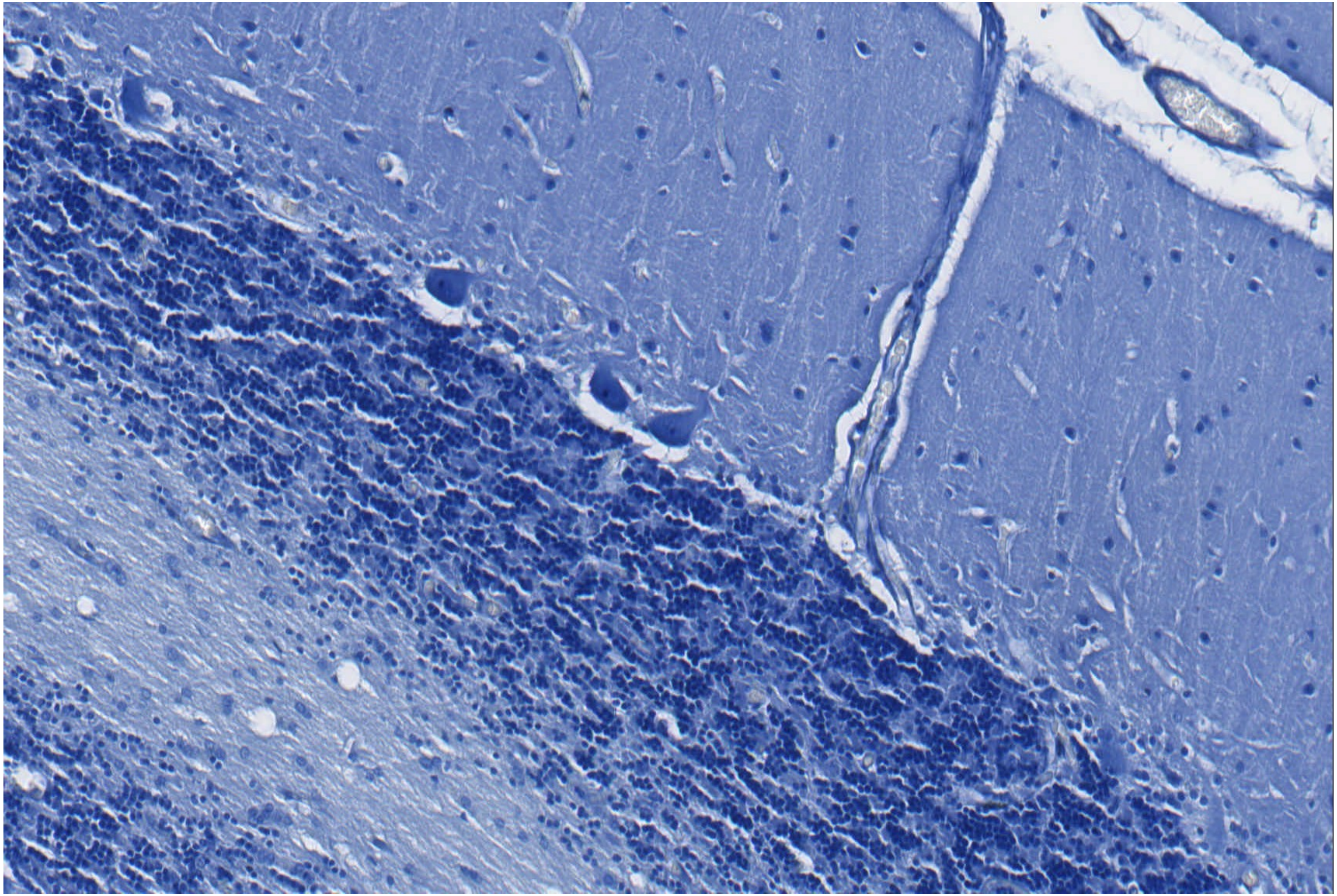
Cerebellum

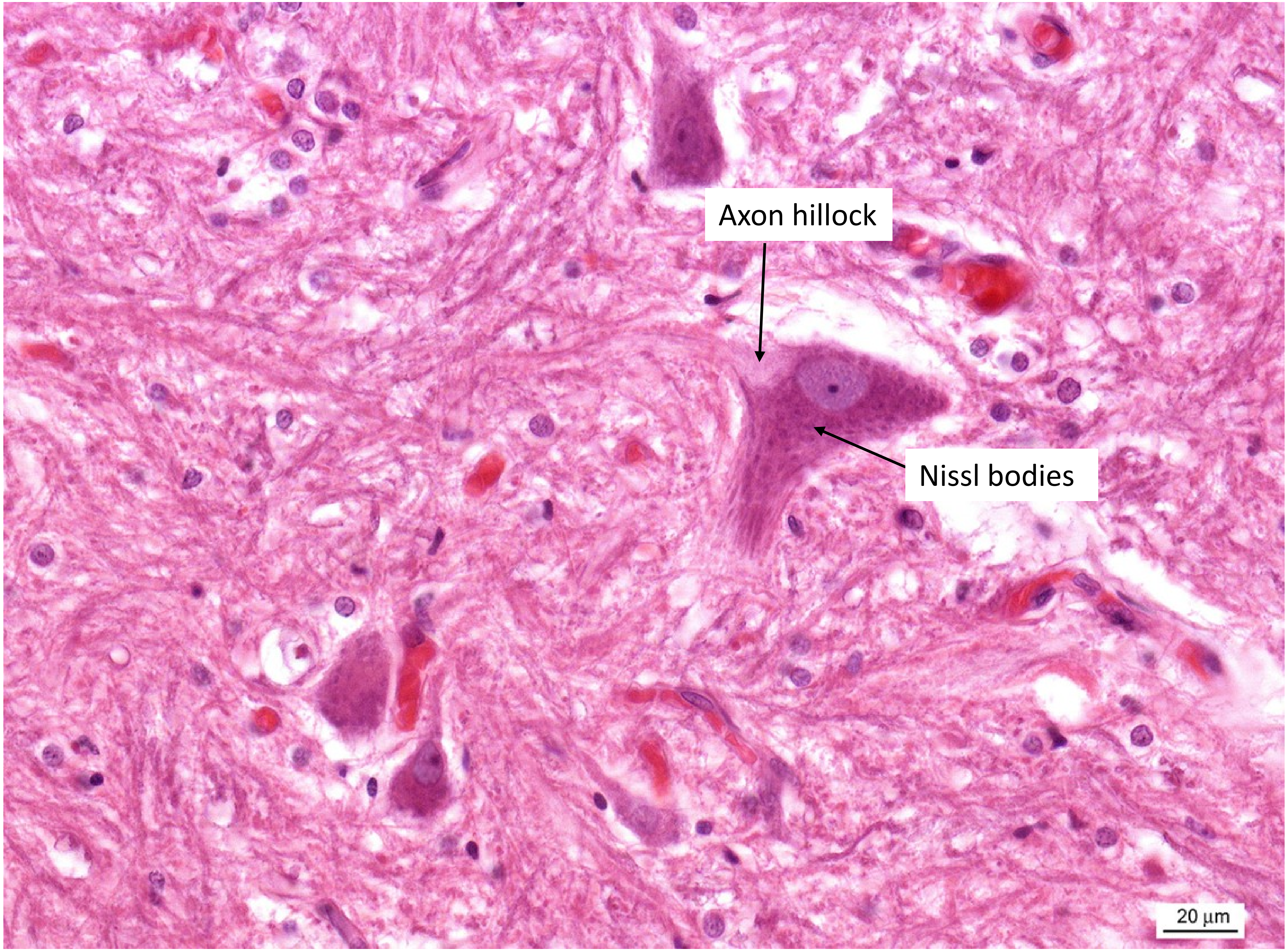


Cerebellum – Purkynje cell

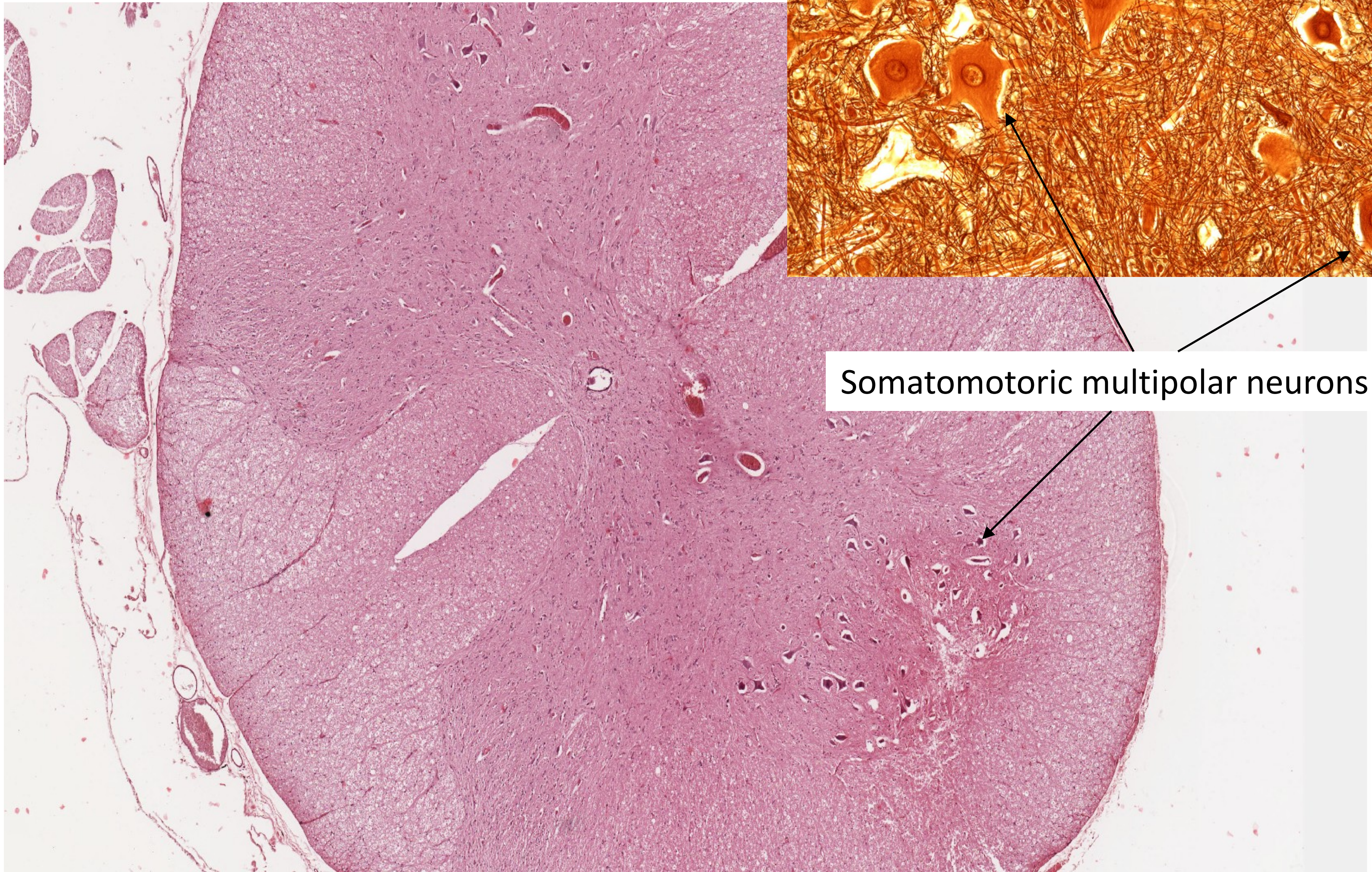


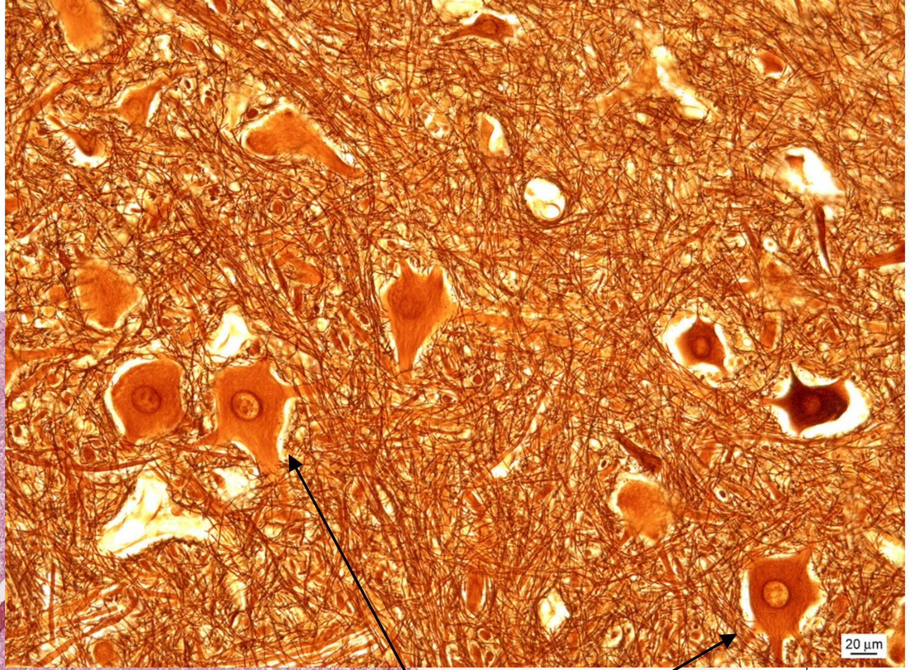
Cerebellum - Nissl bodies




Axon hillock
Nissl bodies
20 µm

Medulla spinalis

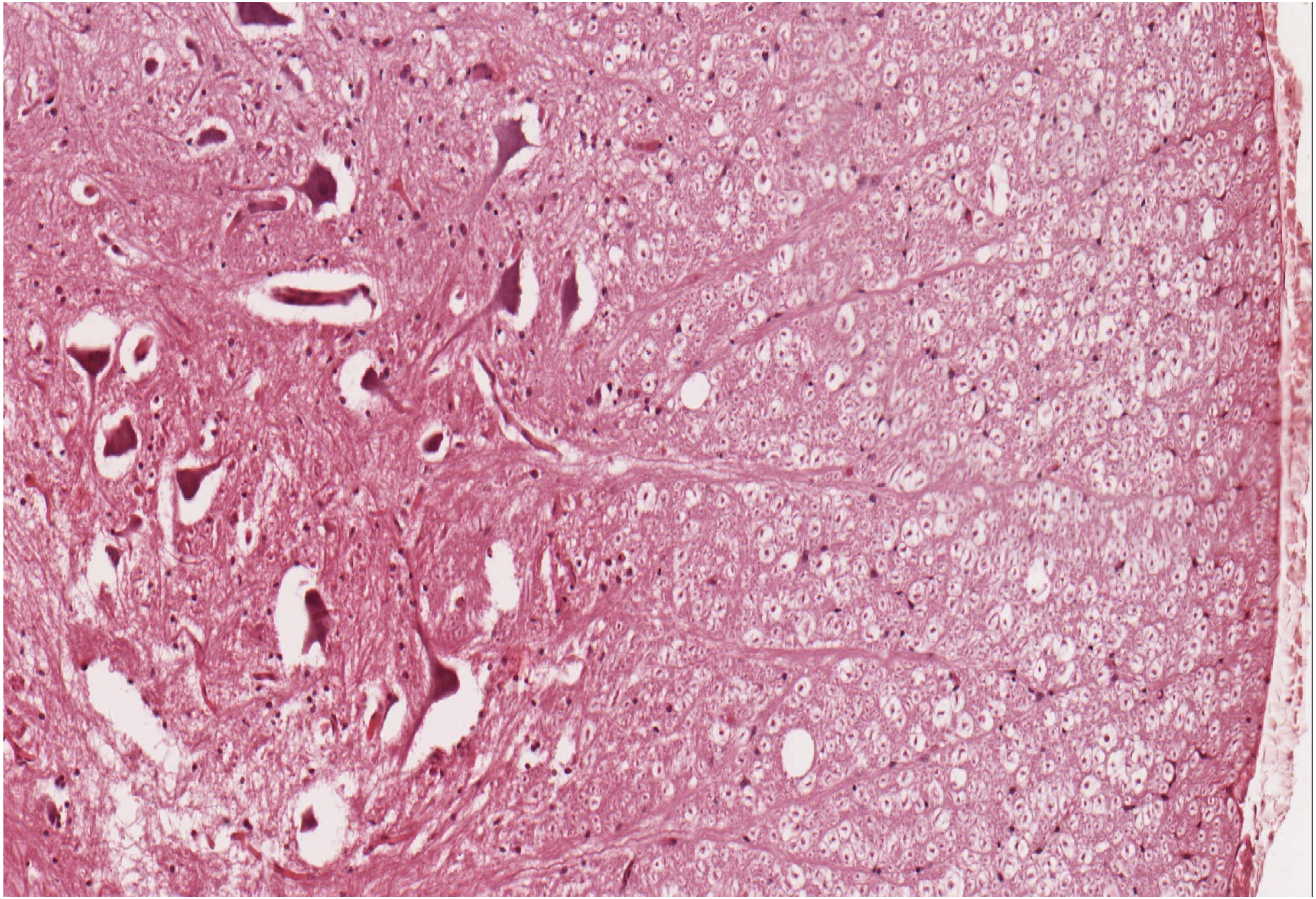




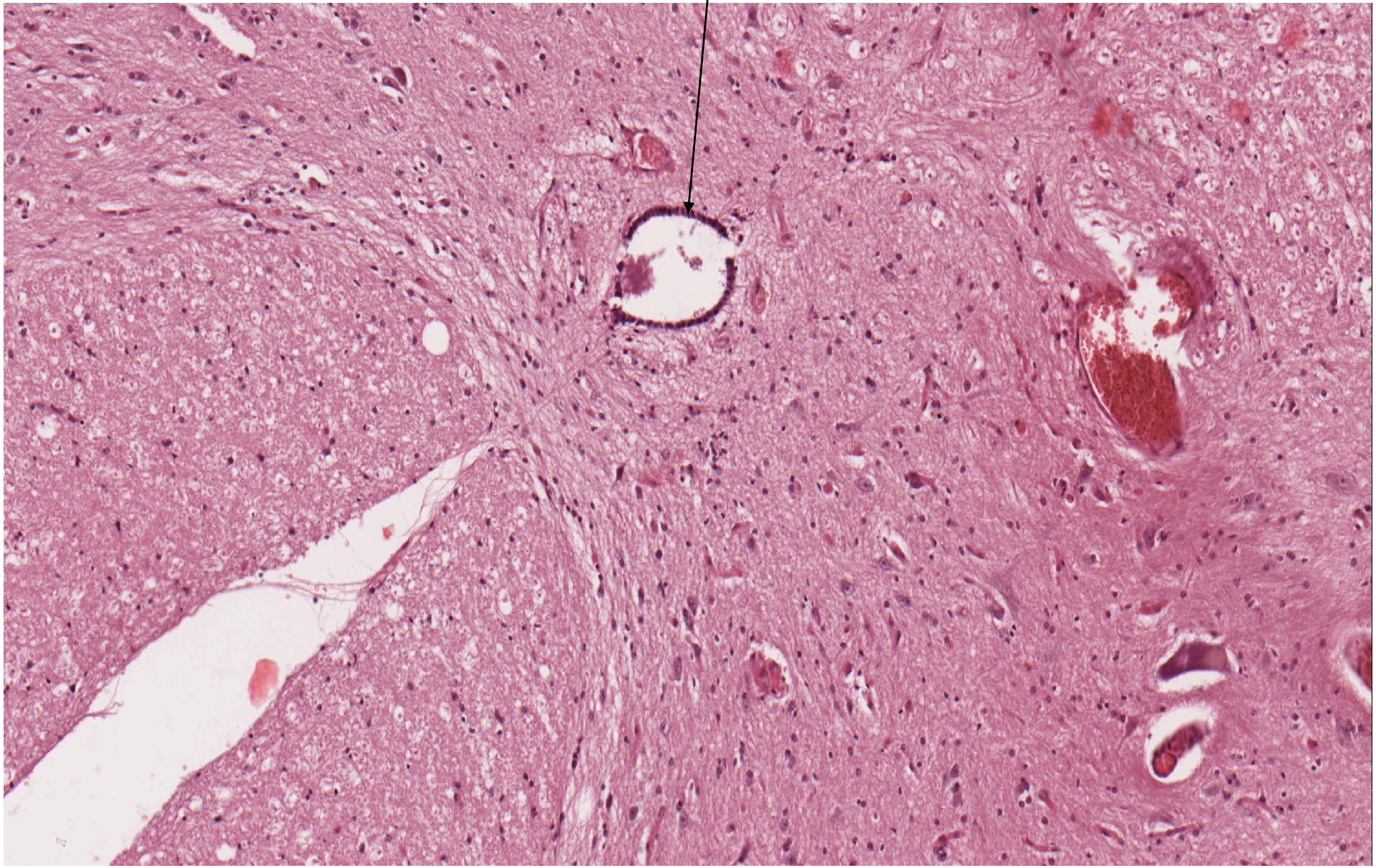
Somatomotoric multipolar neurons

Somatomotoric multipolar neurons

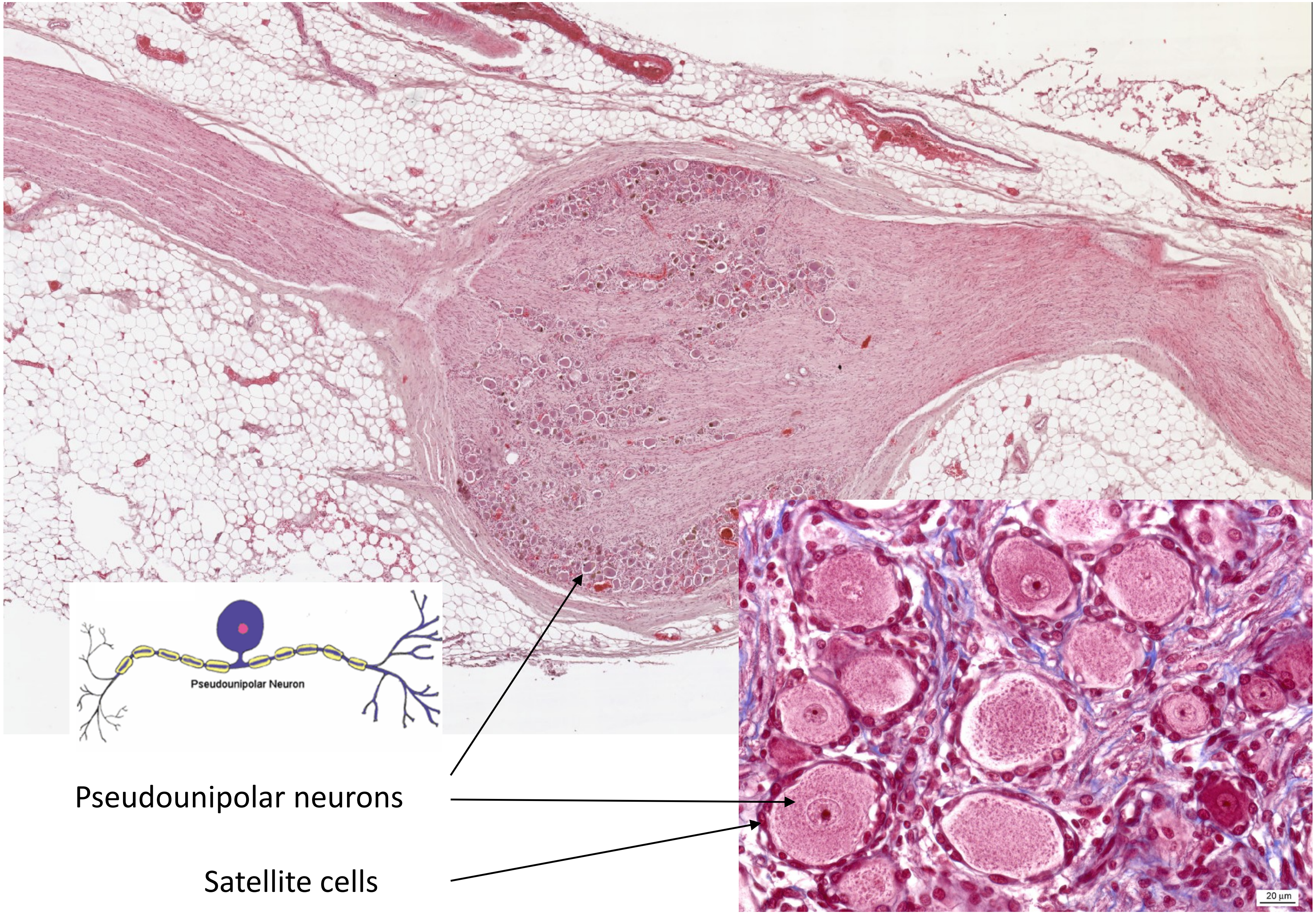
Myelinated axons



Medulla spinalis – ependymal cells



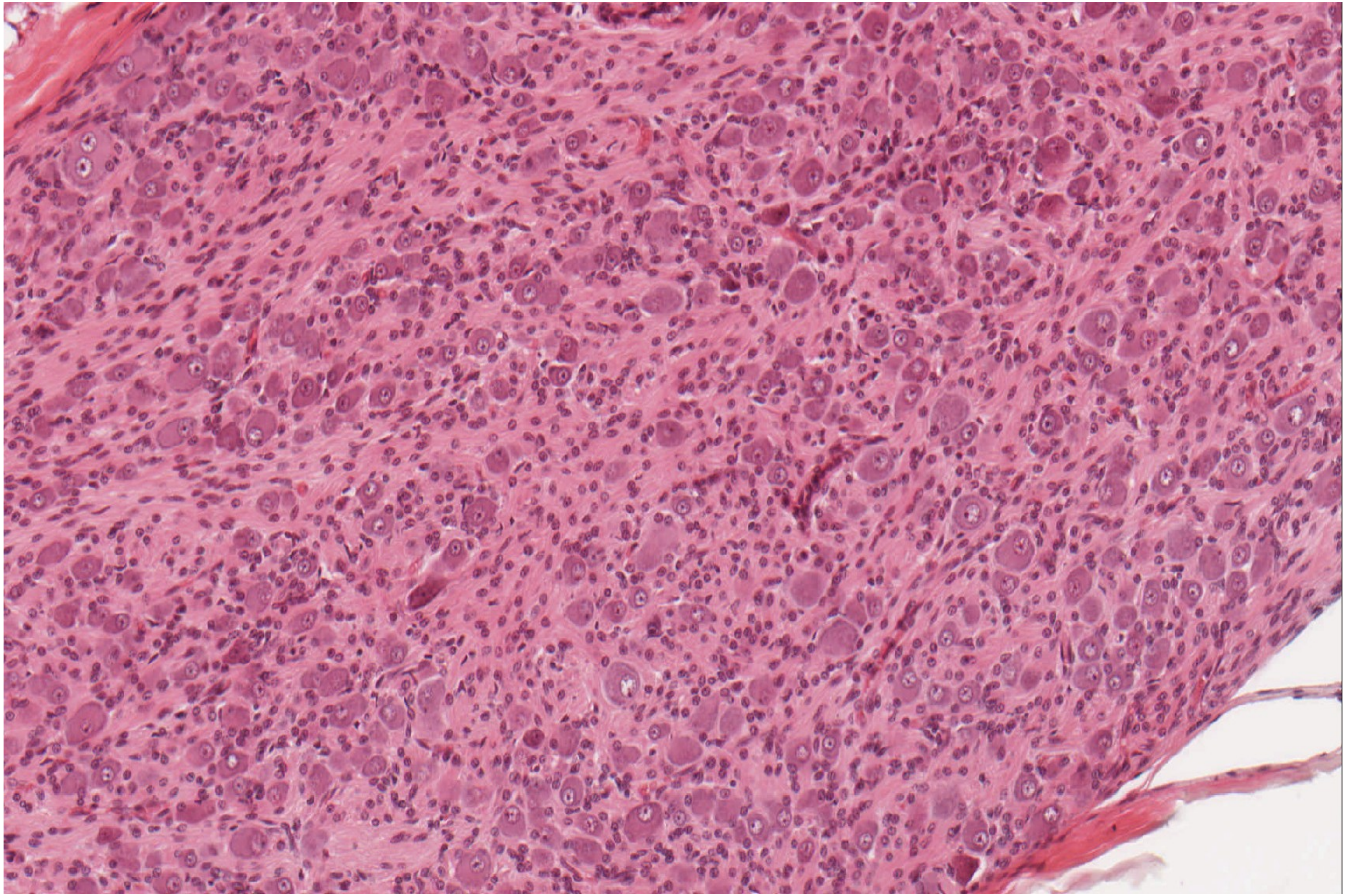
Ganglion spinale

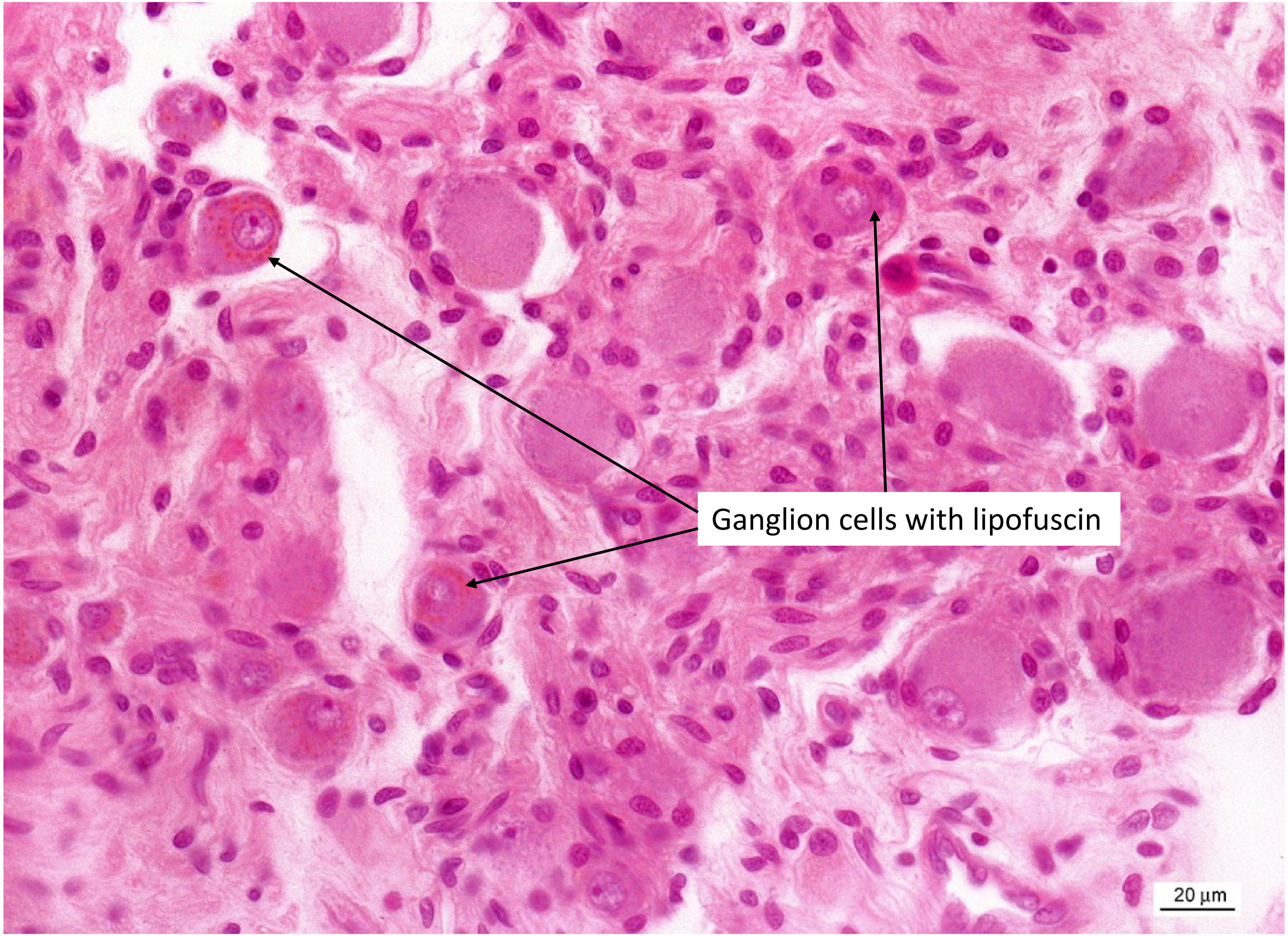


Pseudounipolar neurons

Satellite cells

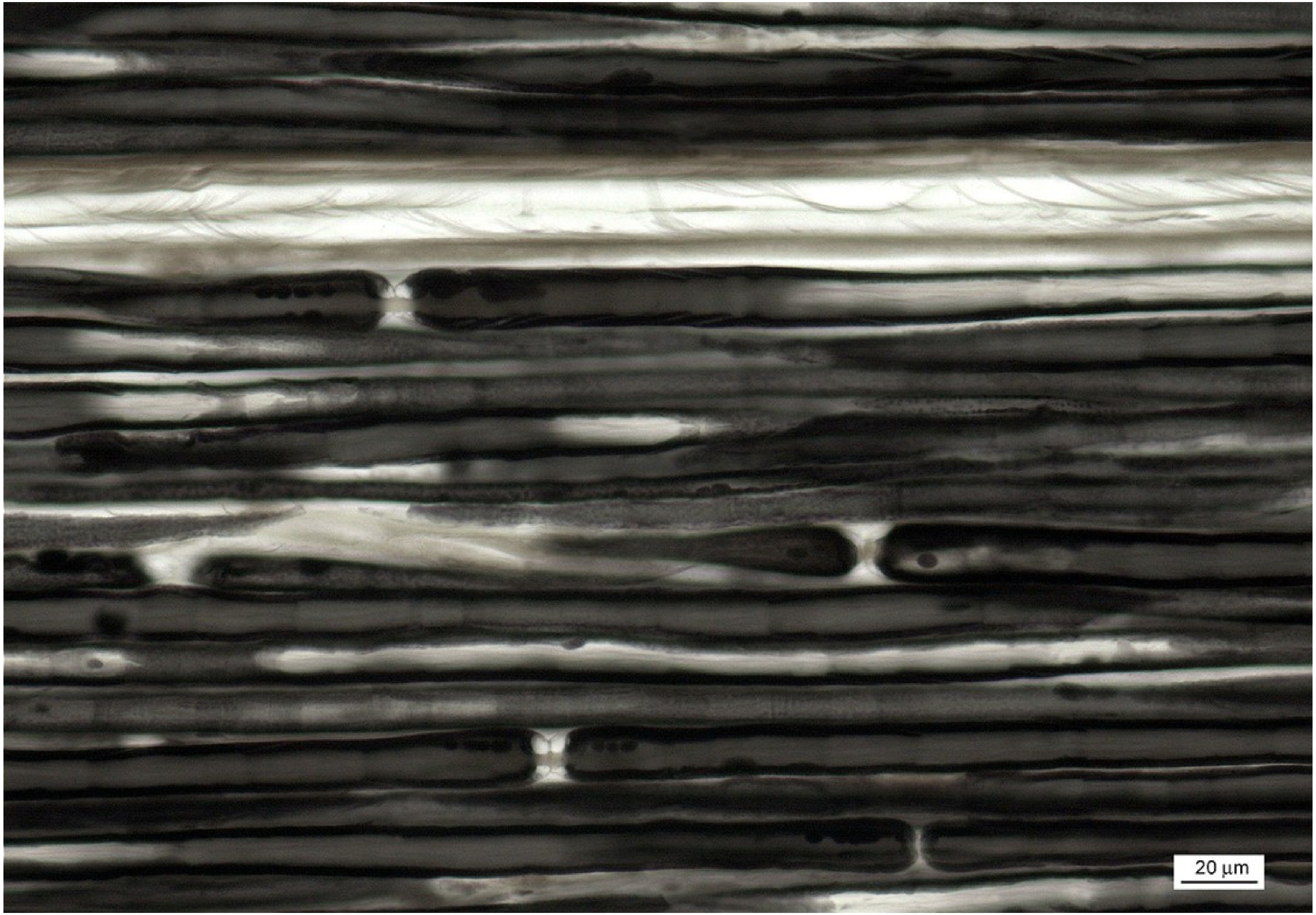
Vegetative ganglion – ganglion cells (multipolar neurons), satellite cells



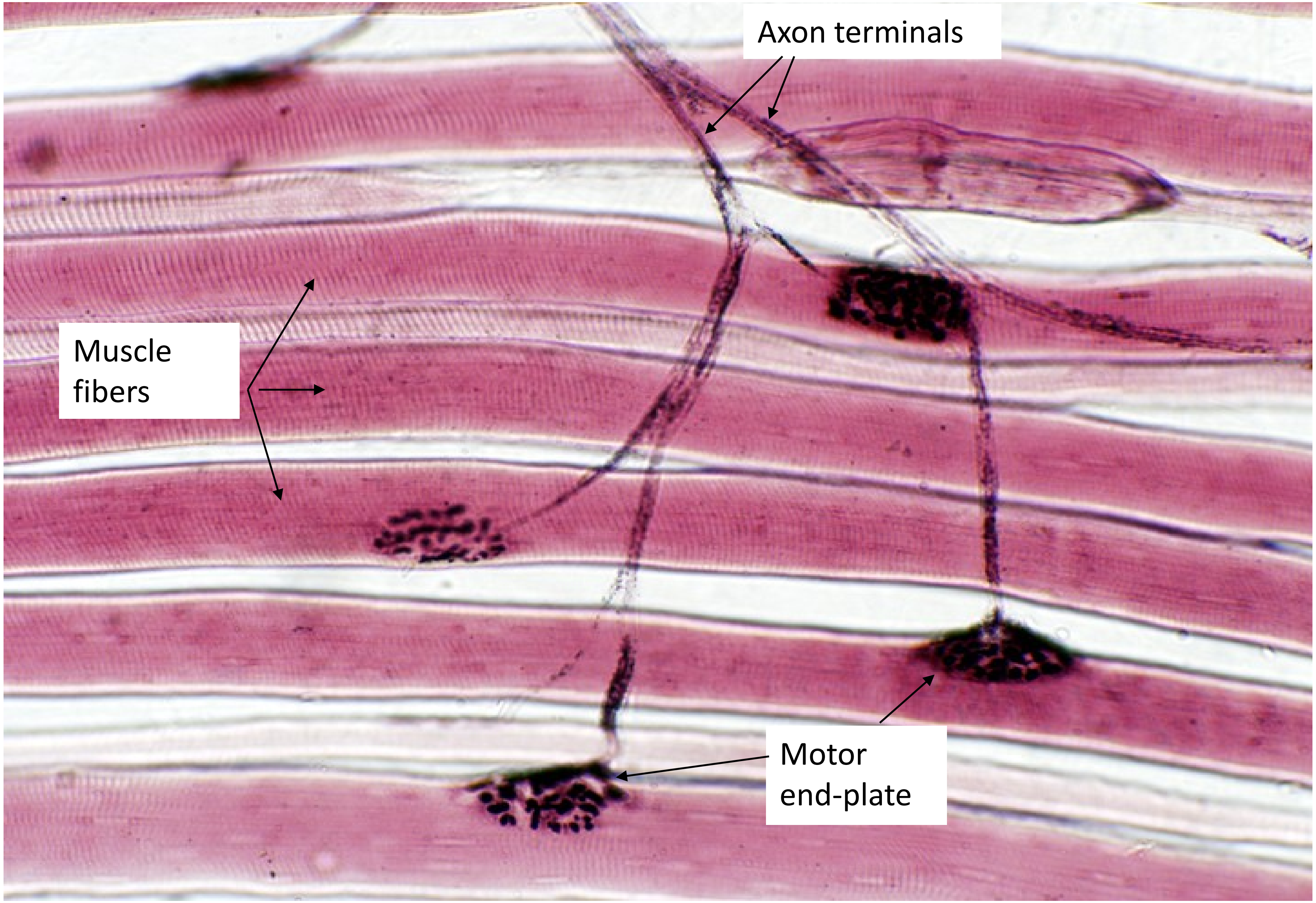

Ganglion cells with lipofuscin
20 µm

Peripheral nerve – longitudinal section

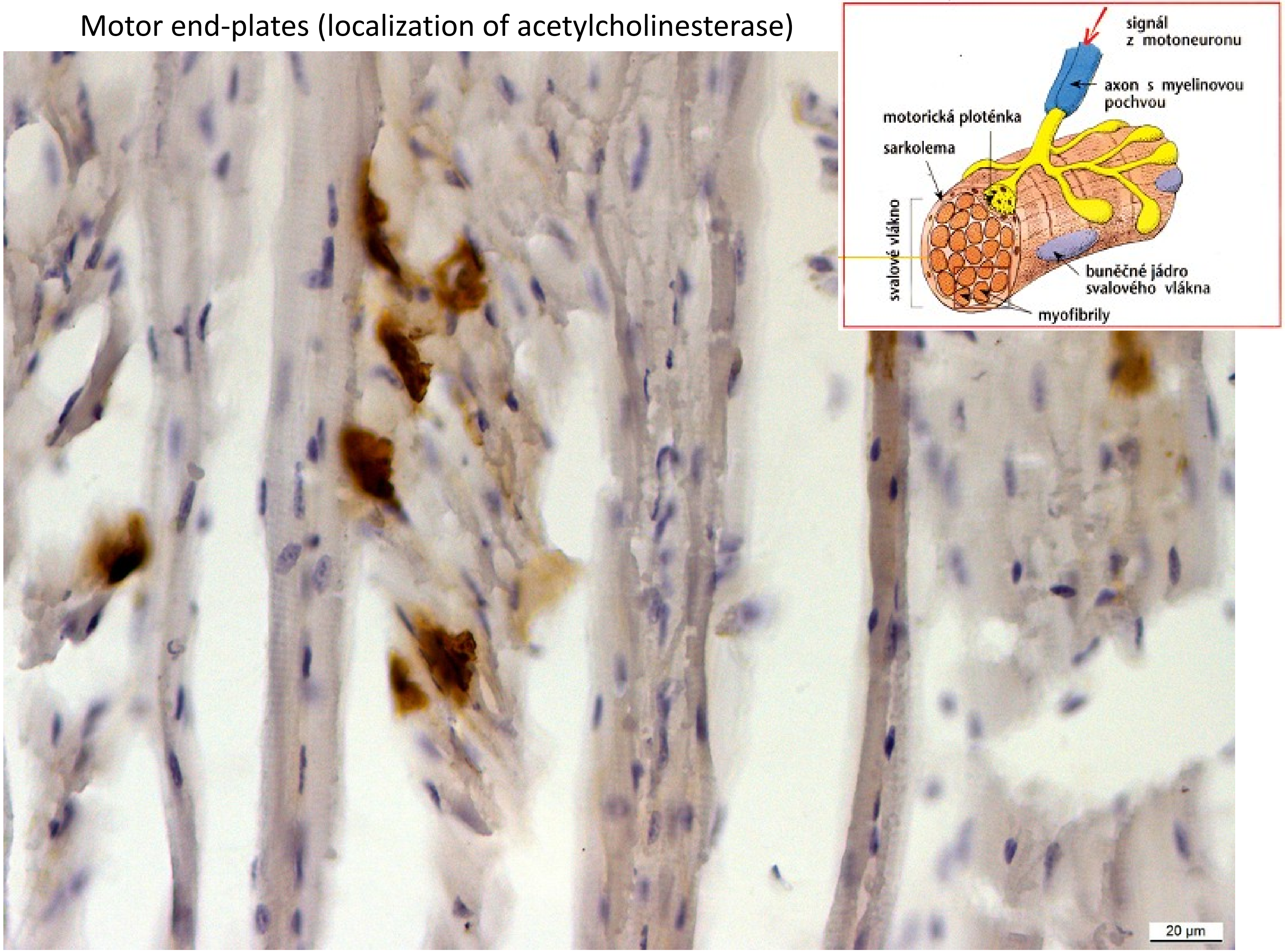
Myelin sheaths with nodes of Ranvier – peripheral nerve (OsO_4)

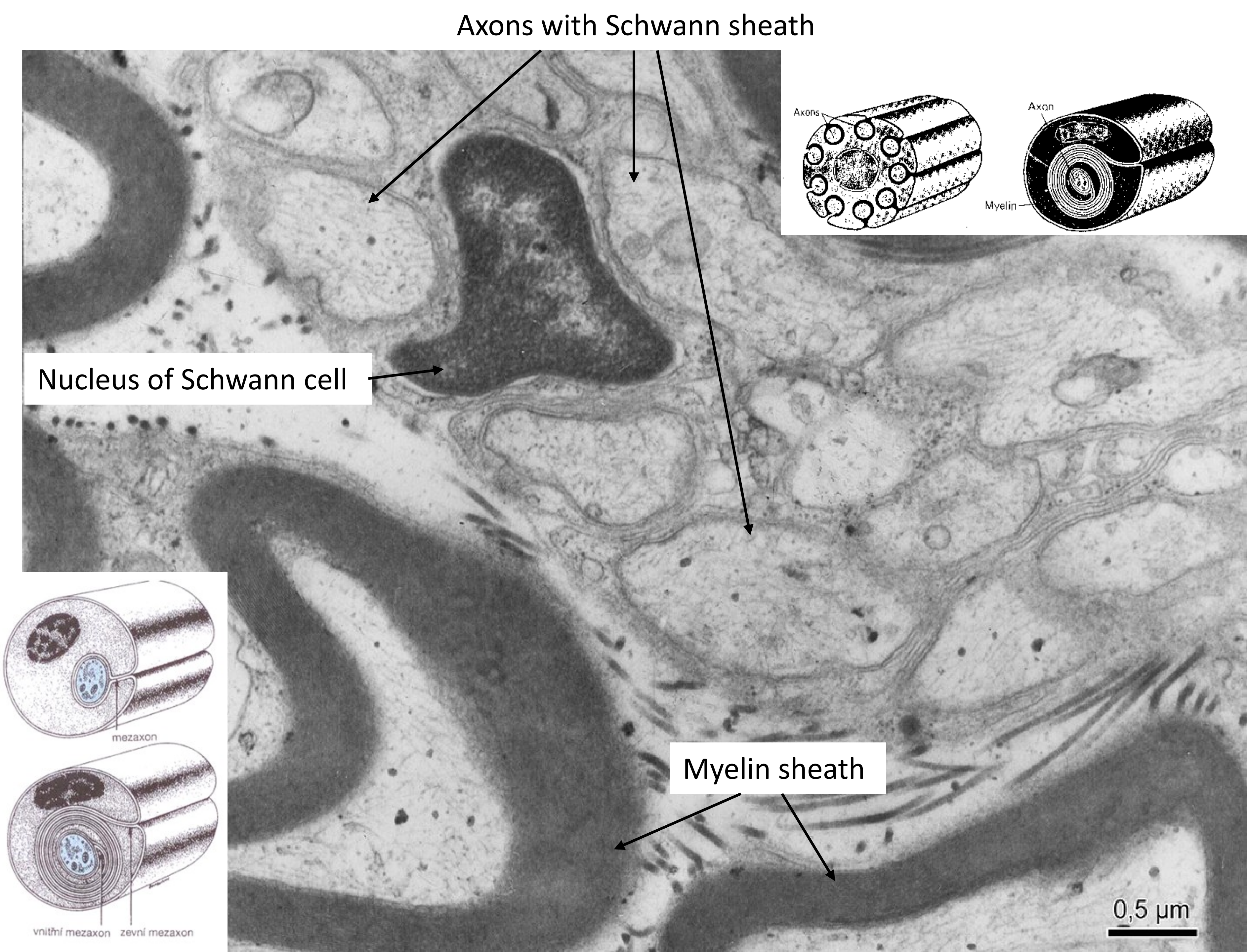


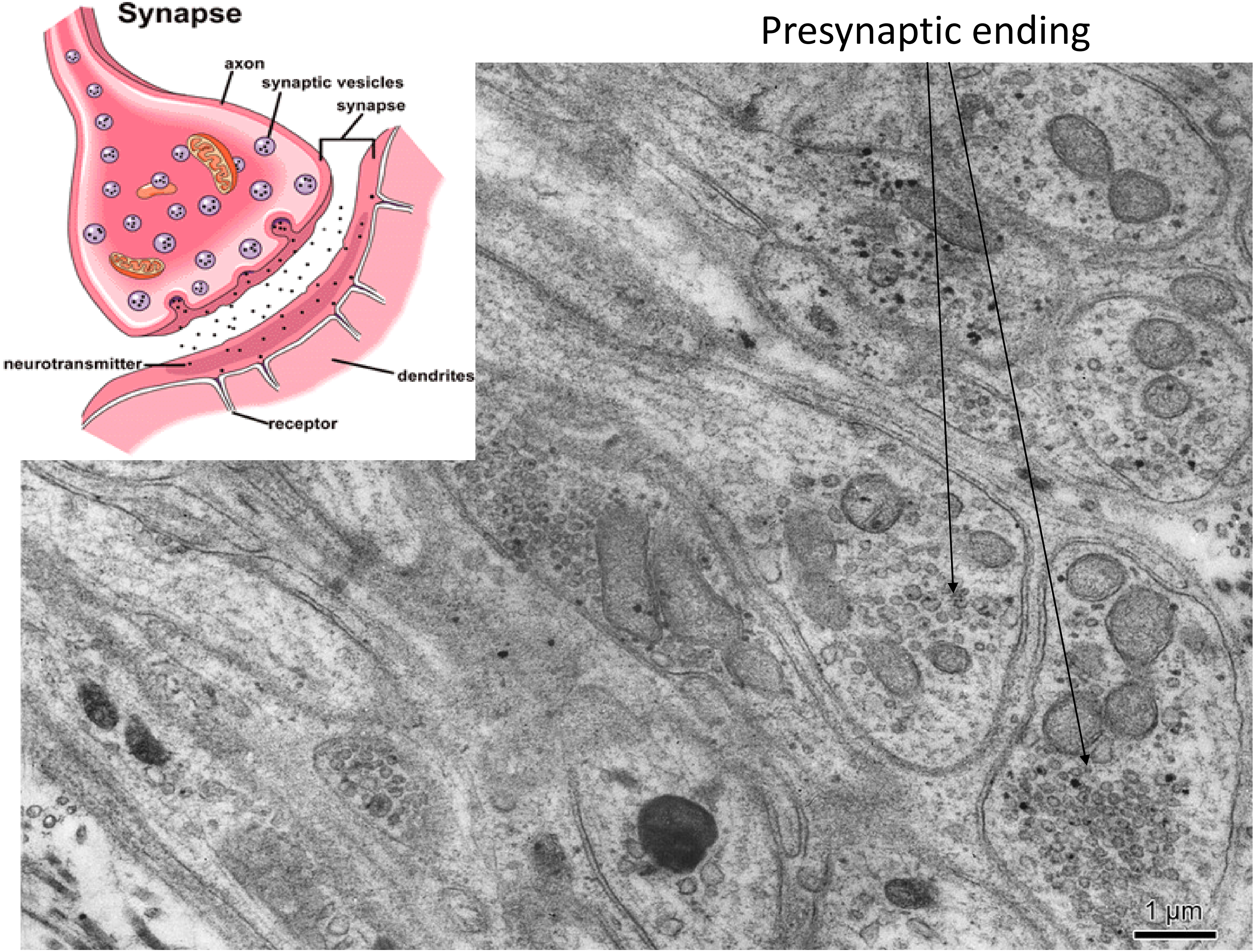
Motor end-plates in motor unit



Motor end-plates (localization of acetylcholinesterase)




Axons with Schwann sheath
Nucleus of Schwann cell
Myelin sheath
Axons
Axon
Myelin
mezaxon
vnitřní mezaxon
zevní mezaxon
0,5 µm


Synapse
axon
synaptic vesicles
synapse
neurotransmitter
dendrites
receptor
Presynaptic ending
1 µm

NERVE TISSUE

Slides:

Pyramidal cell (75, 76. Cortex cerebri)
Purkinje cell (77. Cerebellum)
Nissl substance (78. Cerebellum)
Somatomotoric multipolar neuron (79. Medulla spinalis)
Pseudounipolar neuron (81. Ganglion spinale)
Axon with myelin and Schwann sheath (84, 86. Peripheral nerve)
Myelin sheath (87. Peripheral nerve)
Motor end plate (acetylcholinesterase detection)

Atlas EM:

Nucleus (3) and cytoplasm of neuron (55)
Axons with sheaths (56, 58)
Presynaptic endings (57)