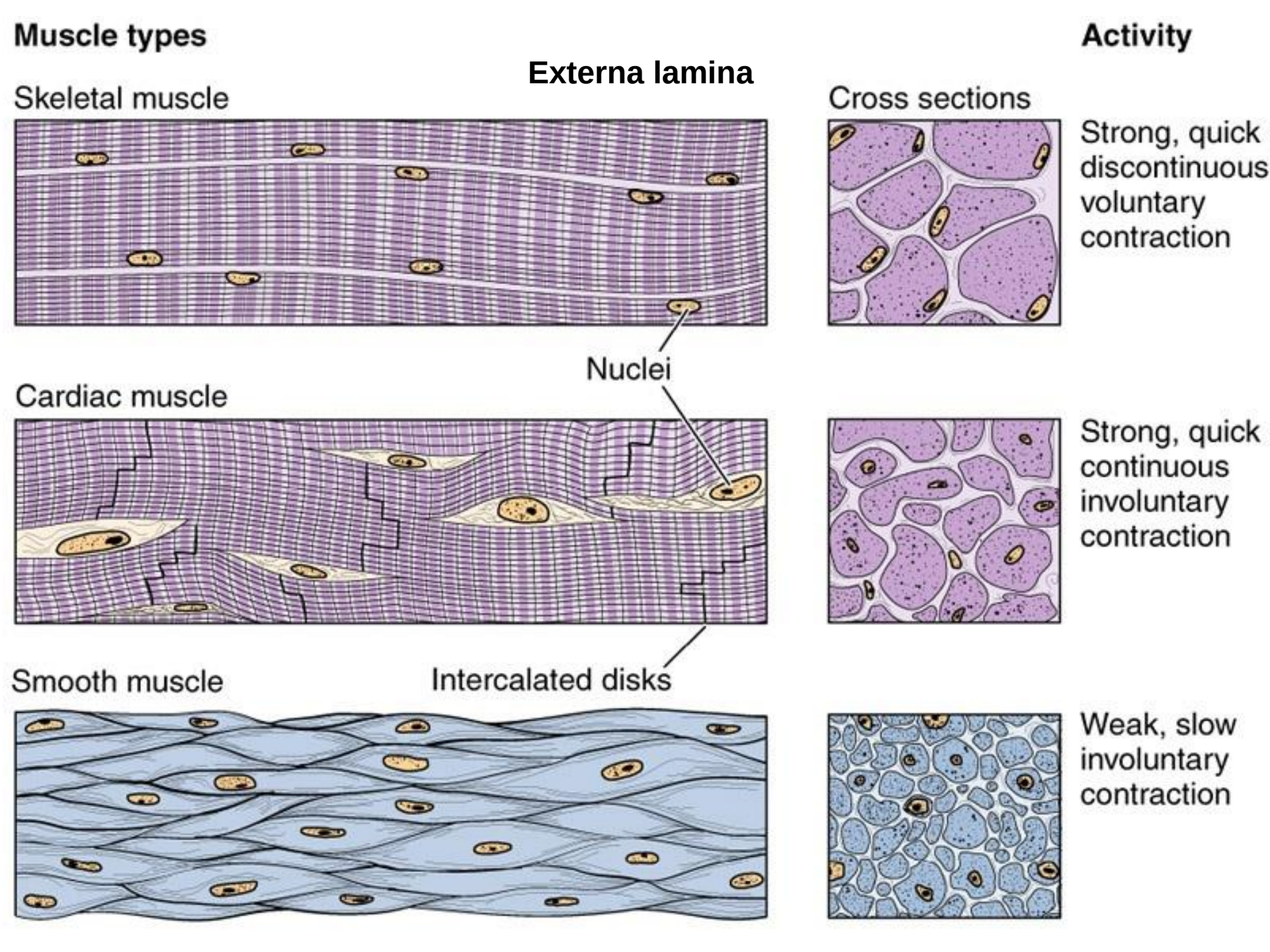
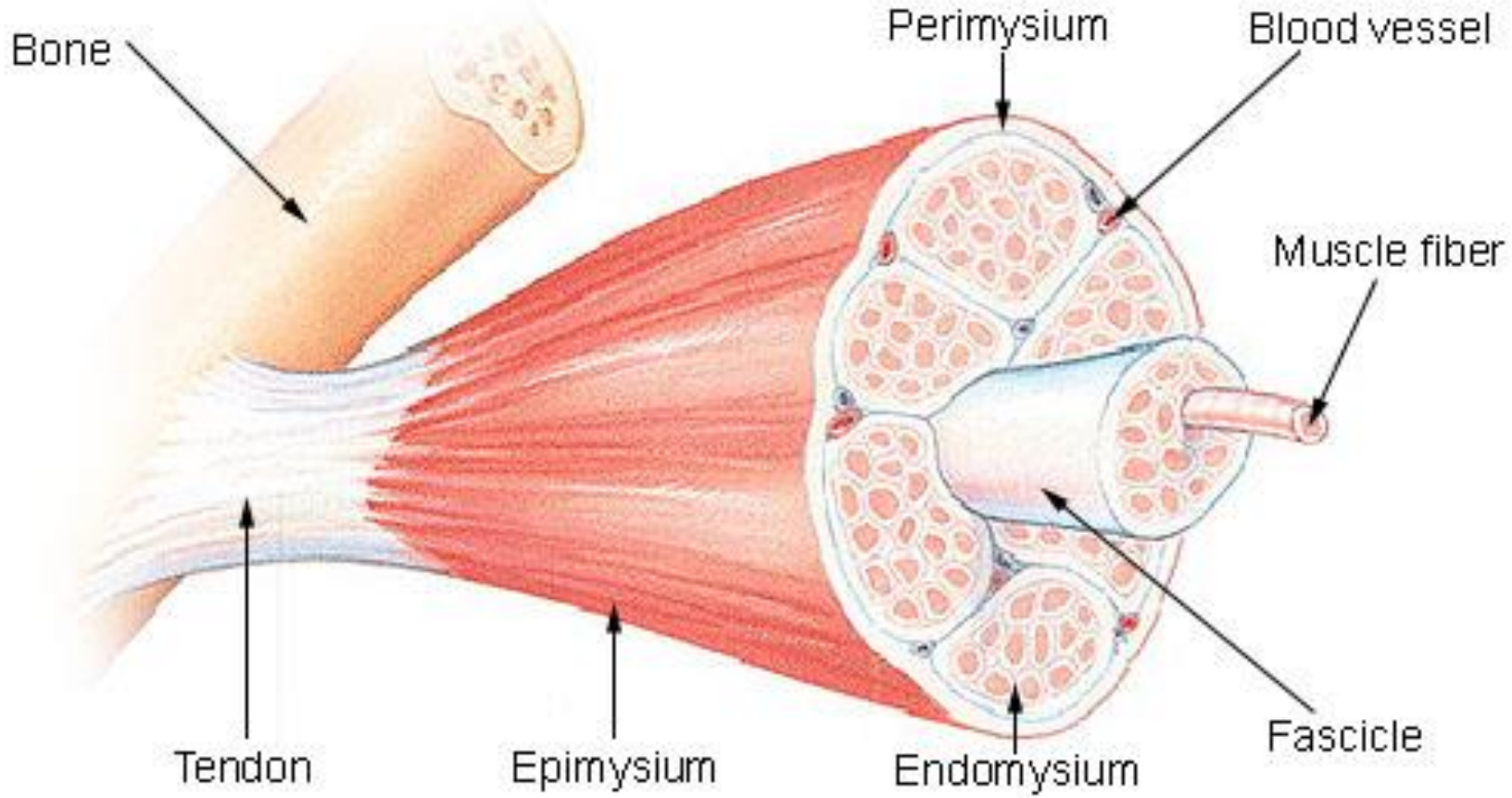
MUSCULAR TISSUE

- maintaining and changing posture - locomotion
- movement of internal organs
  - contraction of the heart
  - movement of food through the digestive system


Muscle types
Activity
Externa lamina
Skeletal muscle
Cross sections
Strong, quick discontinuous voluntary contraction
Nuclei
Cardiac muscle
Strong, quick continuous involuntary contraction
Intercalated disks
Smooth muscle
Weak, slow involuntary contraction

Structure of a Skeletal Muscle



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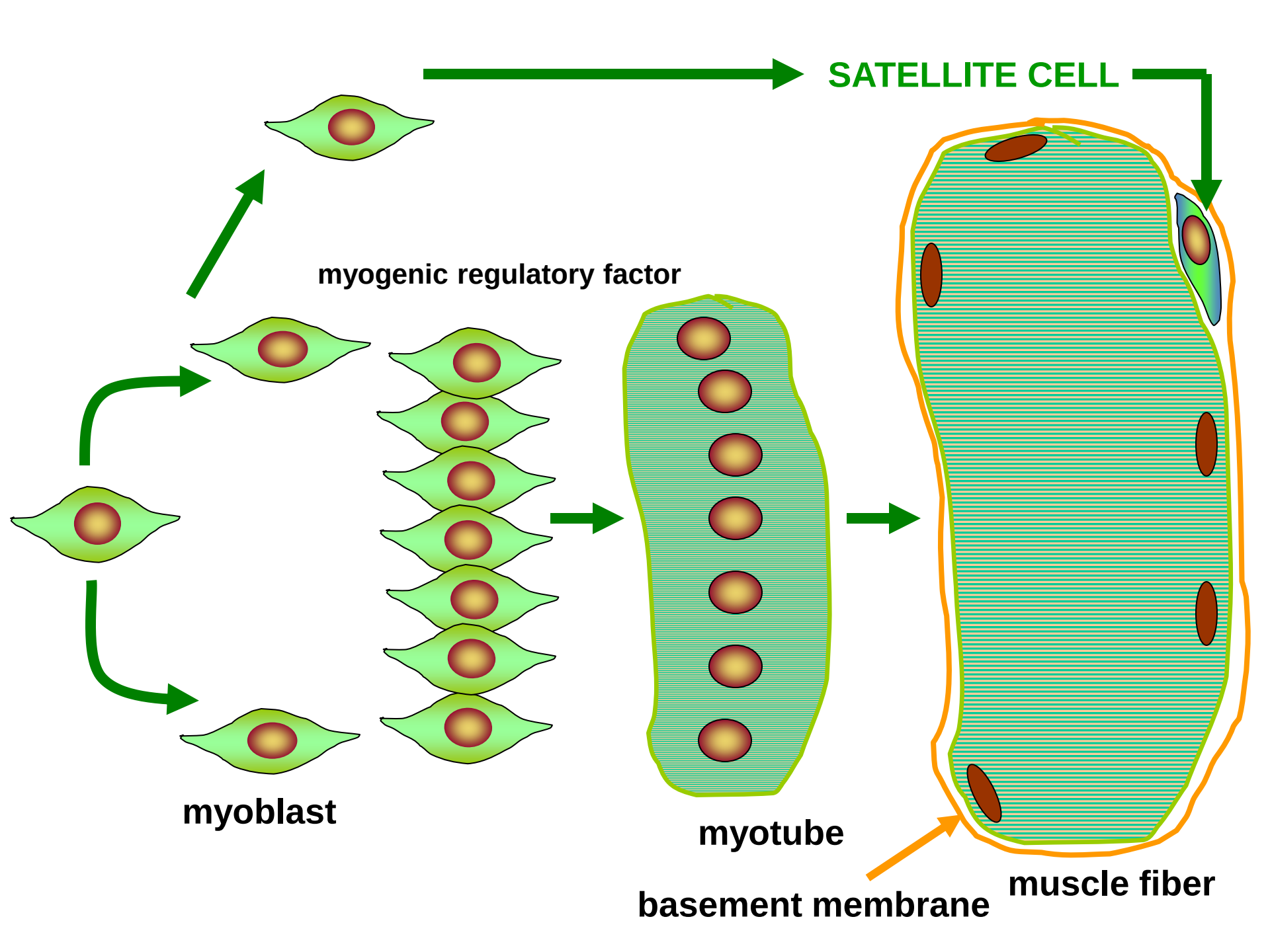
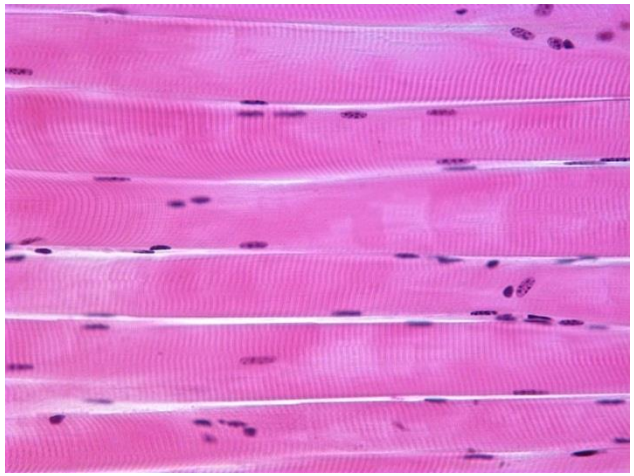
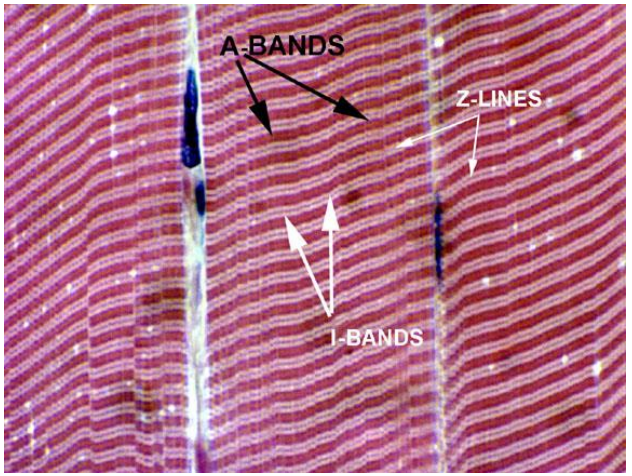
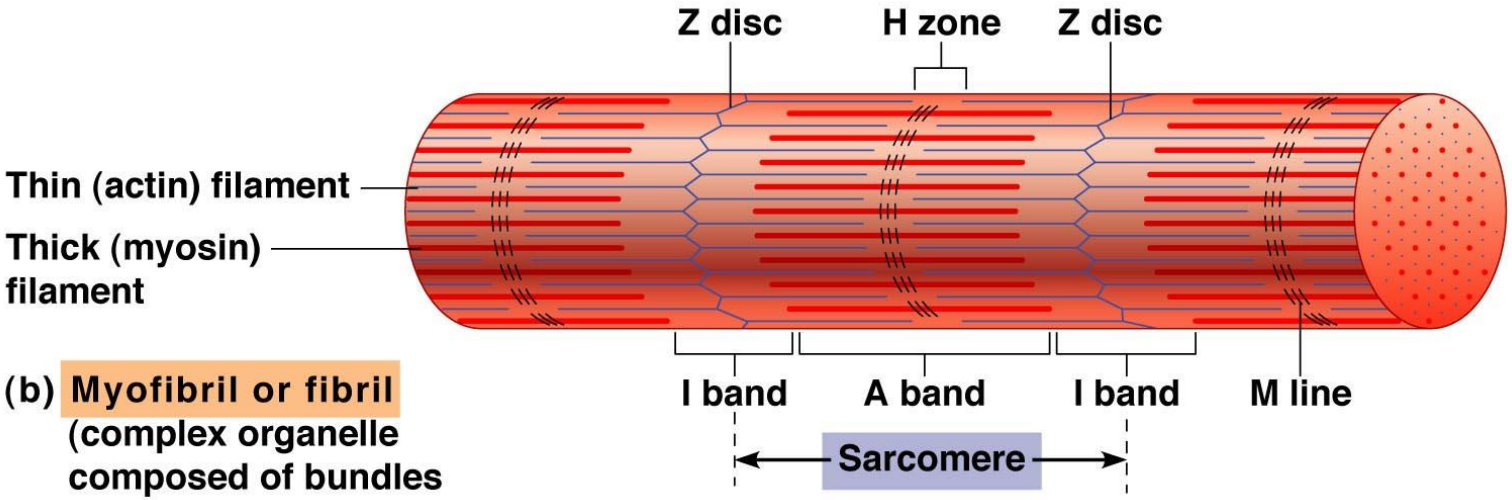

SATELLITE CELL
myogenic regulatory factor
myoblast
myotube
basement membrane
muscle fiber

Organization of myofibrils and sarcomeres within a skeletal muscle cell

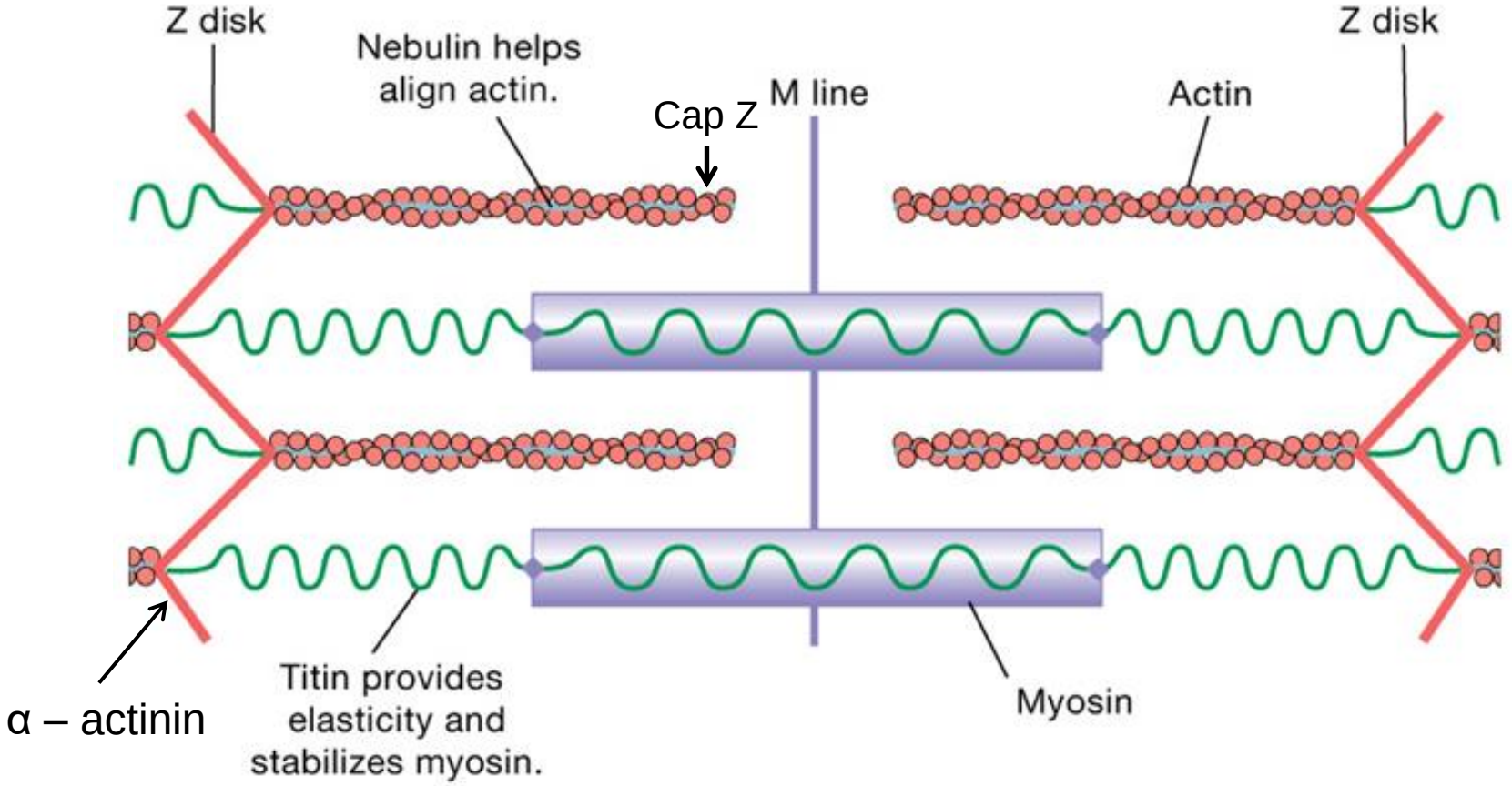






(b) **Myofibril or fibril** (complex organelle composed of bundles of myofilaments)

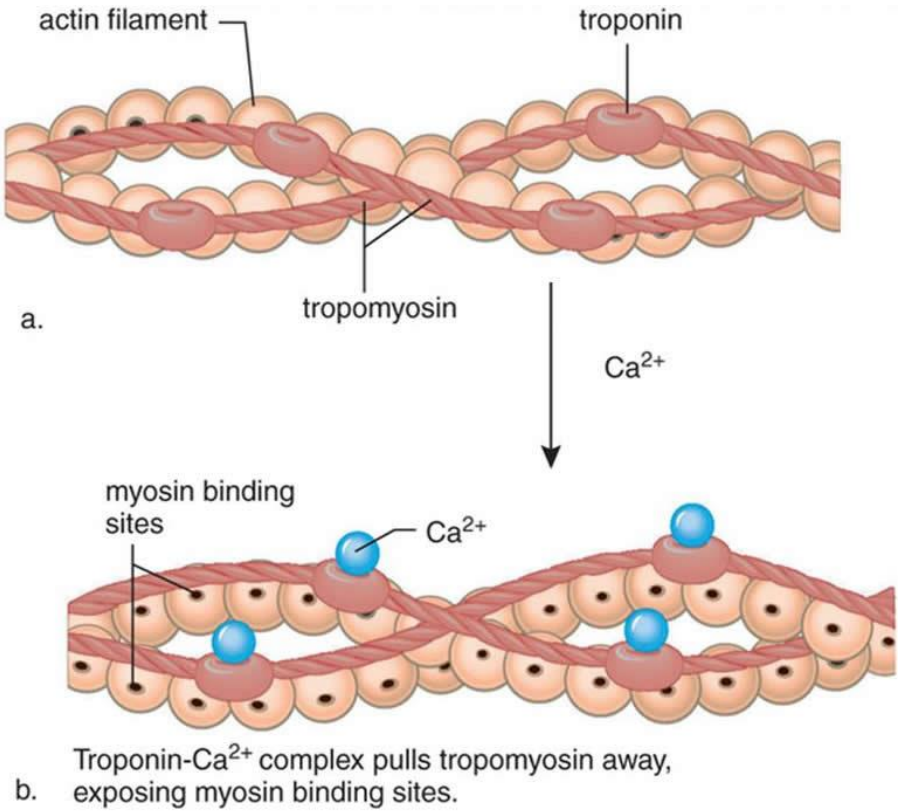
Additional proteins associated with sarcomer



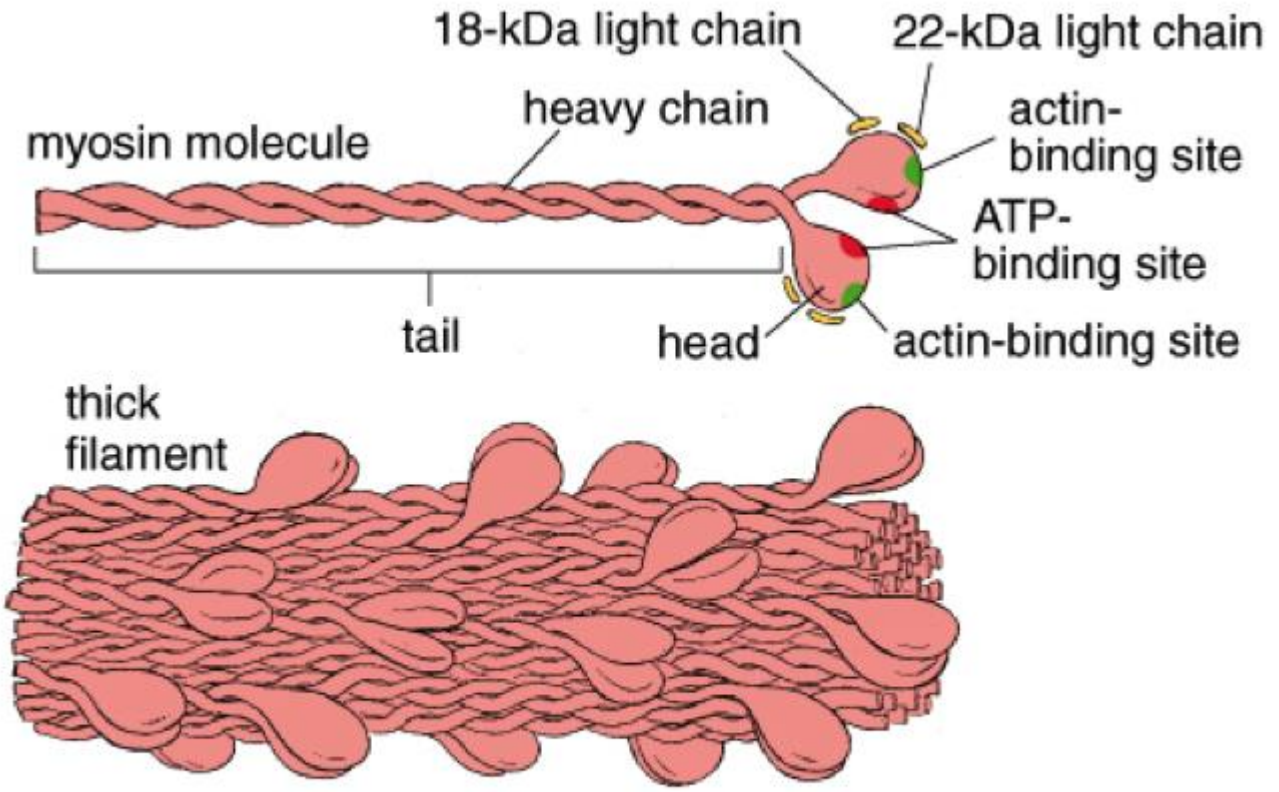
Titin - connects the Z line to the M line in the sarcomere

α – actinin - is necessary for the attachment of actin filaments to the Z-lines

THIN FILAMENTS –ACTIN and TROPONIN

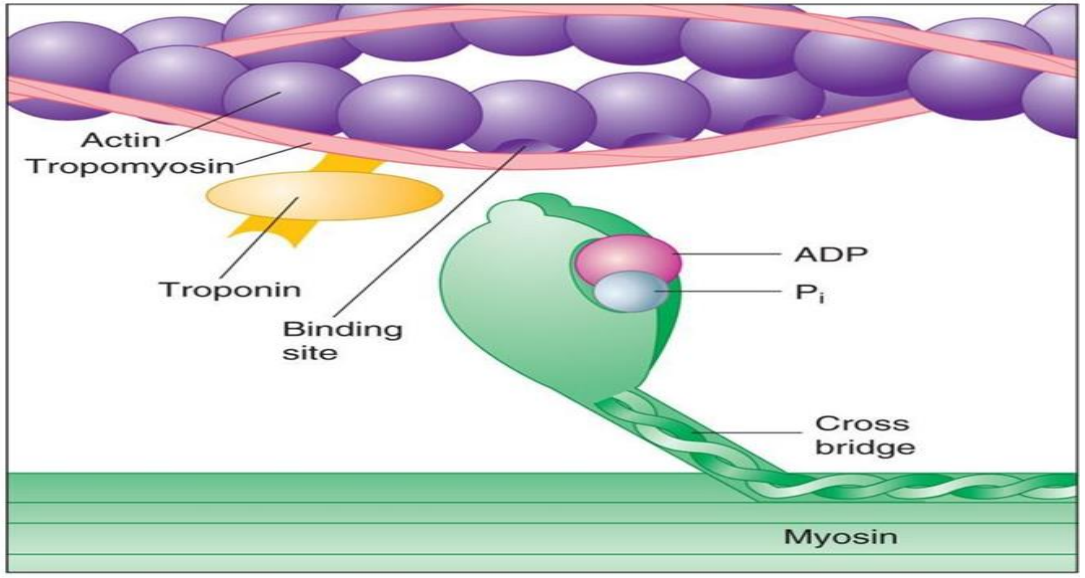


THICK (MYOSIN) FILAMENT

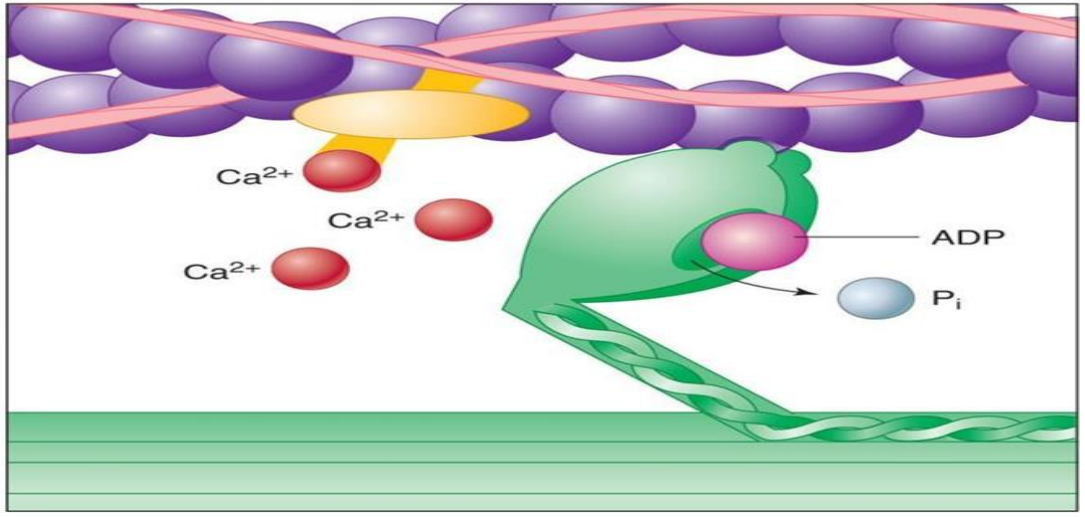


Unfig. 10.2. **Thick filament.**

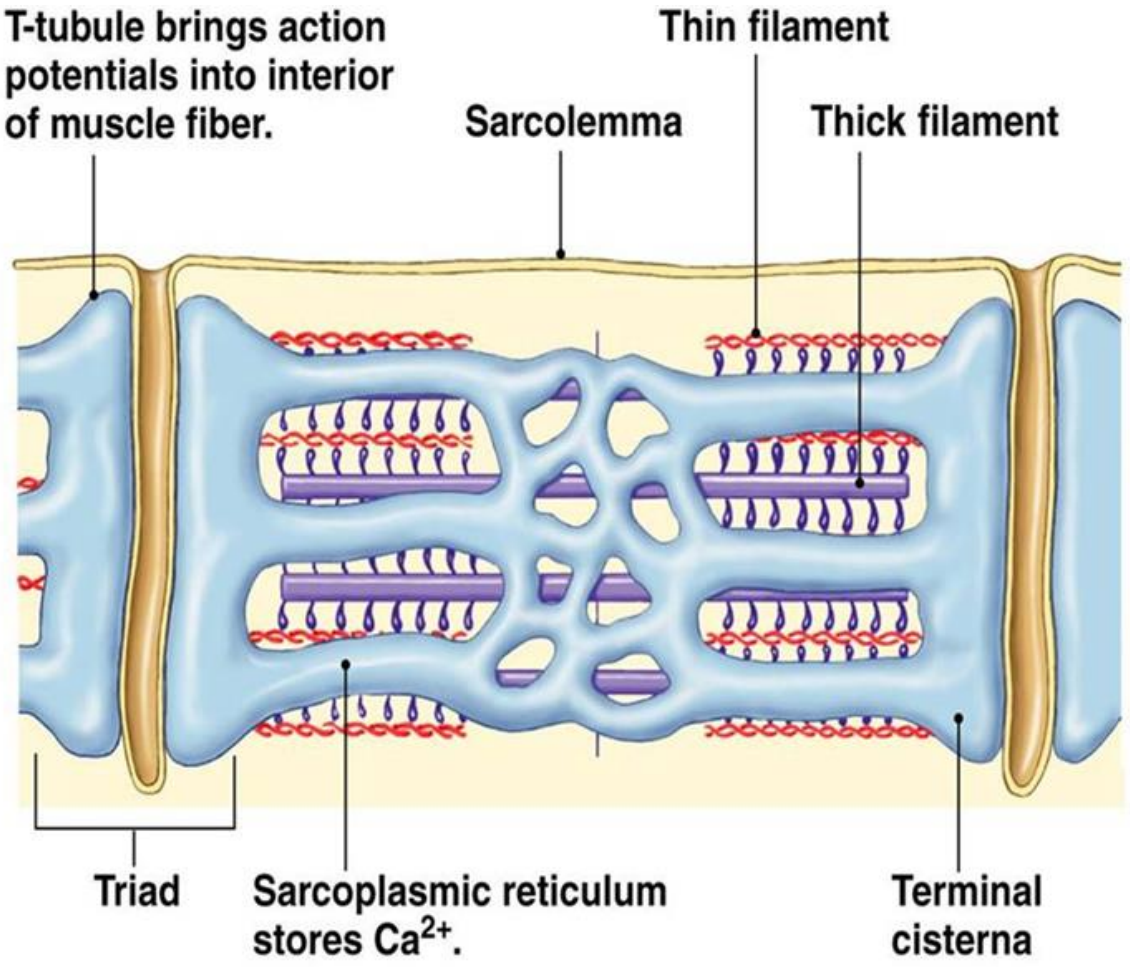
Relaxed muscle: tropomyosin blocks the binding site

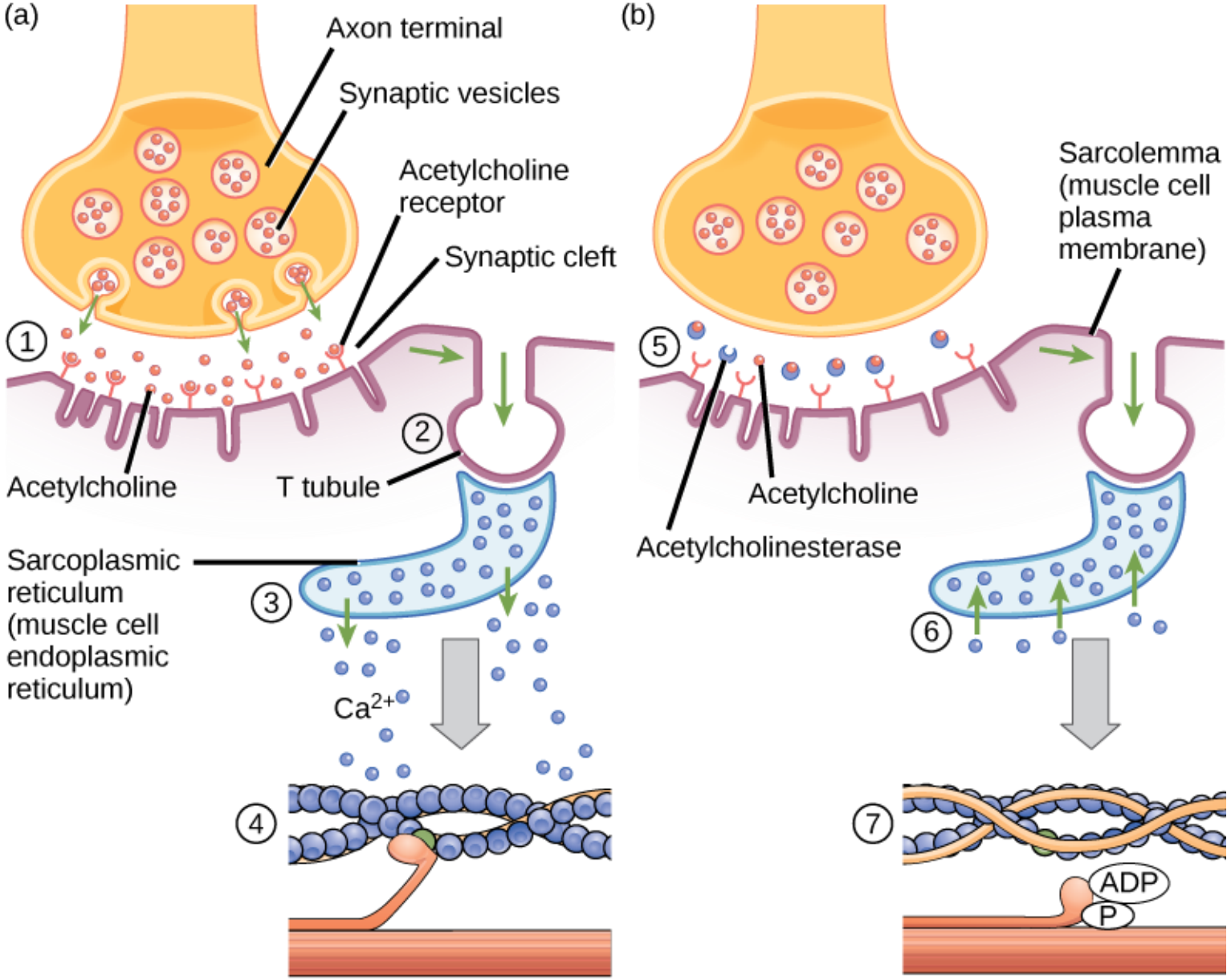


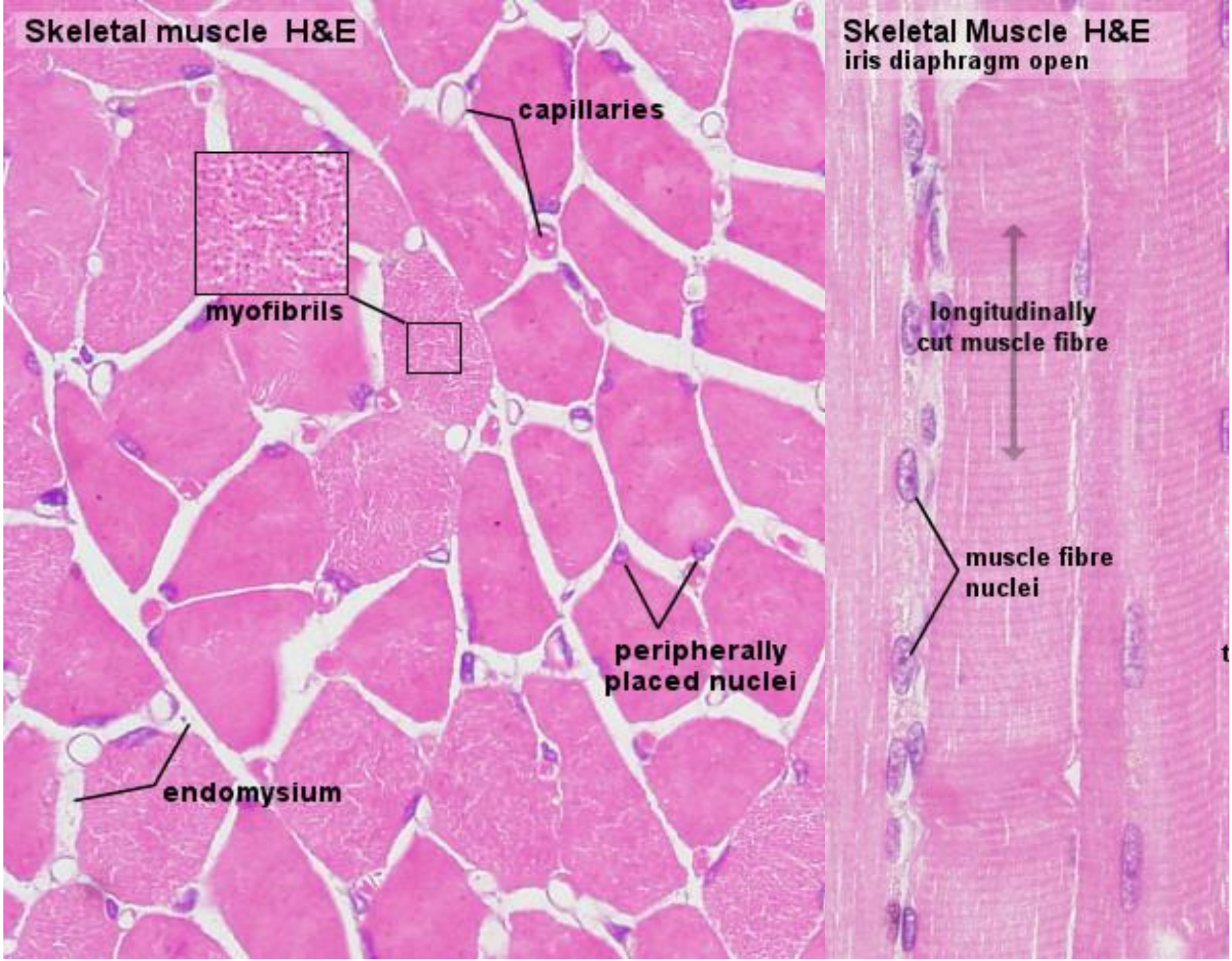
Contracting muscle: myosin head binds to actin



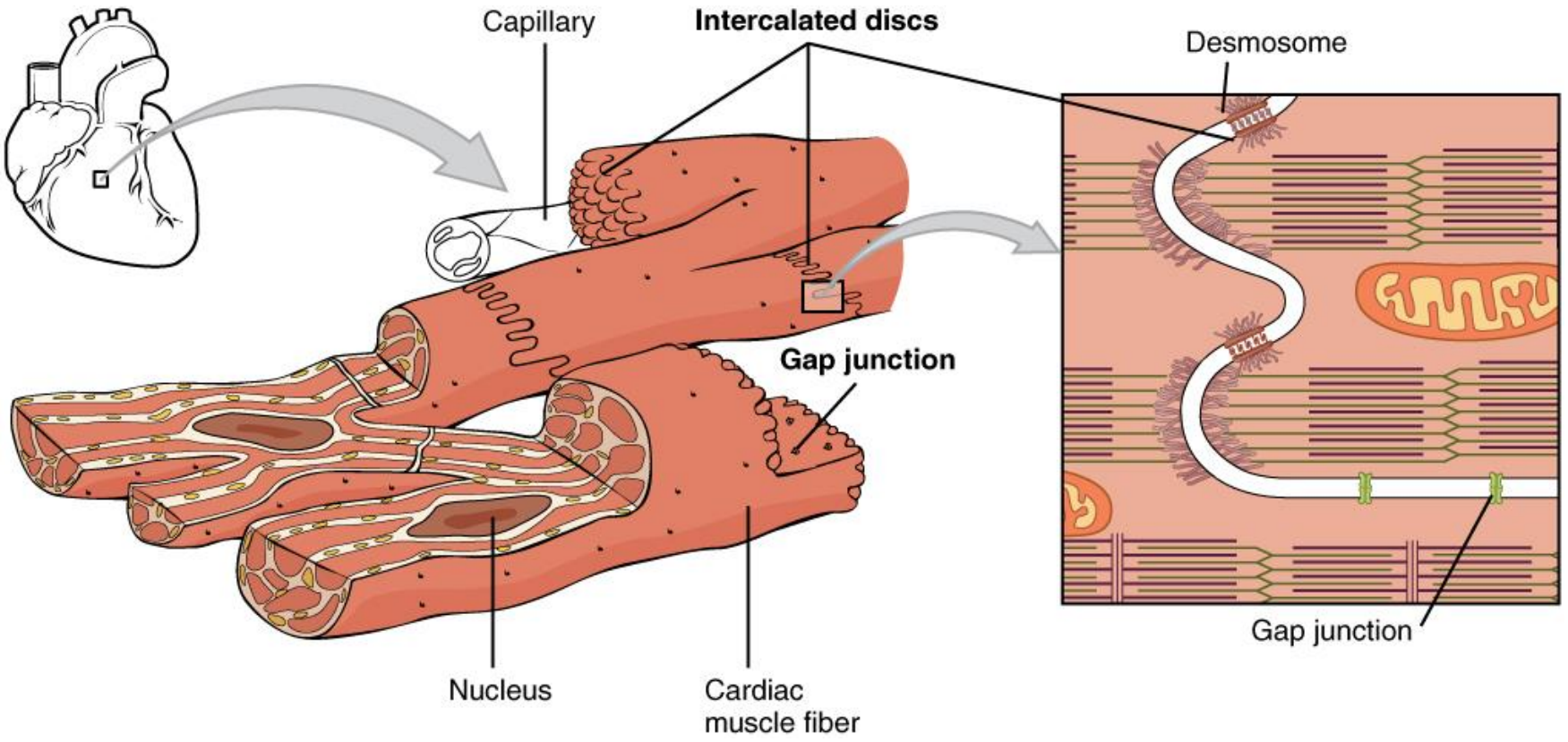
Calcium ions are stored in sarcoplasmic reticulum
Sarcoplasmic reticulum and T-tubule form triad



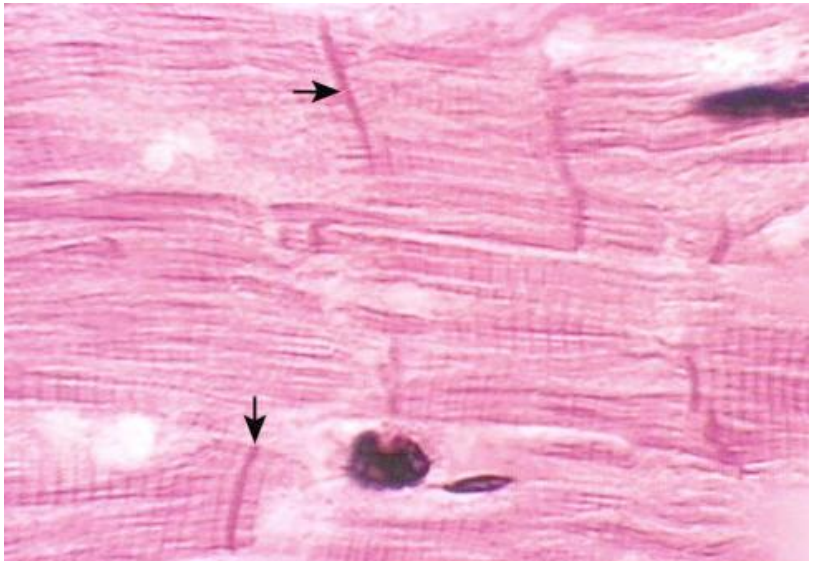

(a)
Axon terminal
Synaptic vesicles
Acetylcholine receptor
Synaptic cleft
1
Acetylcholine
2
T tubule
Sarcoplasmic reticulum (muscle cell endoplasmic reticulum)
3
Ca^{2+}
4
(b)
Sarcolemma (muscle cell plasma membrane)
5
Acetylcholine
Acetylcholinesterase
6
7
ADP
P

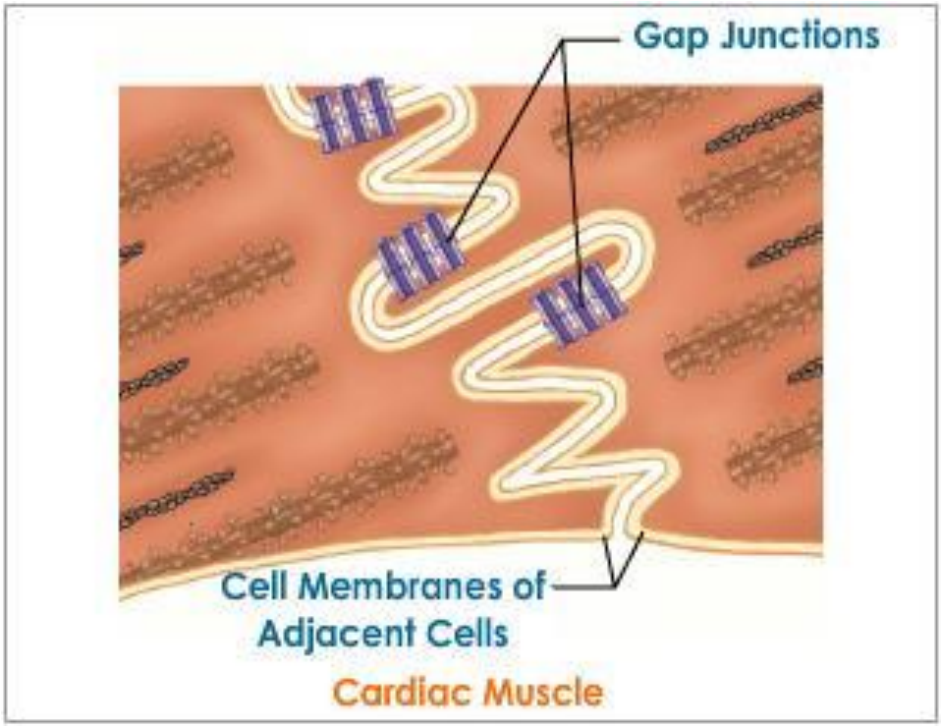

Skeletal muscle H&E
capillaries
myofibrils
peripherally
placed nuclei
endomysium
Skeletal Muscle H&E
iris diaphragm open
longitudinally
cut muscle fibre
muscle fibre
nuclei

CARDIAC MUSCLE

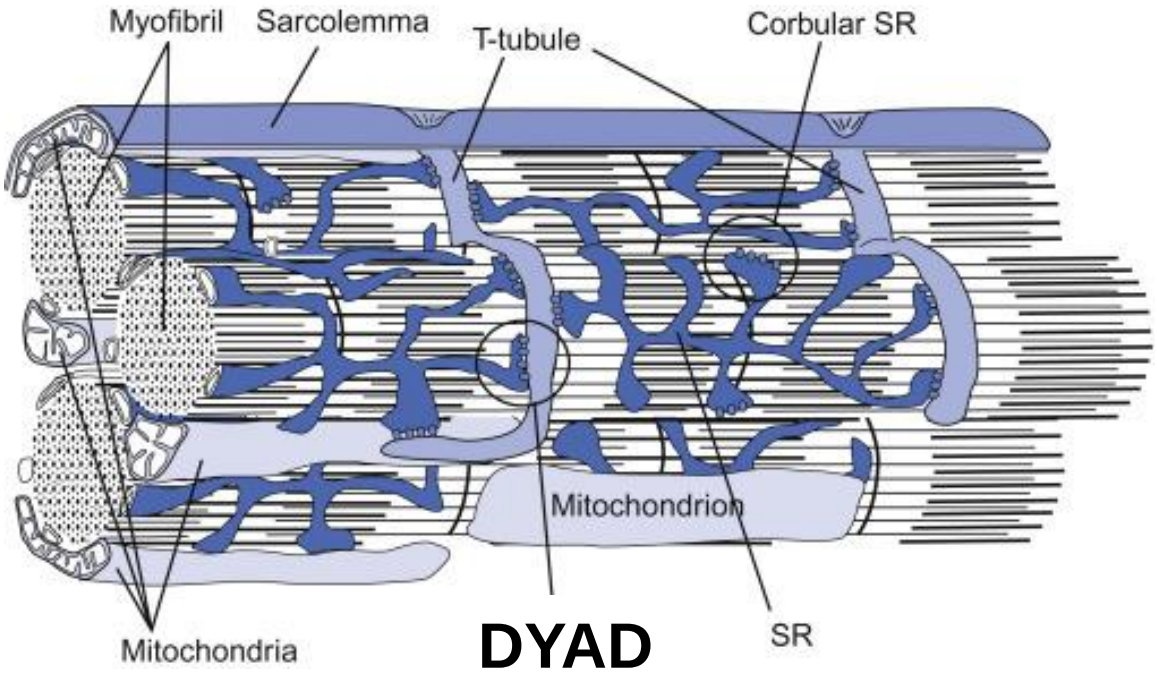


INTERCALATED DISKS

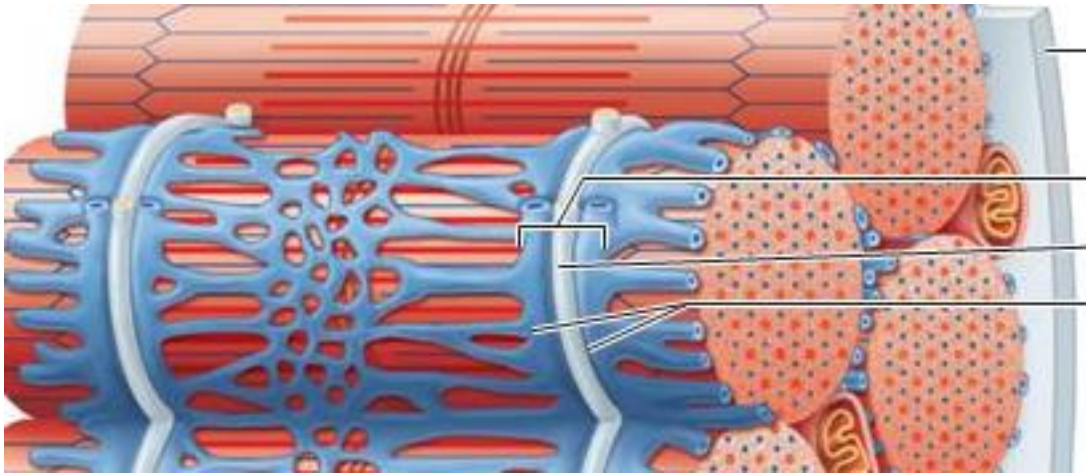




Intercalated discs support synchronised contraction of cardiac tissue



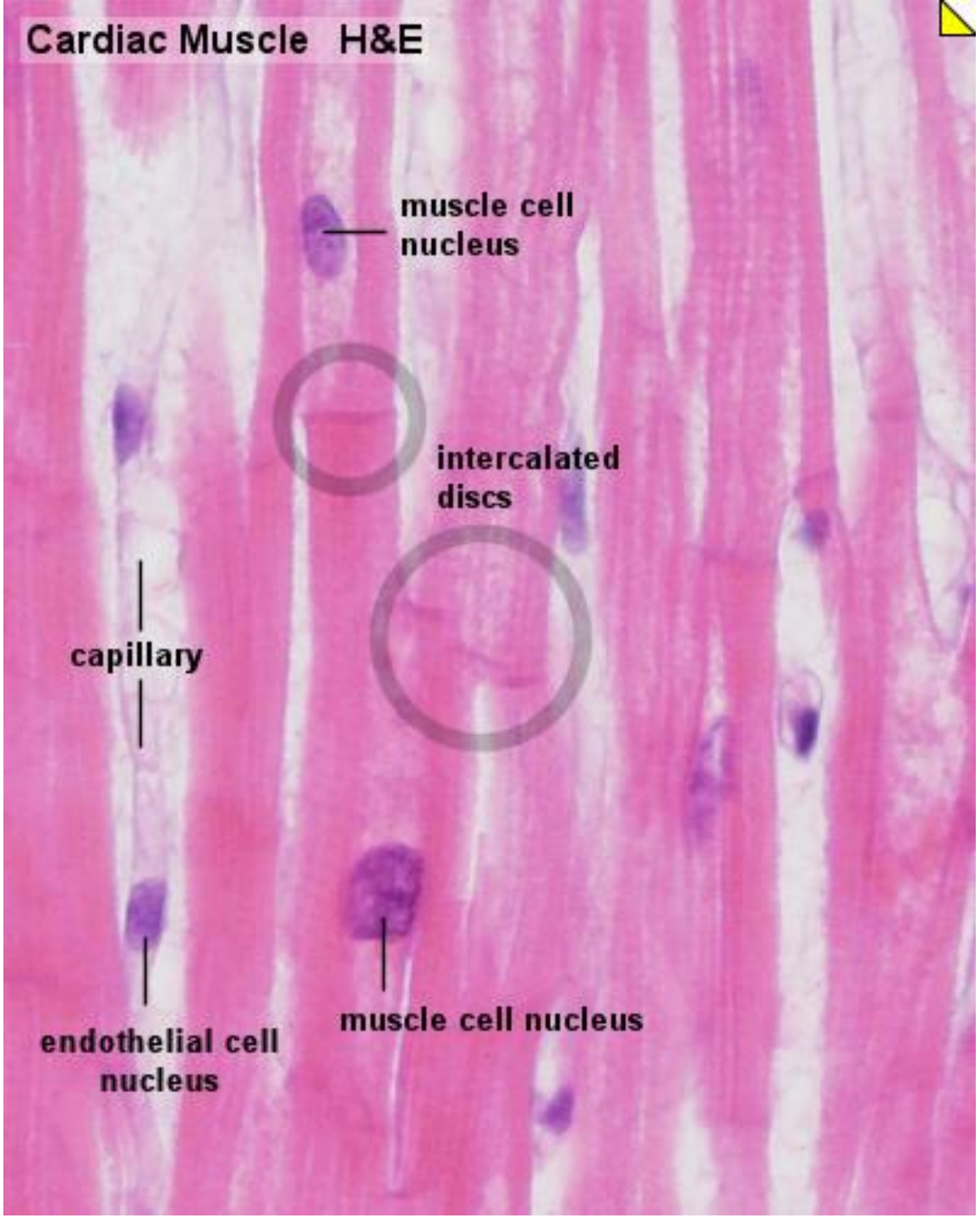
DYAD



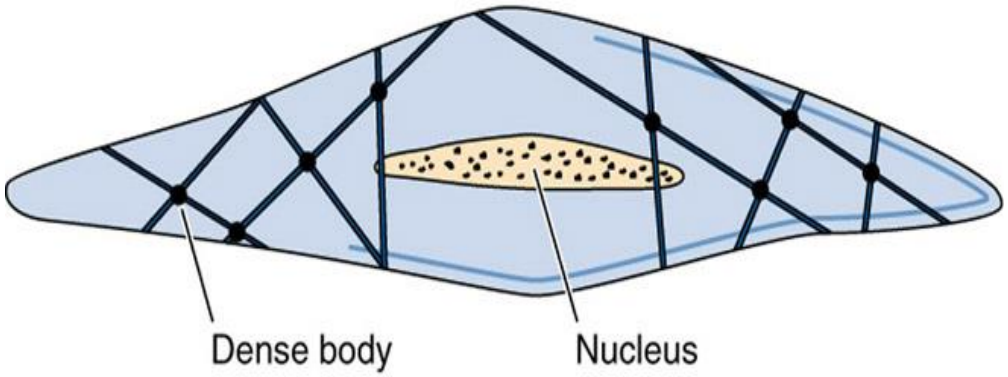
Sarcolemma

Triad:

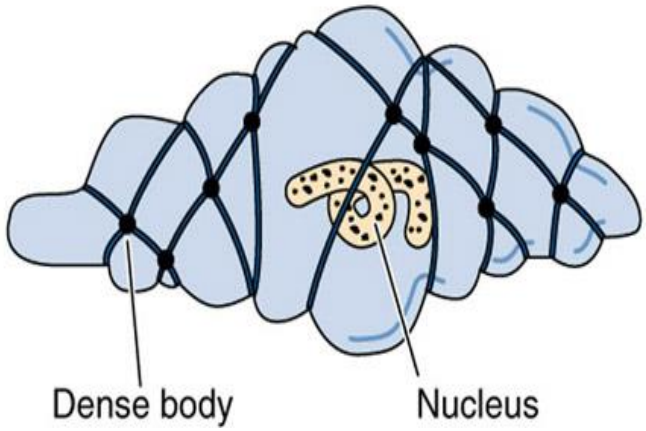
- **T tubule**
- **Terminal cisternae of the SR (2)**


Cardiac Muscle H&E
muscle cell nucleus
intercalated discs
capillary
endothelial cell nucleus
muscle cell nucleus

Relaxed smooth muscle cell



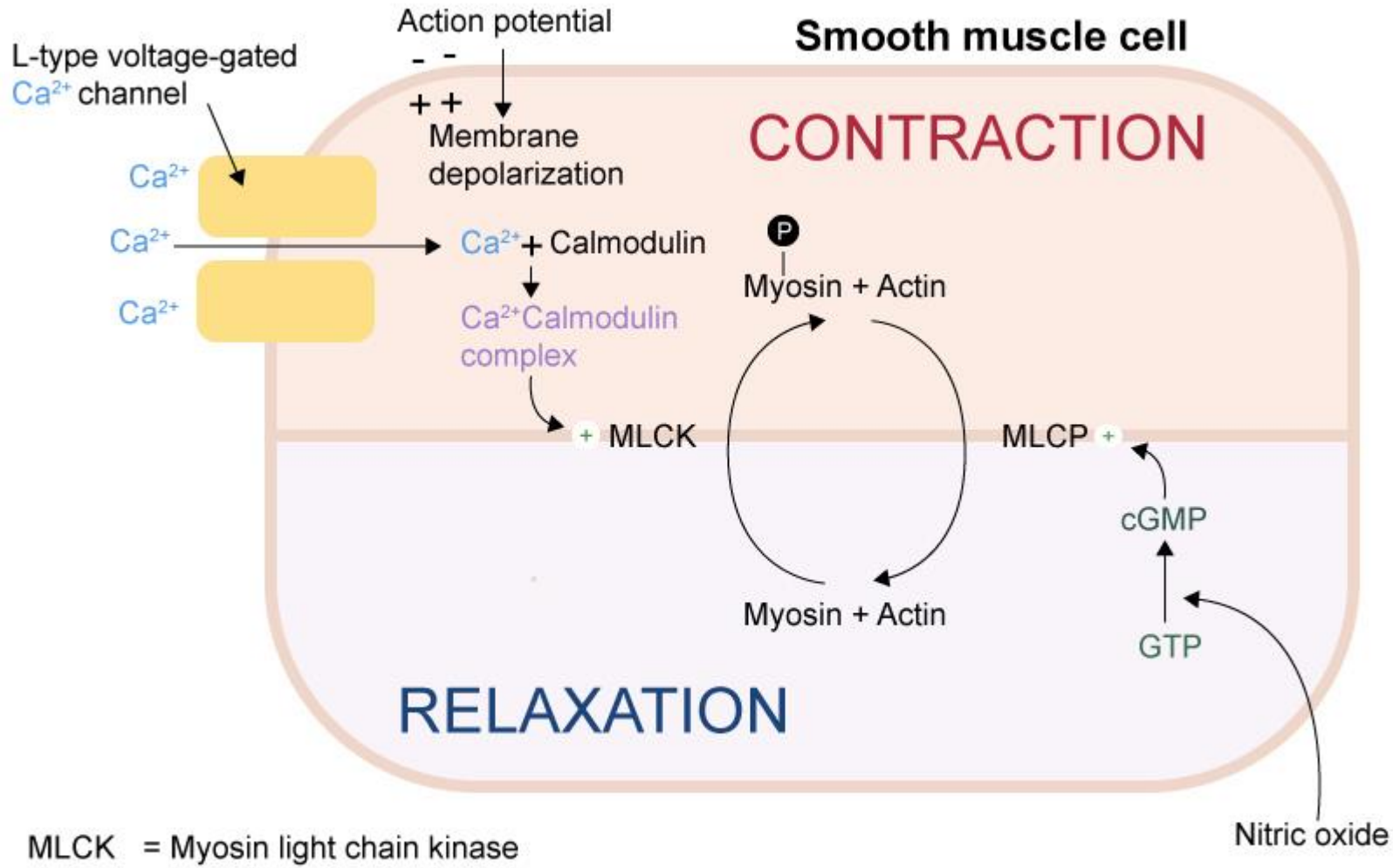
Contracted smooth muscle cell



The myosin and actin are the contractile elements of smooth muscle cells that stretch across the cell. The actin filaments are attached to dense bodies. Dense bodies are rich in α-actinin

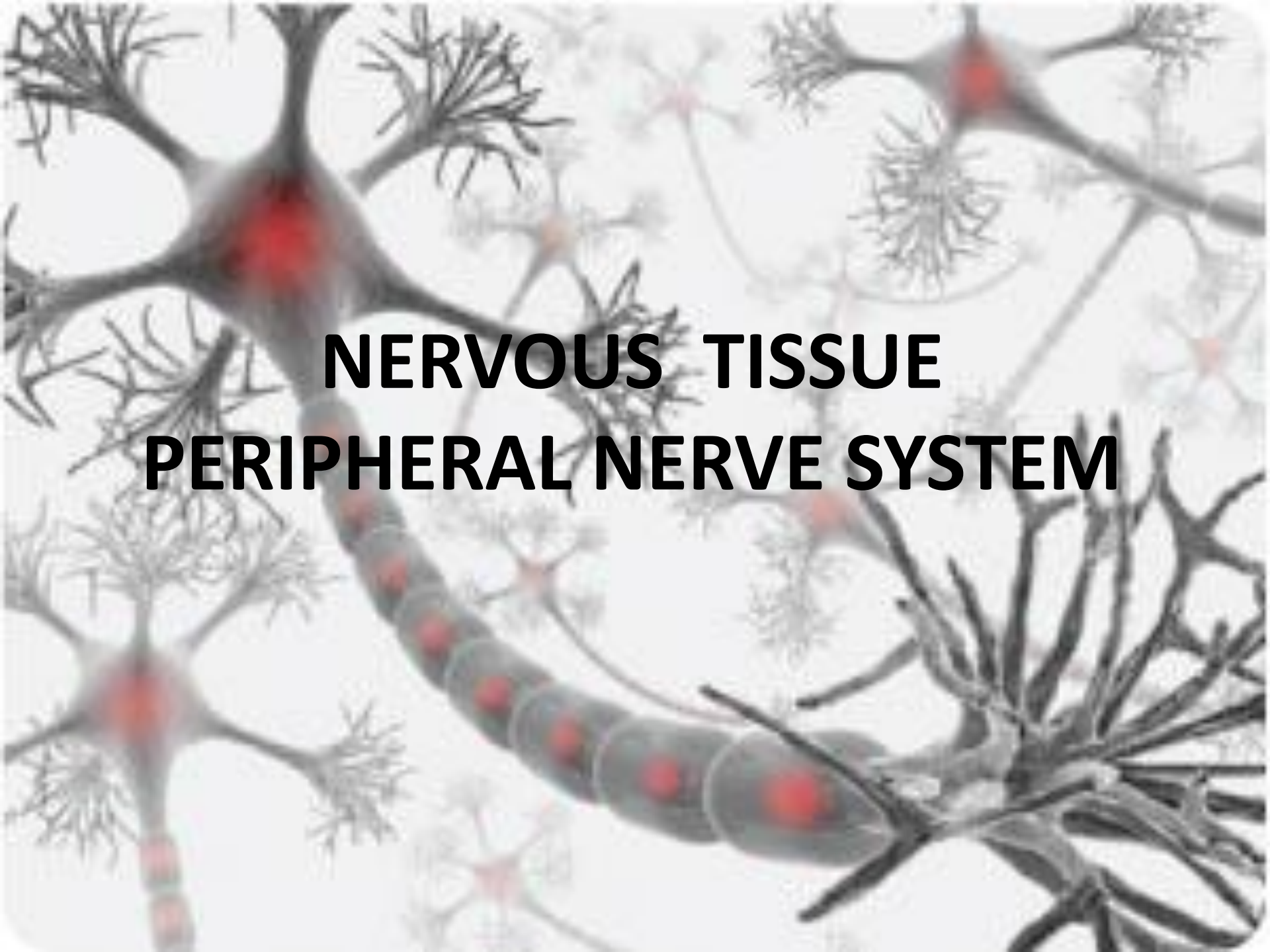
During muscle shortening, the nucleus assumes a characteristic "corkscrew appearance."

Smooth Muscle Contraction



MLCK = Myosin light chain kinase
MLCP = Myosin light chain phosphatase
GTP = Guanosine triphosphate
cGMP = Cyclic guanosine monophosphate

Lucy Liu



NERVOUS TISSUE
PERIPHERAL NERVE SYSTEM

NERVOUS TISSUE

develops from ectoderm

neurons (red)

nerve cells

glial cells (blue)

support and protect neurons

FUNCTIONS:

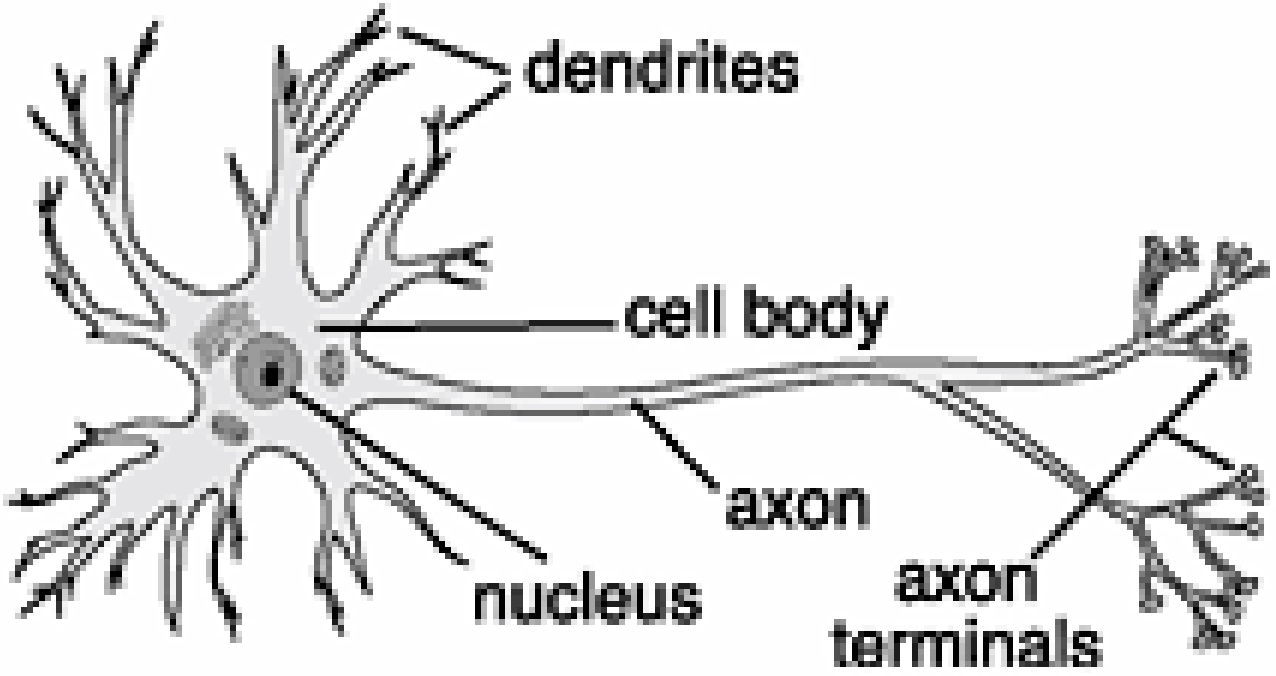
- organization and coordination of organism activity (intellect, consciousness, sub consciousness, motion, visceral and gland activity)

- receiving, conducting, processing and transmission impulses about organism condition and environment.

NEURON

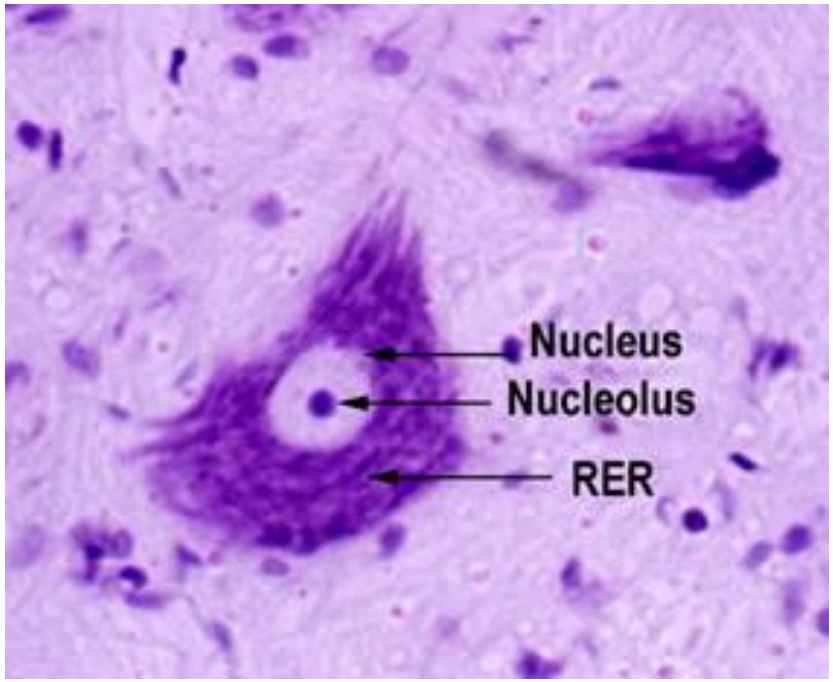
cell body (perikaryon)

processes (axon and dendrites)



PERIKARYON (cell body)

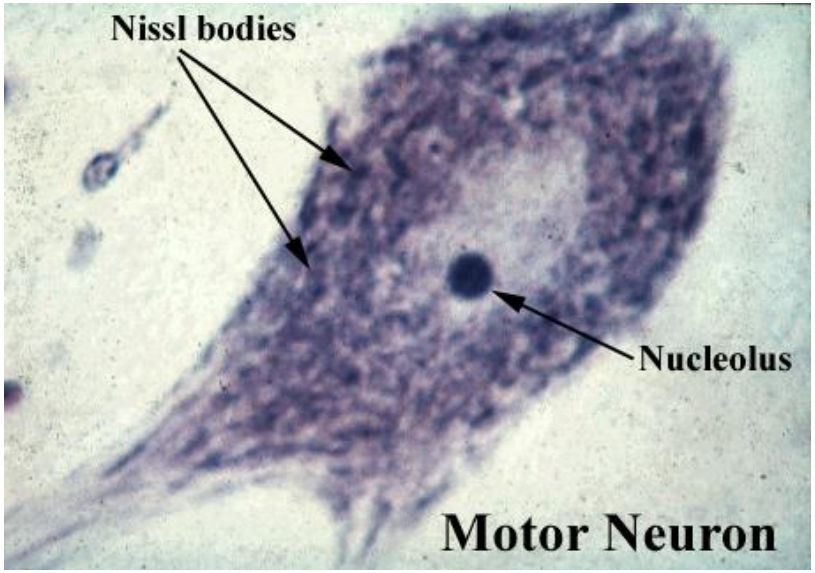
Contains:
- nucleus (1 or 2) with dispersed chromatin
- abundant RER and polyribosomes (Nissl bodies or tigroid)
- neurofilaments (type IV),
- microtubules + MAP-2

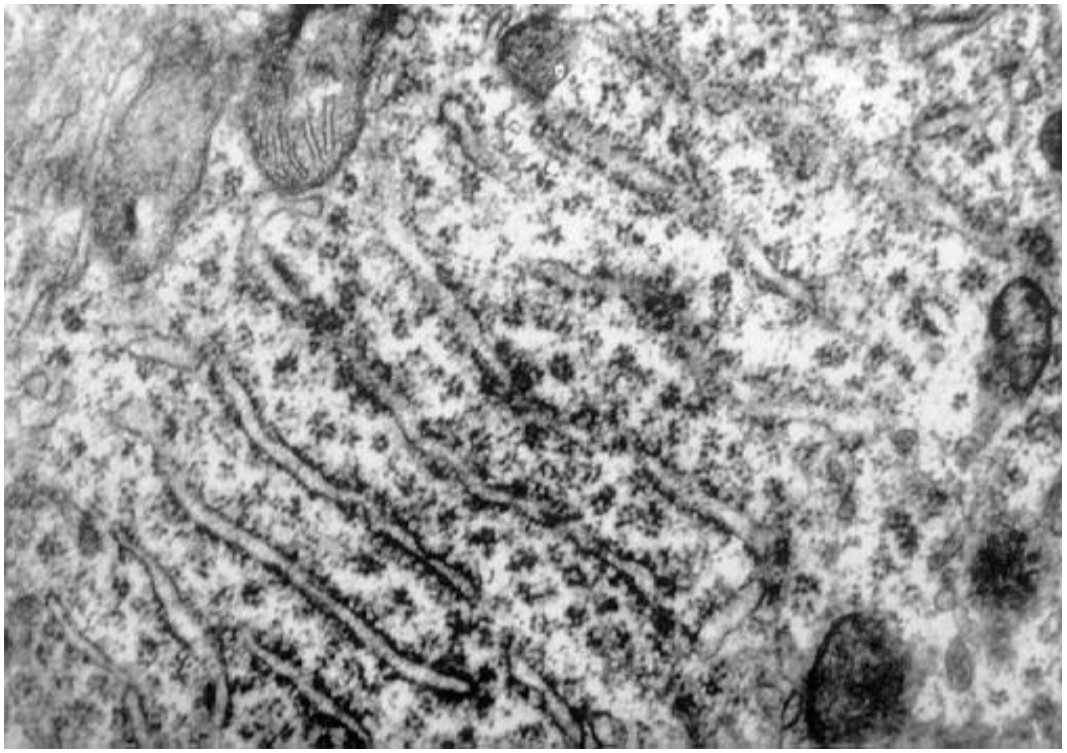


FUNCTIONS:

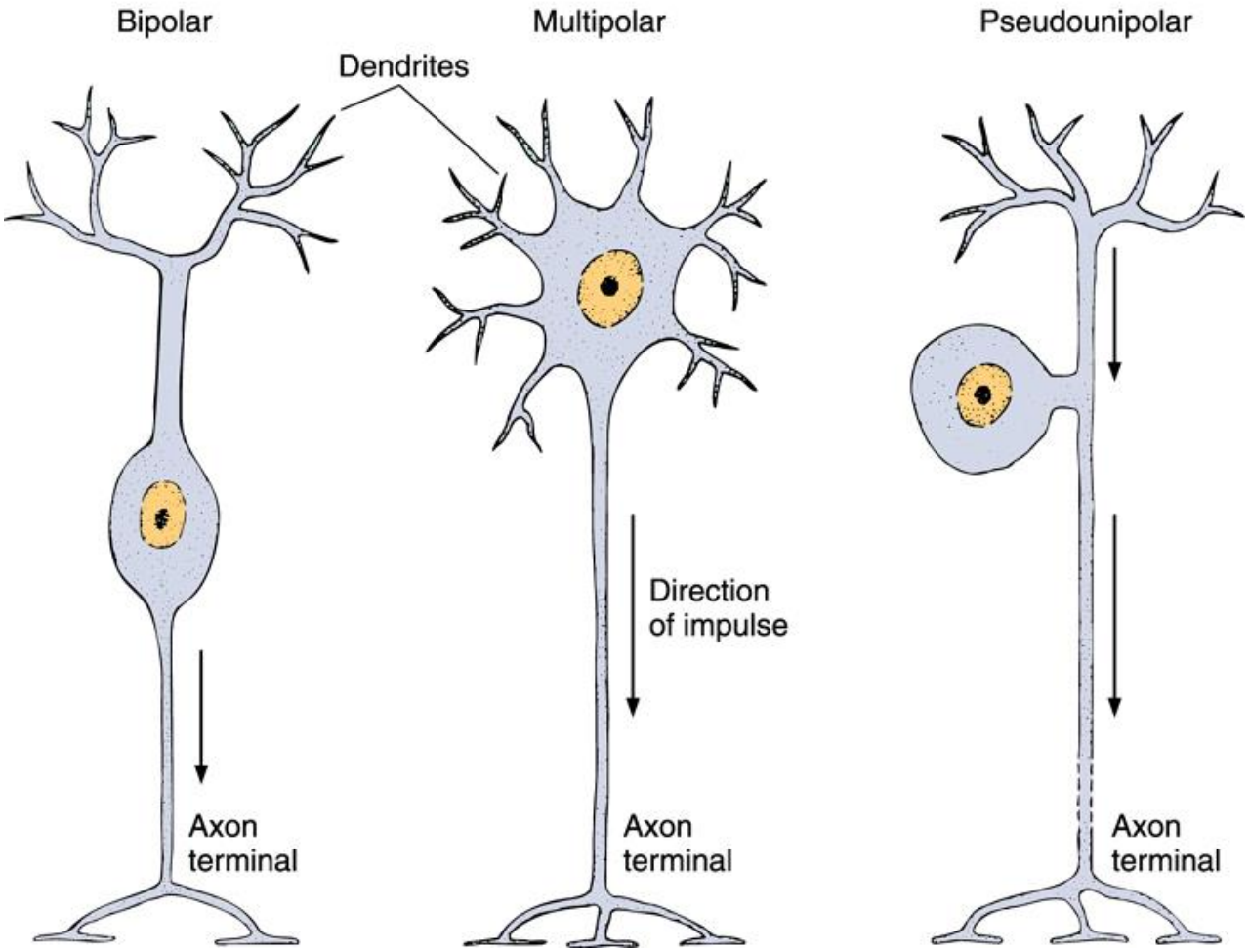
- **synthesis of macromolecules**
- **control of the distribution of proteins throughout the cell**
- **Speed control of the impulse, impulse generation**

NISSL BODIES





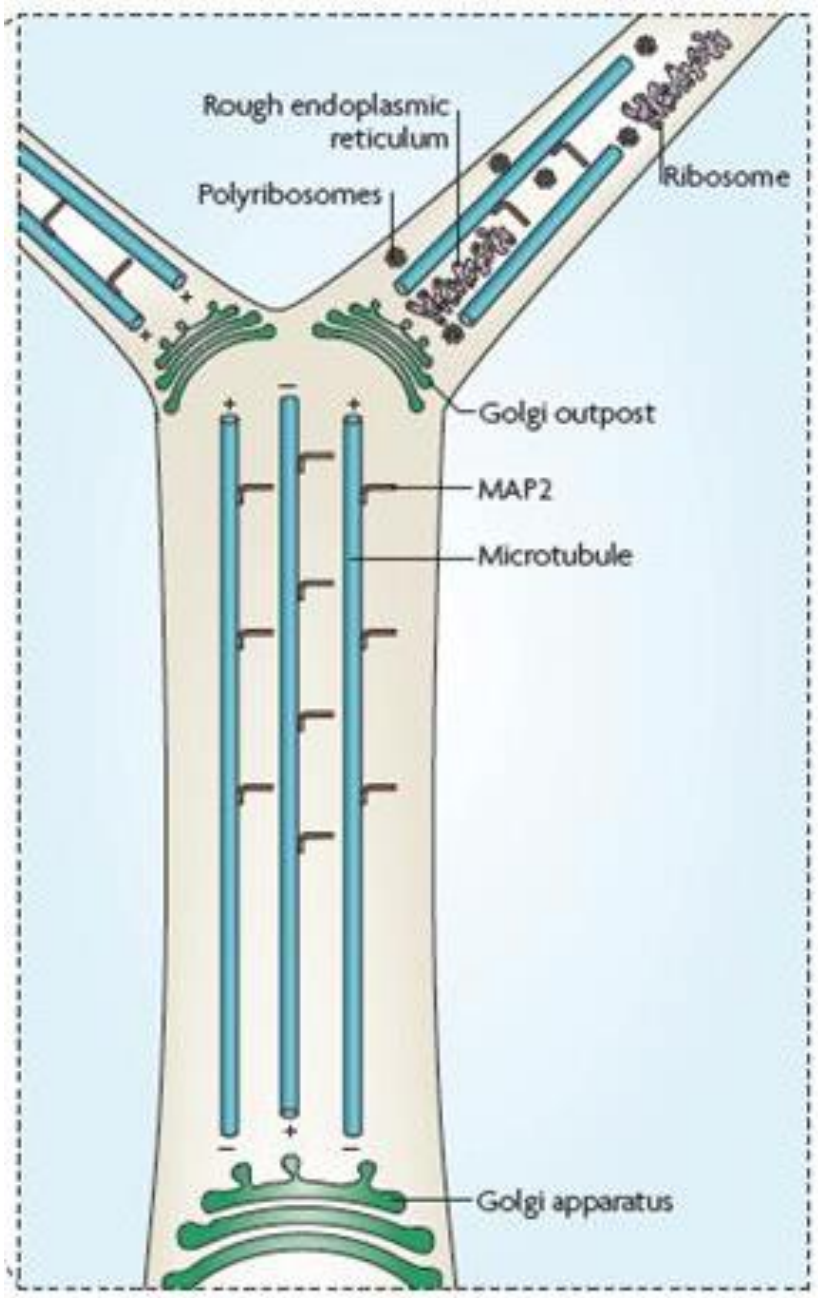
MAIN TYPES OF NEURONS



Dendrites

Contain:
- Microtubules + MAP-2
- small bundles of neurofilaments,
- RER and ribosomes (Nissl bodies) only in region nearest to cell body

Dendrites - functions:
- receiving stimuli
- transmission of nerve impulses
- integration multiple impulses - numerous synapses
- anterograde and retrograde transport of macromolecules

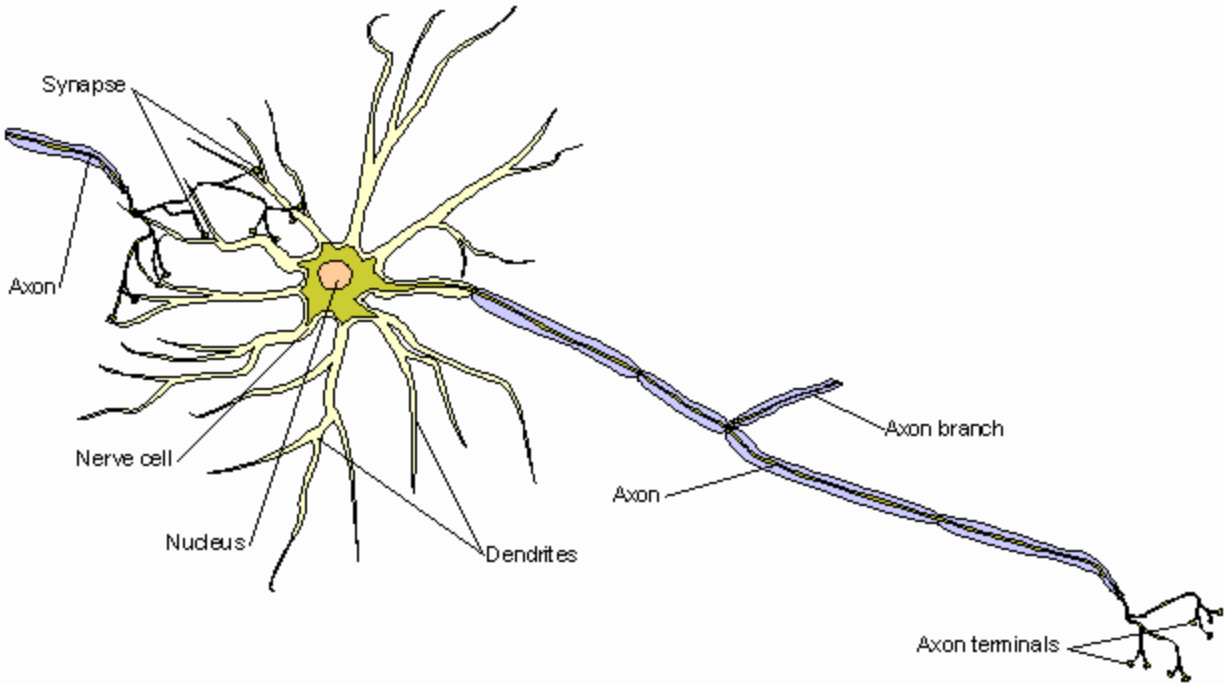


AXON

- length up to 1m, constant diameter, axon hillock without Nissl bodies

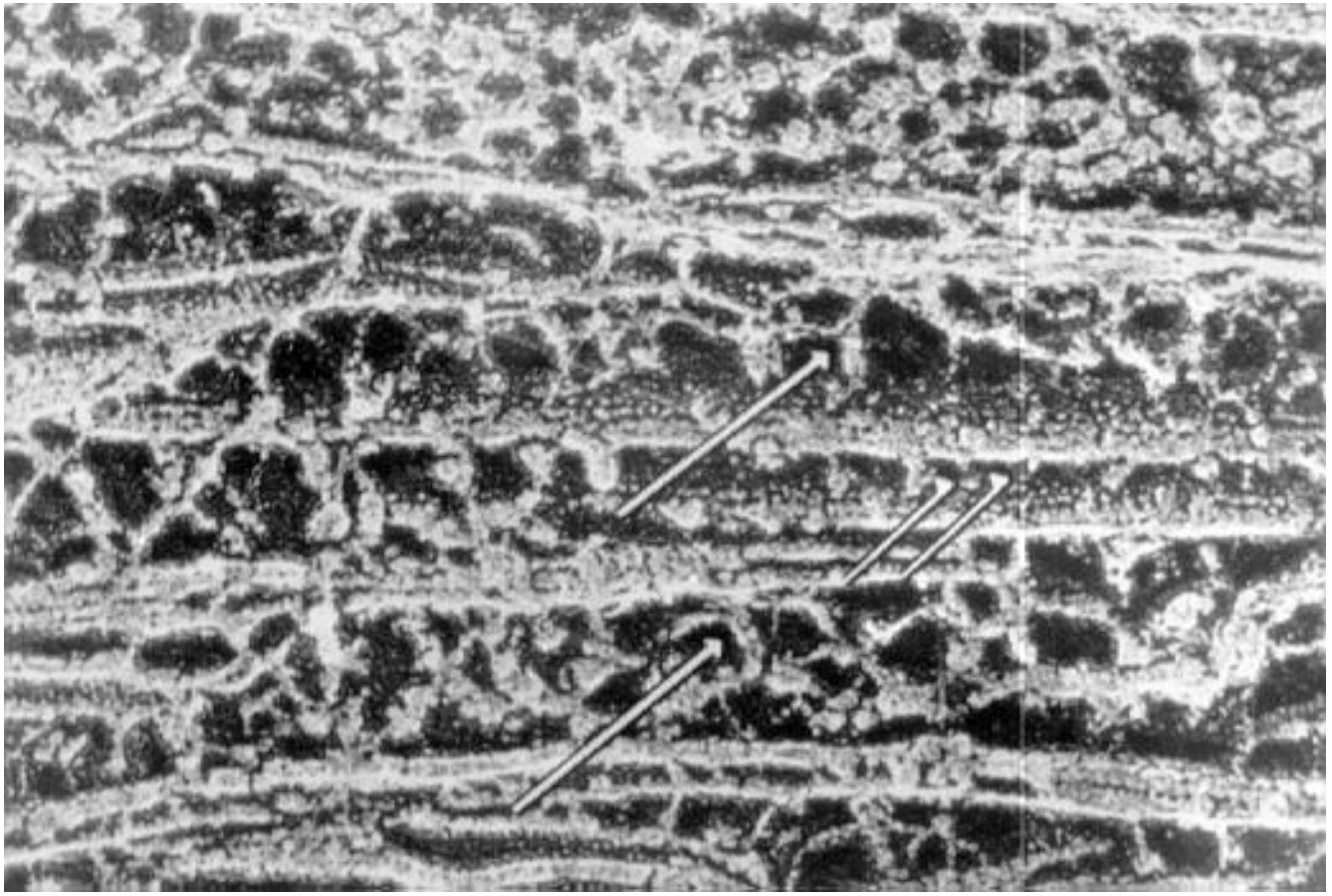
- collateral axons (lateral branches), terminal arbor

- abundant microtubules + *tau* and neurofilaments (regulation of the axon's diameter)



Axoplasm of nerve fiber from rat ischiadic nerve

Tau proteins bind microtubules (arrows)

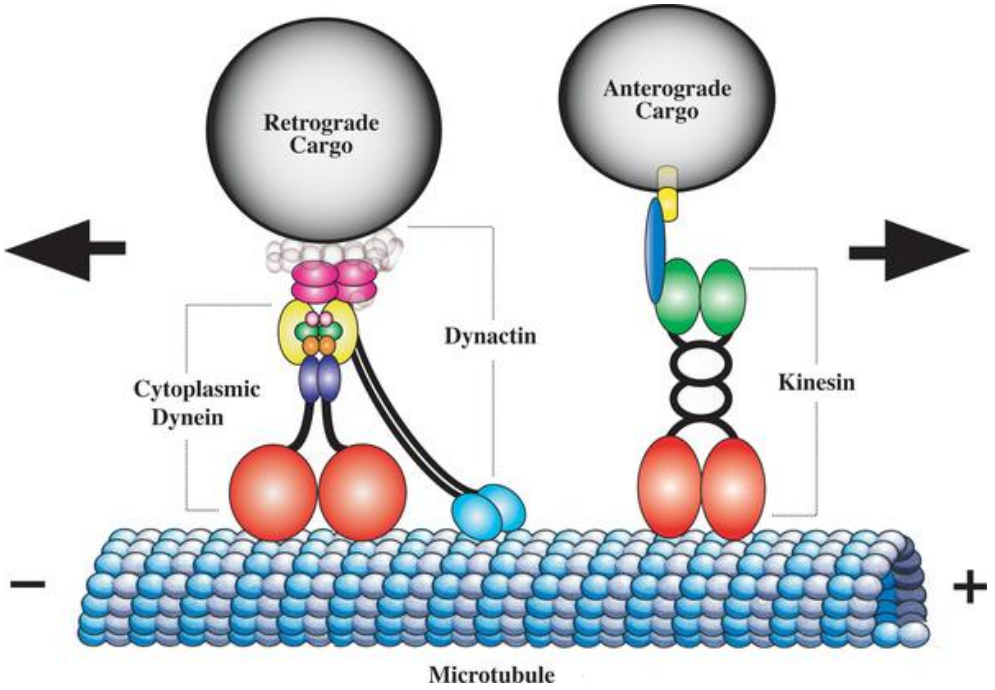


AXON - FUNCTIONS:

- conduction of impulses from cell body toward the synapses and transmission them to other neurons, muscle cells or glands.

- anterograde transport (organelles, vesicles, macromolecules)

- retrograde transport (neurofilament proteins, subunits of microtubules, macromolecules and endocytic material)



GENERATION AND CONDUCTION OF NERVE IMPULSES

Resting potential (-90mV)– arises because of two mechanisms.

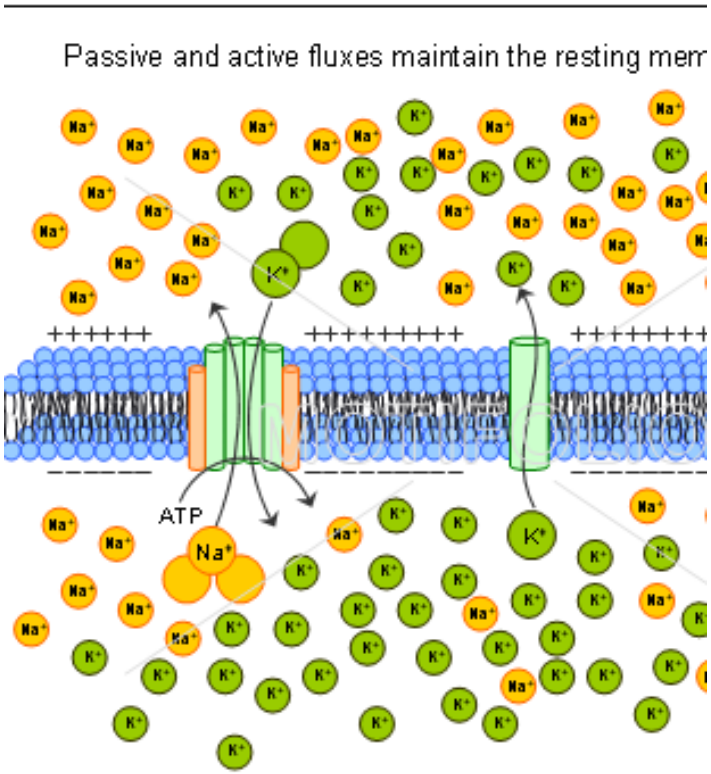
1. Na^+ /K^+ pumps

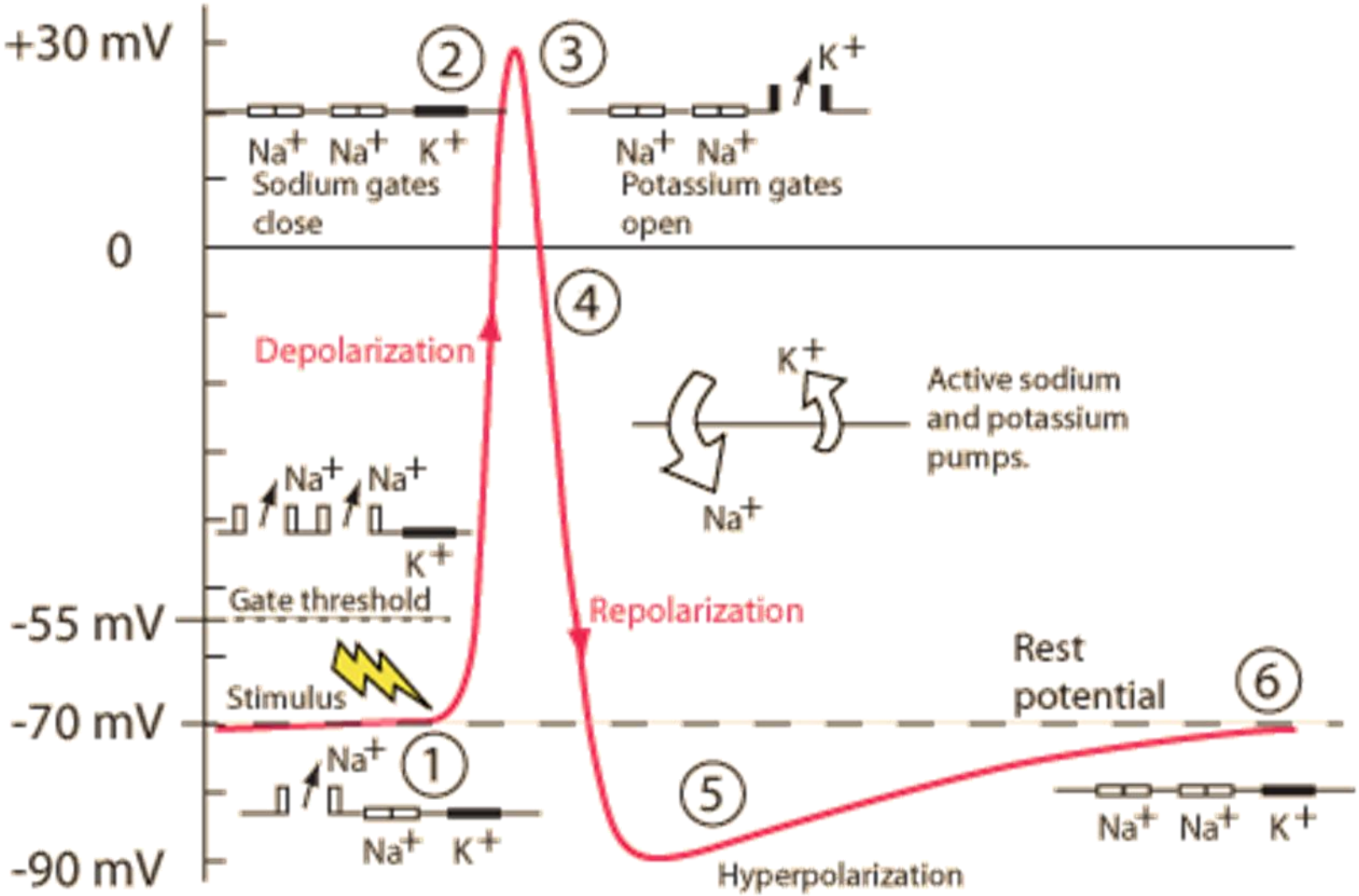
-pump Na^+ out of the cell, and K^+ into the cell in ratio 3 : 2 (for every 3 sodium ions pumped out, 2 potassium ions enter the cell)

2. K^+ leak channels

-permit free flow of K^+ out of the cell (Na^+ can enter to the cell but in ratio K^+: Na^+ 100:1).

The concentration of K^+ ions is higher inside the cell, whereas Na^+ ions outside the cell.



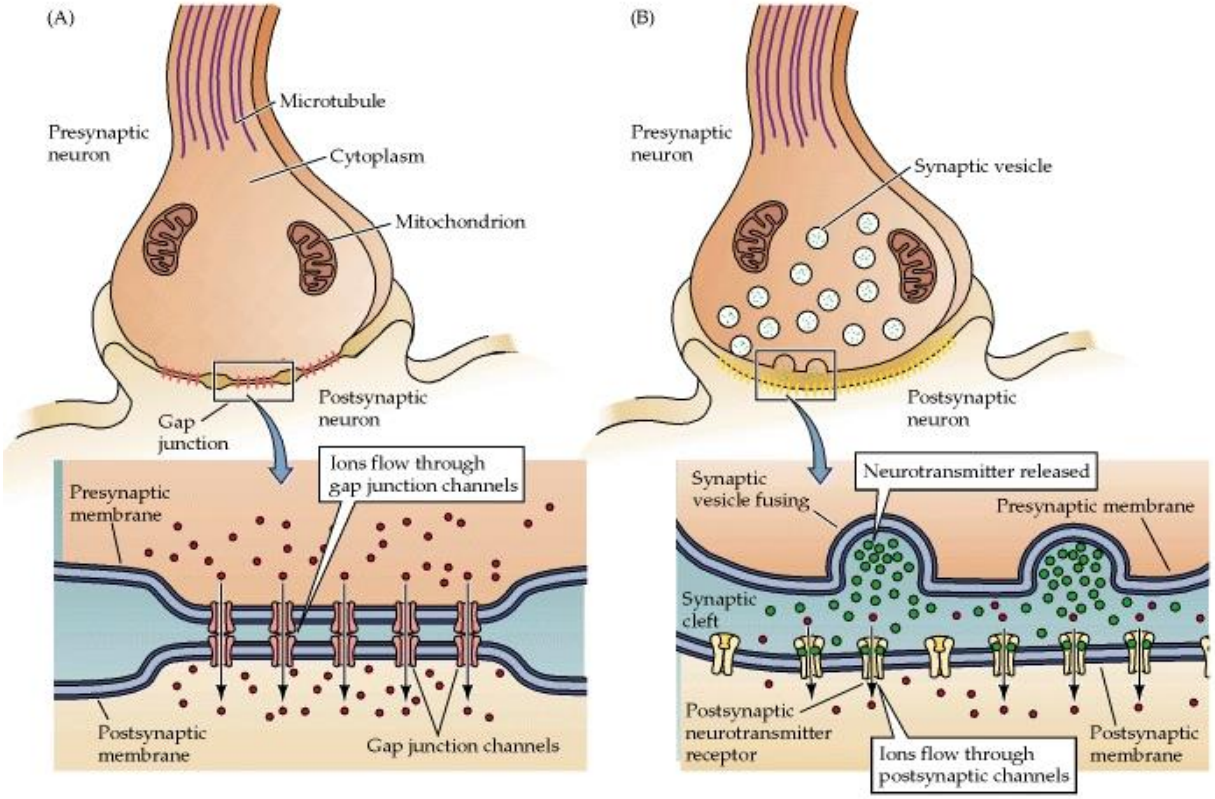

+30 mV
0
-55 mV
-70 mV
-90 mV
2
3
Na+ Na+ K+
Sodium gates close
Na+ Na+
K+
Potassium gates open
4
Depolarization
K+
Active sodium and potassium pumps.
Na+
Na+ Na+
K+
Gate threshold
Repolarization
Stimulus
Rest potential
6
1
Na+
Na+ K+
5
Hyperpolarization
Na+ Na+ K+

SYNAPSE

the site of impulse transmission
from the neuron to another neuron, muscle cell or cell of gland.

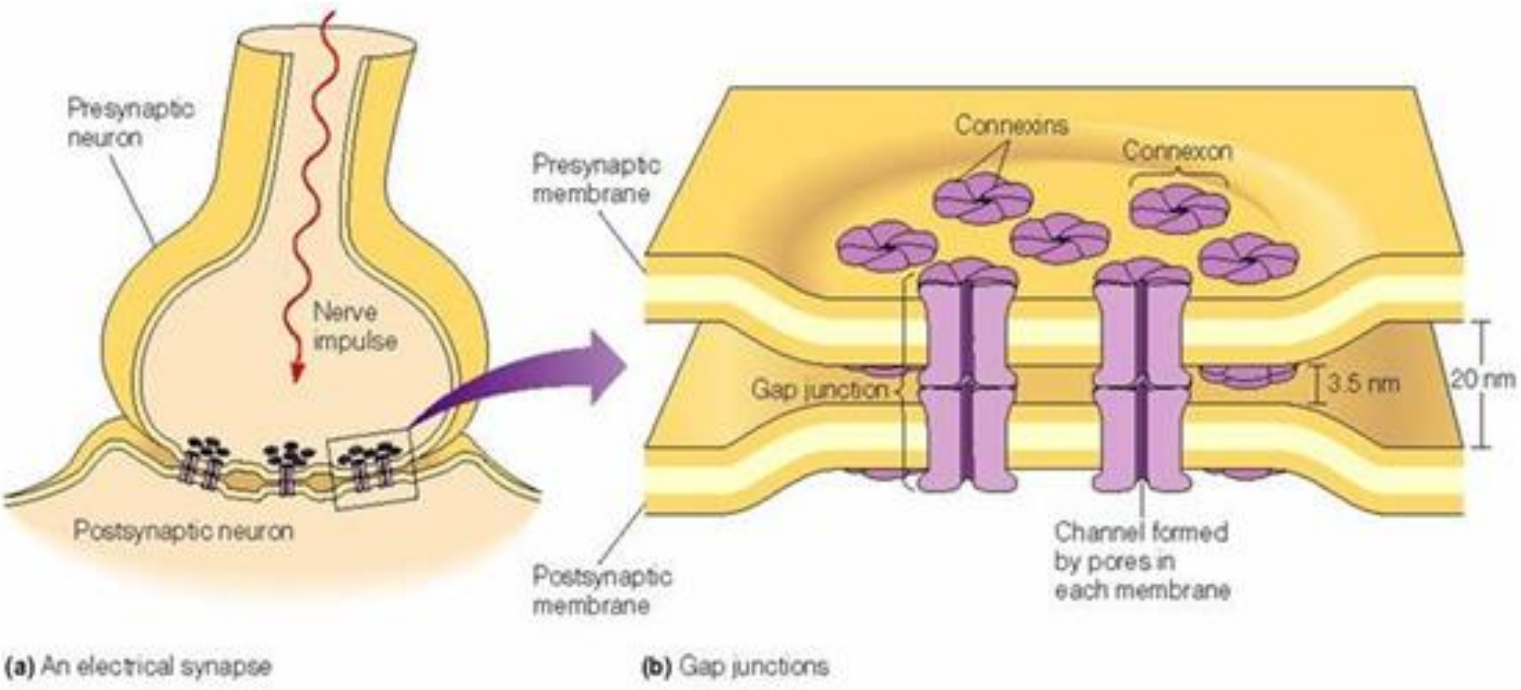
ELECTRICAL SYNAPSES
- present in brain stem, retina and cerebral cortex.
- contain gap junctions

CHEMICAL SYNAPSES are the most common manner of communication between nerve cells.



ELECTRICAL SYNAPSE

- nexus (gap junction)
-Cell-cell adhesion
-Formed from connexins

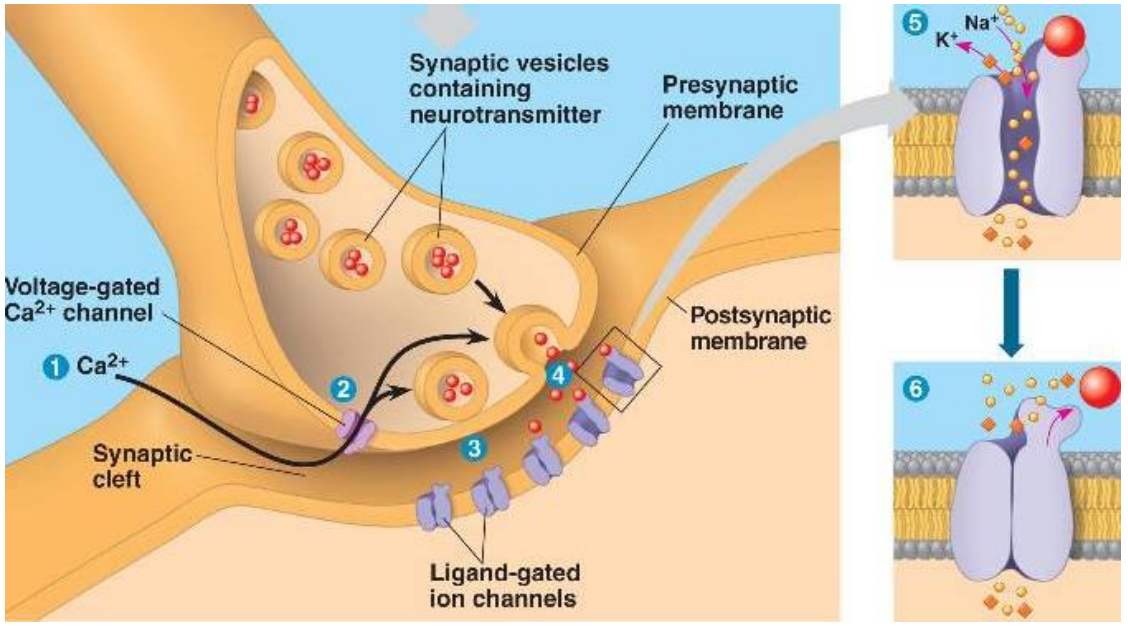


CHEMICAL SYNAPSE

-**Presynaptic membrane (transmitting cell) with synaptic vesicles with neurotransmitters**

-**Synaptic cleft**

-**Postsynaptic membrane (receiving cell) with gated ion-channel receptors for neurotransmitters. Binding of neurotransmitters causes opening of ion channels, which permits the passage of ions, altering the membrane permeability and reverse its membrane potential.**

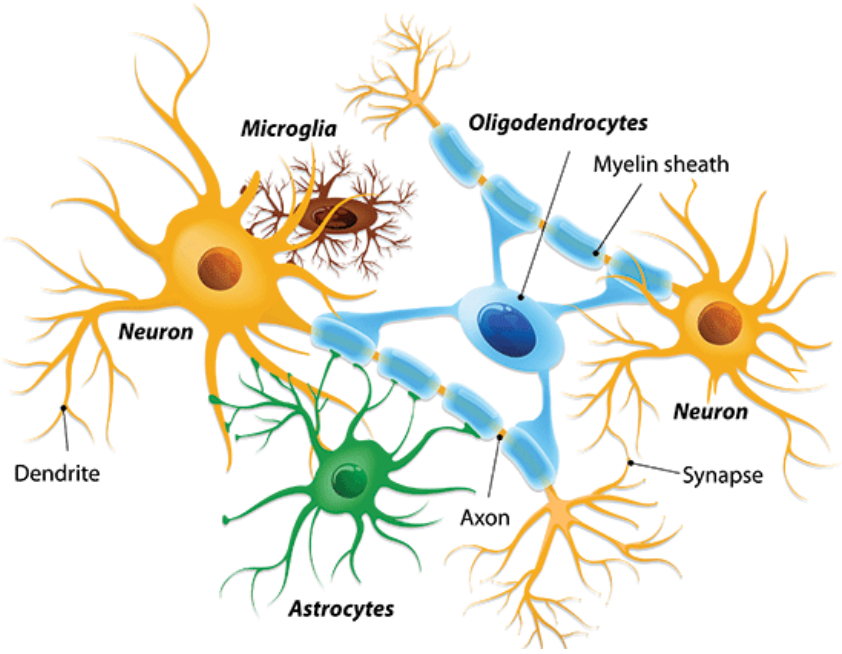


NEUROGLIAL CELLS

- physical support for neurons
- supply nutrients and oxygen to neurons
- destroy pathogens and remove dead neurons
- Neuroglial cells undergo mitosis

Types of glial cells

- Ependymal cells
- Astrocytes
- Oligodendrocytes
- Microglial cells
- Schwann cells (located in PNS)

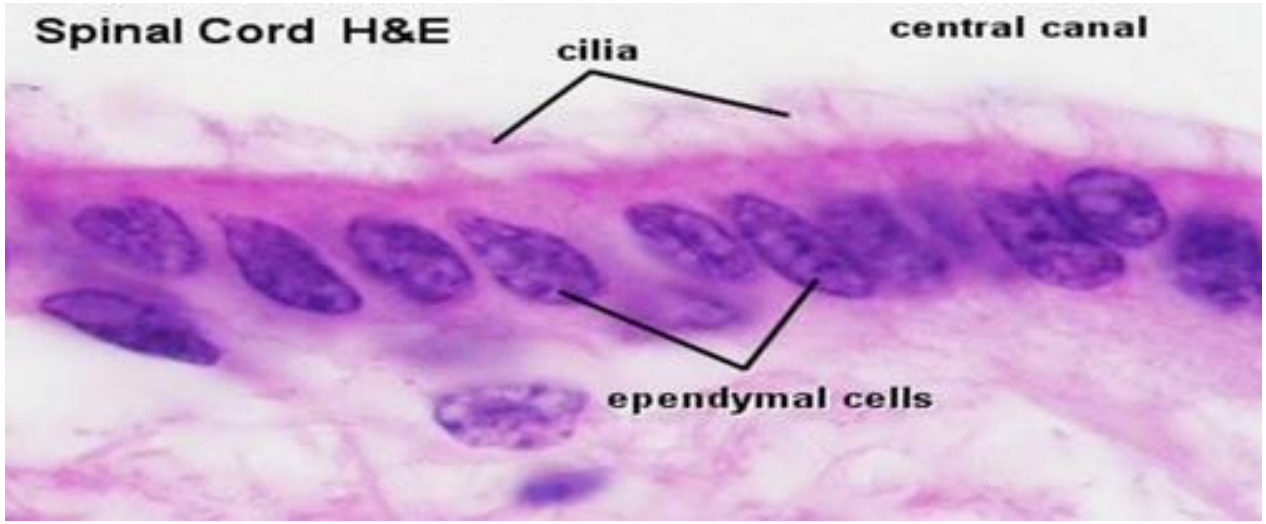


EPENDYMOCYTES

– cuboidal epithelial cells lining ventricles of the brain and central canal of the spinal cord forming ependyma.

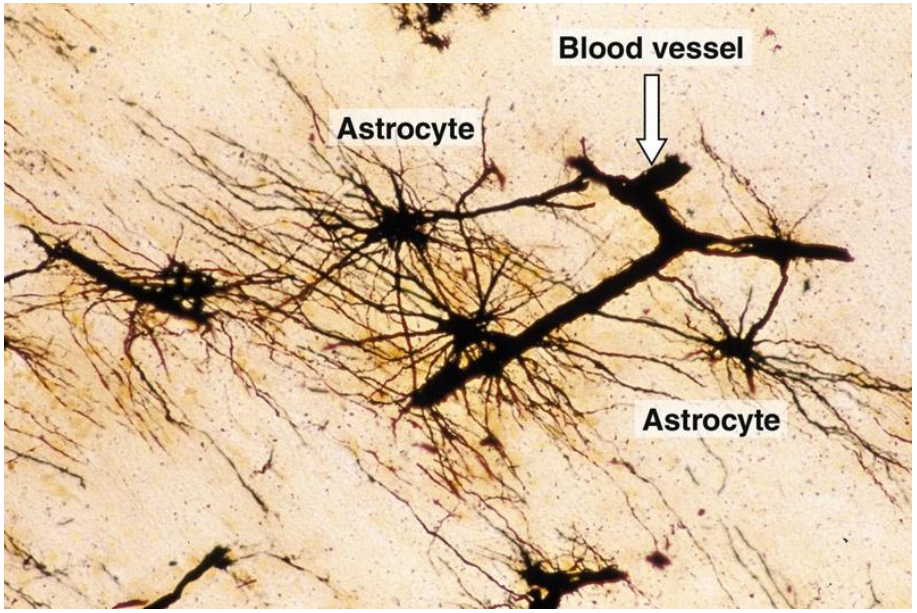
- **contain cilia or microvilli.**
- **create and secrete cerebrospinal fluid (CSF)**
- **contain stem cells ???**

TANYCYTES – III brain chamber



ASTROCYTES

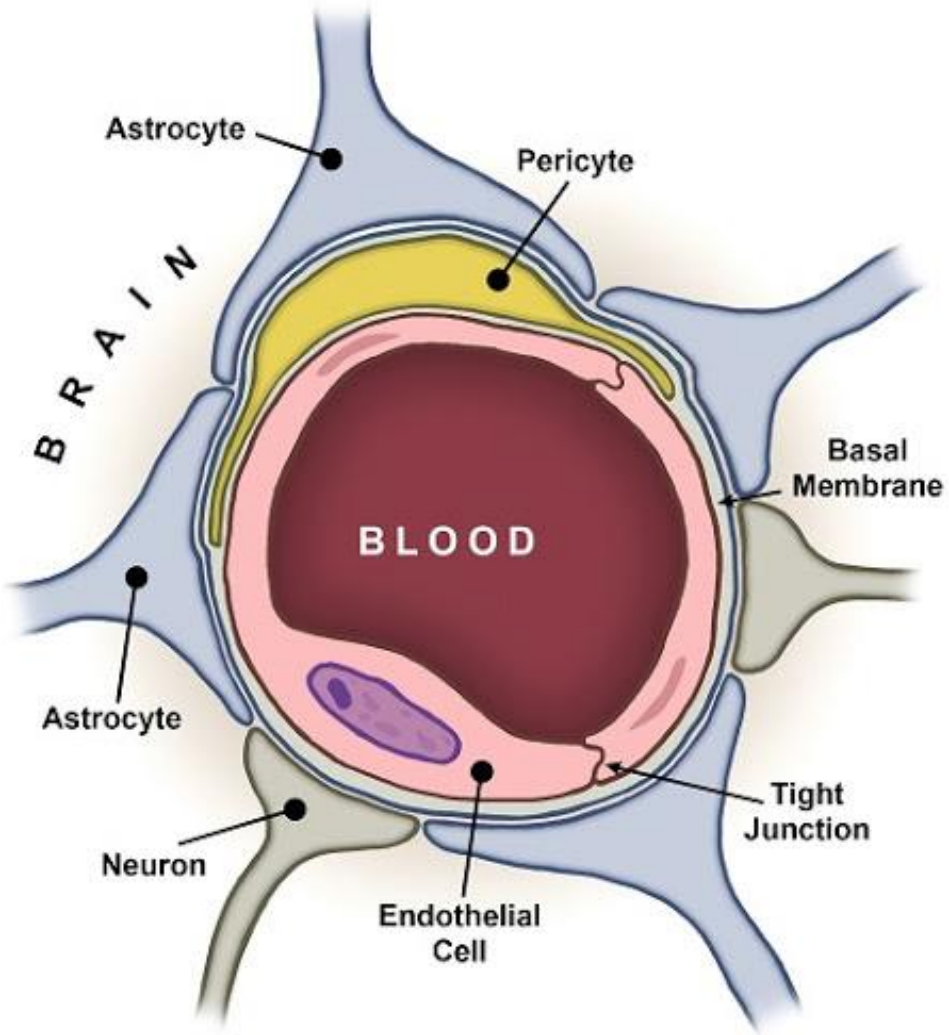
- The largest of the neuroglial cells
- Protoplasmic astrocytes (grey matter of CNS)
- Fibrous astrocytes (white matter of CNS)



Function of astrocytes

- separation of blood vessels from direct contact with nerve tissue (blood-brain barrier)
- transport nutrients to neurons by transcytosis (*Transcytosis* is the process by which various macromolecules are transported across the interior of a cell)
- maintenance of extracellular ion balance (express potassium channels)
- production, storage and secretion neurotransmitters and enzymes inactivating them
- regulate the transmission of electrical impulses within the brain.

Blood-brain barrier

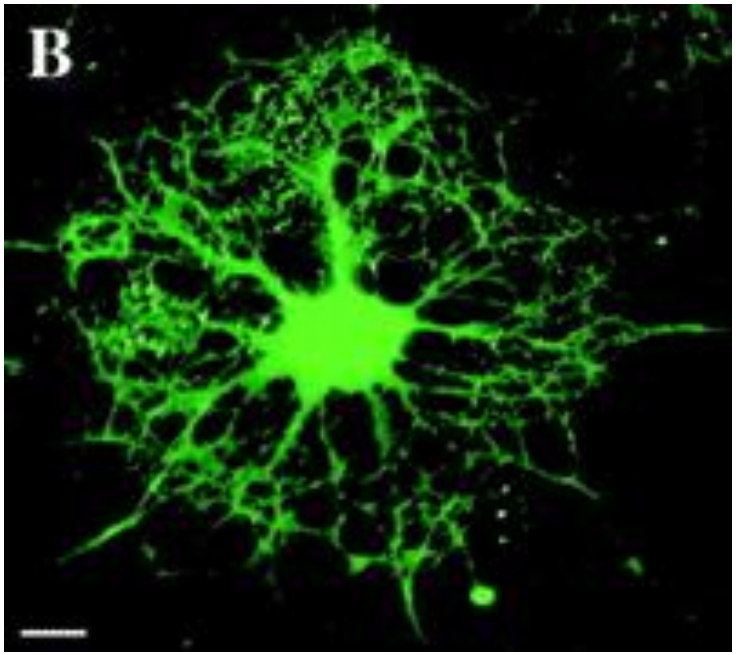


OLIGODENDROCYTES

- located in white and gray matter of CNS

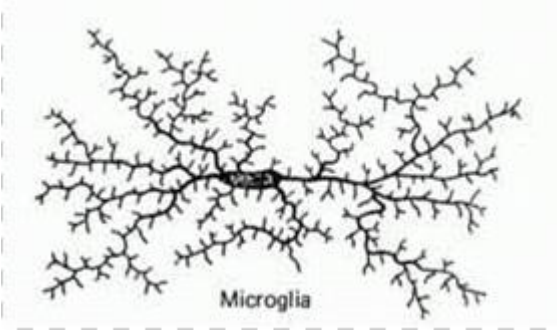
- posses a few processes with sparse branching.

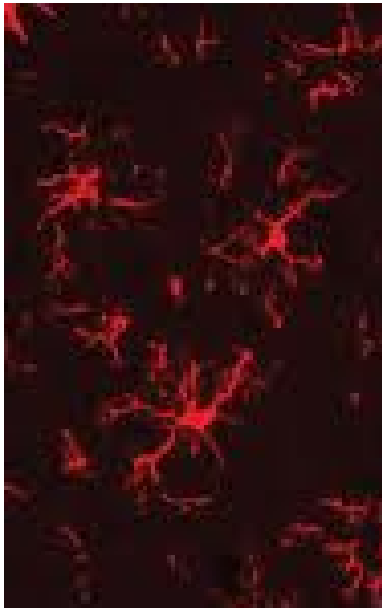
- Interfascicular oligodendrocytes produce the myelin sheath around the axons in CNS.
- Satellite oligodendrocytes are located close to cell bodies of large neurons; their function is not clear.

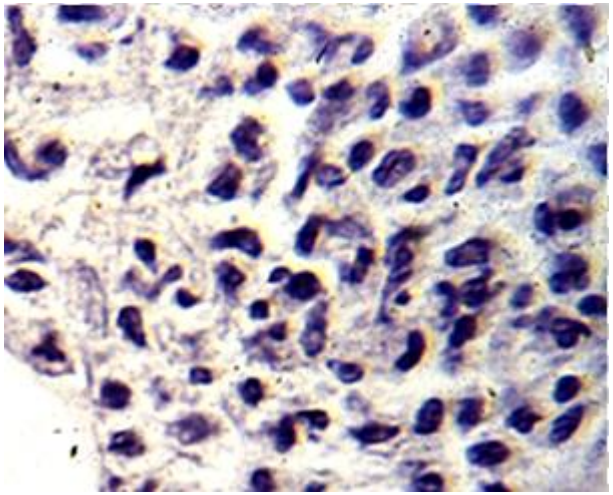


MICROGLIAL CELLS

- belong to mononuclear phagocyte system and derived from mesoderm
- exhibit irregular short processes, and spines on the cell body and processes
- function as phagocytes in clearing debris in CNS and in protecting nerve cells from pathogens and tumor formation



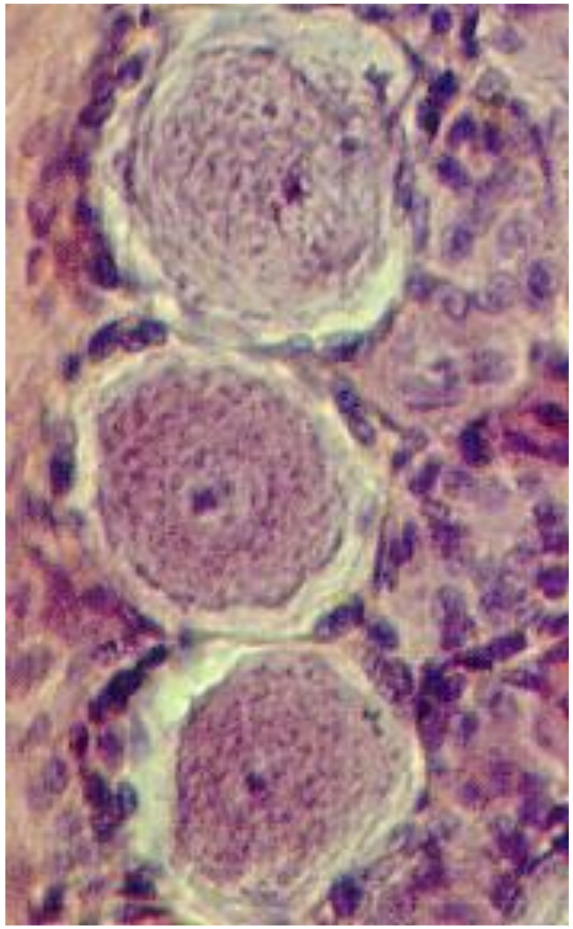




GLIAL CELLS OF PERIPHERAL NERVOUS SYSTEM (PNS)

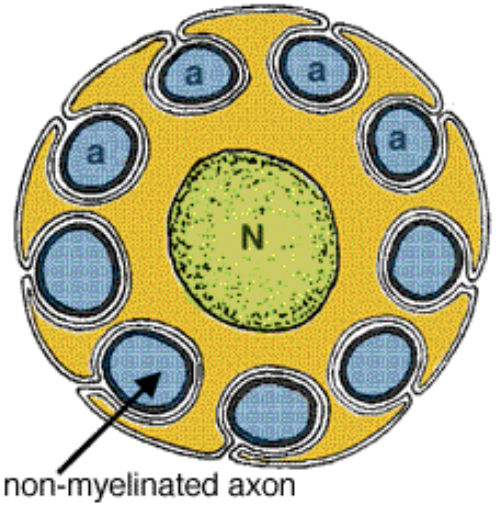
SATELLITE CELLS – envelop the cell bodies of unipolar neurons of sensory ganglia

LEMMOCYTES –Schwann cells – form both myelinated and unmyelinated coverings over axons in PNS

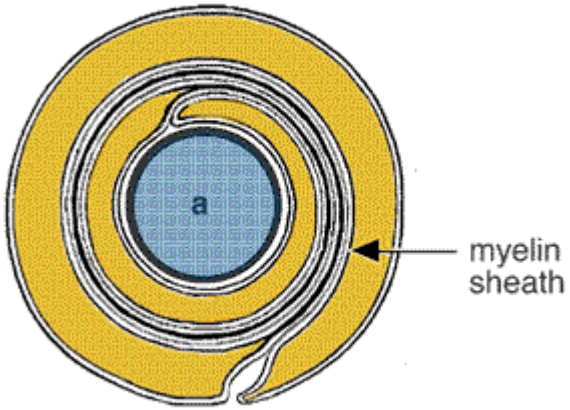


Axon sheath

1. Unmyelated axons



3. Myelated axons

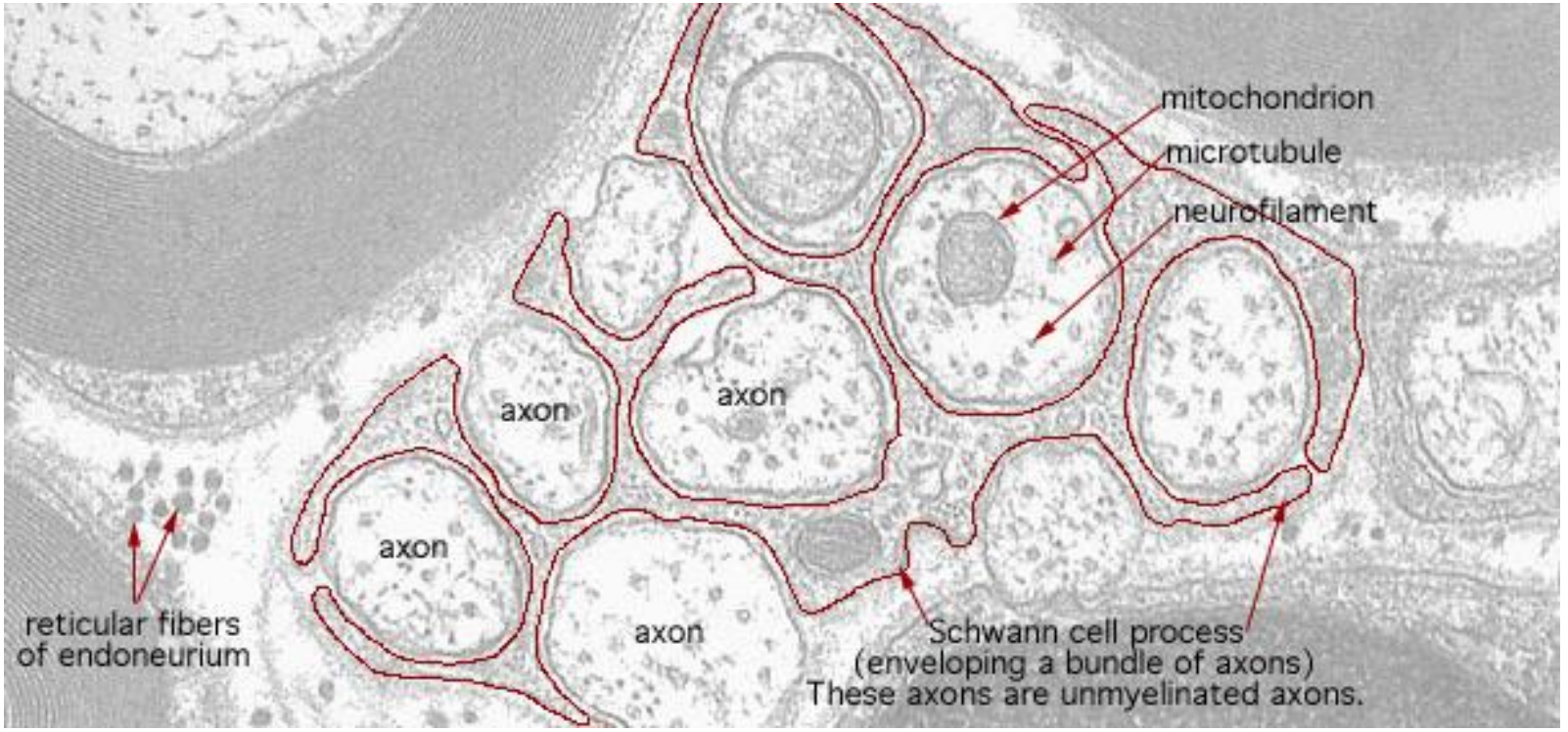


NEUROLEMMA

Unmyelinated axons – surrounded by a single layer of Schwann cell plasma membrane and cytoplasm of the Schwann cell

- several unmyelinated axons may be enveloped by a single Schwann cell

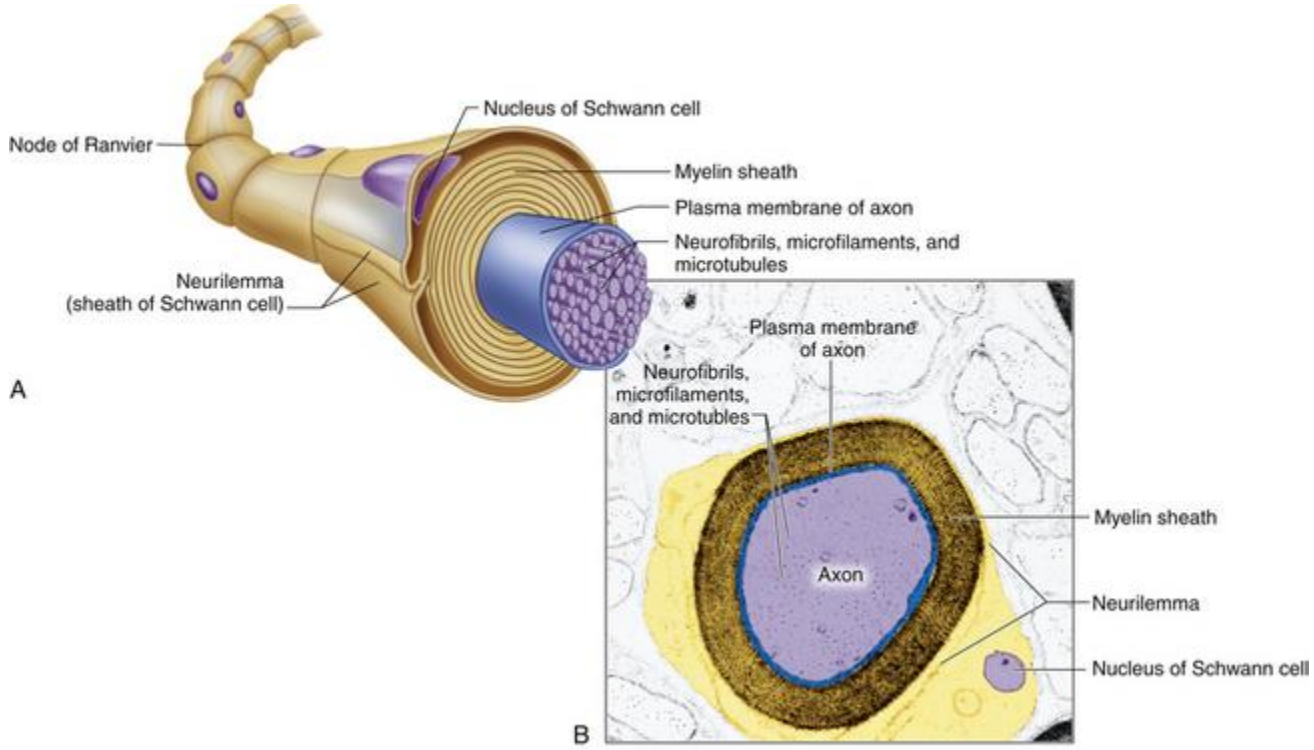
- the outermost cytoplasmic layer of Schwann cells that surrounds the axon of the neuron forms neurolemma



FORMATION OF MYELIN SHEATH IN PNS

- **whole Schwann cell wraps its membrane around the axon and forms one internodal segment**

- **the cytoplasm is squeezed into the body of Schwann cell**



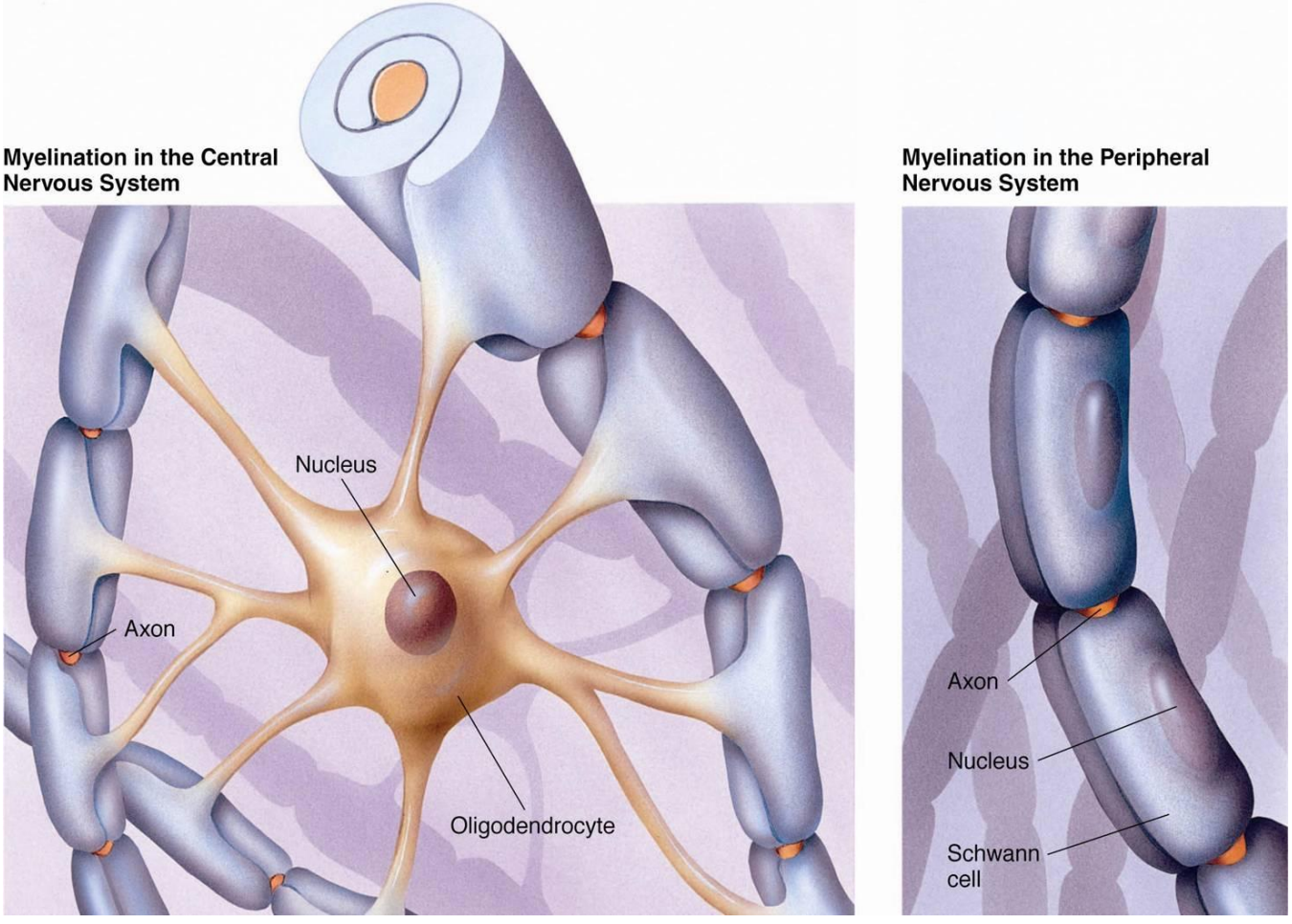
MYELINATION IN

CNS

one oligodendrocyte- some internodal segments – some axons

PNS

one Schwann cell – one internodal segment - one axon

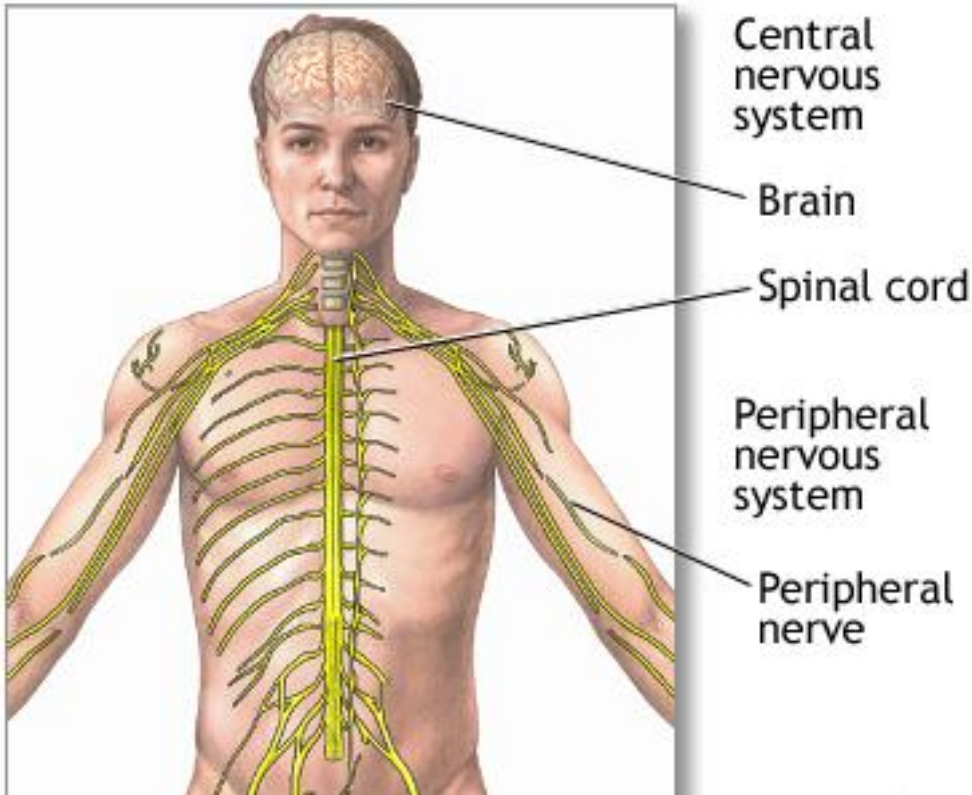


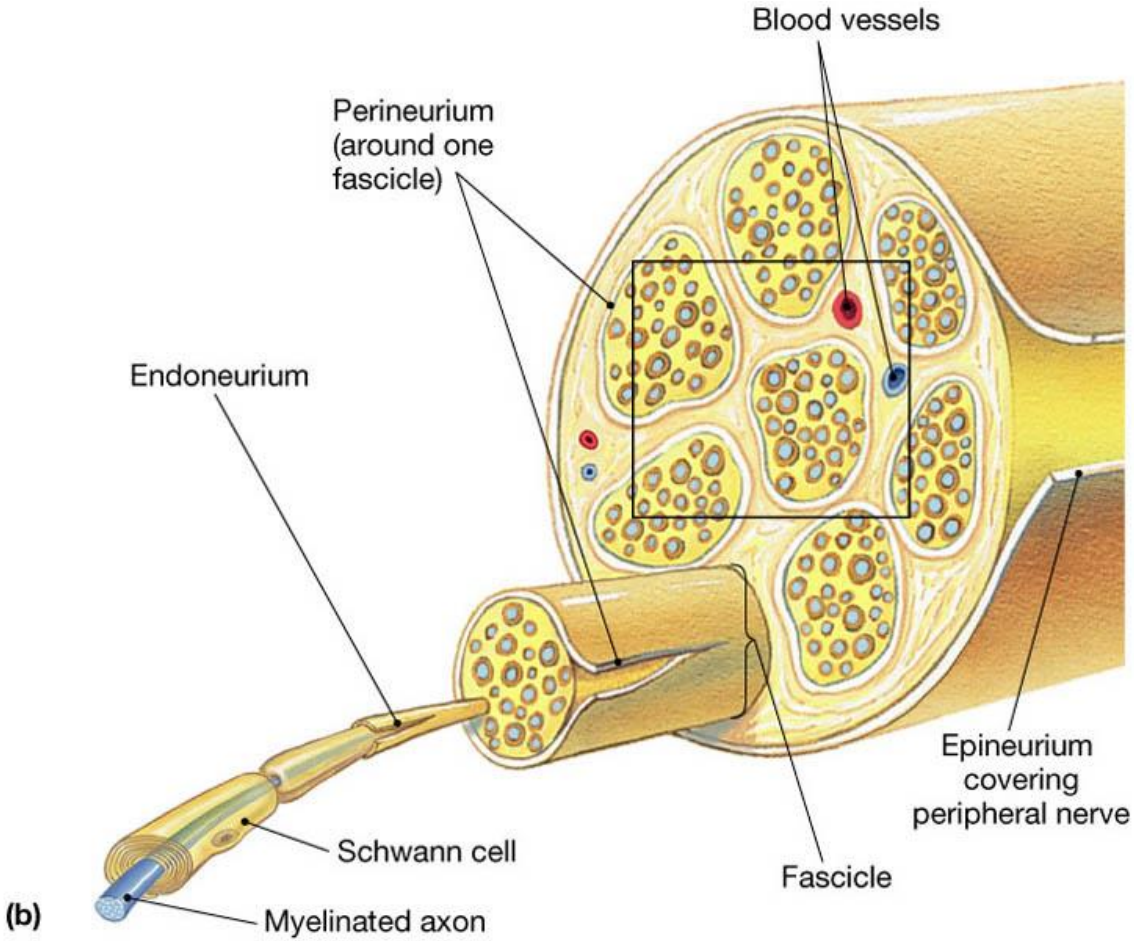
Nervous system - consists of two main parts

- the central nervous system (CNS)
- the peripheral nervous system (PNS)

The CNS contains the brain and spinal cord.

The PNS consists mainly of nerves which connect the CNS to every other part of the body.





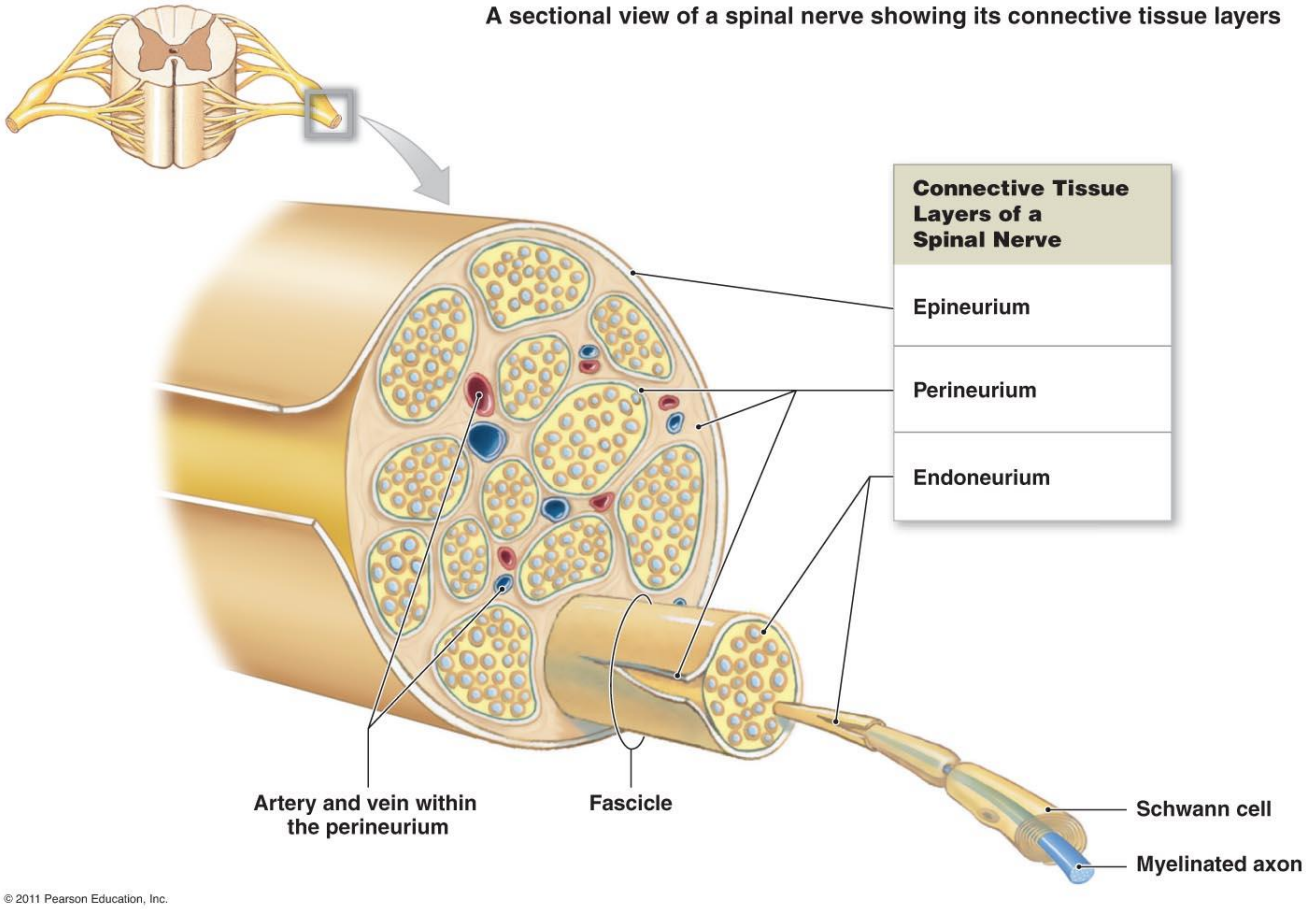
Peripheral nerve – collection of bundles of nerve fibers (axon with its sheats) with connective tissue investments.

PERIPHERAL NERVE – CONNECTIVE TISSUE INVESTMENTS

EPINEURIUM
Outermost layer, covers the nerve, dense, irregular connective tissue

PERINEURIUM
Middle layer, covers each bundle of nerve fibers, dense connective tissue (thinner than epineurium)

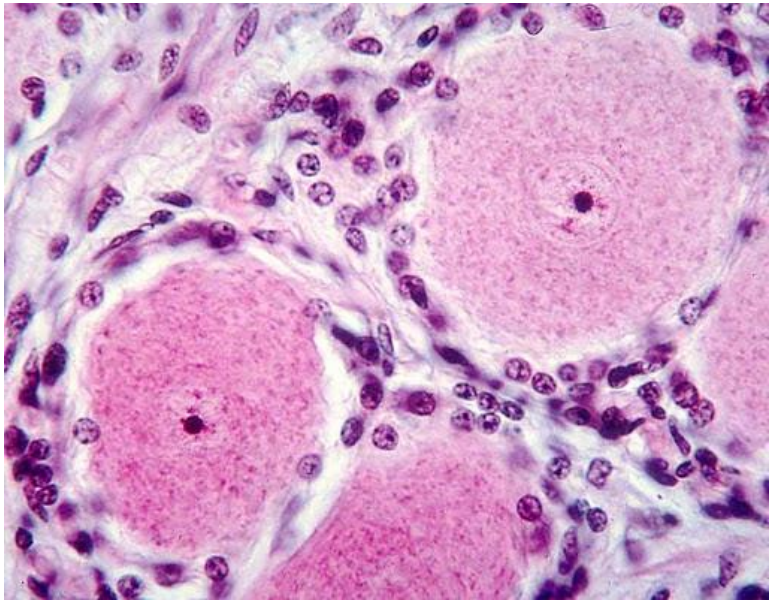
ENDONEURIUM
Innermost layer, surrounds the individual nerve fibers (axons), loose connective tissue

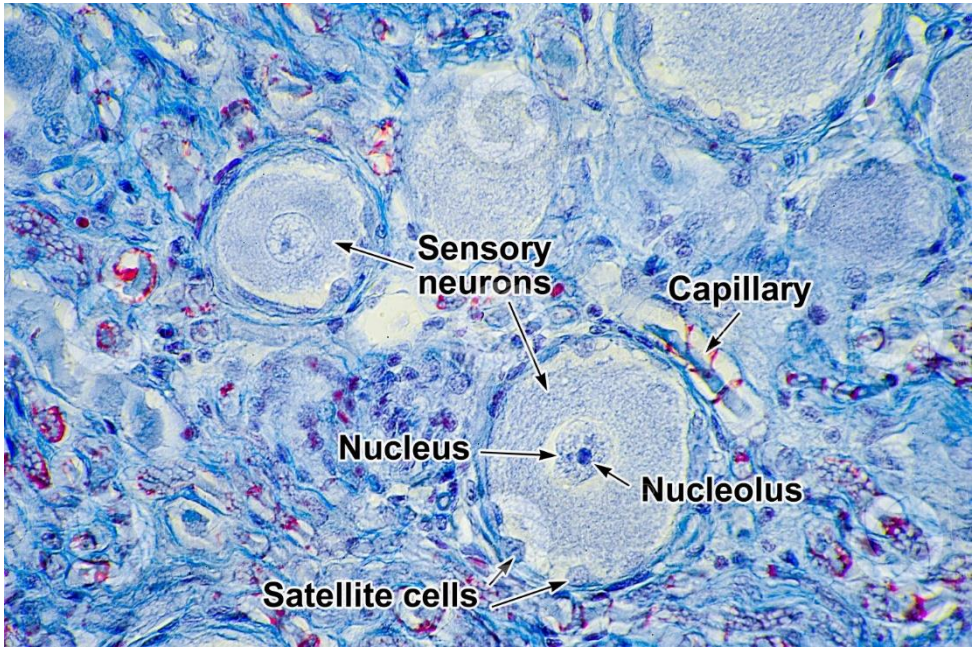


Ganglion

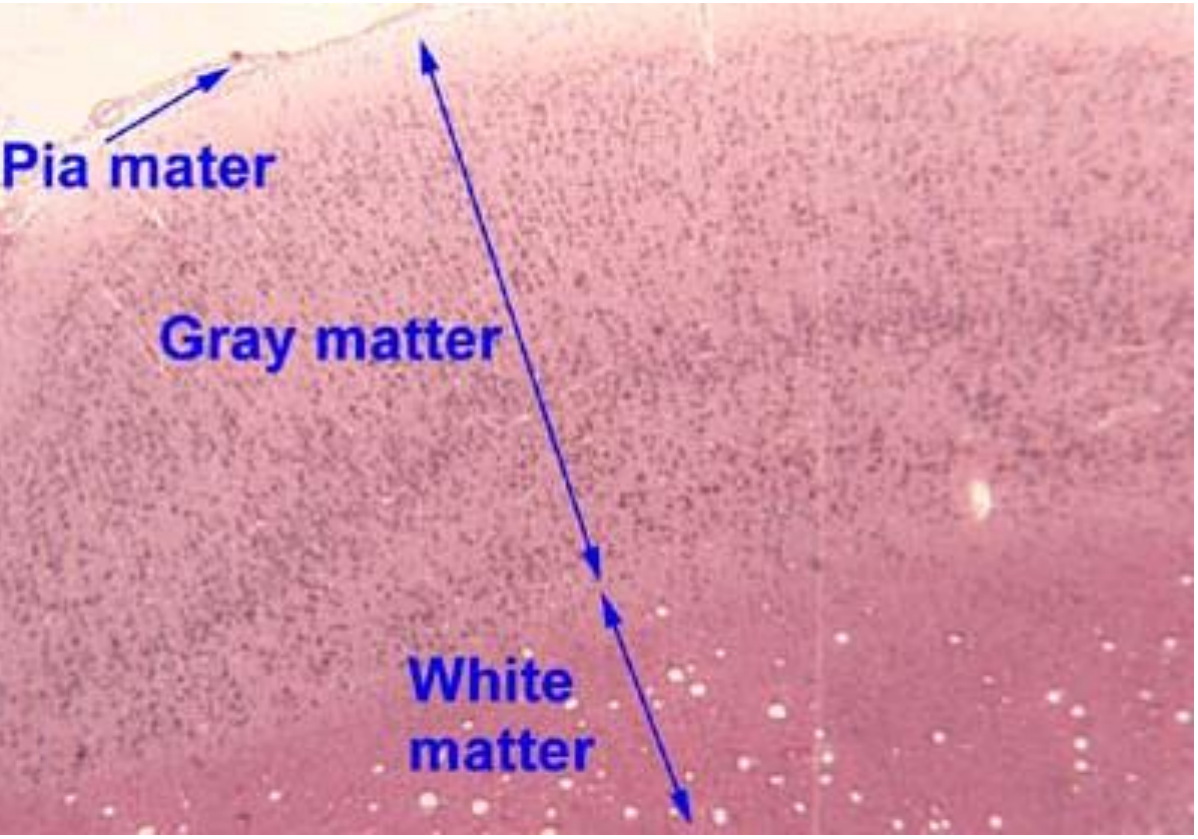
CAPSULE – dense connective tissue

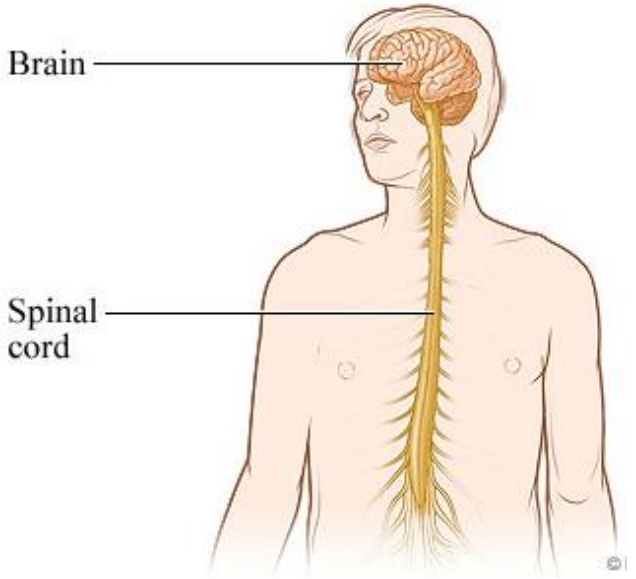
STROMA – loose connective tissue proper with fibroblasts, fibers, macrophages, blood vessels





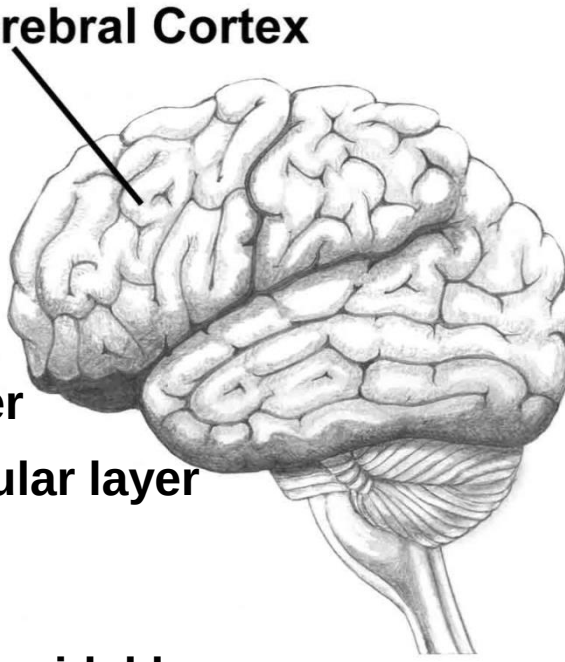
The central nervous system contains white and gray matter

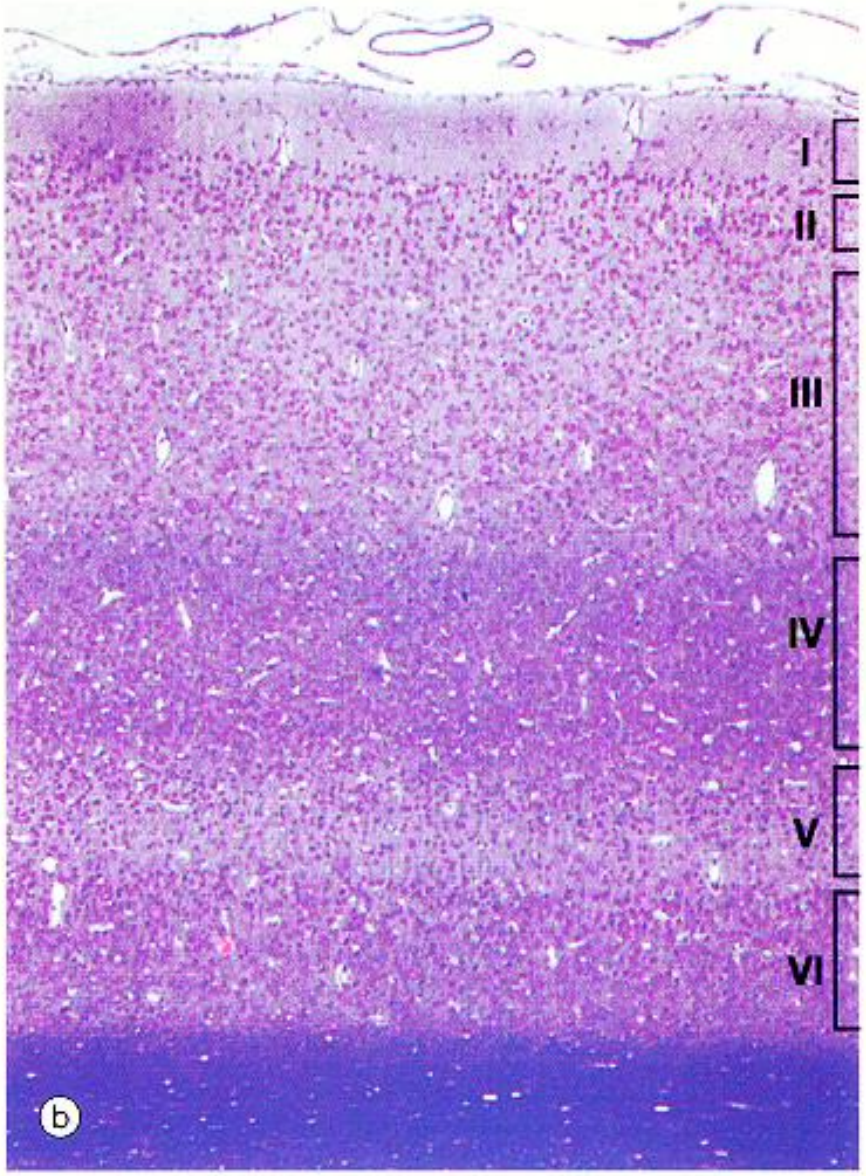




White matter – composed mostly of myelinated nerve fibers, some unmyelinated fibers and neuroglial cells (myelin = white color)
Gray matter – contains cell bodies, dendrites, unmyelinated axons and neuroglial cells (absence of myelin = gray color)

Cerebral cortex





I. The molecular layer

II. The external granular layer

III. The external pyramidal layer

IV. The internal granular layer

V. The internal pyramidal layer

VI. The multiform layer

Three layers of the cerebellar cortex:

Outer molecular layer

- a few cell bodies (Stellate cells)
- dendrites of Purkinje cells

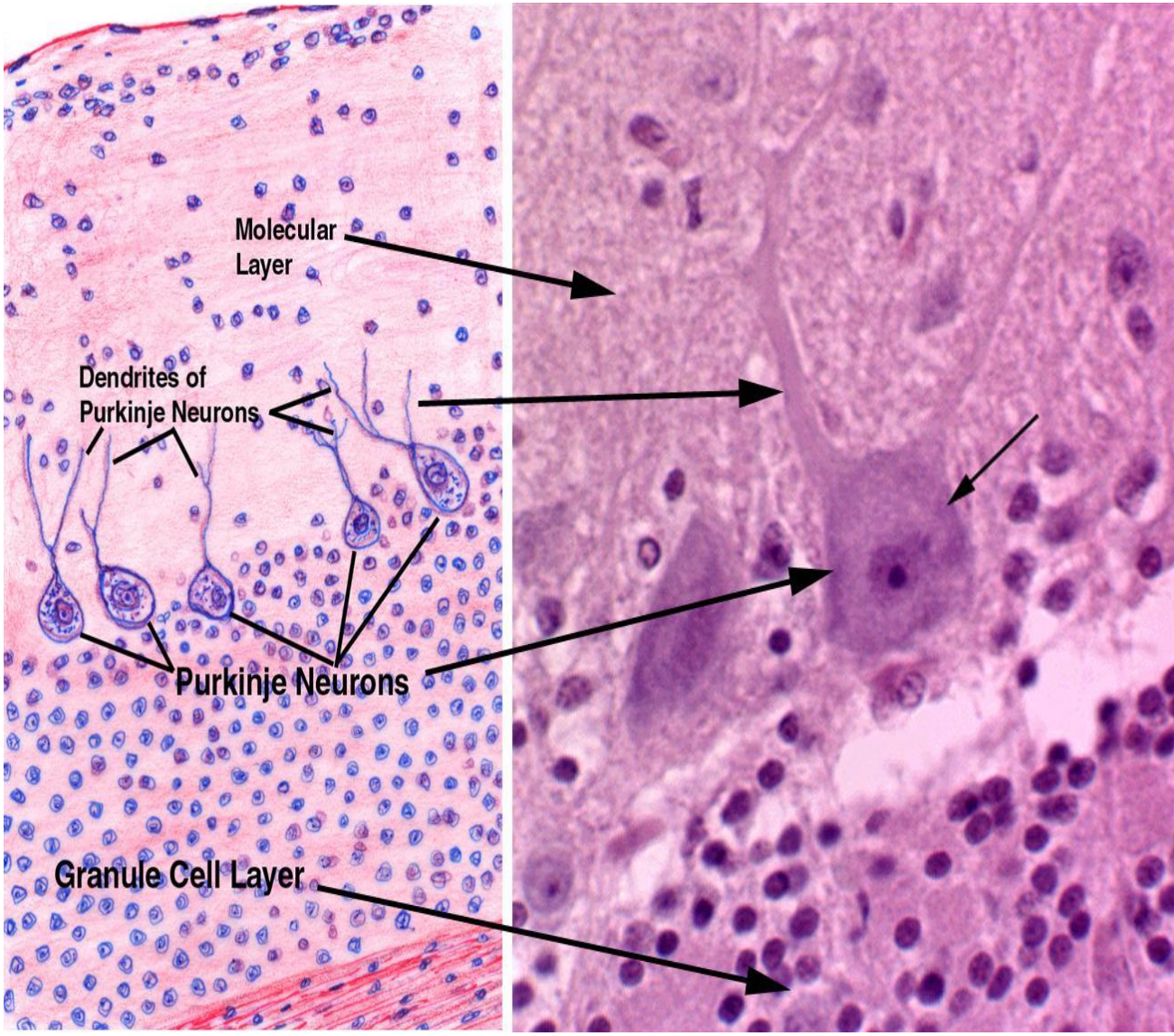
Central layer of large Purkinje cells

- large flask-shaped Purkinje cells (only in cerebellum)

Inner granular layer

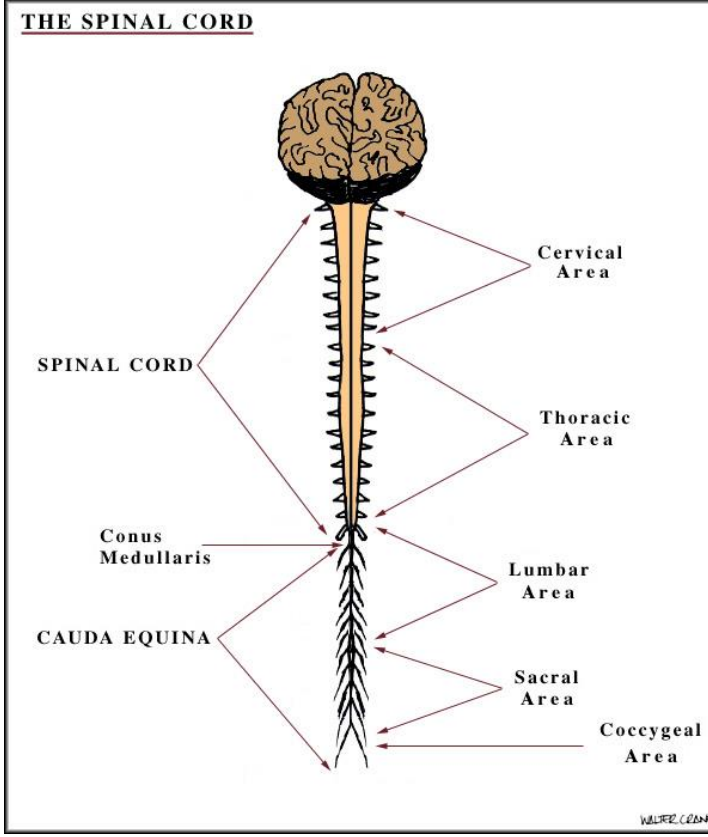
very small neurons

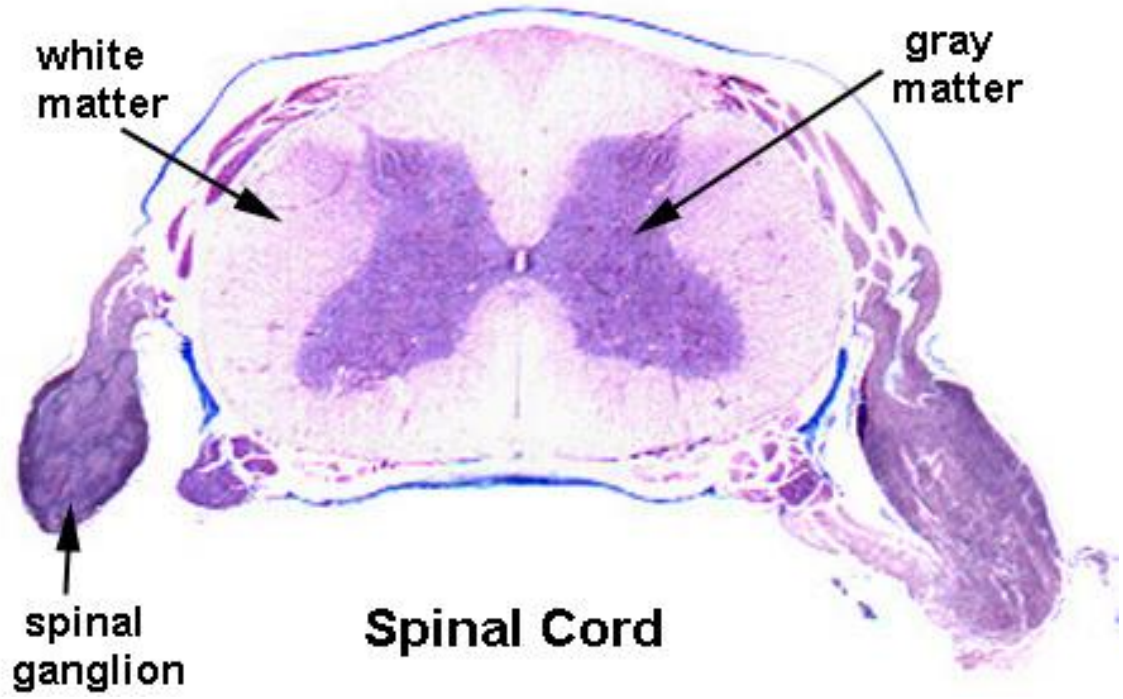
(the smallest in the body)



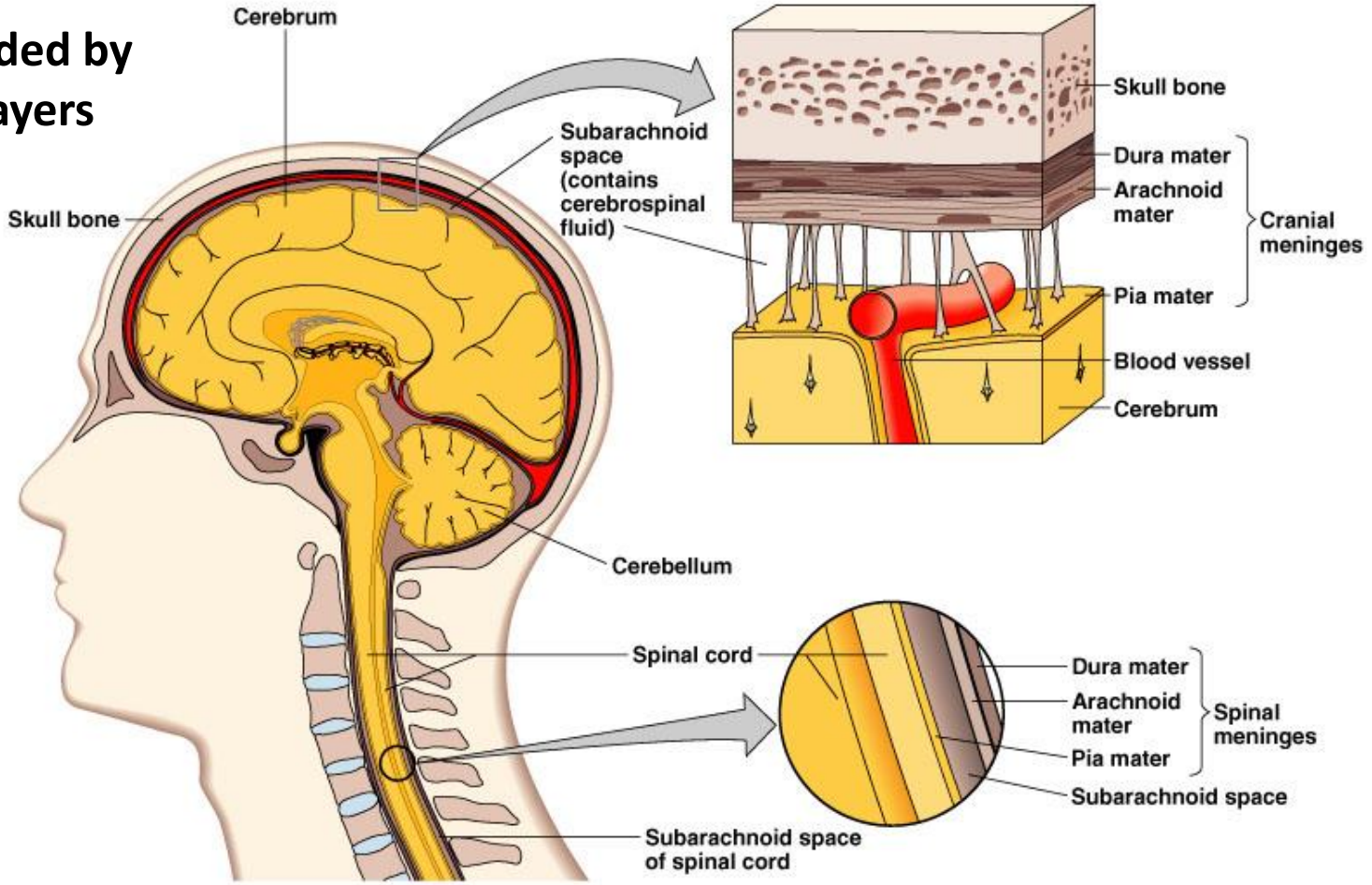
Spinal cord

- is a long, thin, tubular bundle of nervous tissue and support cells that extends from the brain
- is the main pathway for information connecting the brain and peripheral nervous system



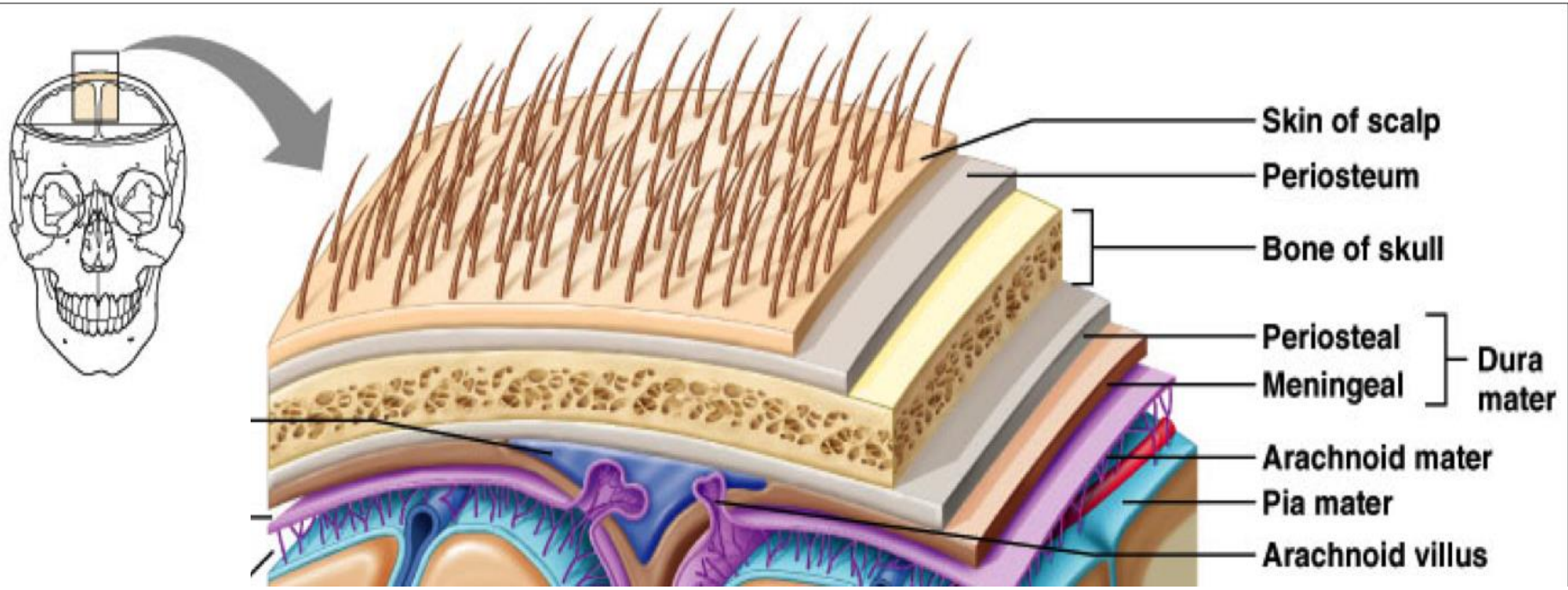


The CNS is surrounded by connective tissue layers



MENINGES

- the connective tissue membranes that envelop the central nervous syste
- dura mater
- arachnoid
- pia mater



Dura mater

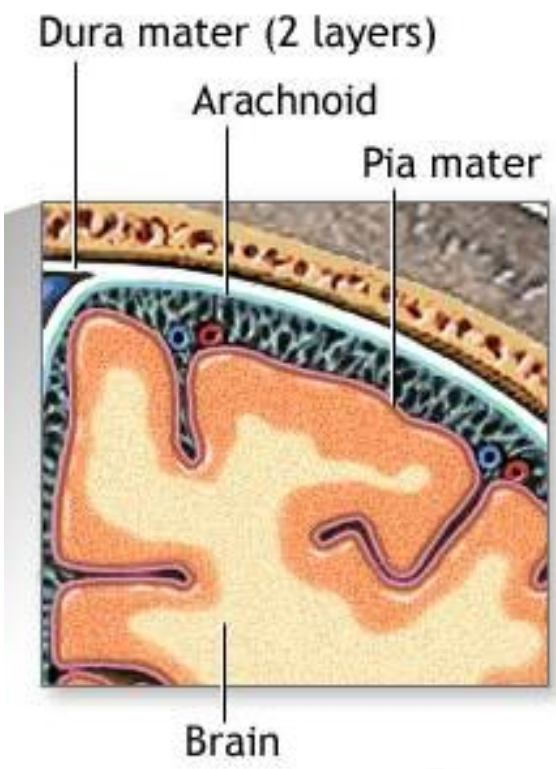
- **outermost layer**
- **composed of two layers:**

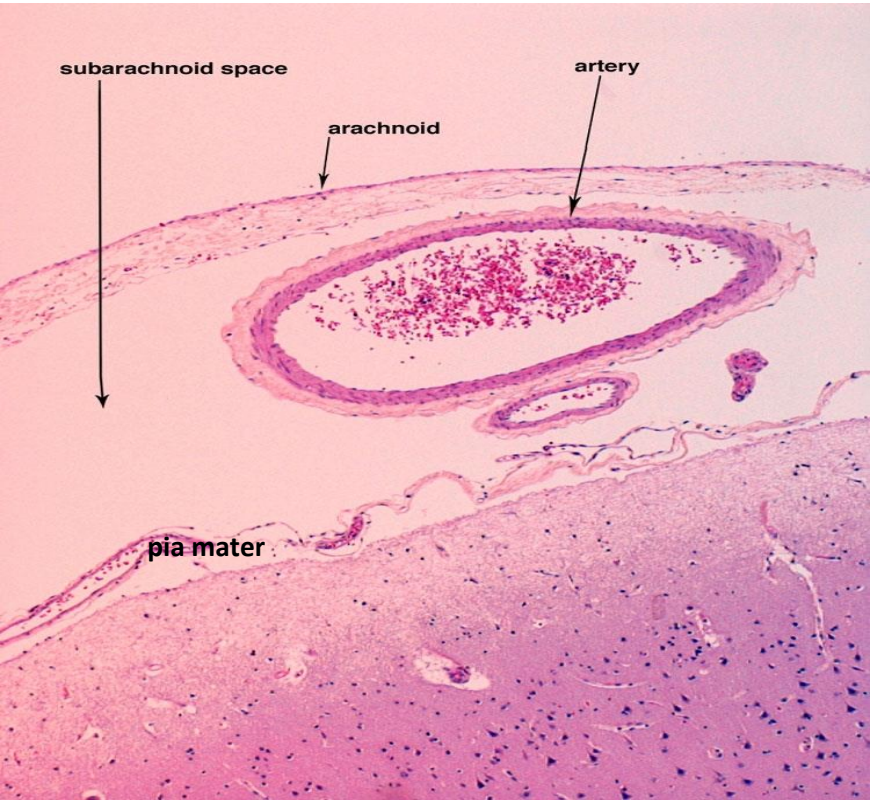
periosteal dura mater – serves as the periosteum of the inner surface of a skull, well vascularized, contains osteoprogenitor cells, fibroblasts and collagen fibers

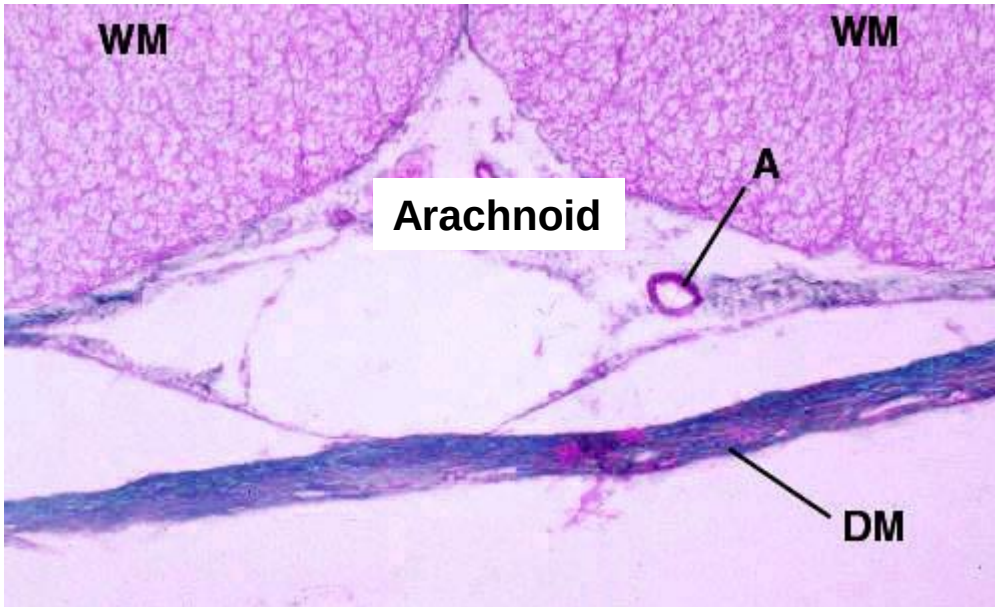
meningeal dura mater – contains fibroblasts and layer of fine collagen fibers (border cell layer – flattened fibroblasts)

Arachnoid

- is interposed between the two other meninges, the more superficial and much thicker dura mater and the deeper pia mater, from which it is separated by the subarachnoid space
- Cerebrospinal fluid (CSF) flows under the arachnoid in the subarachnoid space







Pia mater

- is intimately assciated with the brain tissue (separted from neural tissue by neuroglial processes)
- is highly vascular connective tissue layer
- the pia mater allows blood vessels to pass through and nourish the brain