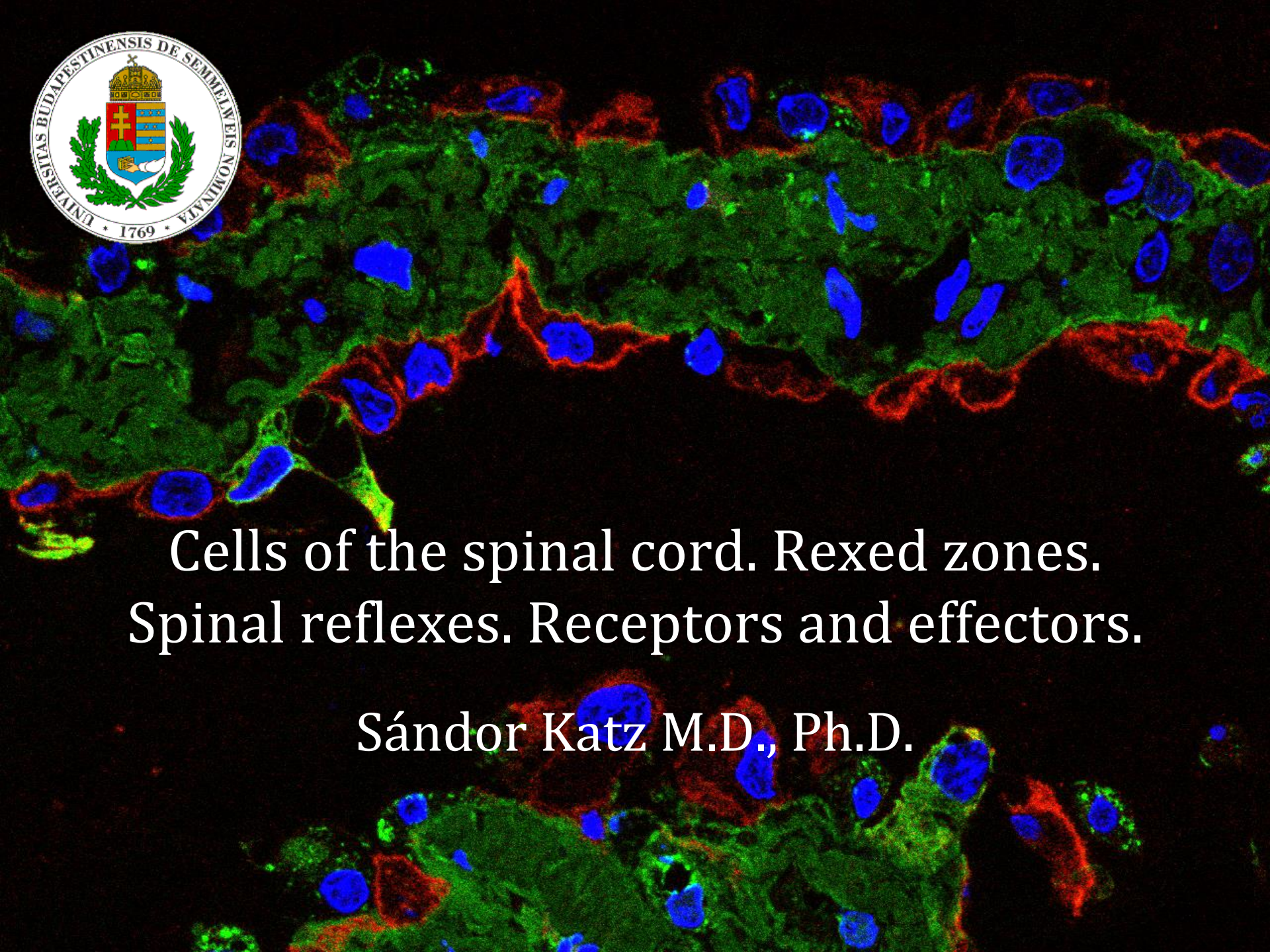
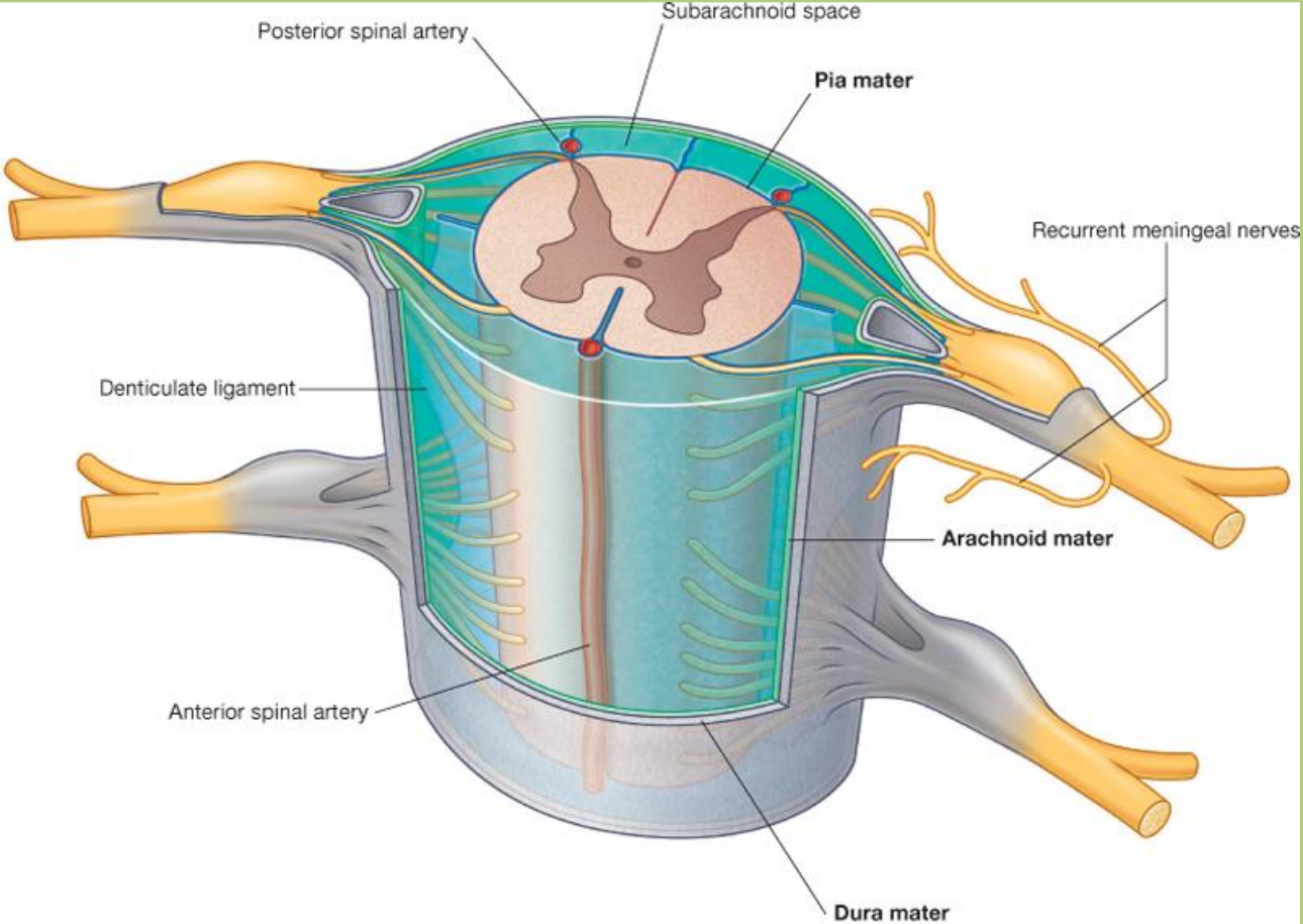


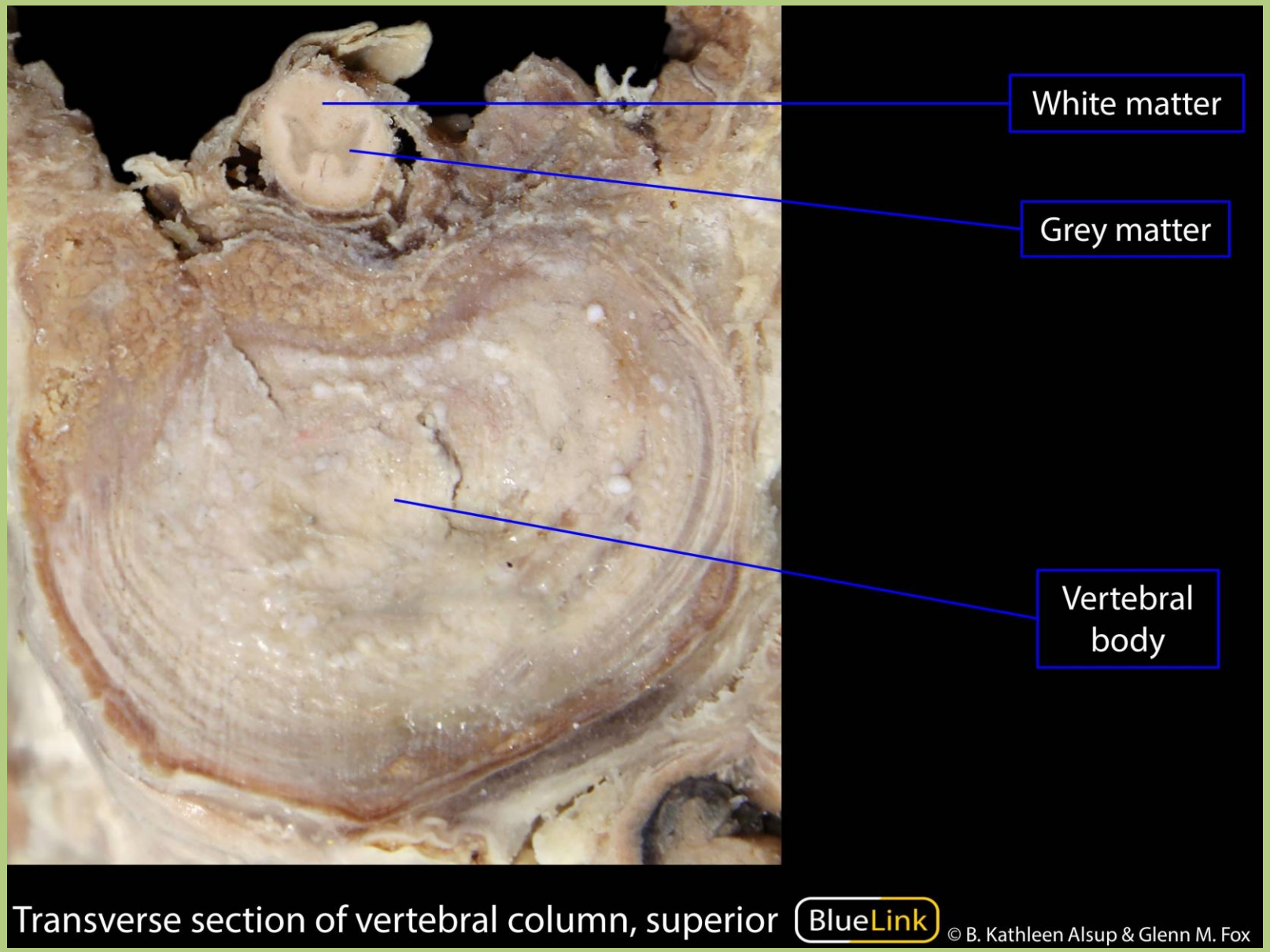
Cells of the spinal cord. Rexed zones. Spinal reflexes. Receptors and effectors.

Sándor Katz M.D., Ph.D.

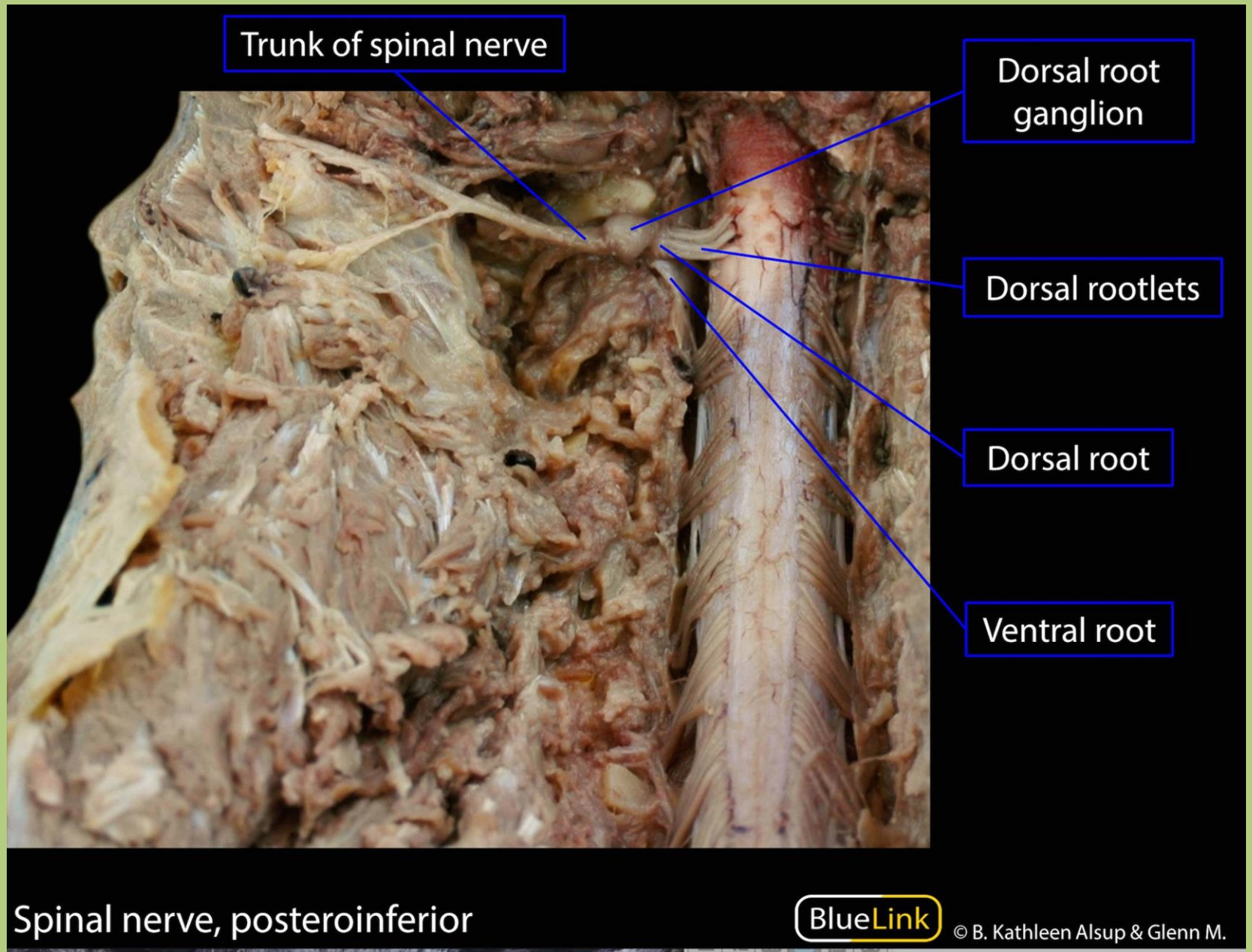
Spinal cord - gross anatomy (overview)



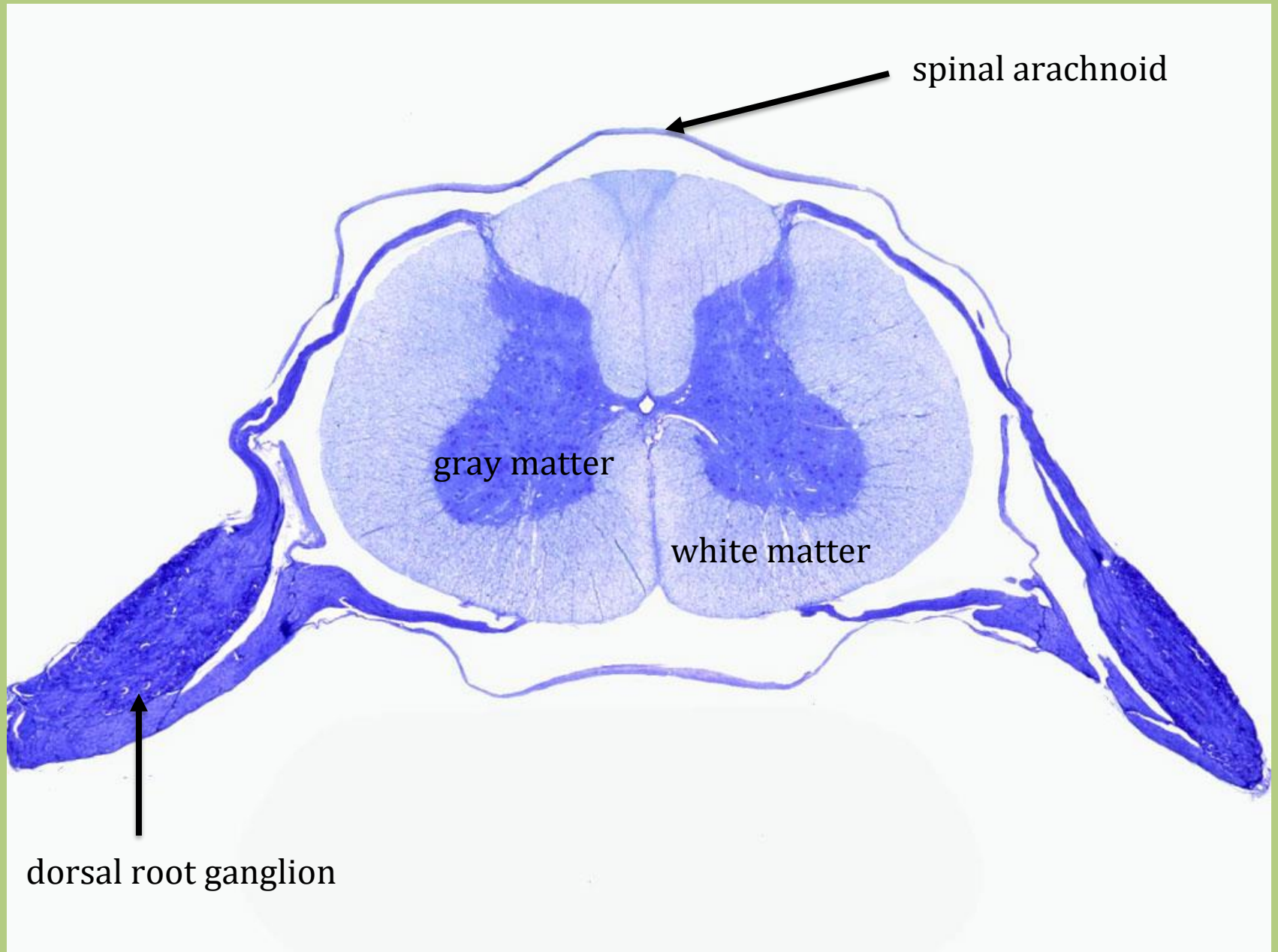
Spinal cord - gross anatomy



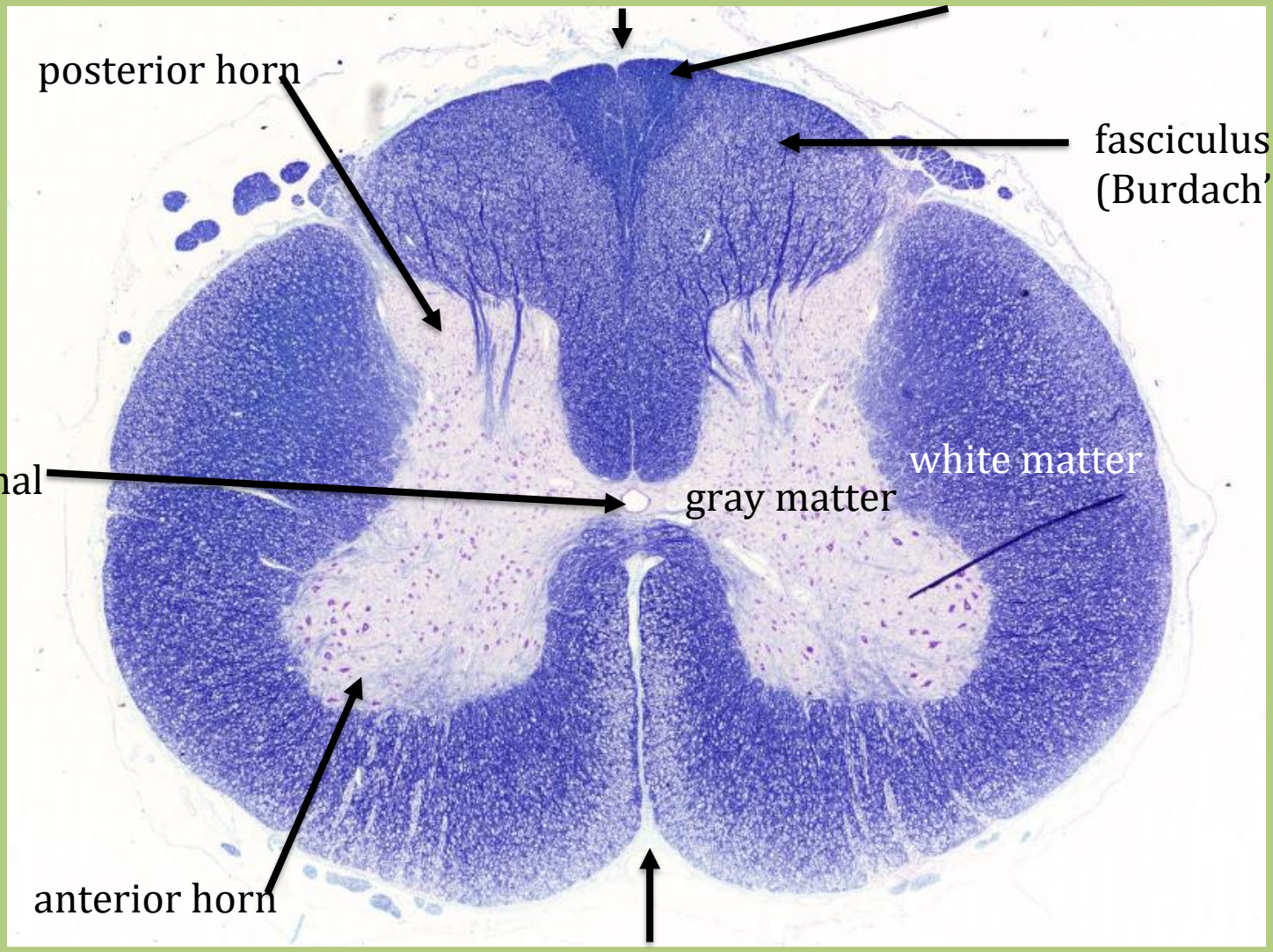
Spinal cord - gross anatomy



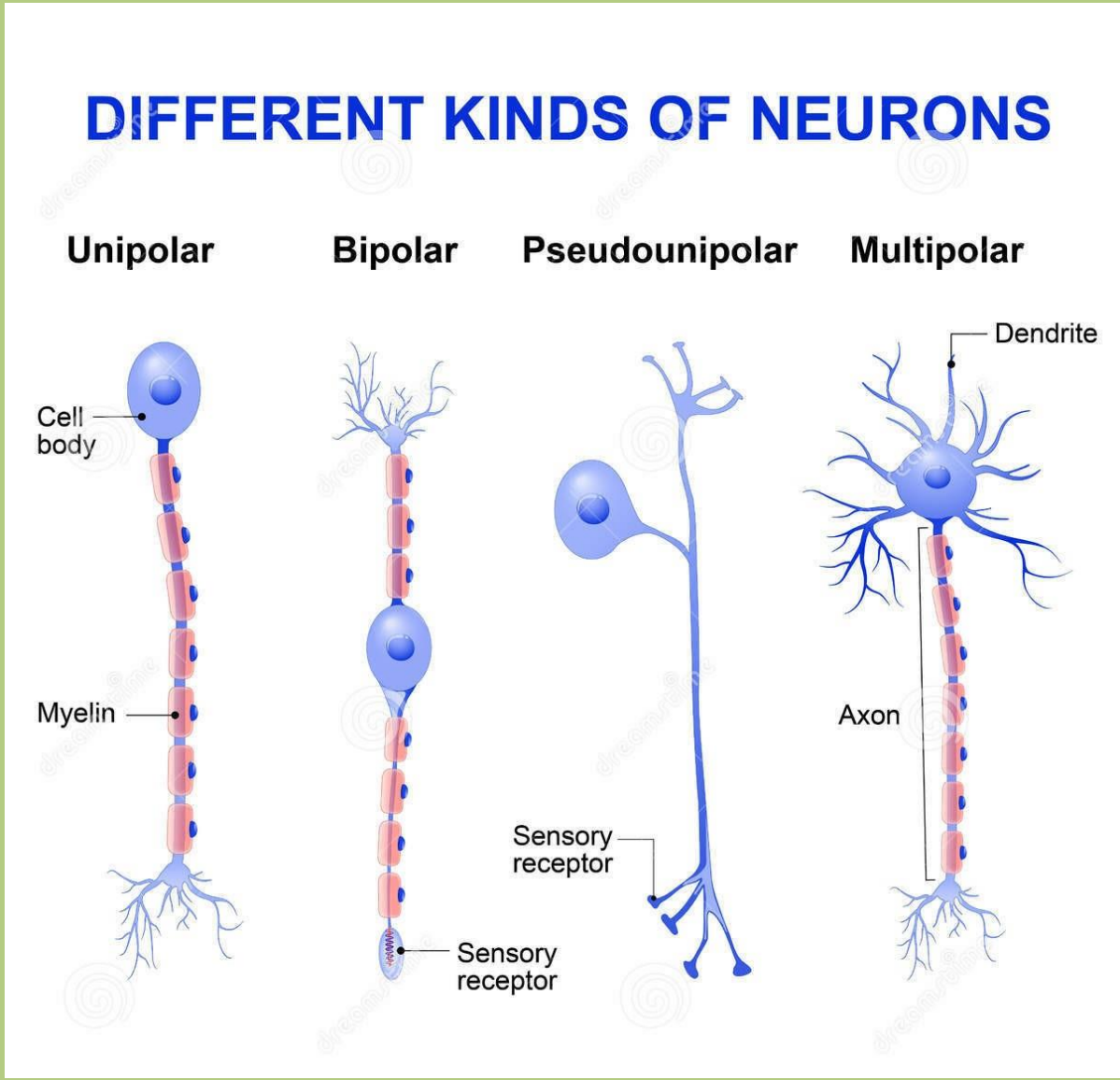
Spinal cord - histology



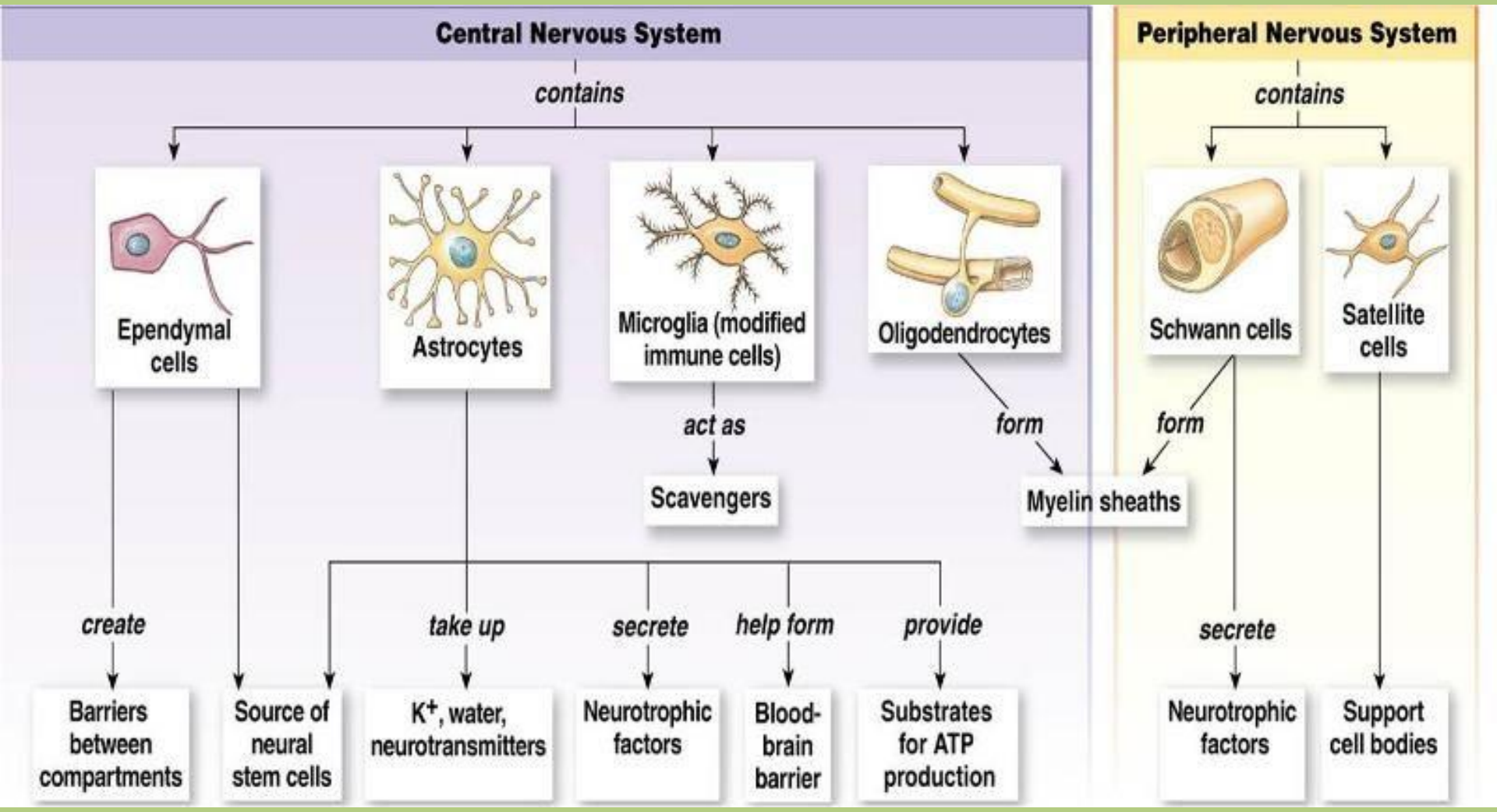
Spinal cord - histology



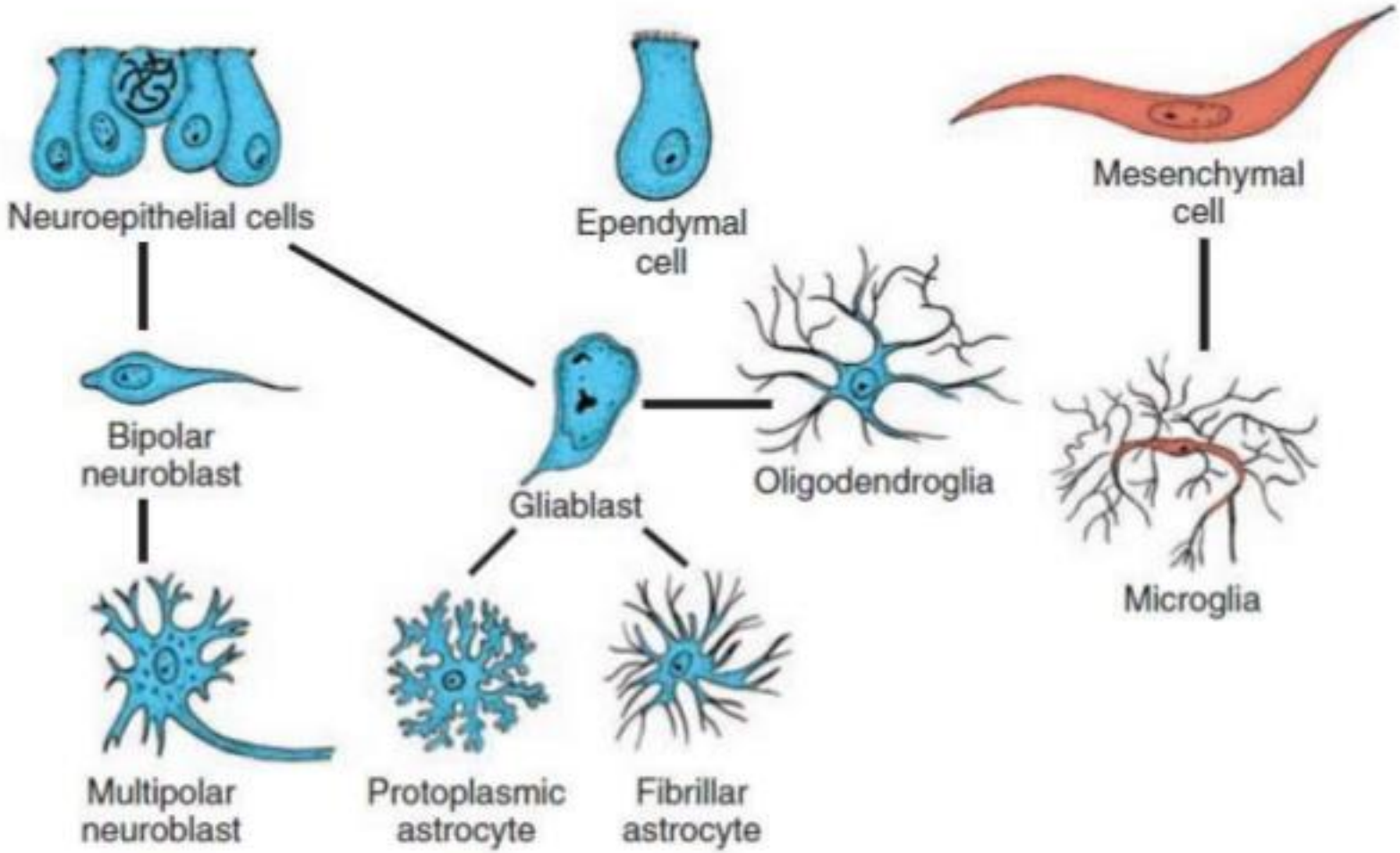
Composition of nerve tissue - neurons



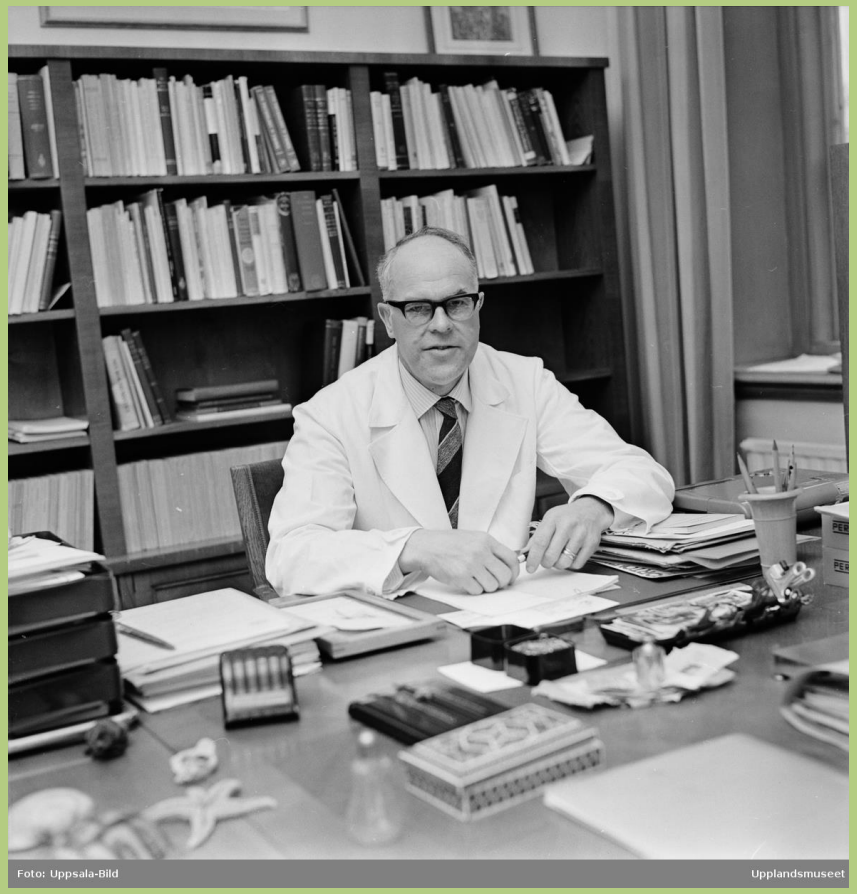
Composition of nerve tissue - neuroglial cells



Origin of the nerve cell and glial cells

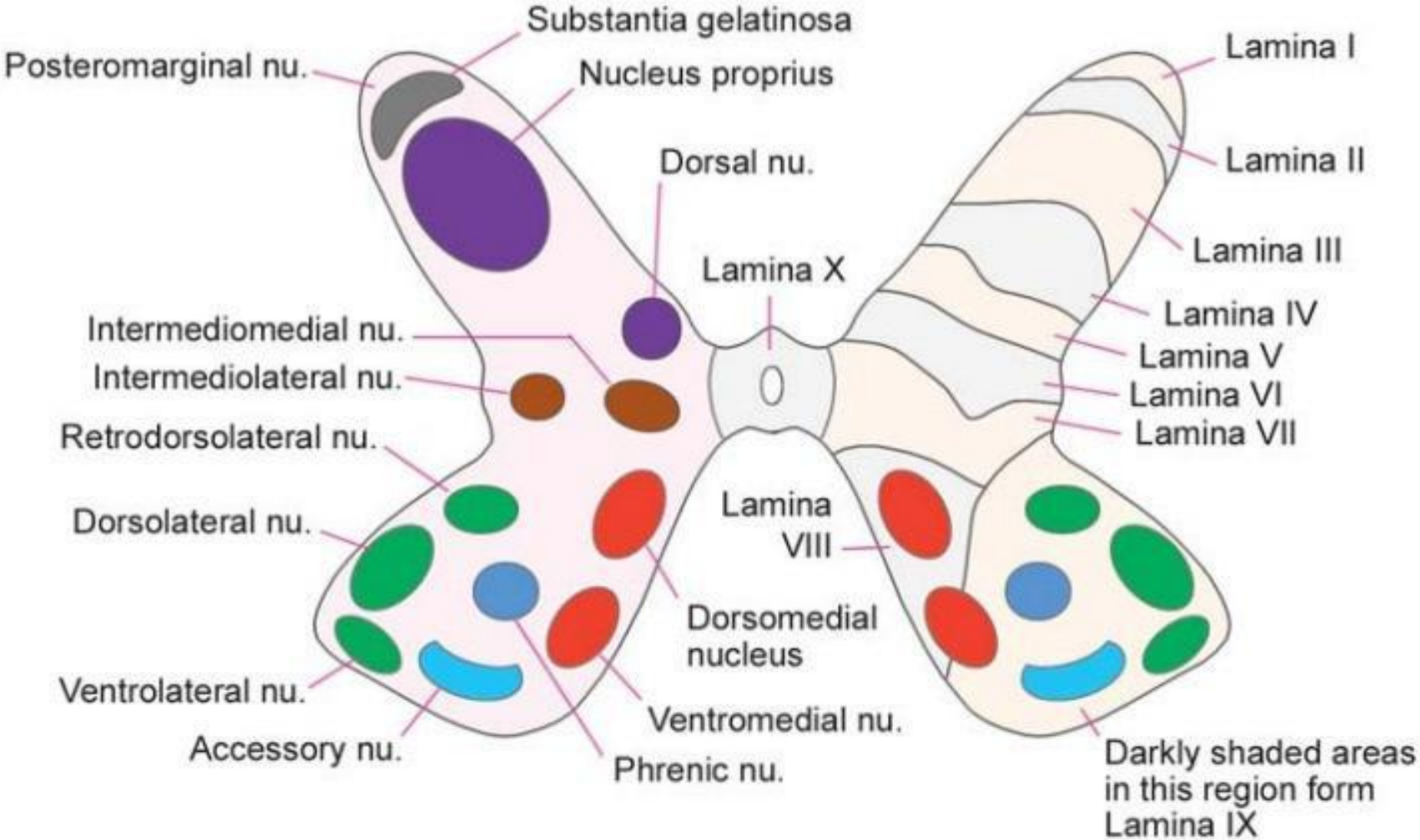


Subdivisions of the gray matter of spinal cord

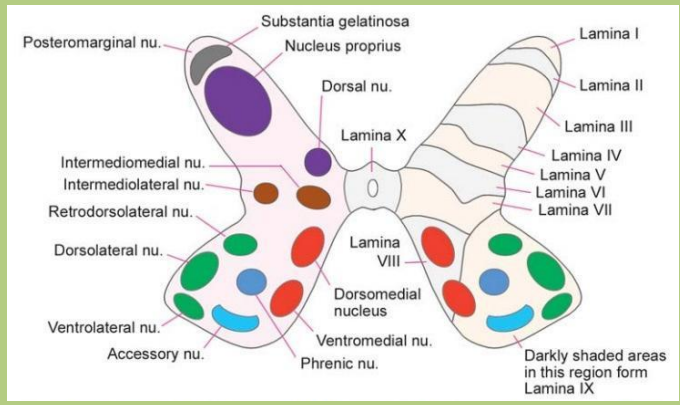


Bror Rexed: Swedish neuroscientist who described the gray matter of the spinal cord in 10 layers (***Rexed laminae***) in the early 1950s.

Subdivisions of the gray matter of spinal cord

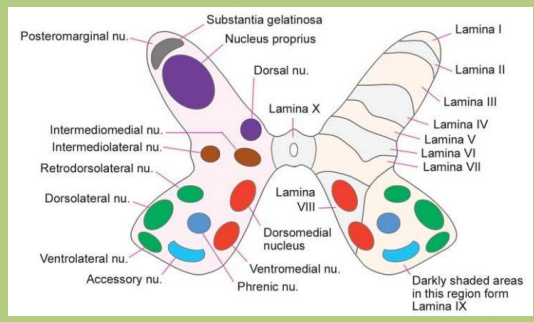


Lamina I. - Marginal zone



It receives input primarily from Lissauer's tract and ***relays information related to pain and temperature*** sensation.

Lamina II. - Substantia gelatinosa (Rolando's substance)

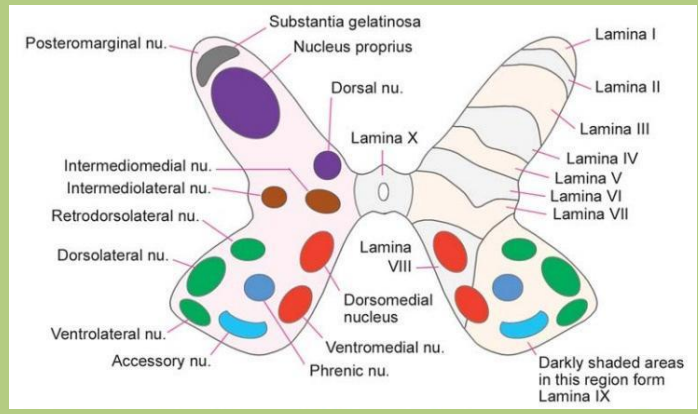


It extends the ***entire length of the spinal cord*** and into the medulla oblongata where it ***becomes the spinal nucleus of trigeminal nerve.***

It receives direct input from the dorsal (sensory) nerve roots, especially those fibers ***from pain and thermoreceptors***. Composed of fine ***networks of interneurons***, it contains high levels of substance P as well a ***large number of opiate type receptors***, both of which are involved in the perception of pain.

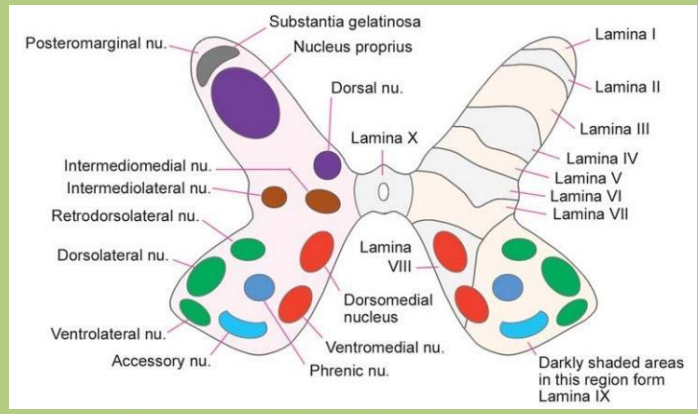
Thus, the substantia gelatinosa is believed to ***play an important role in the modulation of and/or mediation of pain perception*** at the spinal level.

Lamina III, IV. - Nucleus proprius



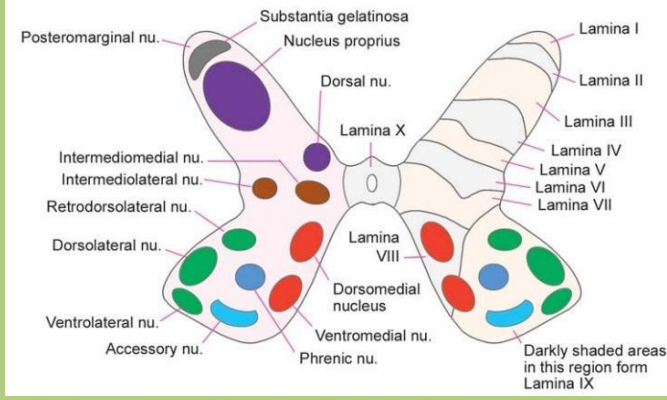
It can be found in the gray matter in all levels of the spinal cord. It constitutes the ***first synapse of the spinothalamic tract*** carrying ***pain and temperature sensations*** from peripheral nerves. Cells in this nucleus project to deeper laminae of the spinal cord.

Lamina V, VI. - Basis of the posterior horn



The neurons here are mainly involved in processing ***sensory afferent stimuli from cutaneous, muscle and joint mechanical nociceptors as well as visceral nociceptors***. This layer is home to wide dynamic range tract neurons and interneurons. ***Viscerosomatic pain signal*** convergence often occurs in this lamina as well.

Lamina VII, X.



Lamina VII.:

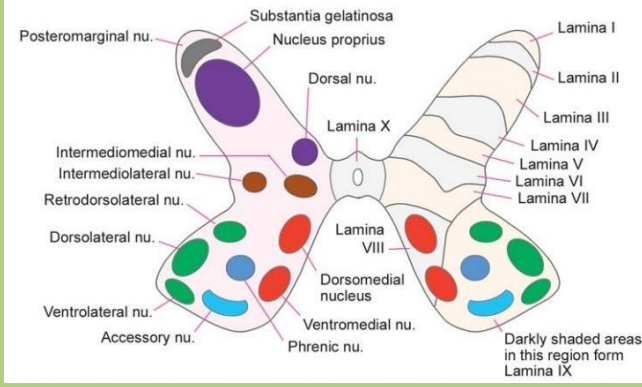
Clark's column (posterior thoracic nucleus): it spans segments C8-L(2)3. The ***fibres of proprioceptive sensibility*** from the muscles terminate here.

Intermediomedial and intermediolateral nuclei: extend from T1 to L2, and contain the ***autonomic motor neurons that give rise to the preganglionic fibers of the sympathetic nervous system.***

Lamina X.:

It's an area surrounding the central canal.

Lamina VIII-IX.



Lamina VIII.:

Interneurons, commissural nucleus of Lenhossék: The axons of their neurons cross in the white commissure.

Lamina IX.:

Motor neurons (alpha and gamma), *phrenic and accessory nuclei - only in the cervical region.*

Motor neurons -

their axons form the ventral root

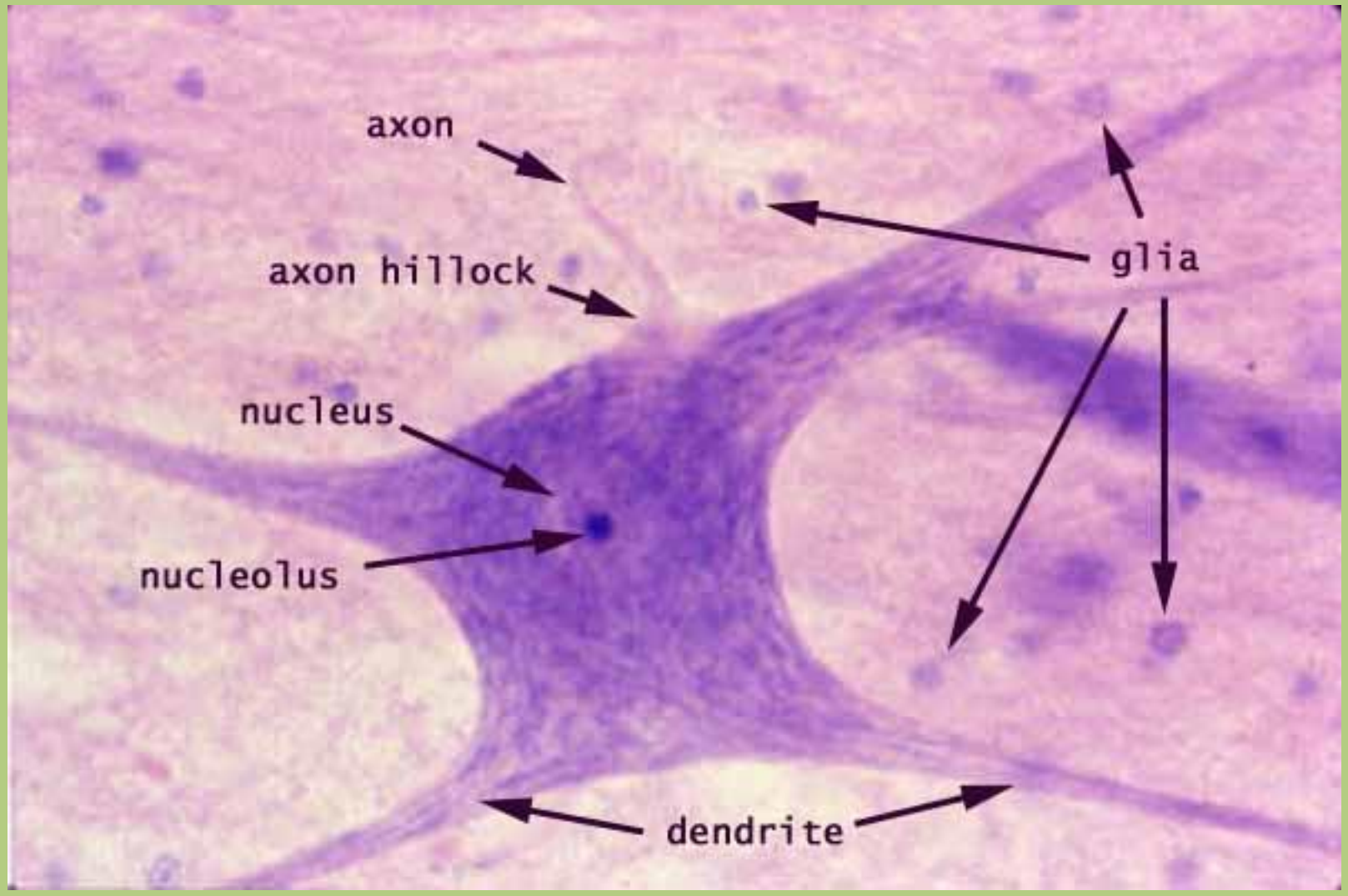
Somatic motor neurons:

Alpha and gamma motor neurons

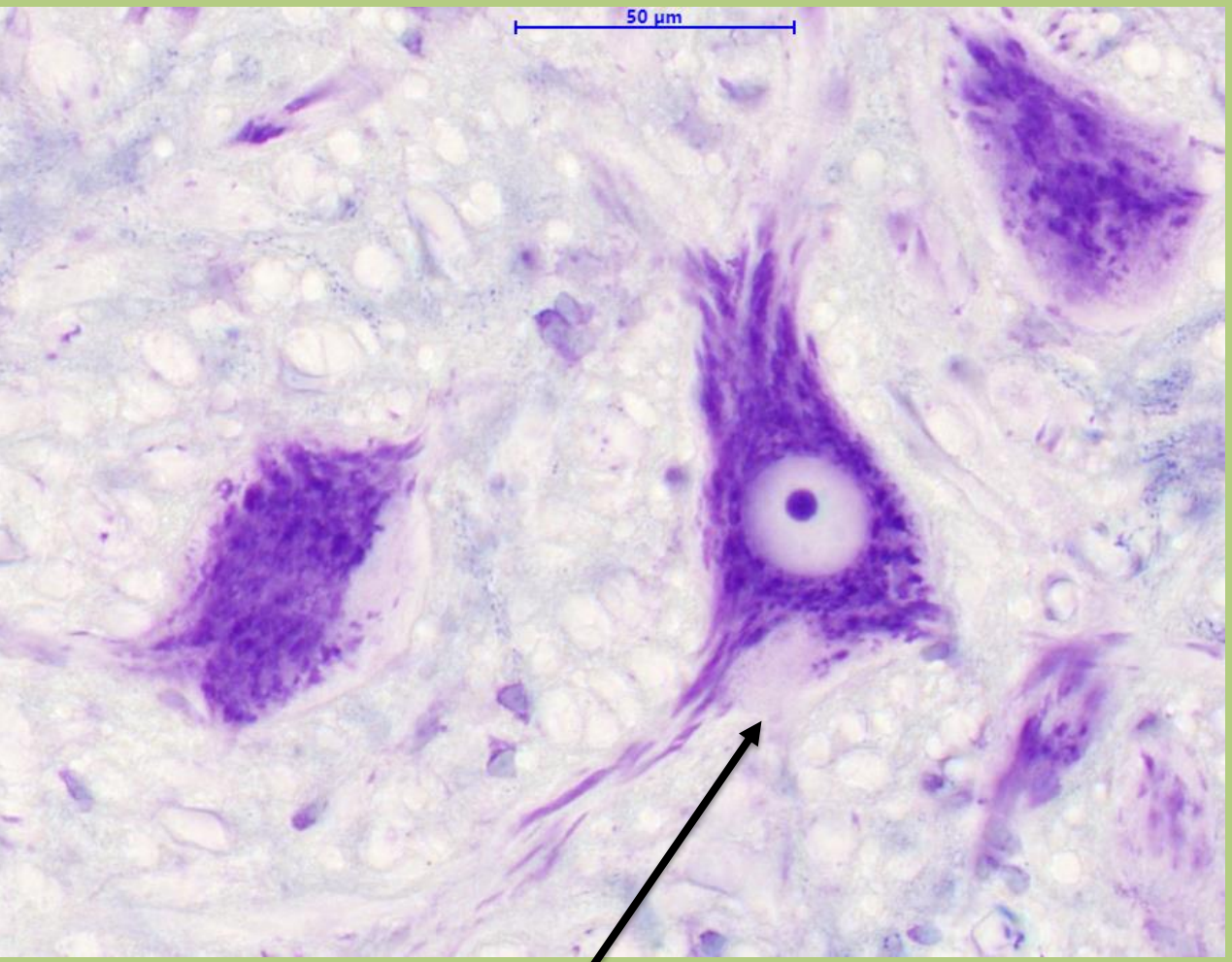
Visceral motor neurons:

Preganglionic neurons innervating ganglion cells. At the thoracolumbar region they are sympathetic neurons, at the mid-sacral level they are parasympathetic neurons.

Alpha motor neurons



Alpha motor neurons



axon hillock (free of Nissl bodies)

Fig. 16. On the Starnberg lake, from left to right: Alzheimer, Kraepelin, Gaupp, Nissl (about 1908)

<u>Nissl bodies:</u>

In the cytoplasm ***well-developed rough endoplasmic reticulum*** is presented (intensely stained small bodies), indicating intense protein synthetic activity.

Intrinsic neurons -

their axons go to other CNS locations

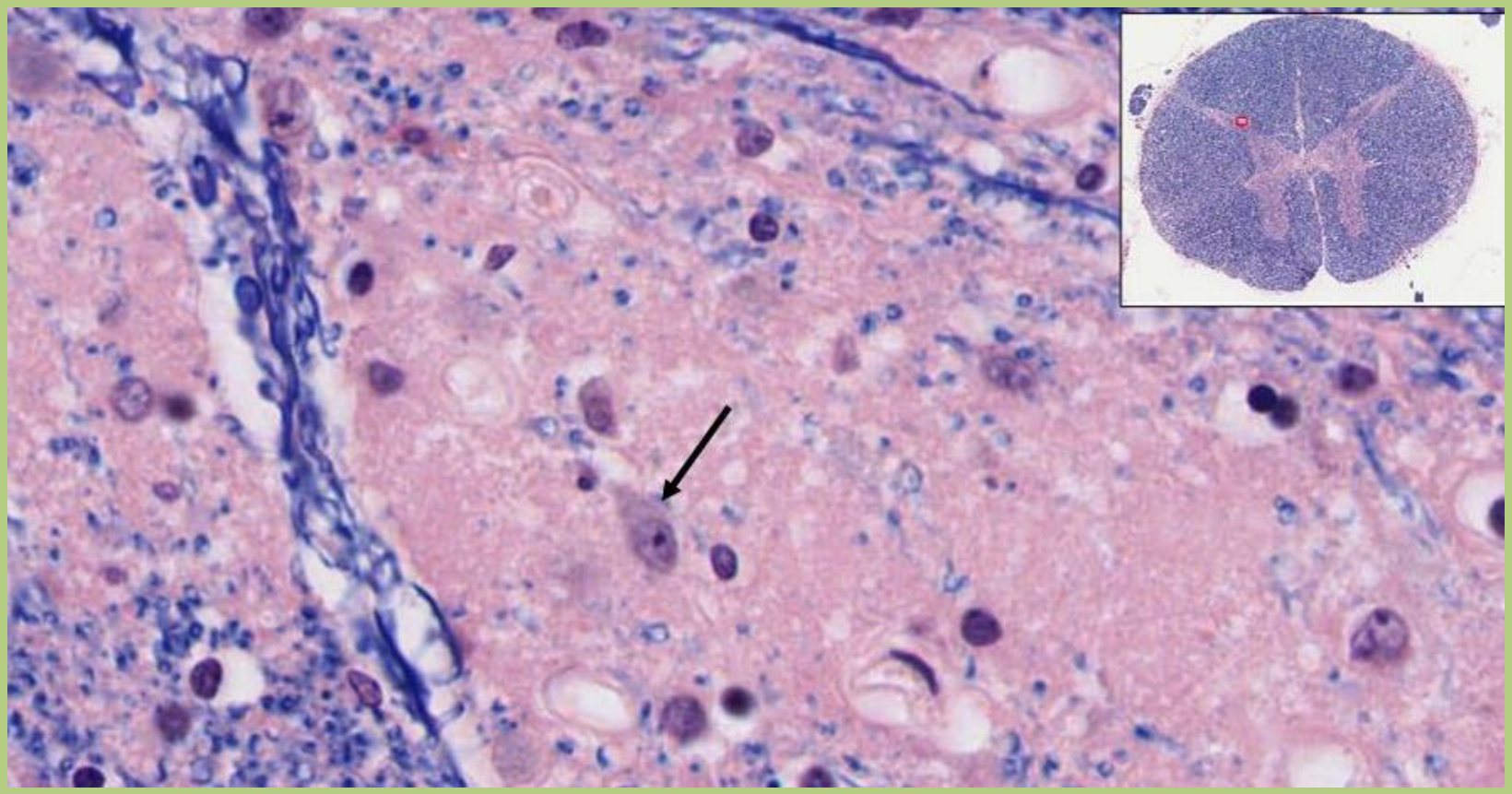
Secondary sensory neurons:

They receive synapses from 1st order neurons whose cell bodies are in the dorsal root ganglia and send their axons in ascending tracts.

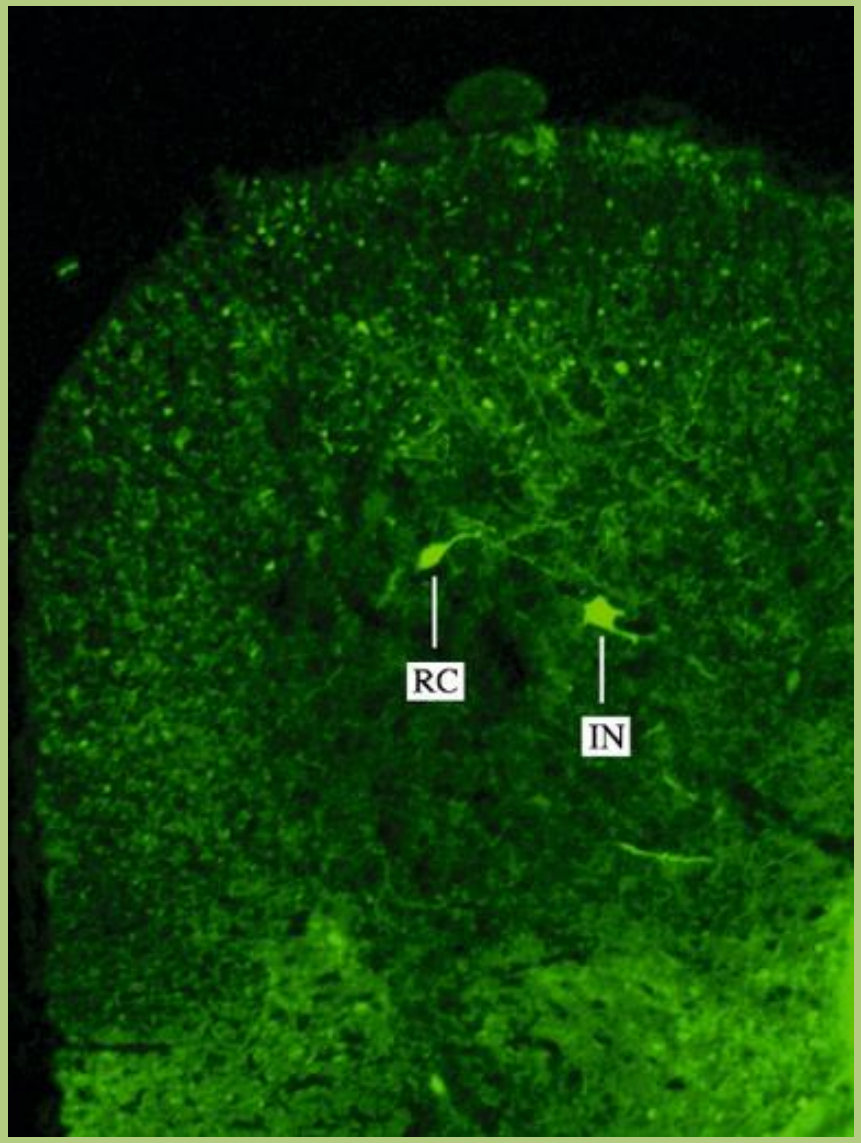
Interneurons:

Intercalated cells: their axons remain at the same segmental level.
Commissural cells: their axons cross in the anterior commissure to the contralateral side.
Association cells: their axons interconnect different spinal segments.
Renshaw cells: inhibitory neurons, excited by axon collaterals of alpha motor neurons. They inhibit their activator alpha motor neurons and the neighboring motor neurons, modulating the firing rate of neurons.

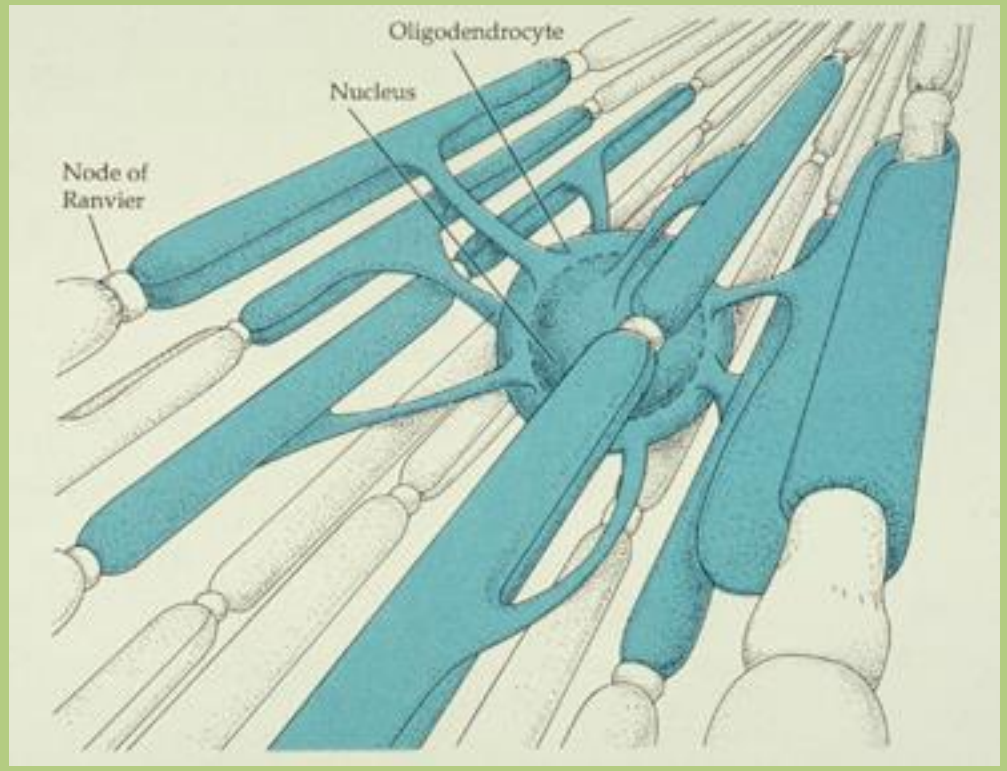
Interneurons

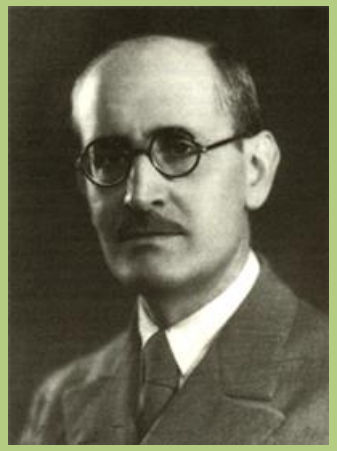


Renshaw cells



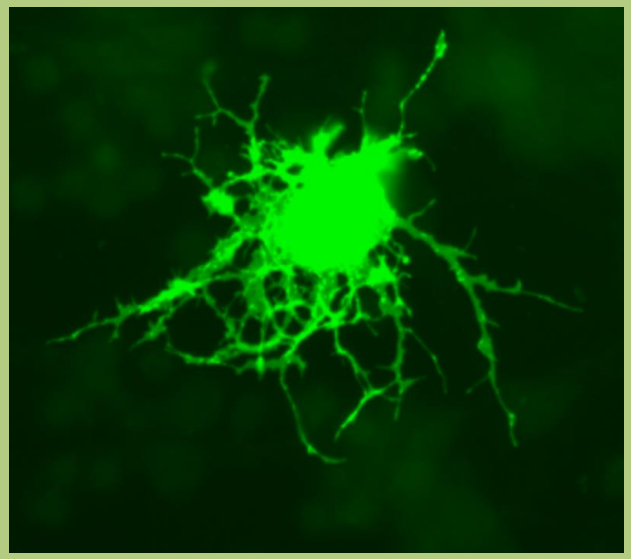
Oligodendrocytes



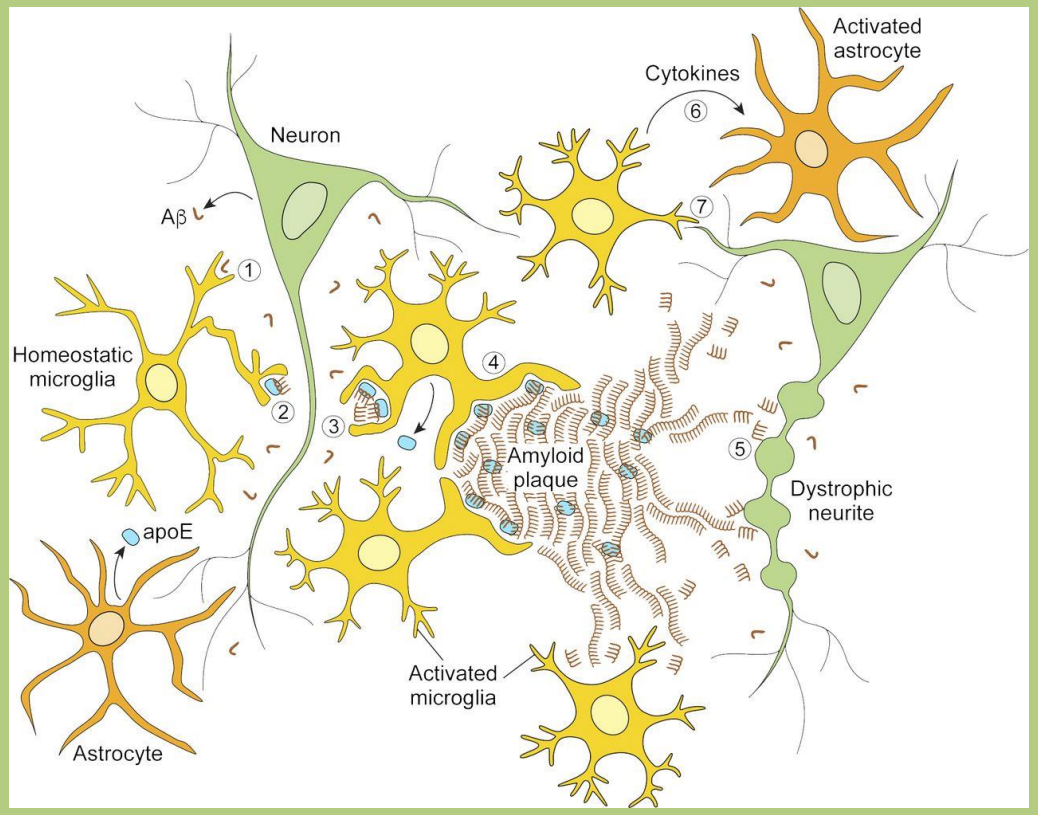


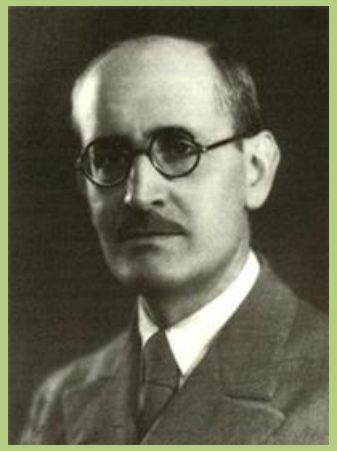
Discovered by Pío del Río Hortega at 1921

Support and insulation of axons in the CNS. A single oligodendrocyte can extend its processes to 50 axons, wrapping approximately 1 μm of ***myelin sheath*** around each axon.

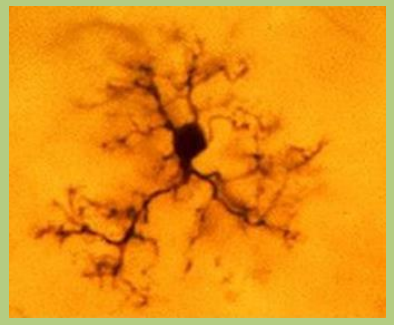


Microglia



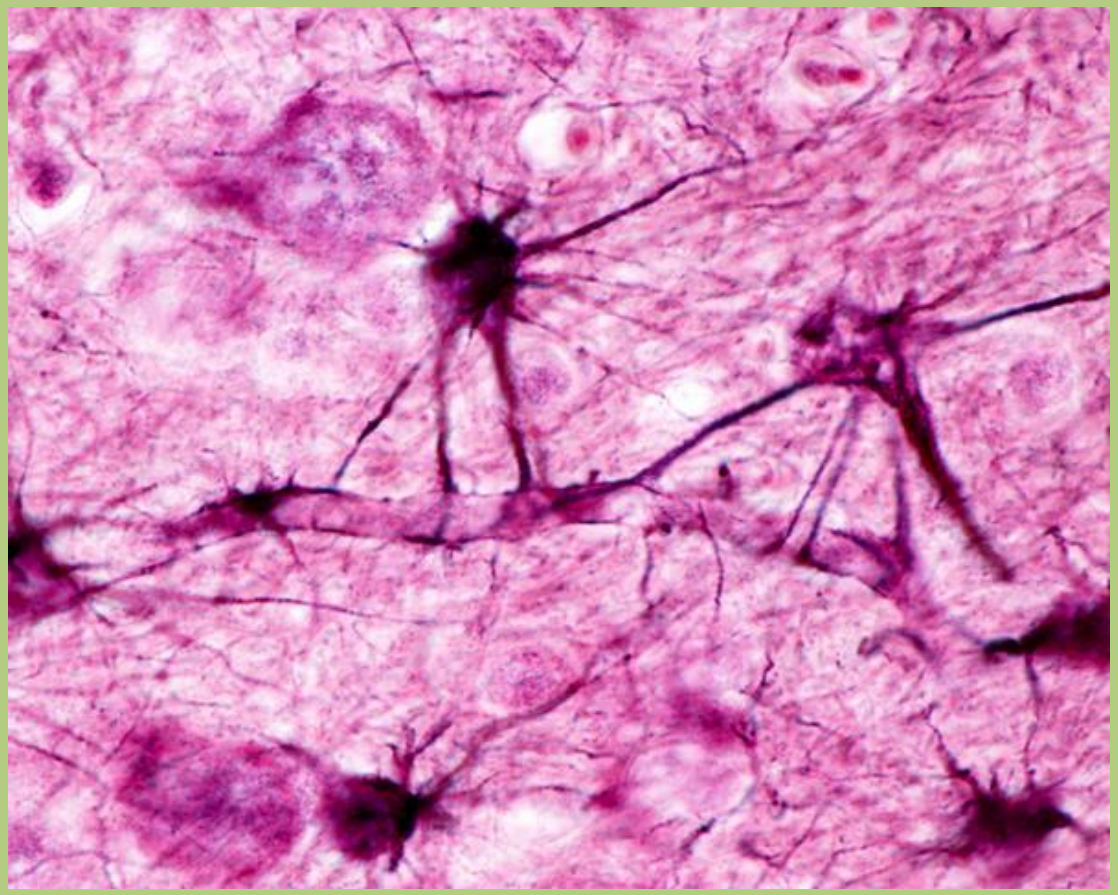


Pío del Río Hortega - 'Father of Microglia'



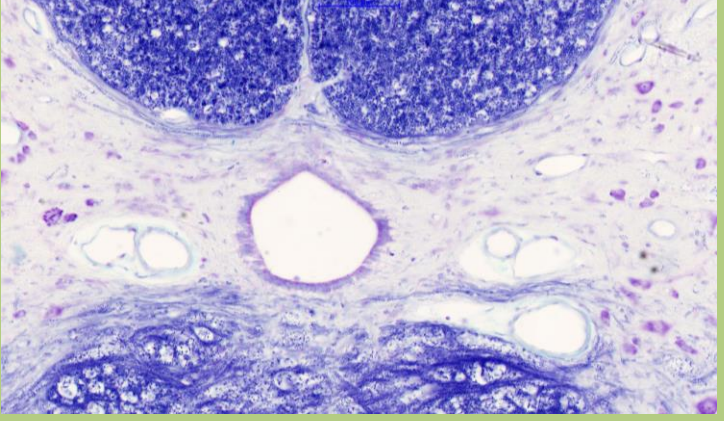
They ***originate from erythromyeloid progenitor cells***. Microglial function is normally ***protective in the brain, with microglial acting as housekeeping phagocytes to maintain tissue homeostasis and keep the extracellular space clean of amyloid bodies***, thereby preventing Alzheimer's disease (AD). ***Sometimes***, because of aging or genetic susceptibility, microglial function becomes inadequate: ***they eat synapses, secrete neurotoxic cytokines that injure neurons***, becoming harmful in AD.

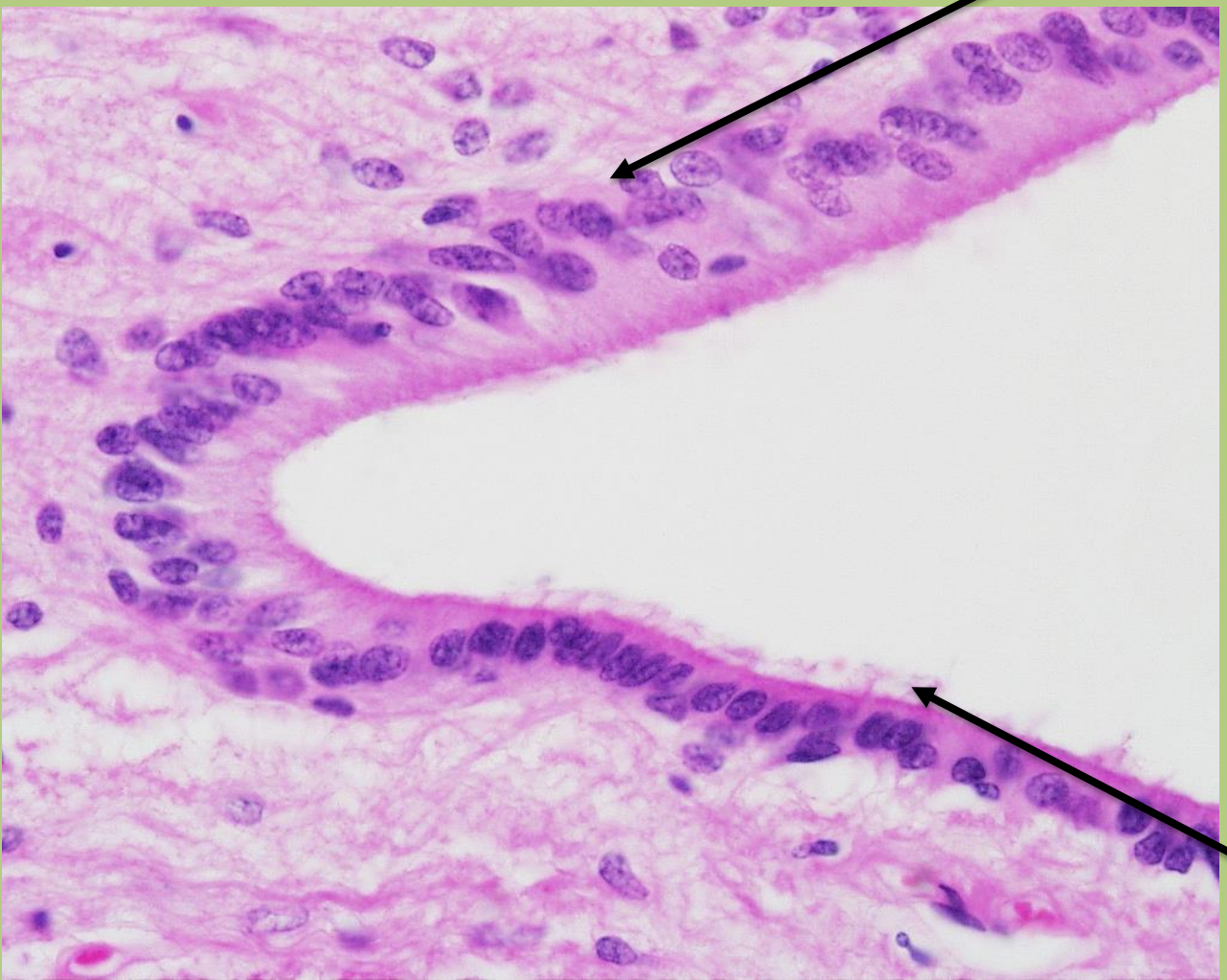
Astrocytes



They perform many functions, including ***biochemical support of endothelial cells that form the blood–brain barrier, provision of nutrients to the nervous tissue, maintenance of extracellular ion balance, and a role in the repair and scarring process*** of the brain and spinal cord following traumatic injuries. Astrocytes also ***signal to neurons*** through Ca^{2+}-dependent release of glutamate.

Ependymal cells



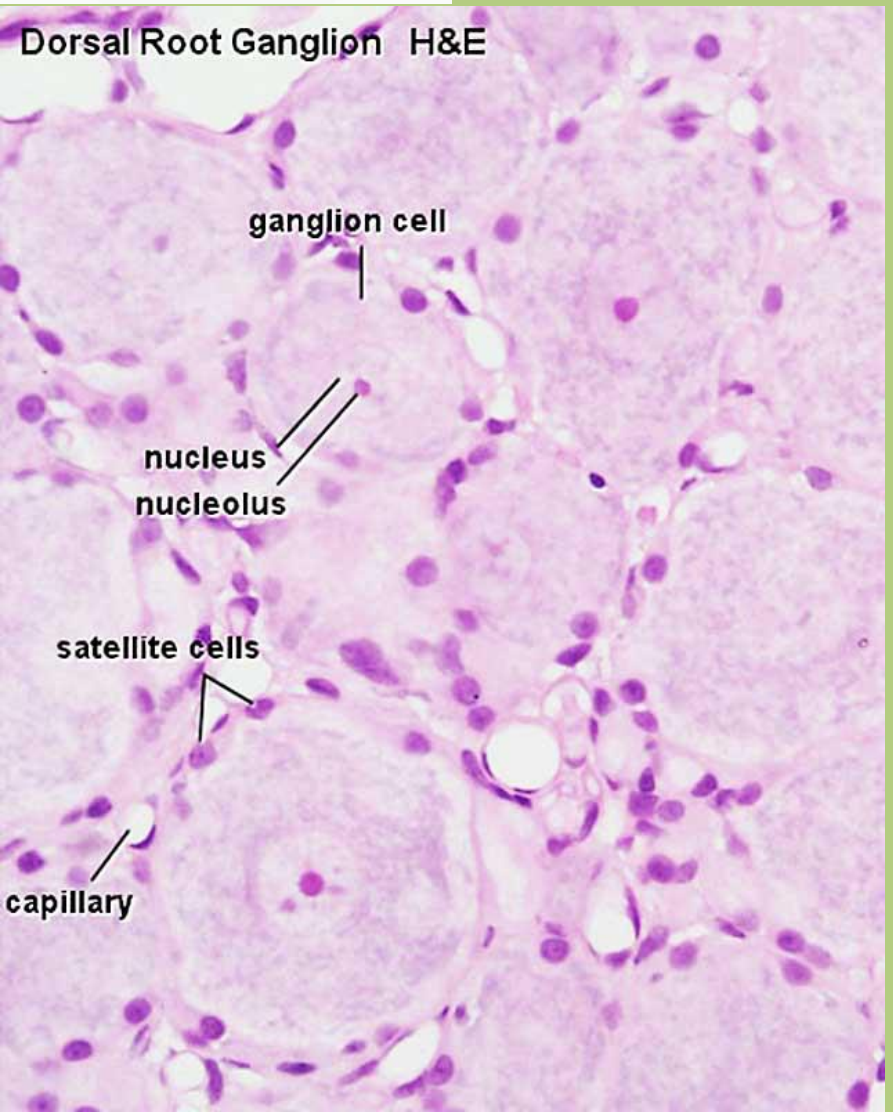


No real basement membrane just tentacle-like extensions of astrocytes are presented.

Neuroepithelial ***lining of ventricular system and central canal***. They play an important role in the ***production and regulation of CSF*** and act as ***reservoir cells*** in the forebrain, which can be activated after stroke.

Microvilli

Dorsal root (spinal) ganglion



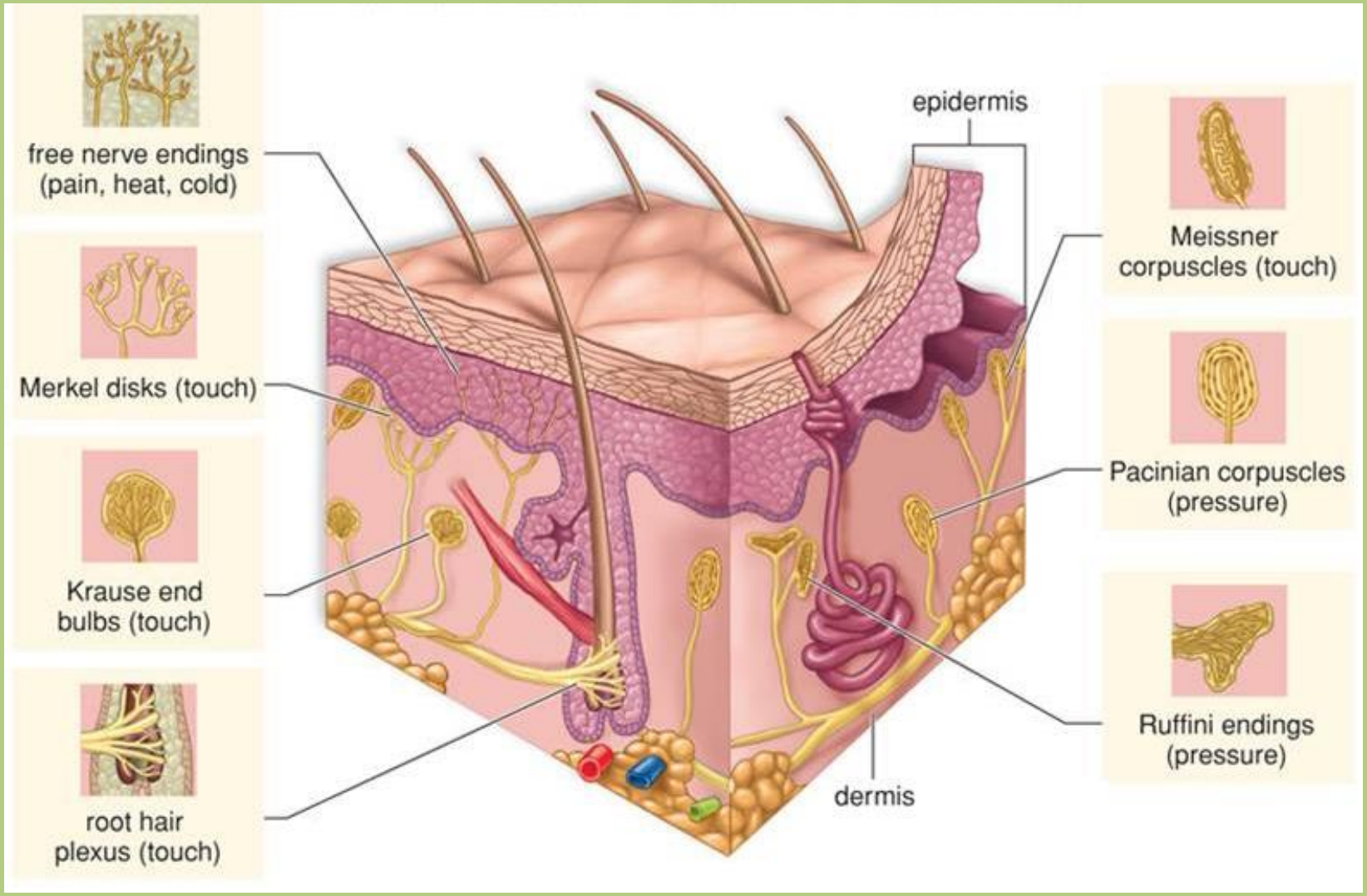
Ganglionic cells:

- pseudounipolar neurons
- 1st order neurons in many ascending sensory tracts

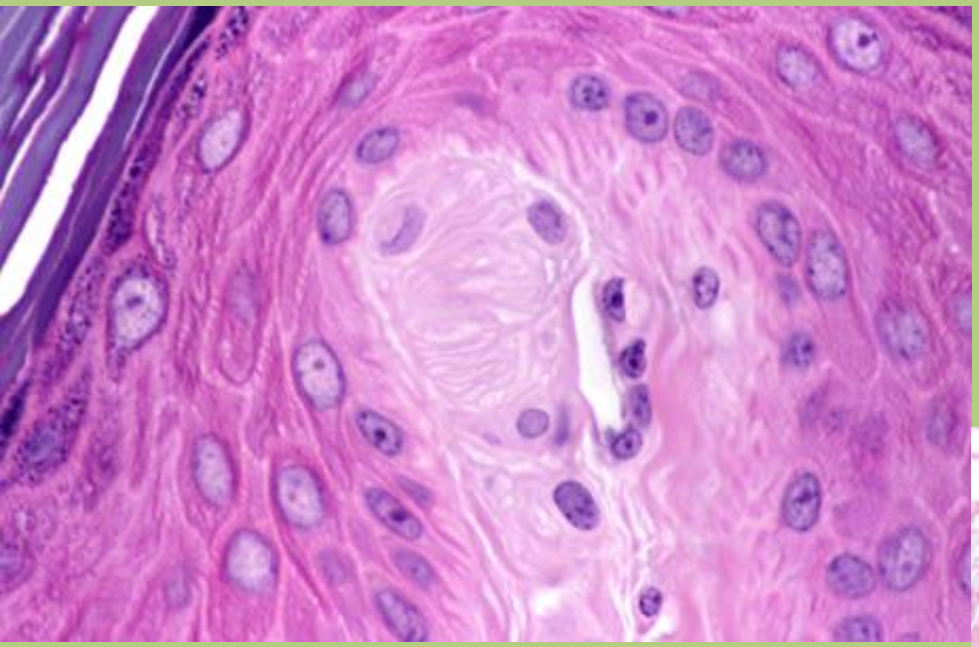
Satellite cells:

- glial cells
- derived from the neural crest
- they keep up special micro environment

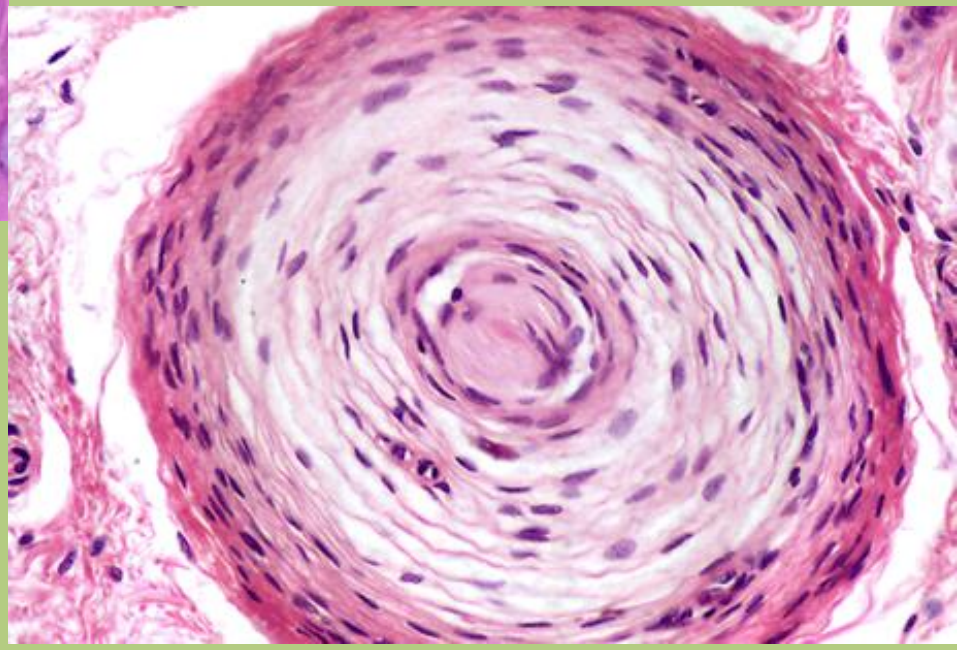
Sensory pathways - receptors



Sensory pathways - receptors



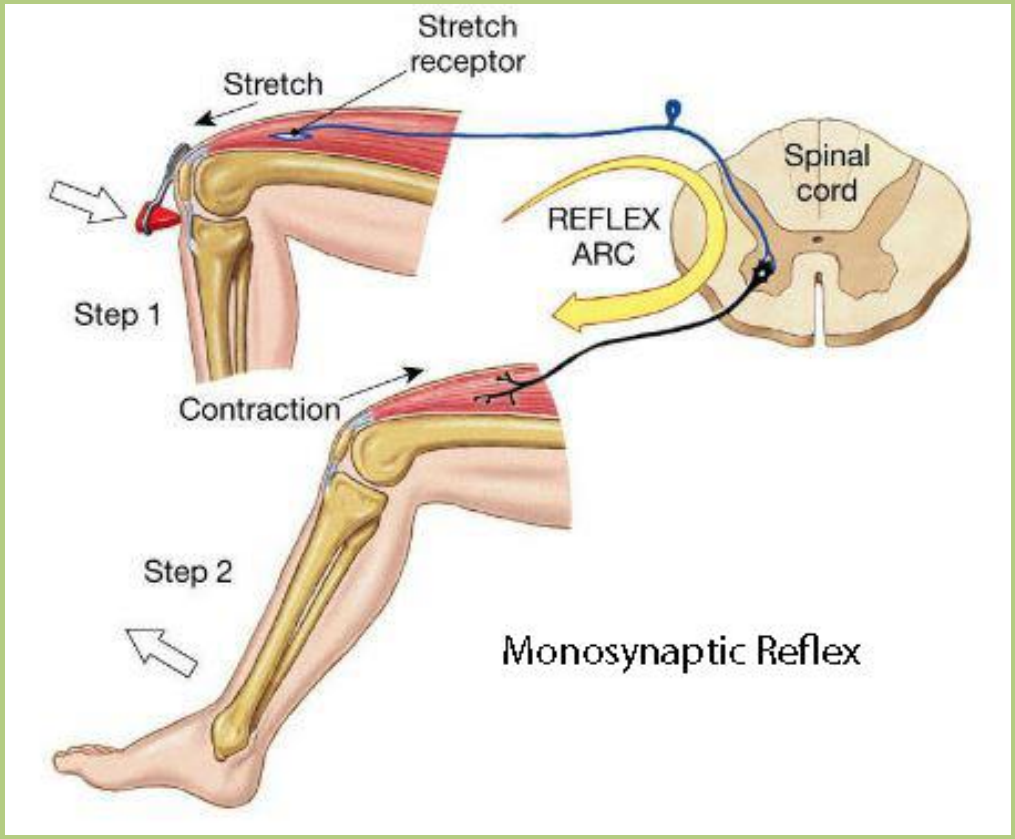
Meissner's corpuscle



Pacinian corpuscle

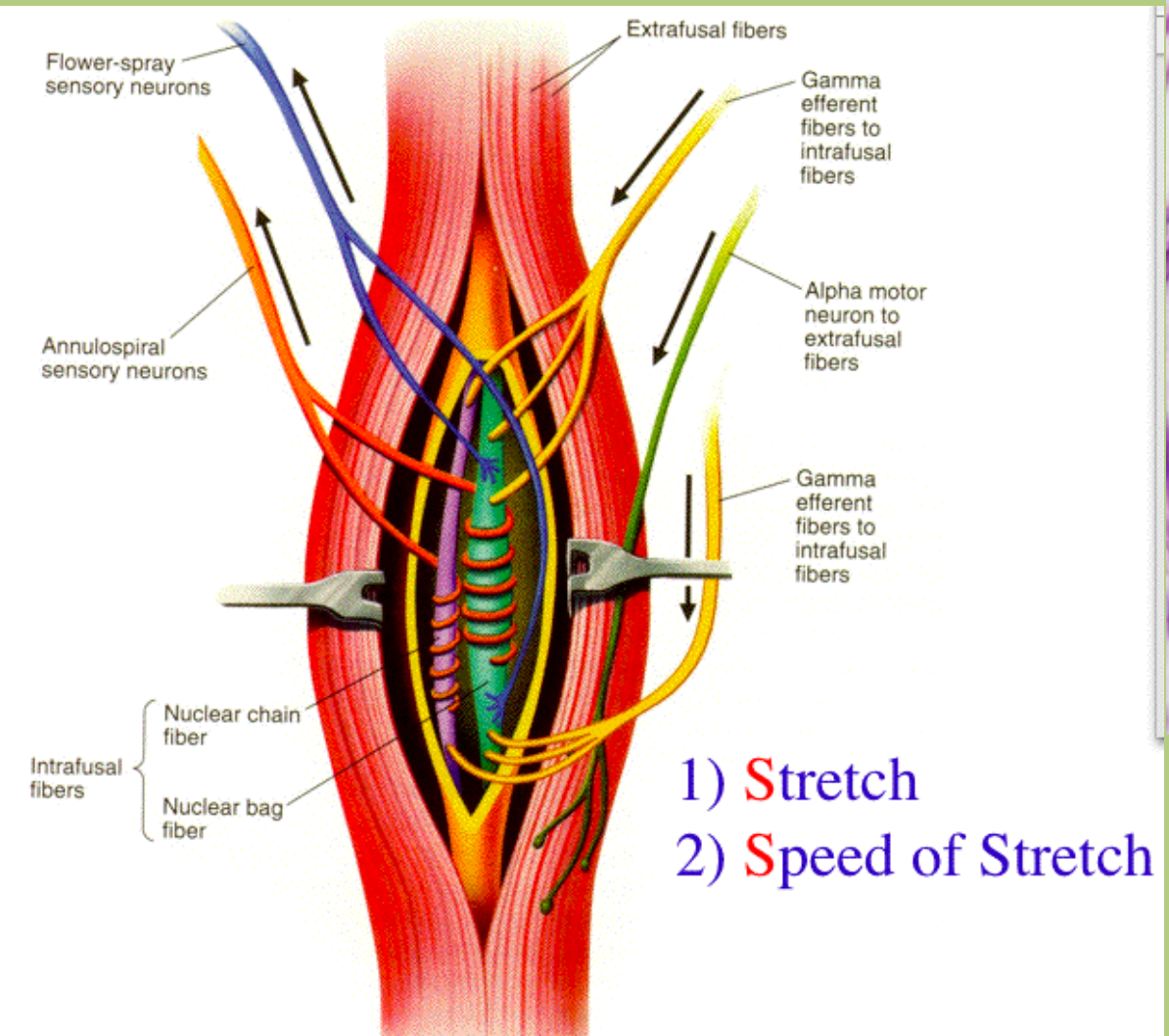
Monosynaptic reflex arc - stretch reflex

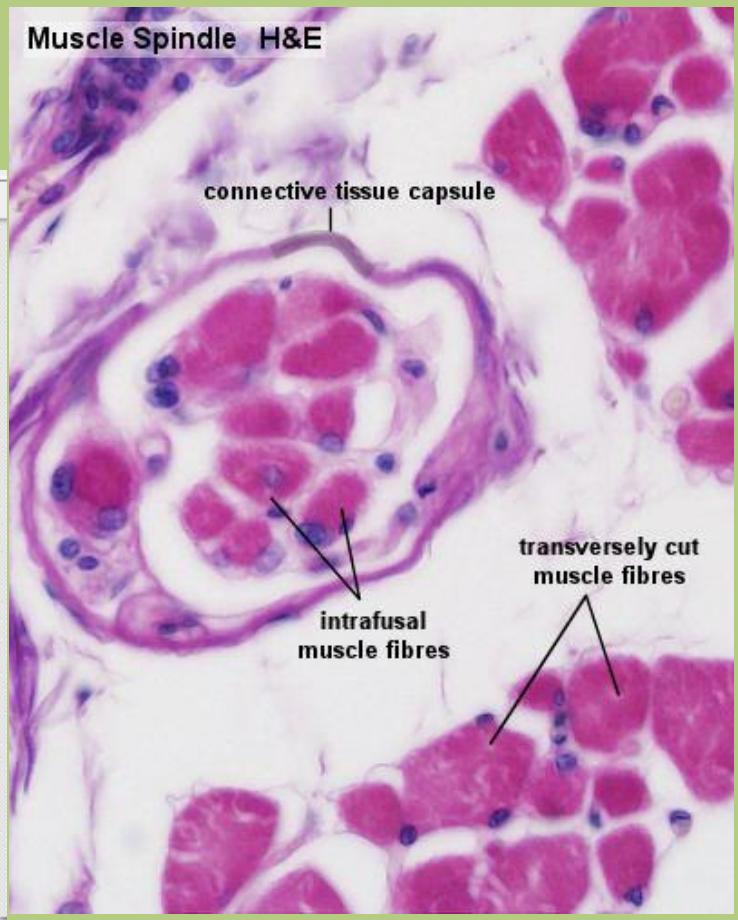
(e.g. patellar reflex)



The ***muscle is briefly stretched*** by a tap on its tendon. ***Stretch receptors*** (muscle spindles) in the muscle ***transmit signals to alpha motor neurons via pseudounipolar neurons*** whose cell bodies are in the dorsal root ganglion. These afferent neurons release excitatory transmitters which cause the alpha motors neurons to ***stimulate muscle contraction***.

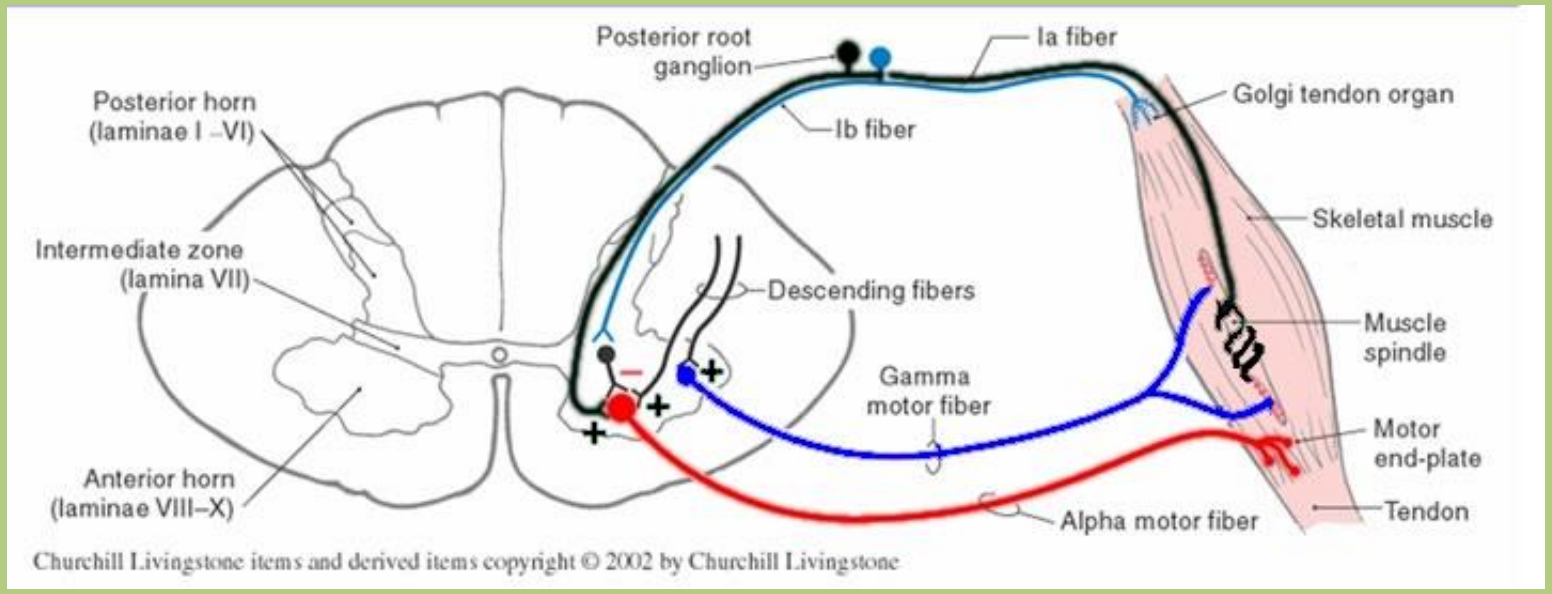
Muscle spindle





Encapsulated stretch receptor.

Gamma loop



The term gamma loop was introduced by Granit to refer to the ***activation of alpha motoneurones indirectly*** through the effect of gamma efferent drive to the muscle spindles.

Thank you for your attention.

"Oops! Sorry about that spontaneous reflex action, doctor!"

References:
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