

Histology of Muscle and Nerve

Electrical Communication of Cells (Theme)

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VETS30015 / VETS90121

Part 1 – Histology of Muscle



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Functions of muscle

- Movement of bones
- Movement of material through hollow organs
- Manipulation of external objects
- Breathing
- Vocalisation
- Eye movement

Three (3) Types of Muscle Tissue

- **Smooth Muscle**

- Walls of most viscera, blood vessels and skin
- Not under conscious control
- Supplied by Autonomic NS
- Not striated

Non-striated involuntary muscle

- **Skeletal Muscle**

- Usually attached to bones
- Under conscious control
- Supplied by somatic NS
- Striated

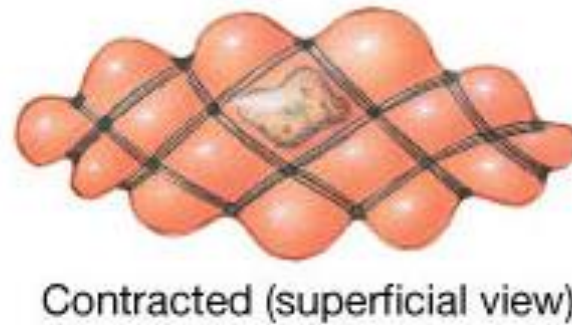
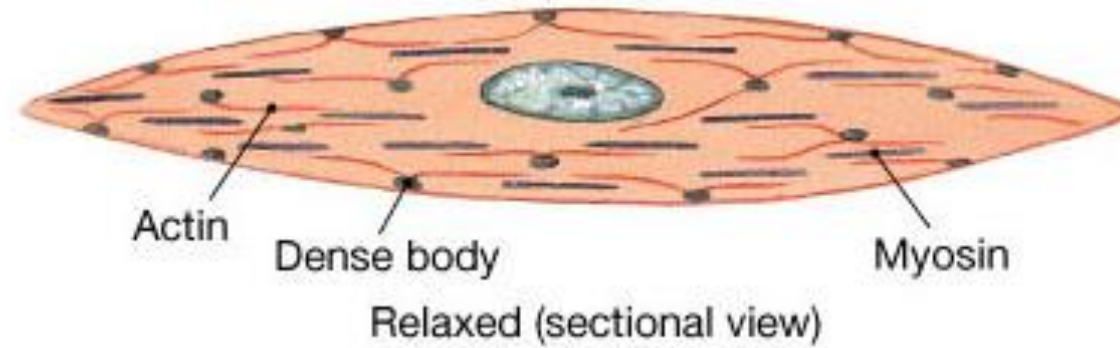
Striated voluntary muscle

- **Cardiac Muscle**

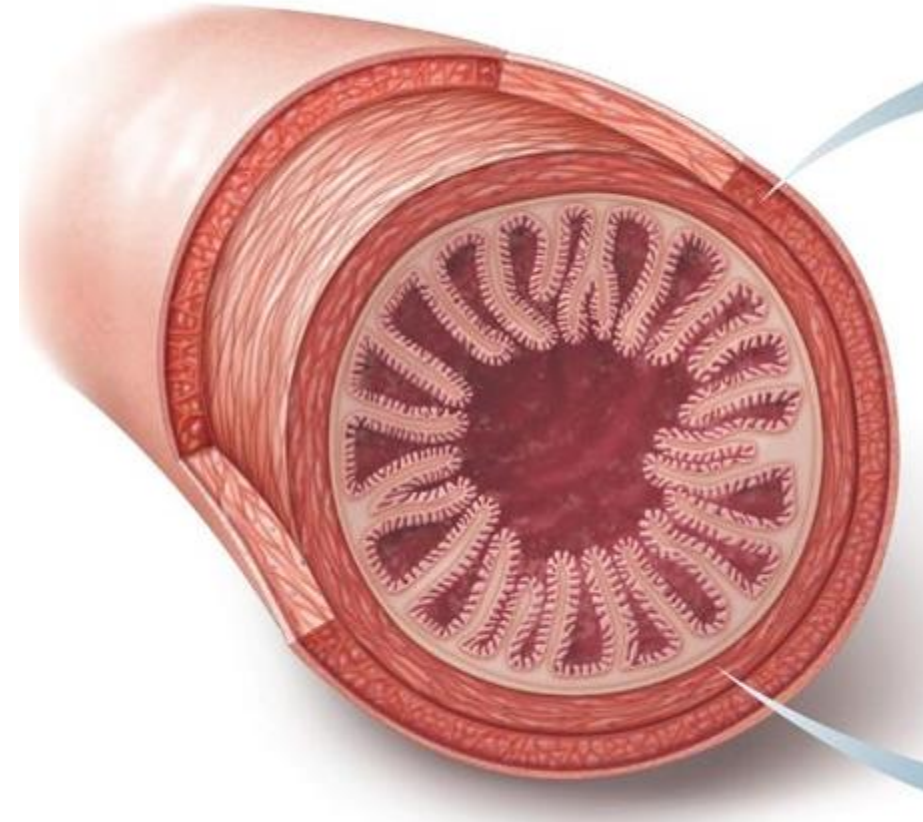
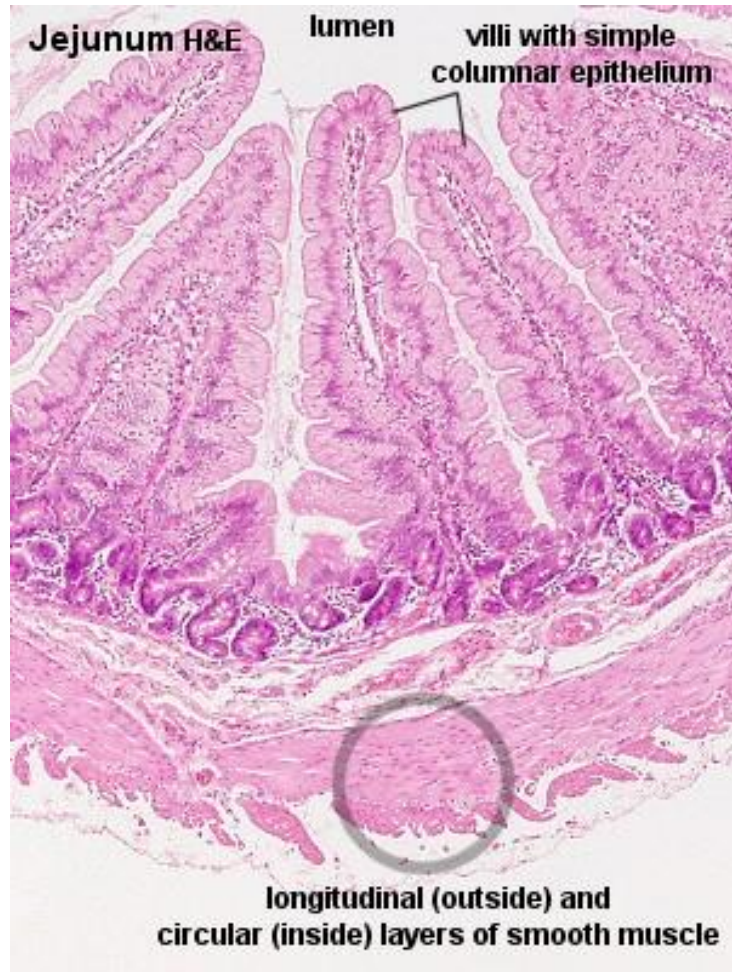
- Wall of heart
- Not under conscious control
- supplied by Autonomic NS
- Striated

Striated involuntary muscle

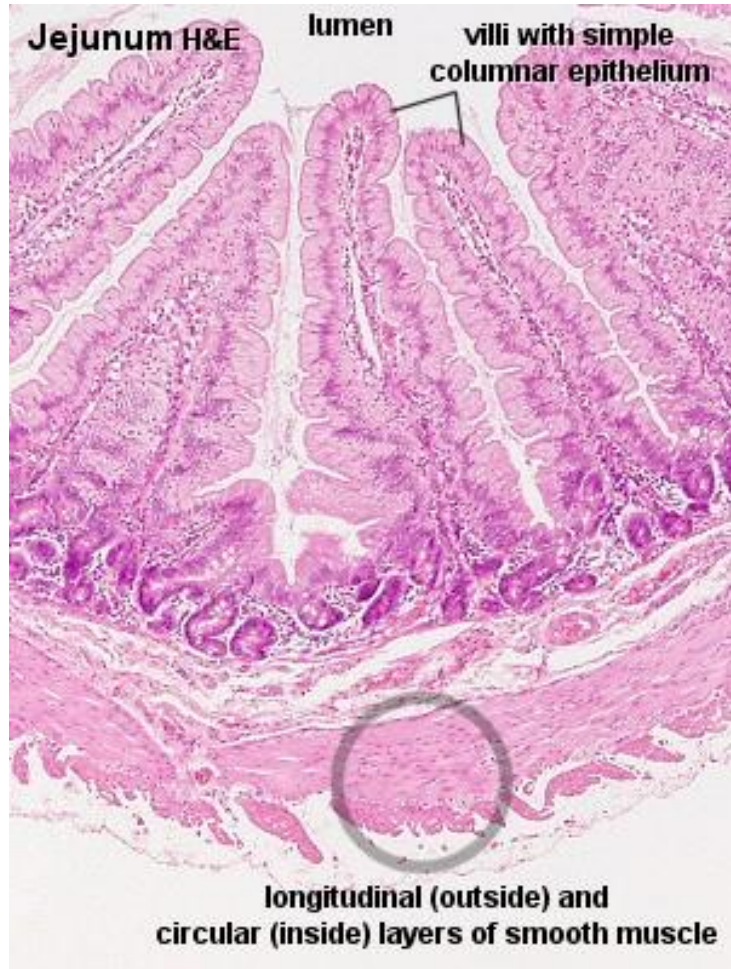
Smooth muscle



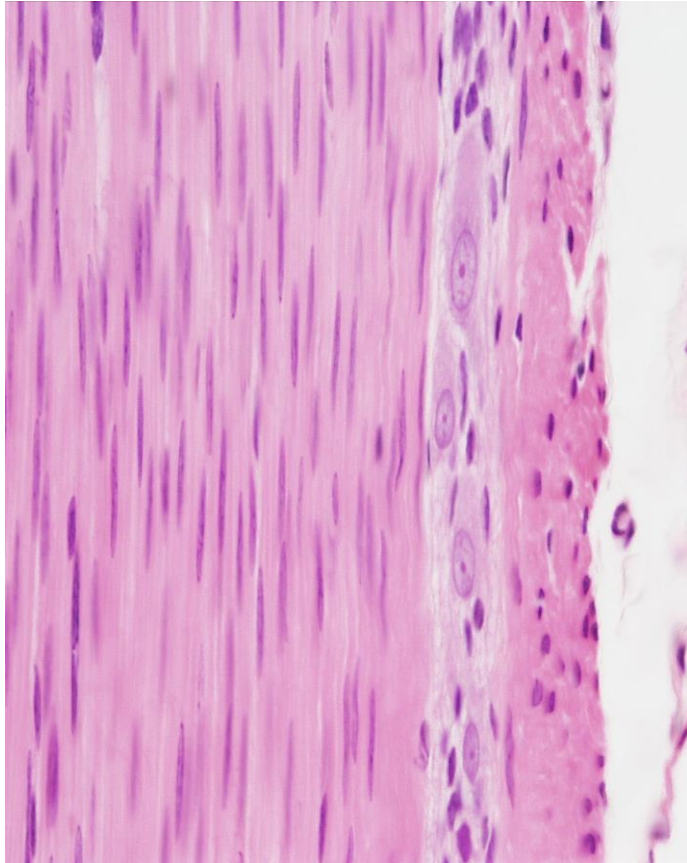
Smooth muscle



Smooth muscle



- Two broad types of smooth muscle
 1. Multiunit
 2. Visceral



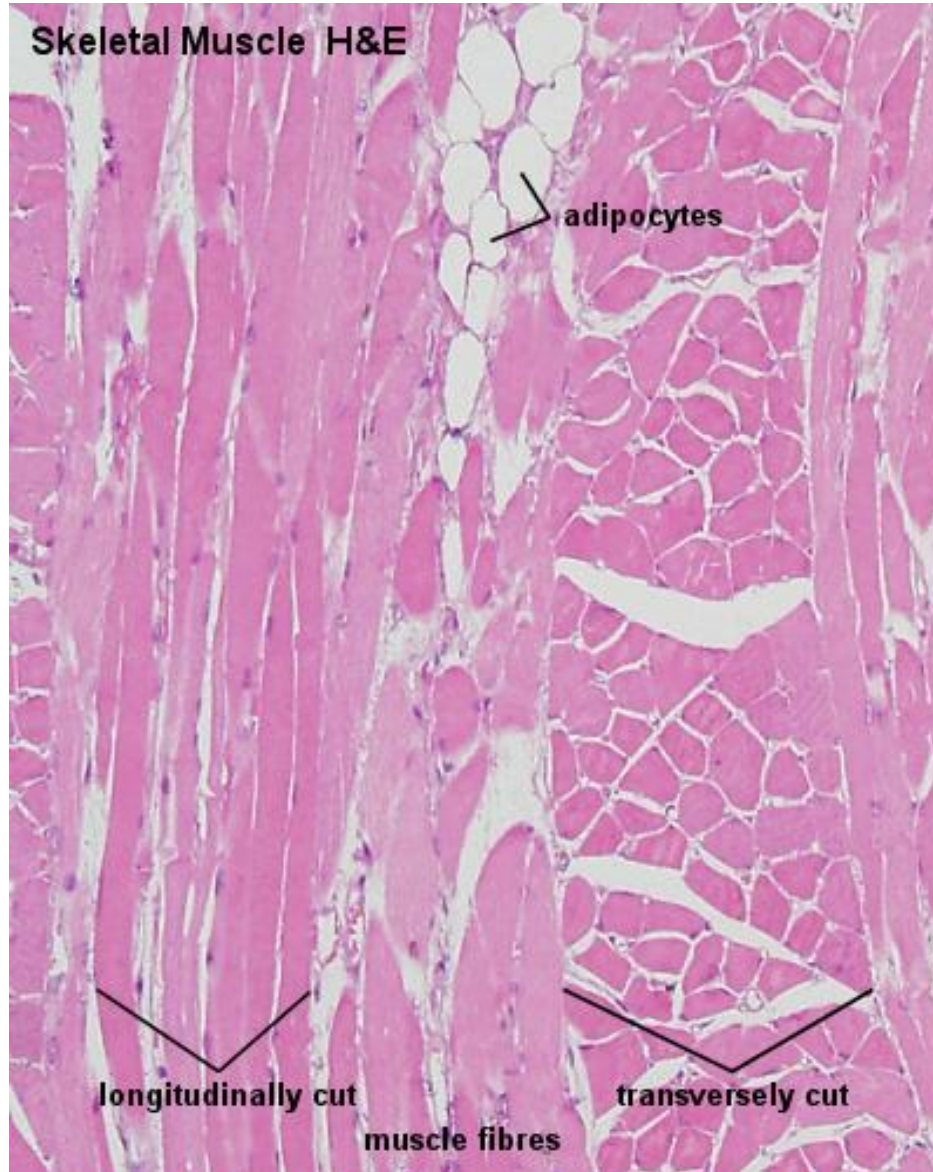
- *Multiunit type*
 - functionally independent smooth muscle cells which are often innervated by a single nerve terminal and which never contract spontaneously
 - smooth muscle in the walls of large blood vessels, the eyes and hair follicles

- *Visceral type*
 - represents bundles of smooth muscle cells connected by GAP junctions, which contract spontaneously if stretched beyond a certain limit
 - smooth muscle in the walls of the intestines or uterus.

Skeletal Muscle

- Skeletal muscle consists of very long tubular cells, which are also called **muscle fibres**.
 - The average length of skeletal muscle cells in humans is about 3 cm (stapedius muscle only about 1 mm, sartorius muscle up to 30 cm). Their diameters vary from 10 to 100 μm .
- Skeletal muscle fibres contain many peripherally placed nuclei. Up to several hundred rather small nuclei with 1 or 2 nucleoli are located just beneath the plasma membrane.
- Skeletal muscle fibres show in many preparations characteristic cross-striations.
- Skeletal muscle is innervated by the somatic nervous system.
- Skeletal muscle makes up the voluntary muscle.

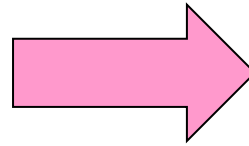
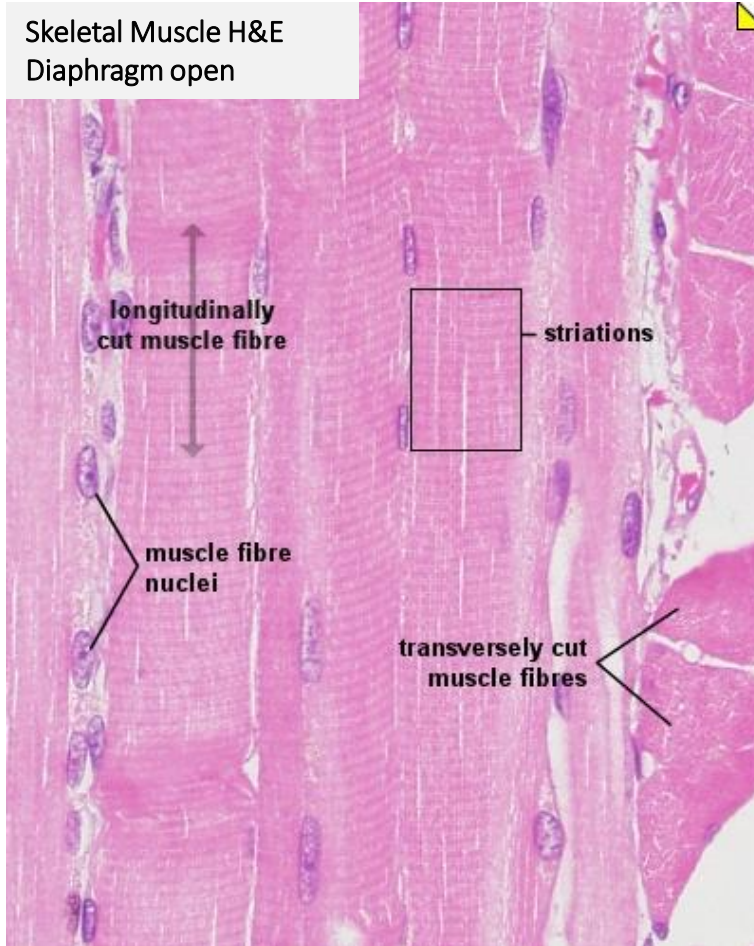
Skeletal Muscle



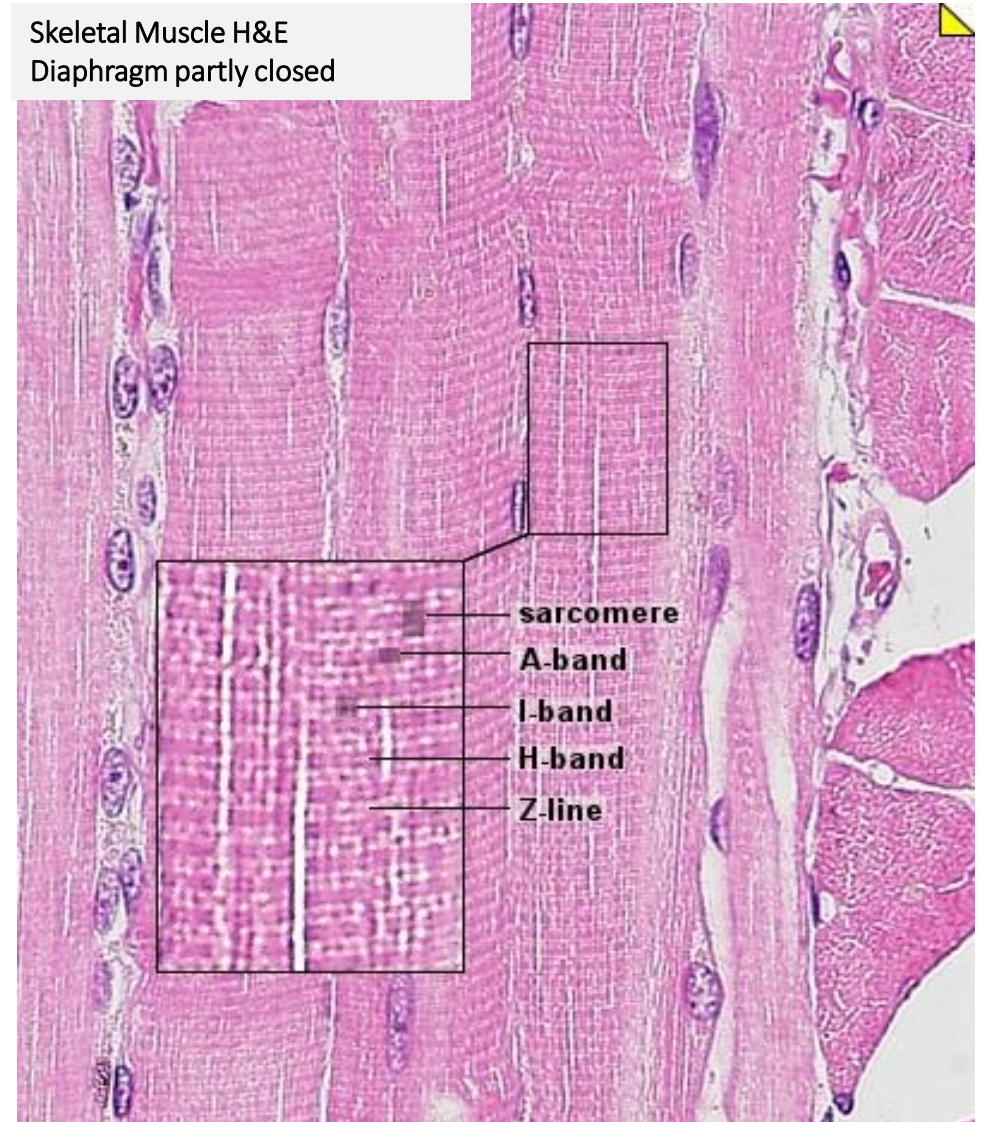
- *Tongue*
 - Both longitudinally and transversely cut fibres present.

Skeletal Muscle

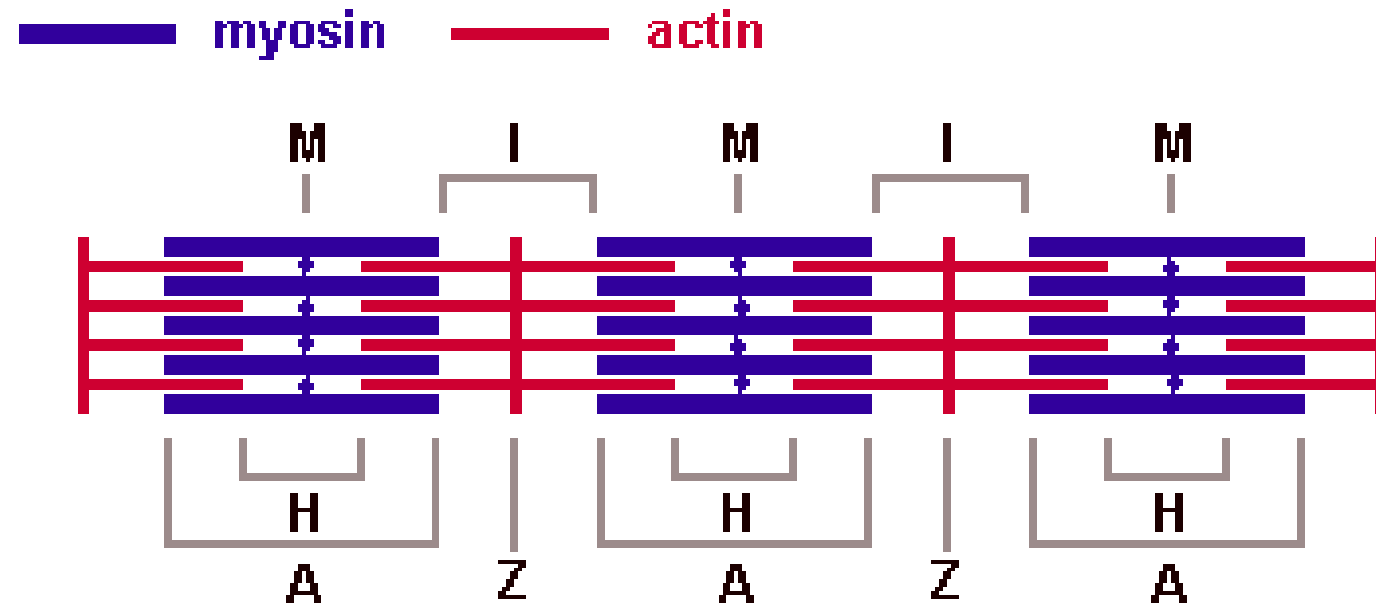
Skeletal Muscle H&E
Diaphragm open



Skeletal Muscle H&E
Diaphragm partly closed

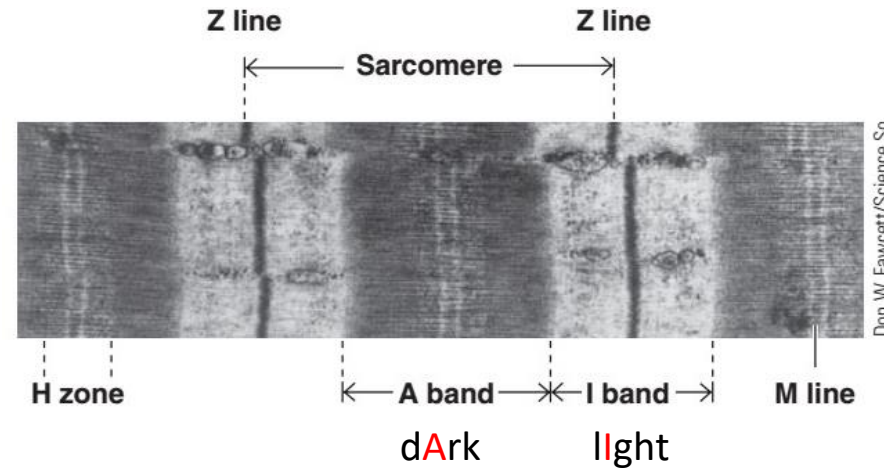


Contractile Apparatus



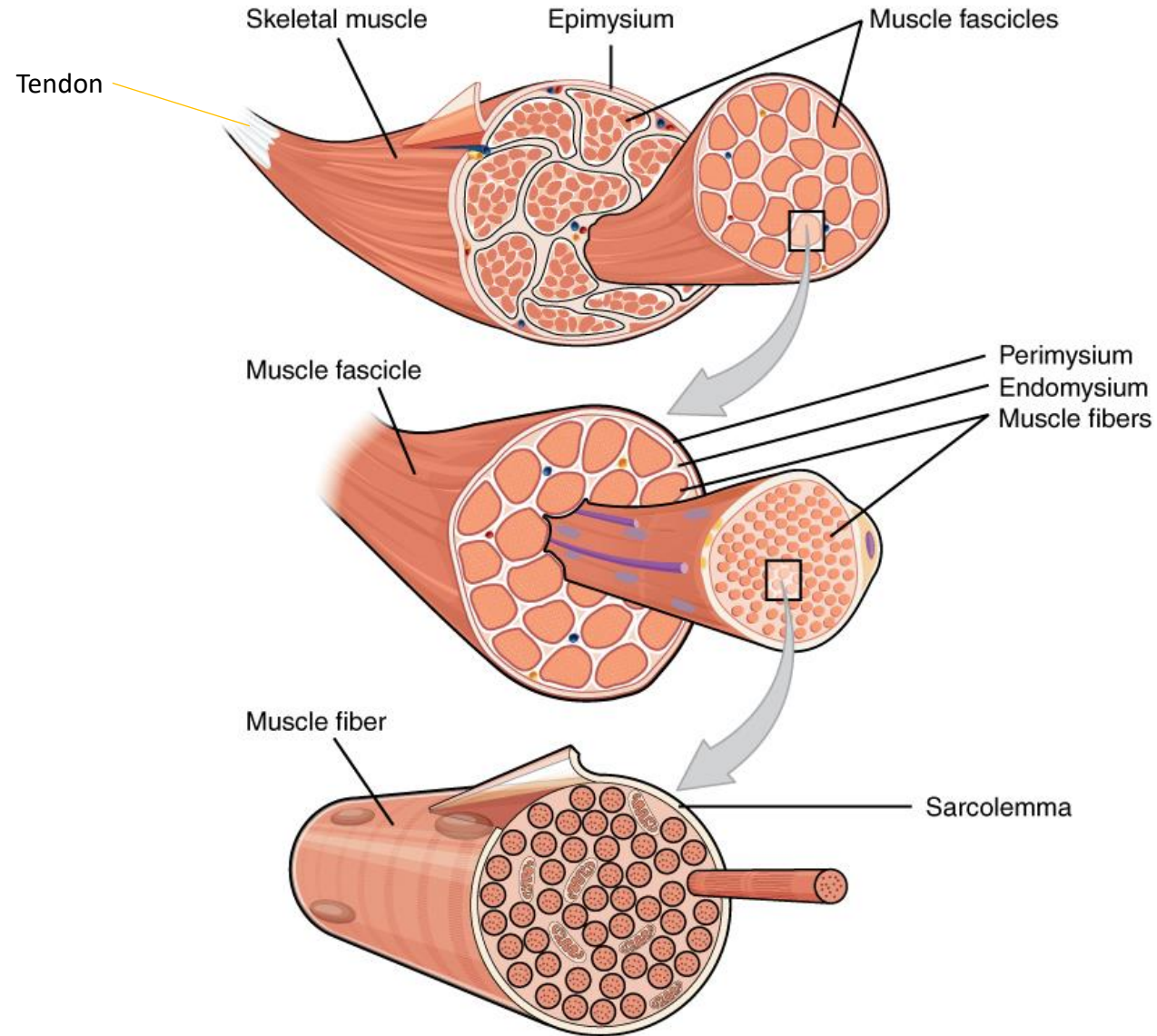
Bands and lines in the contractile apparatus of skeletal muscle

Contractile Apparatus

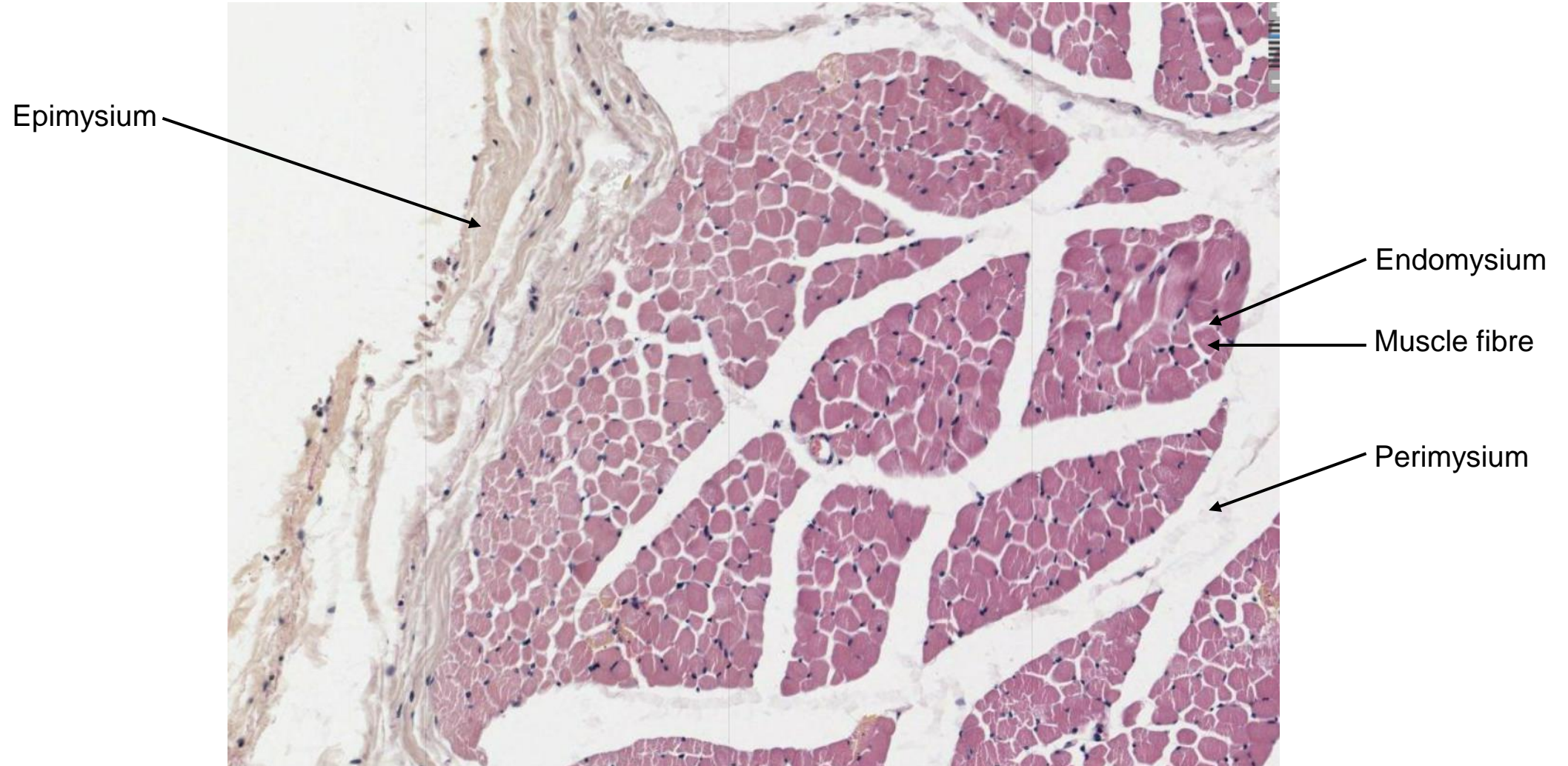


- **A-band** - myosin filaments which may overlap with actin filaments
- **I-band** - actin filaments
- **H-zone** - zone of myosin filaments only (no overlap with actin filaments) within the A-band
- **M-line** - band of connections between myosin filaments (mediated by proteins, e.g. myomesin, M-protein).
- **Z-line** - zone of apposition of actin filaments belonging to two neighbouring sarcomeres (mediated by a protein called alpha-actinin)

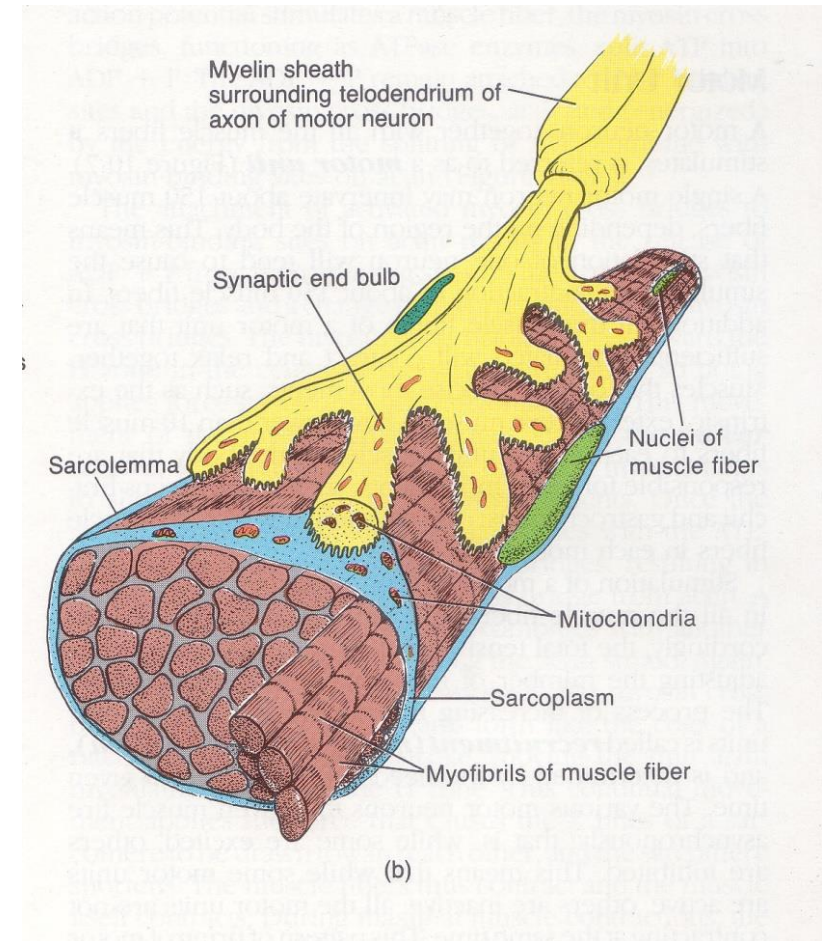
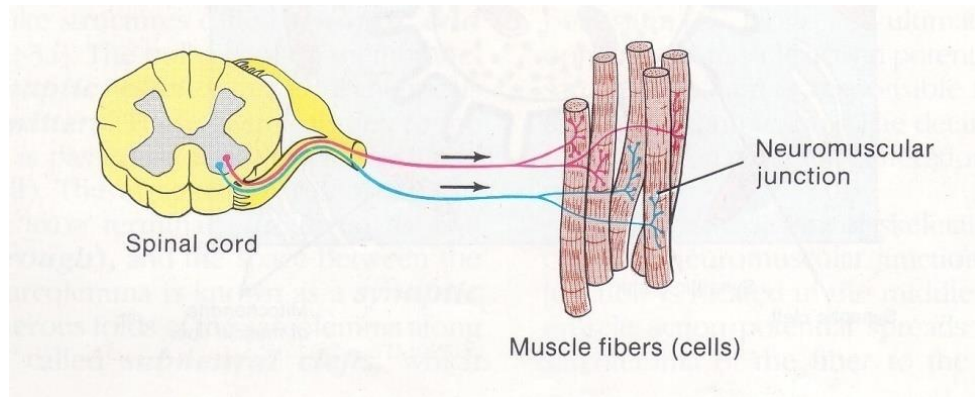
Organisation of skeletal muscle



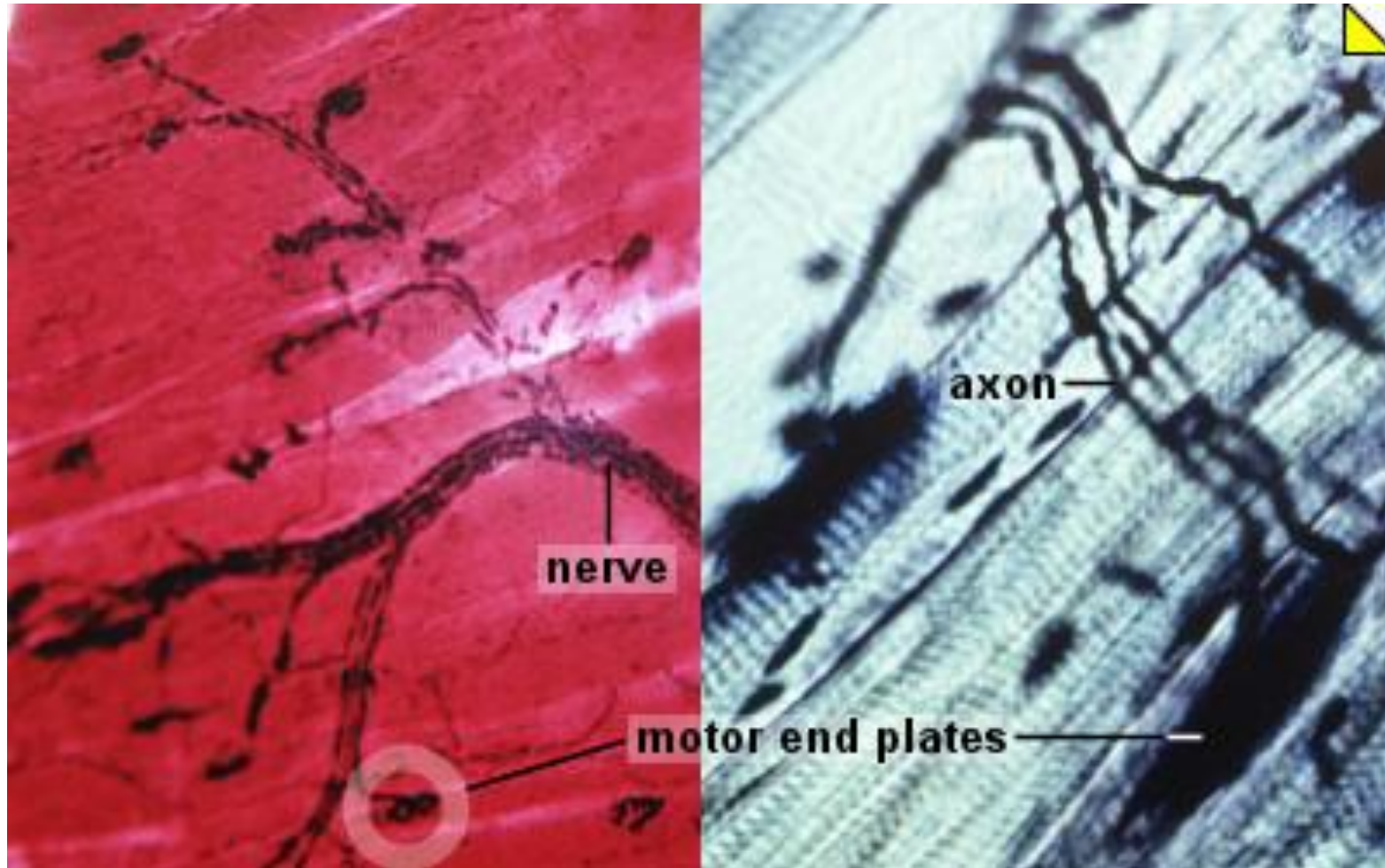
Organisation of skeletal muscle



Motor unit



Neuromuscular Junction



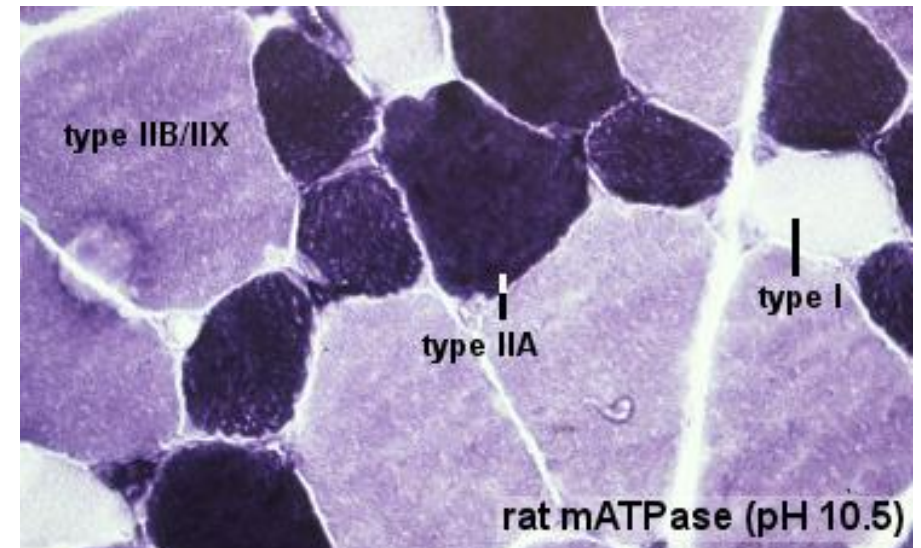
Muscle Fibre Types

Velocity of contraction

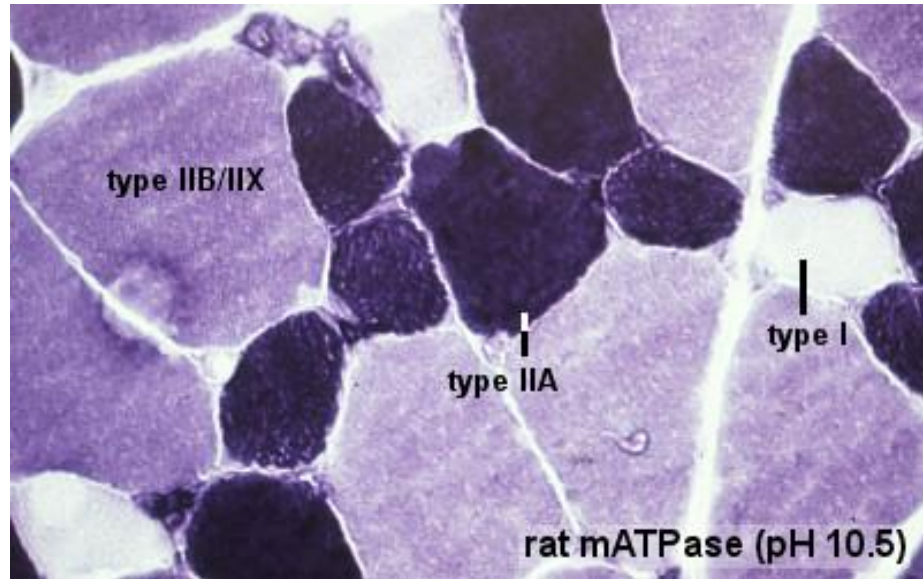
- Type I (slow) fibres
- Type II (fast) fibres

Energy production

- Type I (slow oxidative) fibres
- Type IIA (fast-oxidative) fibres
- Type IIB/ IIX (fast –glycolytic) fibres



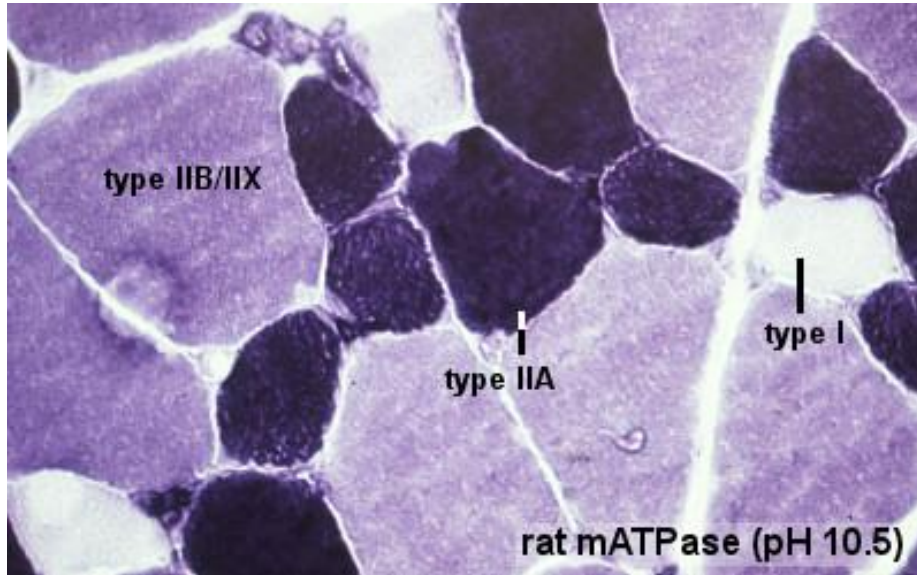
Muscle Fibre Types



Type I (slow – oxidative) fibre

- Predominantly red muscle cells.
- Comparatively thin
- Contains large amounts of myoglobin and mitochondria.
- myosin with low ATPase activity
- Contraction is slow and sustained. e.g. in the control of posture.
- Relatively resistant to fatigue

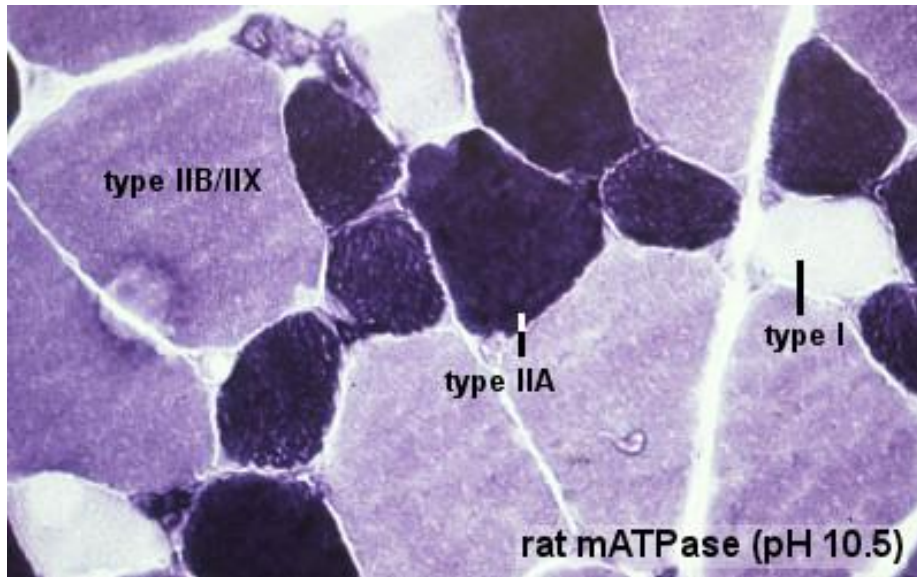
Muscle Fibre Types



Type IIA (fast – oxidative) fibre

- Predominantly found in red muscles
- Thicker fibres
- Contains large amounts of myoglobin and many mitochondria.
- ATPase activity of the myosin isoform is high and contraction is fast.

Muscle Fibre Types



Type IIB (fast – glycolytic) fibre

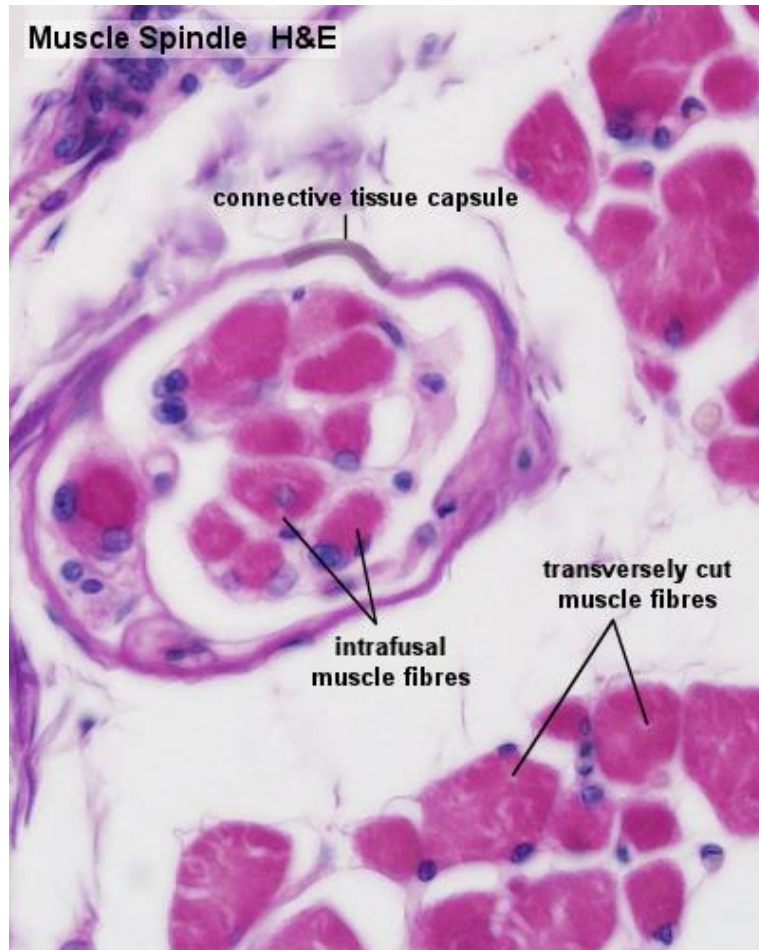
- Predominantly found in white muscles
- Thicker and contain little myoglobin.
- ATPase activity of the myosin isoform in white fibres is high, and contraction is fast.
- Type IIB/IIX fibres contain only few mitochondria.
- usually prone to fatigue

Muscle Spindles



- Muscle spindles are sensory specialization of the muscular tissue.
- A number of small specialised intrafusal muscle fibres (nuclear bag fibres and nuclear chain fibres) are surrounded by a capsule of connective tissue.

Muscle Spindles



- If the muscle is **stretched**, the muscle fibres in the muscle spindle are stretched, sensory nerves are stimulated, and a change in contraction of the muscle is perceived.
- Different types of intrafusal fibres and nerve endings allow the perception of position, velocity and acceleration of the contraction of the muscle.

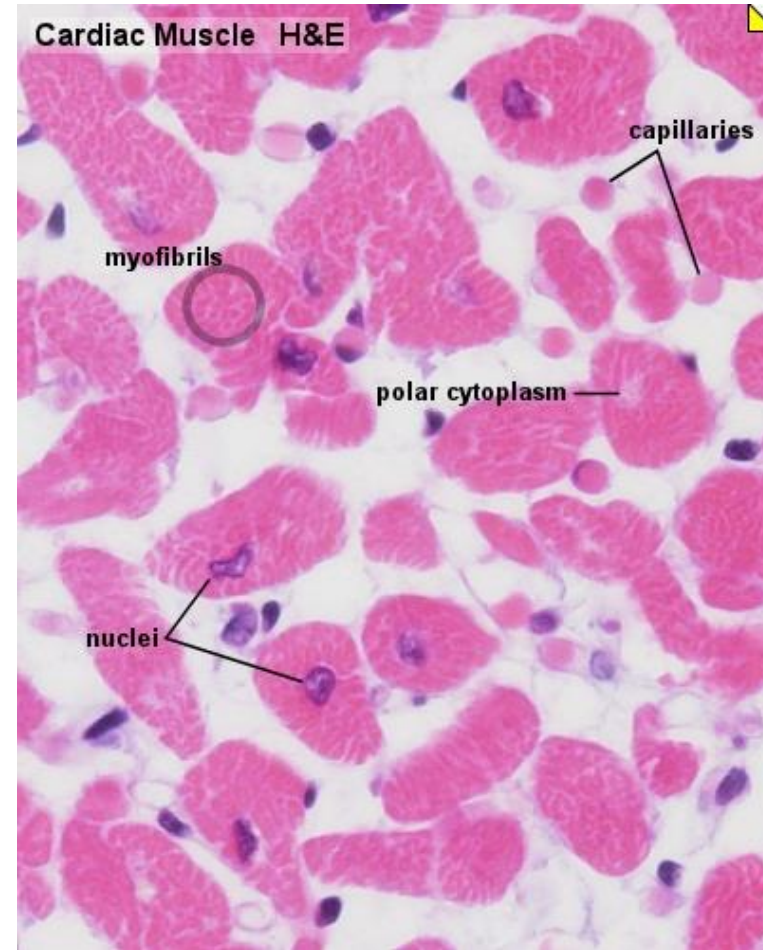
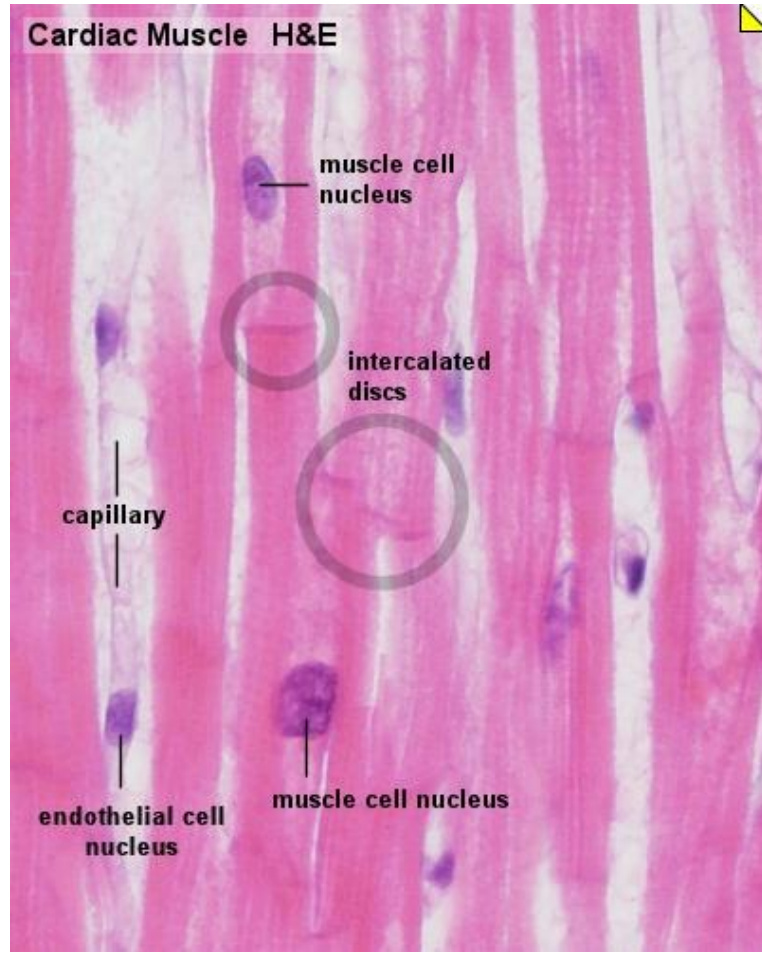
Cardiac Muscle

- Cardiac muscle, the myocardium, consists of muscle cells, **cardiomyocytes**, with **one centrally placed nucleus**.
Nuclei are oval, rather pale and located centrally in the muscle cell which is 10 - 15 μm wide.
- Cardiac muscle cells exhibit **cross-striations**.
- Cardiac muscle cells excitation is mediated by rhythmically active modified cardiac muscle cells.
- Cardiac muscle is innervated by the autonomic nervous system, which adjusts the force generated by the muscle cells and the frequency of the heart beat.
- Cardiac muscle is for these reasons also called involuntary striated muscle.

Cardiac muscle

- Often branch at acute angles and are connected to each other by specialisations of the cell membrane in the region of the intercalated discs.
- Intercalated discs invariably occur at the ends of cardiac muscle cells in a region corresponding to the Z-line of the myofibrils (the last Z-line of the myofibril within the cell is "replaced" by the intercalated disk of the cell membrane).

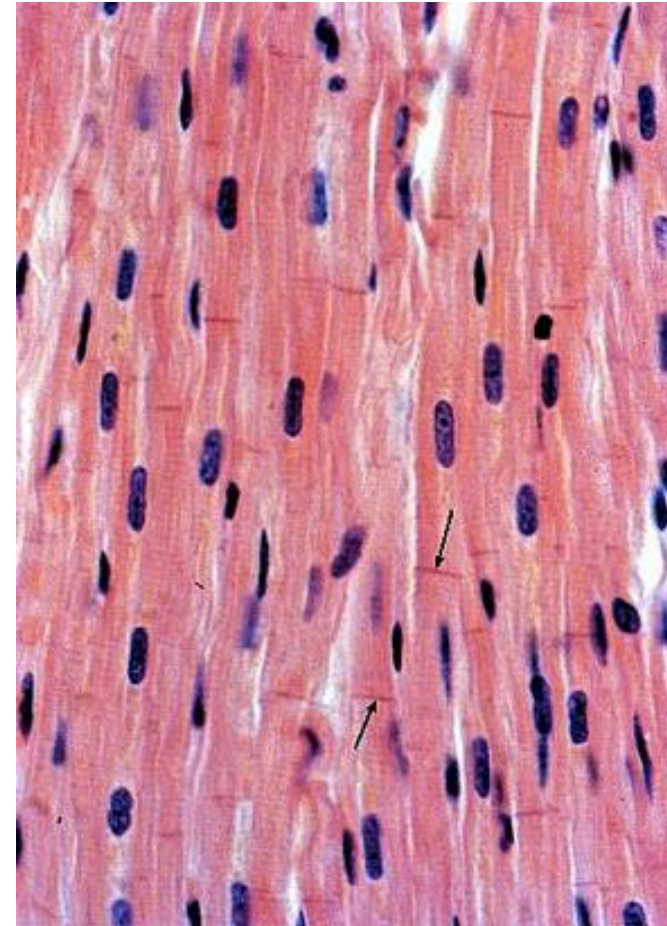
Cardiac Muscle



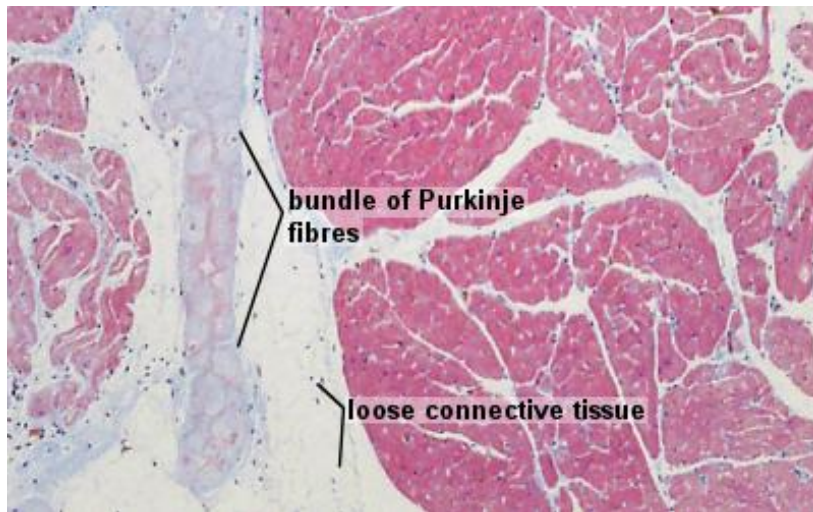
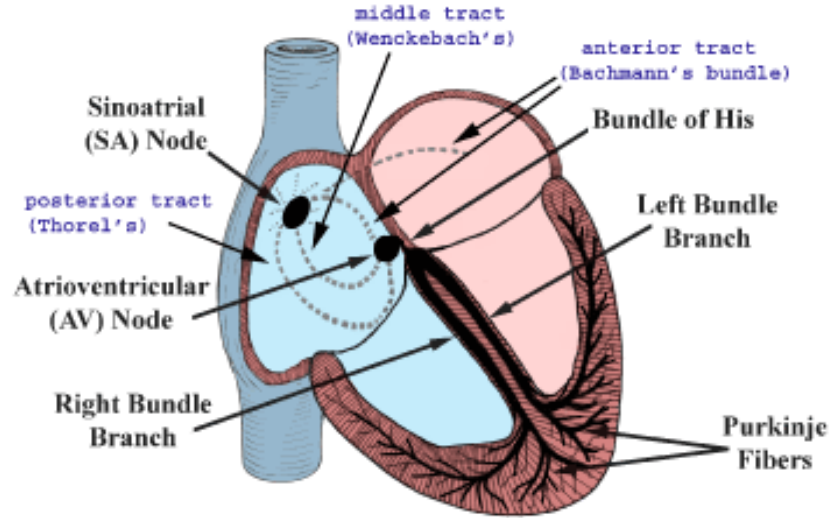
Junctions in the Intercalated disks

- Fascia adherens
 - Anchor actin to nearest sarcomere
- Macula adherens
 - desmosome
 - Stop separation during contraction
- Gap junctions
 - Allow action potentials to spread between cells

Intercalated Disk

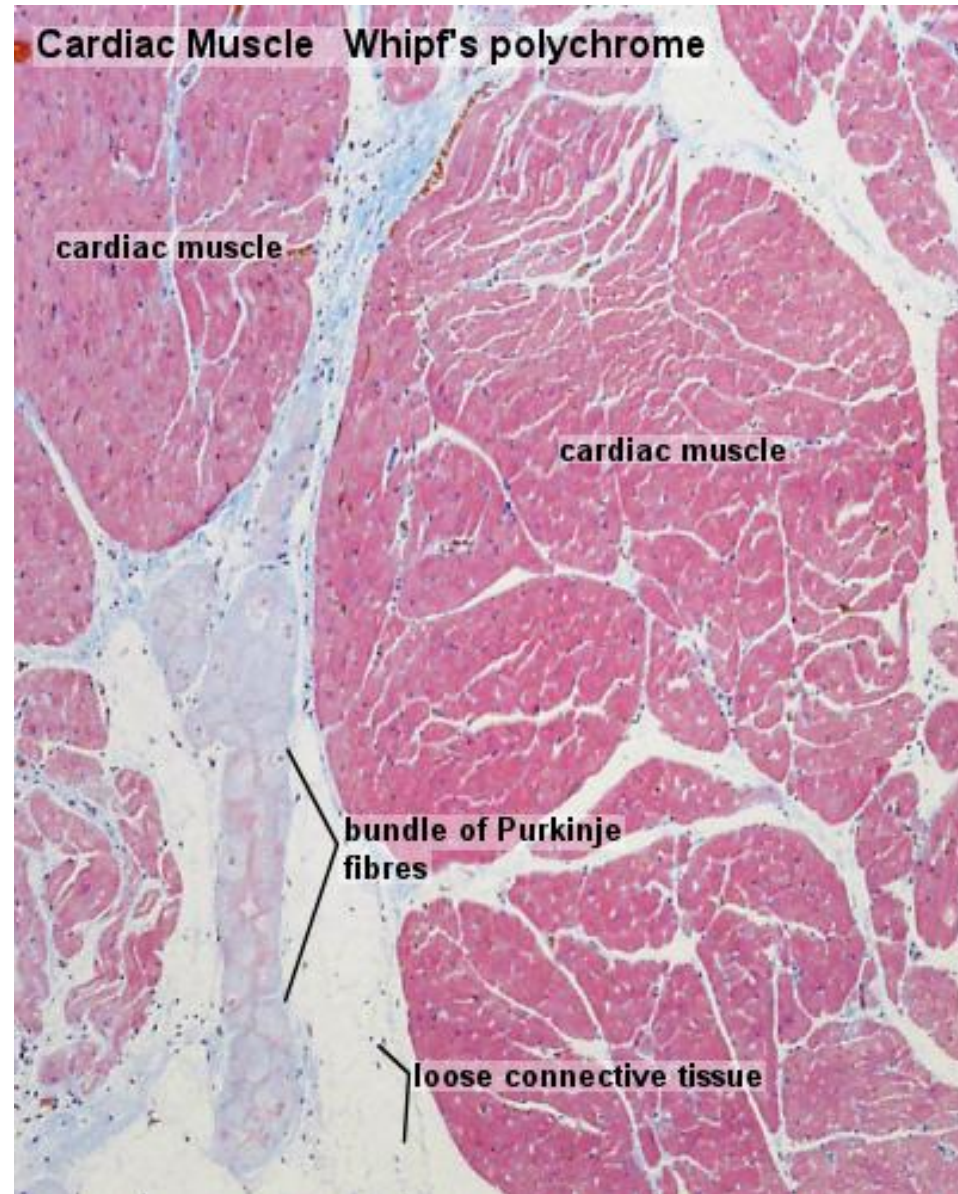


Purkinje fibres



- Conduct stimuli faster than ordinary cardiac muscle cells (2-3 m/s vs. 0.6 m/s).
- A bundle of Purkinje fibres extends from the atrioventricular node, pierces the fibrous body, divides into left and right bundles, and travels, beneath the endocardium, towards the tip (apex) of the heart.
- Branches of the bundle contact ordinary cardiac muscle cells by way of specialisations similar to intercalated discs.
- Purkinje fibres are thicker than ordinary cardiac muscle cells.

Purkinje fibres



Part 2 – Histology of Nervous Tissue

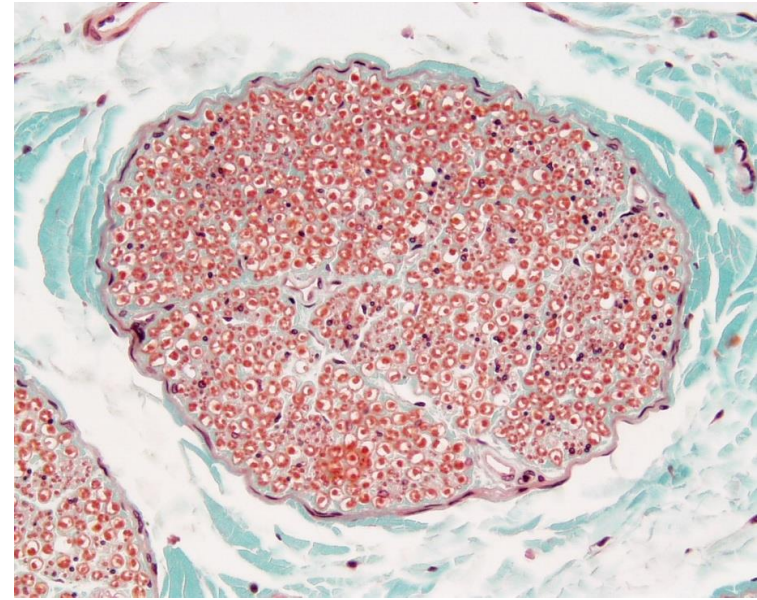
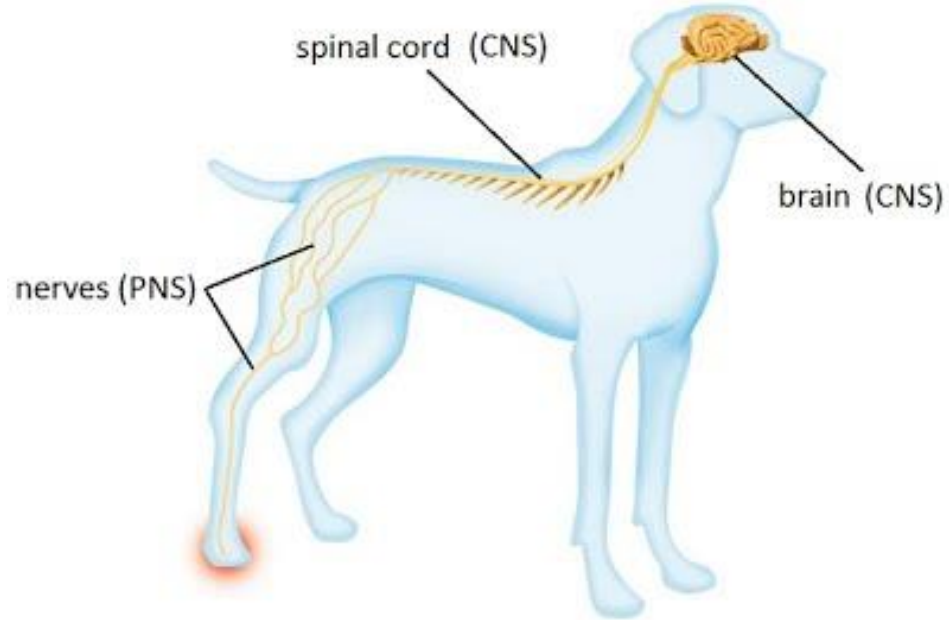
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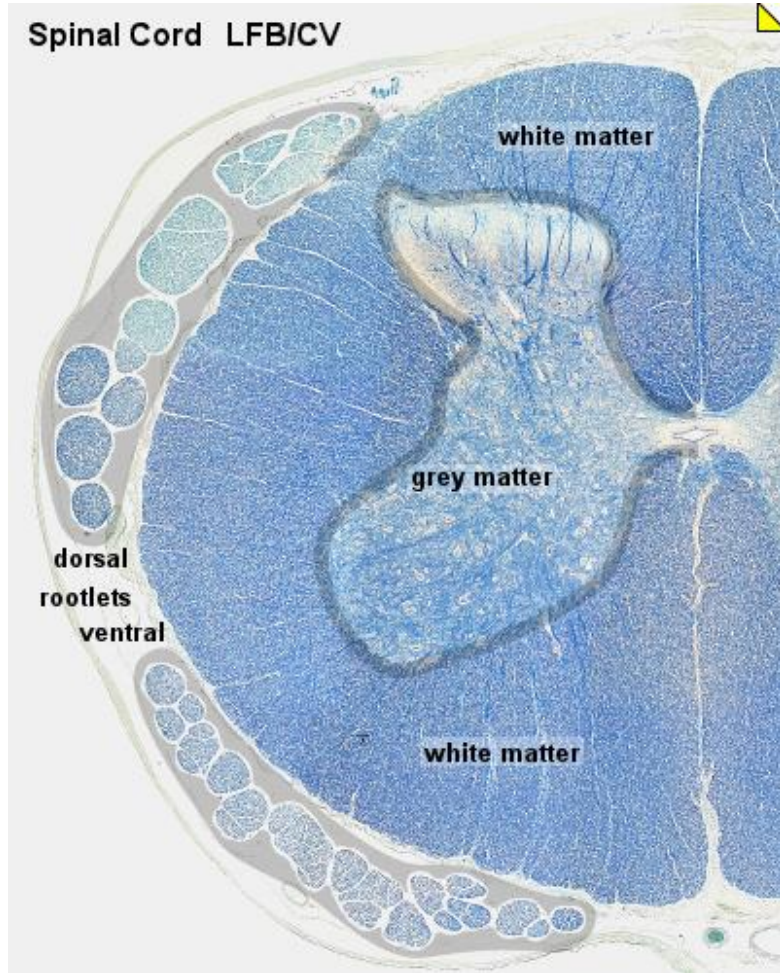
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Nervous Tissue

- Anatomically divided
 - Central nervous system (CNS)
 - Peripheral nervous system (PNS)



Central Nervous System

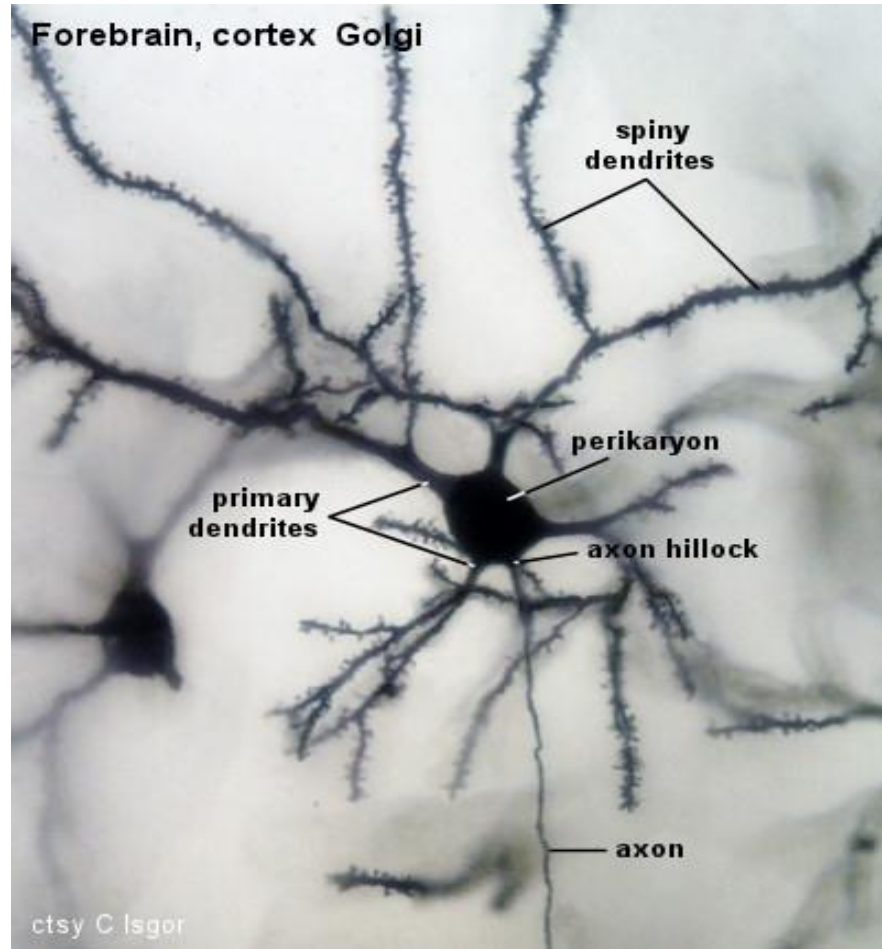


Brain and spinal cord

Two major classes of cells

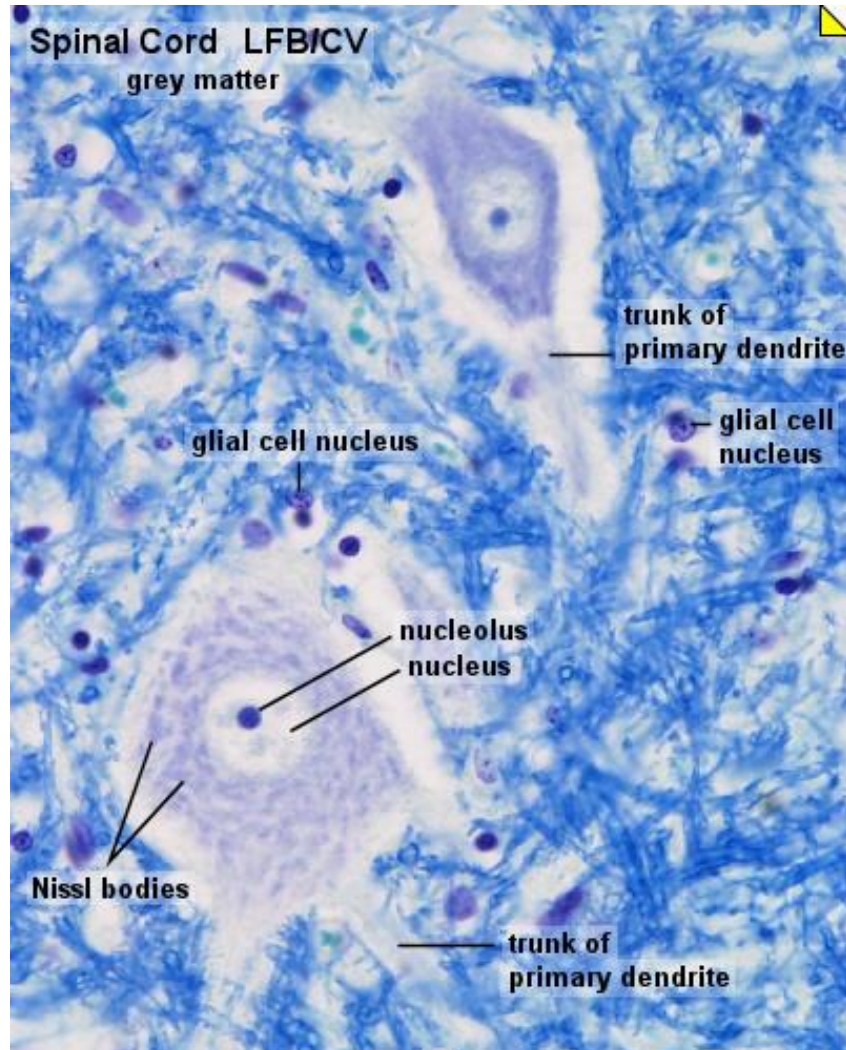
- Neurones (nerve cells)
- Neuroglia (glia cells)
 - Astrocytes
 - Oligodendrocytes
 - Microglia
 - Ependymal cells

Neurones



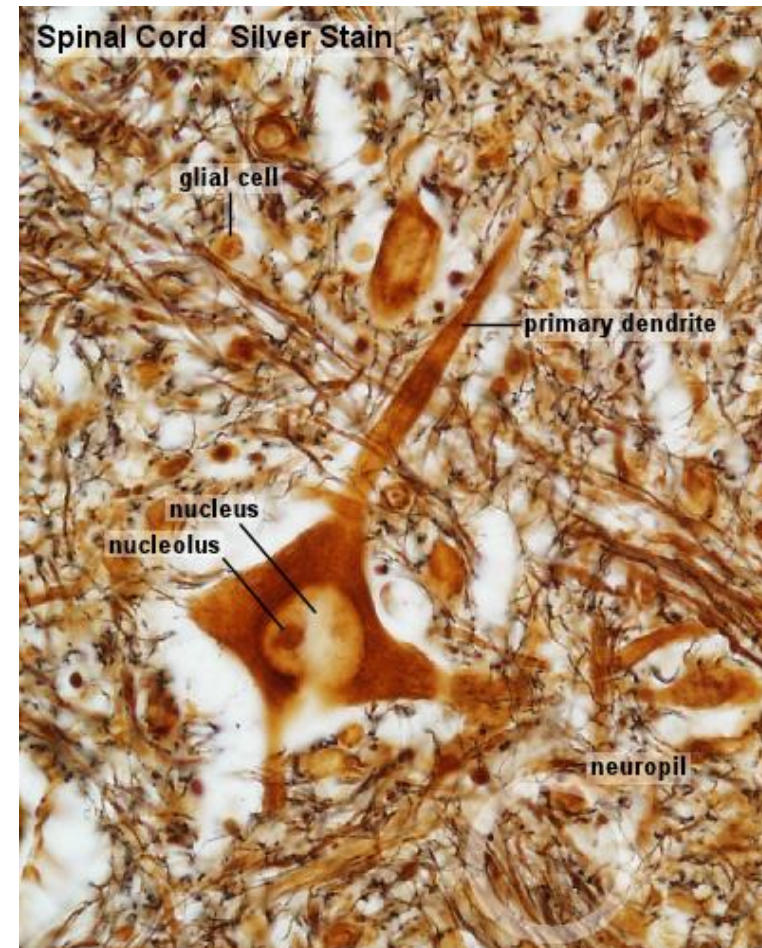
- Long processes extending from *cell body (perikaryon)*
- *Dendrites* receptive surface
- *Axon*: one per cell
- Emerges from the axon hillock

Neurones

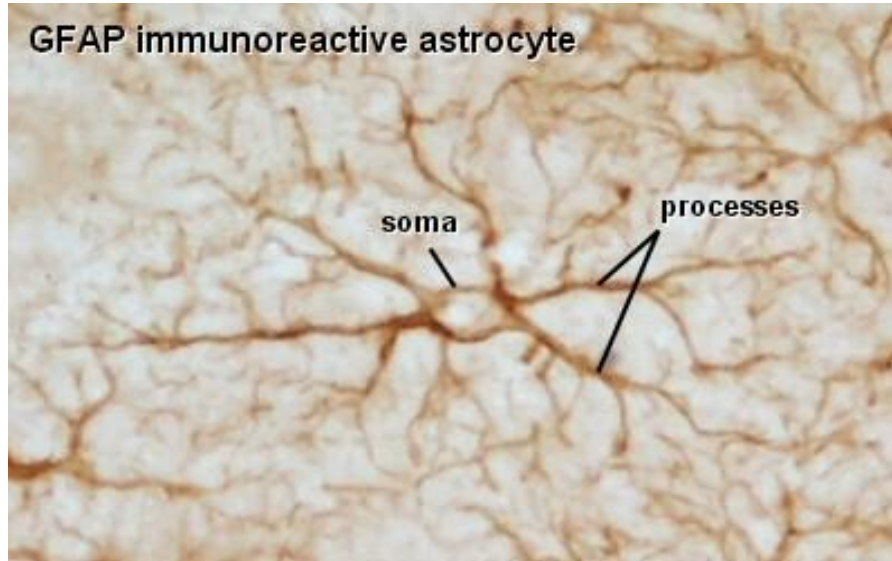


- Light, large nucleus with a distinct nucleolus.
- Cytoplasm of many neurones contains aggregates of rough endoplasmic reticulum (Nissl bodies).
- Prominent in motor neurones in the ventral horn of the grey matter of the spinal cord.
- The size of the perikaryon depends on the level of activity of the neurone and the length of the processes which the neurone has to support.

Neurons



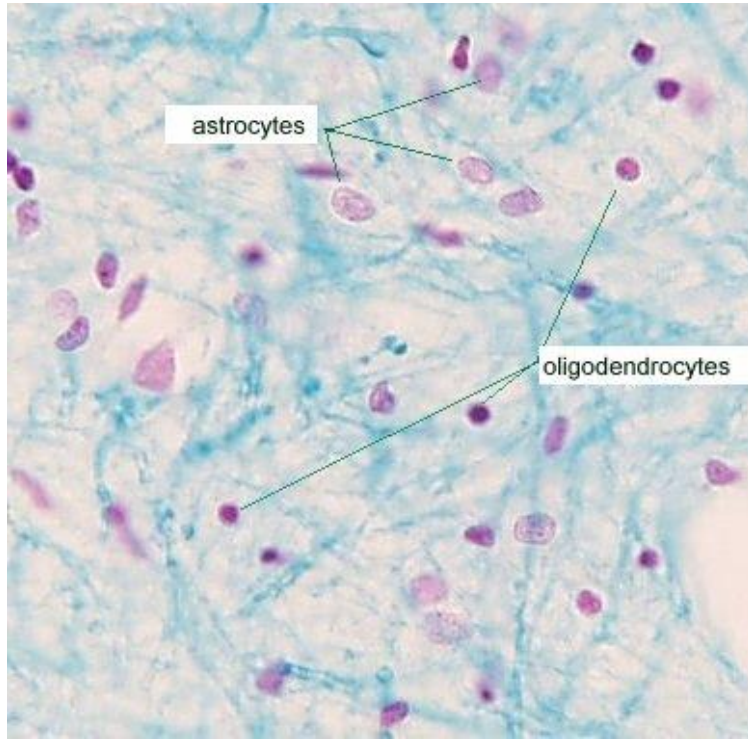
Neuroglia



GFAP – Glial fibrillary acidic protein

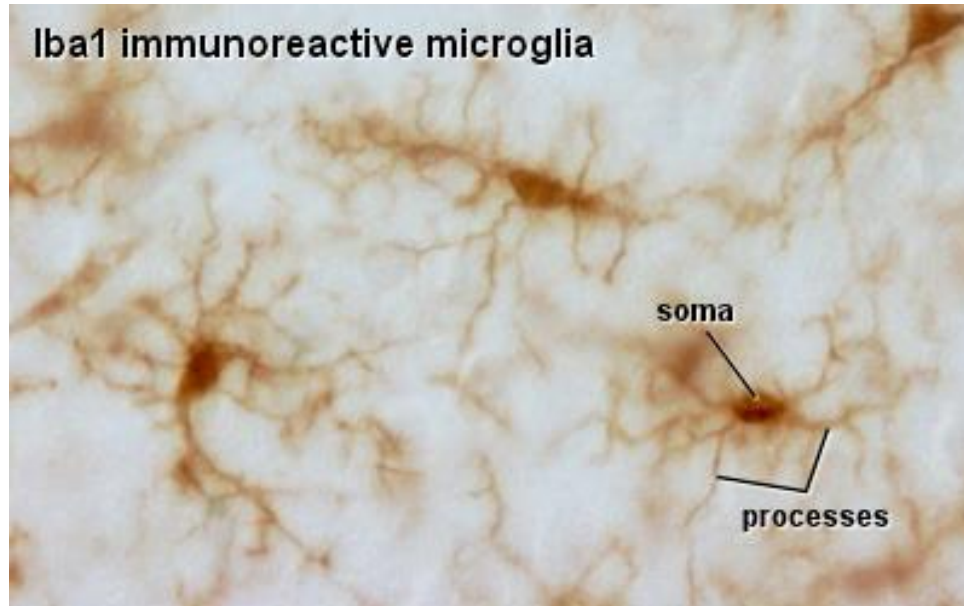
- Astrocytes (*astroglia*)
 - Star shaped cells
 - Processes often in contact with blood vessels
 - Mechanical and metabolic support
 - Scar forming cells of CNS

Neuroglia



- *Oligodendrocytes*
 - Form myelin sheath around axons in CNS
 - May surround several axons

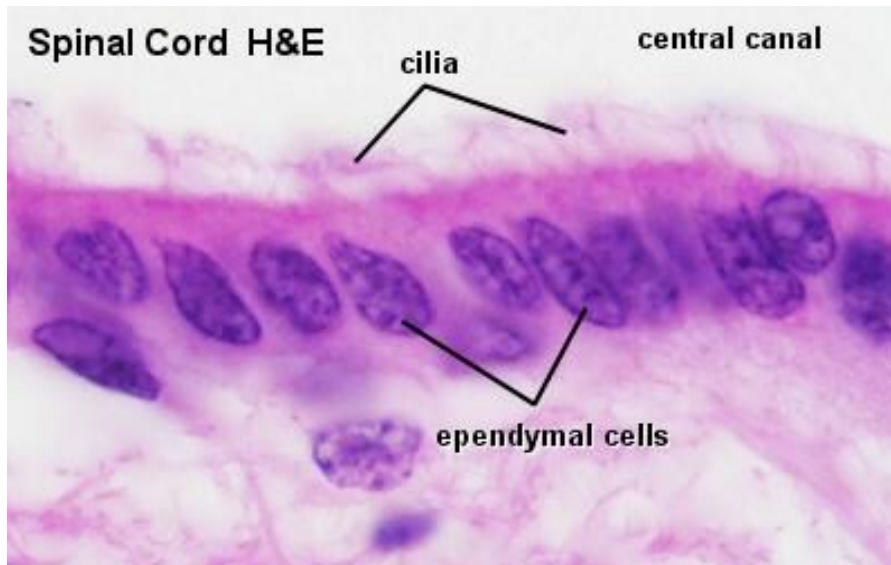
Neuroglia



Iba1 – Ionised calcium binding adaptor molecule-1

- *Microglia*
 - Same derivation as monocytes
 - They are phagocytic during tissue damage

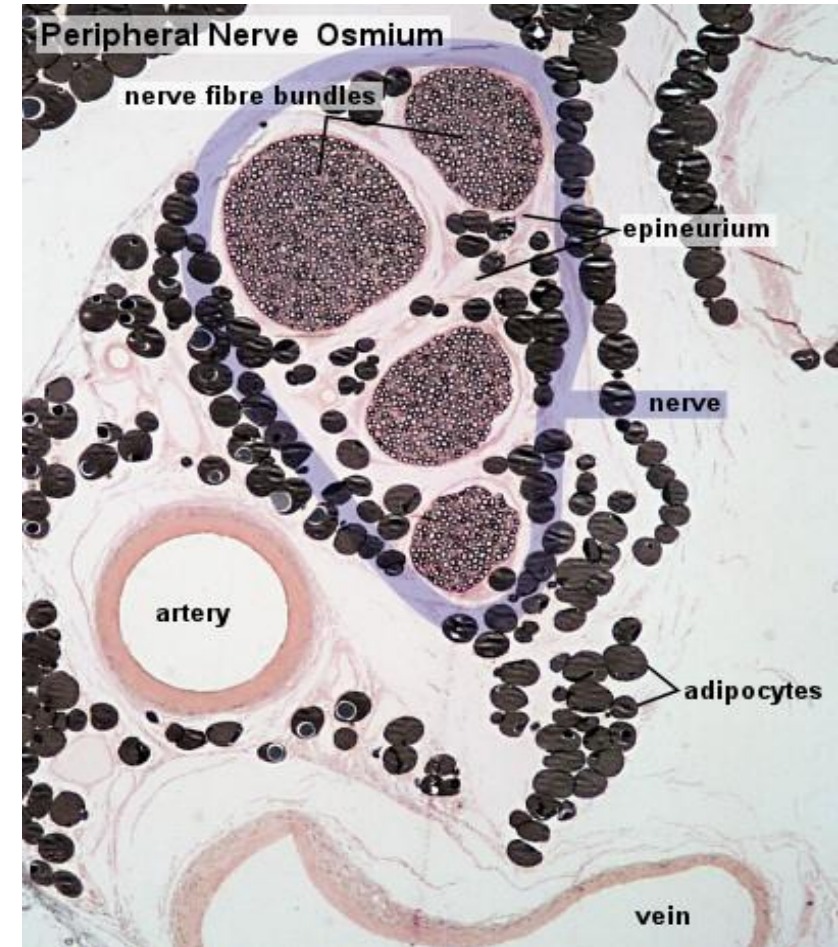
Neuroglia



- *Ependymal cells*
 - Line ventricles of brain and central canal of spinal cord
 - Often ciliated
 - Simple cuboidal or low columnar

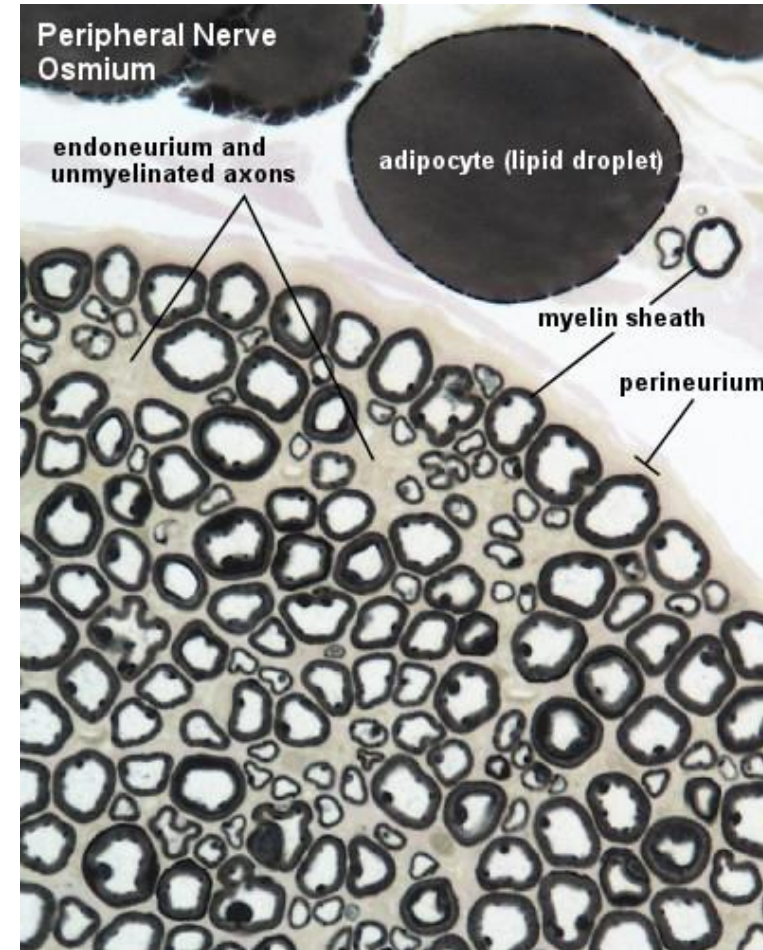
Peripheral Nervous System

- All nervous tissue outside brain
- It consists of:
 - groups of neurones (ganglion cells), called ganglia,
 - feltworks of nerve fibres, called plexuses, and
 - bundles of parallel nerve fibres that form the nerves and nerve roots.

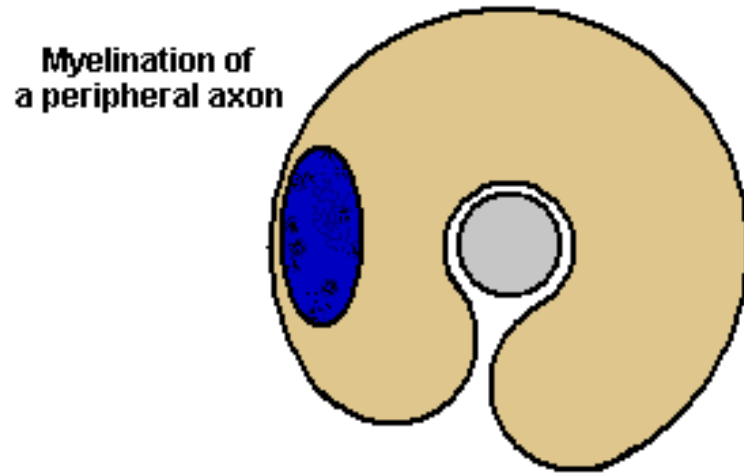


Peripheral Nervous System

- Nerve fibres, which originate from neurones within the CNS and pass out of the CNS in cranial and spinal nerves, are called **efferent or motor fibres**.
- Nerve fibres which originate from nerve cells outside the CNS but enter the CNS by way of the cranial or spinal nerves are called **afferent or sensory nerve fibres**.



Schwann cells

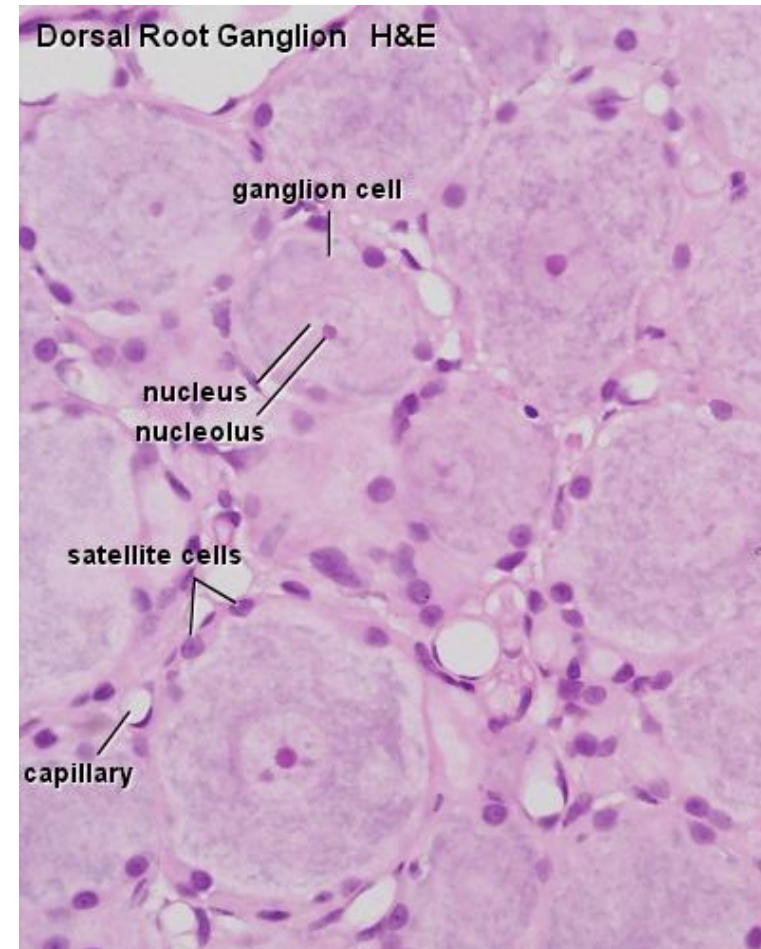


- Nerve fibre. Axon and its nerve sheath.
- Sheath of Schwann cells.
- Schwann cells form a sheath around one axon and surround this axon with several double layers (up to hundreds) of cell membrane.
- Insulates the axon, improves its ability to conduct.

Ganglion

- A ganglion is an aggregate of nerve cells (ganglion cells) outside the CNS
- Individual ganglion cells are surrounded by a layer of flattened satellite cells.

(ganglia – plural)



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