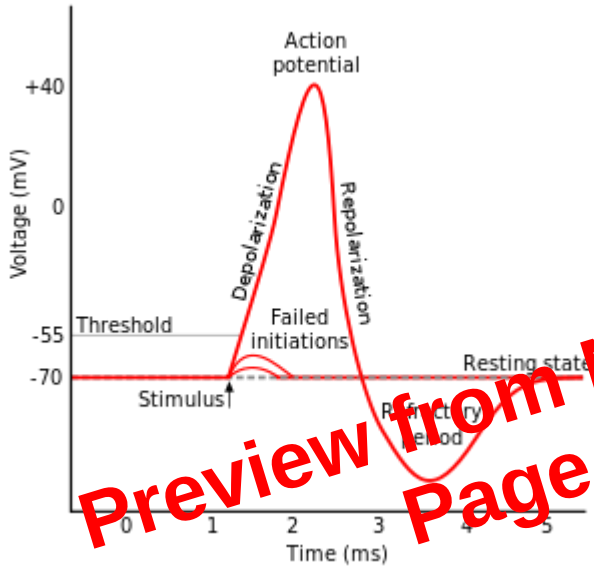
NMS Summary

Nerves

-Cell excitability

Membrane potential = E_m which is effected by multiple ions
$E_m \neq E_{ion}$ because there is an imbalance in electrical and chemical forces
Resting membrane potential of -70 mV is achieved by ion movement across the membrane (through carriers as not lipophilic)
The potential is achieved by ion distribution due to K^+ efflux and Na^+ influx and the potential also influences the movement of these ions
Different protein carriers:

- One for each different ion e.g Na+ K+
- Each with different gating mechanisms e.g. Leak channels, voltage gated channels, ligand channels



Initial stimulus causes an opening of voltage gated Na+ ion channels, this causes threshold to be reached so more open.

The Na+ ion channels open first for depolarisation and then K+ channels open during repolarisation.

Hyperpolarisation occurs during the refractory period where more K+ ions leave the axon than needed, E_m is returned by K+ leak channels

APs are all or nothing events

Conductance of Ions = Permeability of those Ions: This is proportional to the number of open channels that are open

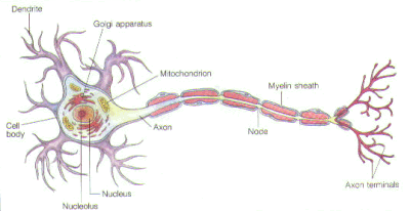
Refractory periods:

- Absolute - occurs during hyperpolarisation where no AP can be sent
- Relative – occurs after hyperpolarisation where it is returning to E_m

Saltatory conduction occurs in myelinated axons and is much faster than normal conduction as the depolarisation jumps between the nodes of ranvier.

-Neurones

The **Central nervous system** comprises of the brain and spinal cord and the **Peripheral nervous system** is the nerves that run away from the CNS. Neurones are specialised cells which have very high metabolic rate and so many mitochondria, they also possess **Nissl bodies** which are bundles of RER and Ribosomes for the high levels of protein synthesis.



The Myelin sheathes are produced by different cells depending on the location of the neurone. In CNS oligodendrocytes myelinate multiple axons in comparison to Schwann cells which can only

Muscles are innervated by motor neurones, there are 2 motor neurones involved in every contraction, the upper (in the brain) and lower (at the vertebral level) motor neurones. To change contractile force only certain slow twitch motor units are activated for smaller forces, the strength is determined by the number of fascicles innervated by the motor unit. If a great force is required then multiple fast twitch motor units are activated. Motor units are always recruited from **Weakest to Strongest.**

- Graded forces

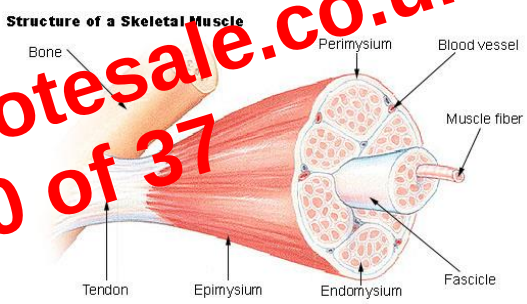
  - **Recruitment –** change in the number of motor units firing
  - **Rate coding –** alteration in the rate of firing for individual motor units
  - **Contractile force –** this is proportional to the number of cross bridges formed, the force produced by each cross bridge and the velocity of the cross bridge motion

Muscles have 4 properties:

- **Excitability** – they can respond to a stimulus
- **Contractility** – they are able to shorten with force
- **Extensibility** – they can be stretched beyond their normal resting length
- **Elasticity** – when stretched muscle cells can recoil to their normal resting length

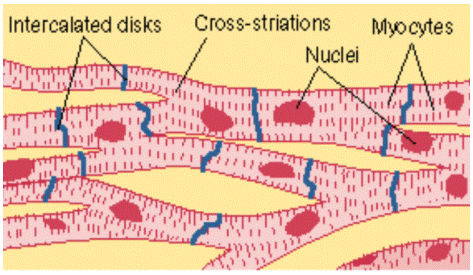
-Skeletal Muscle

- Produce movements by contracting
- Striated muscle due to the presence of sarcomeres and actin and myosin myofibrils in the sarcoplasm
- Is innervated by somatic nervous control and so we have conscious control
- Formed of long multinucleated cells with nuclei found in the periphery of the cell
- Found in limbs and other areas of voluntary control
- The endomysium, perimysium and epimysium are all examples of loose connective tissue which all allow for metabolic exchange



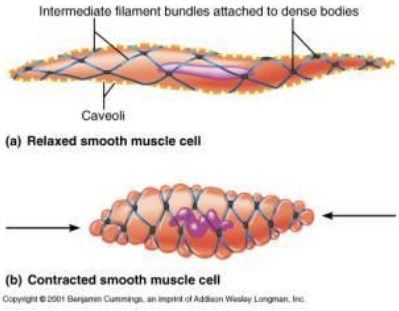
-Cardiac Muscle

- Striated muscle due to myofibrils in the muscle fibres
- Shorter branched cells with central nuclei that connect to adjacent cells by intercalated disks
- Purkinje fibres are located surrounding the cells which allow the electrical transmission
- Found in the heart
- Myogenic in its contractions however has parasympathetic and sympathetic innervation to speed up or slow down contraction rate



-Smooth Muscle

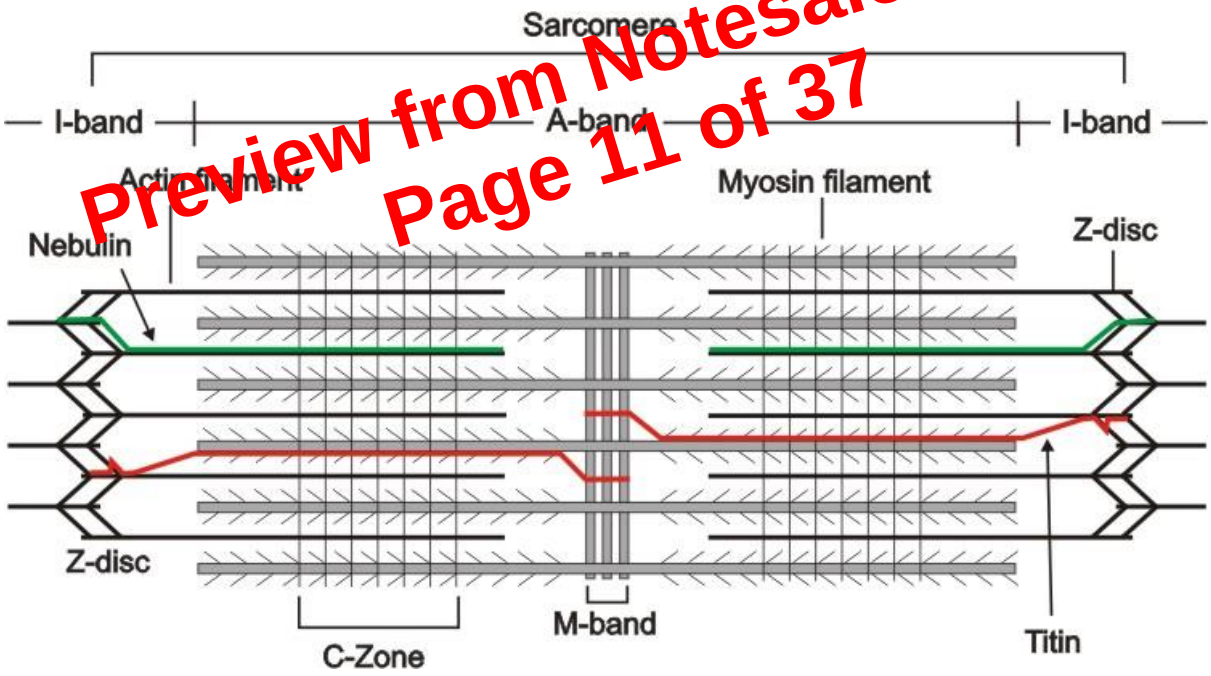
- Not striated muscles due to the absence of sarcomeres within smooth muscle
- Exist as small spindle shaped cells with small central nuclei, with intermediate filaments criss-crossing the cells which causes an overall contraction of the cells
- Innervated by parasympathetic and sympathetic nerves to increase or decrease motility
- Located in the blood vessels for Vaso-dilation and constriction and motility in the GIT



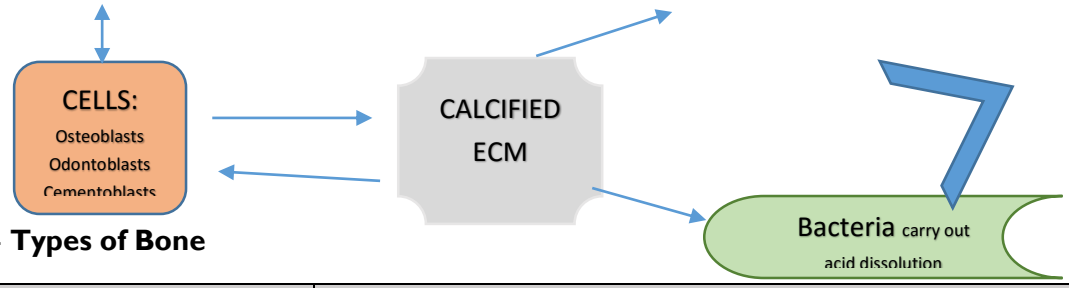
Blood supply is important for cardiac muscle as it has a high rate of contractility and if it dies then the rest of the body will not get any blood so will die and as cardiac muscle cannot regrow unlike other muscles.

Muscle contraction mechanism

1. Ca^{2+} is secreted from sarcoplasmic reticulum after depolarisation of the sarcolemma
2. Ca^{2+} binds to troponin which causes a conformational change, moving tropomyosin out of the myosin binding site
3. Myosin heads attach to actin at the binding site and form an actin myosin cross bridge
4. The myosin head moves forward in a power stroke contracting the sarcomere
5. ATP binds to the myosin filament and breaks the cross bridge and the head recocks



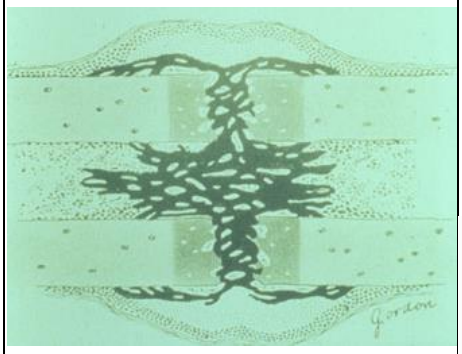
Type I Muscles	Type II Muscles
• Slow Twitch • Red • Slow, Weak contractions due to them having fewer contractile elements • Lots of Myoglobin	• Fast twitch • White • Fast, Powerful contractions • Small levels of myoglobin • Fewer mitochondria

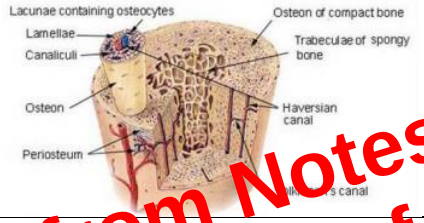


- Types of Bone

Woven Bone	Lamellar bone

• Immature bone found after trauma to the bone such as in fractures or in infants
• Random organisation of collagen
	• Mature bone found in adults
	• Successive layers of bone make up this bone (lamellae)
	• Can be categorised into:
	  • **trabecular**
	  - open and spongy bone with a network of trabeculae surrounding the bone marrow
	  - trabeculae are formed from irregular bone lamellae
	  - has no Haversian canals
	  - osteocytes are linked to blood sinusoids by canaliculi
	  • **Compact**
	  - Dense layers that are both circumferential and concentric
	  - Concentric lamellae are arranged around the Haversian canal to form structures known as osteons, which are the main structural bone units.
	  - Outermost layer of compact bone merge with dense cortical bone
	  - Innermost layer merges with trabecular bone





- Components of the bone matrix

Collagen (type I), proteoglycans, matrix proteins, growth factors, calcium hydroxyapatite crystals

- Ossification

Intramembranous ossification is the formation of usually flat bone from hyaline cartilage and fibrous membranes. The condensation of mesenchymal cells which differentiate into osteoblasts which group together in an ossification centre produces osteiod to form the extracellular matrix both inside and outside that eventually becomes mineralised, whilst this is happening there is continued differentiation of mesenchymal cells in addition to this, osteoblasts in the middle of the

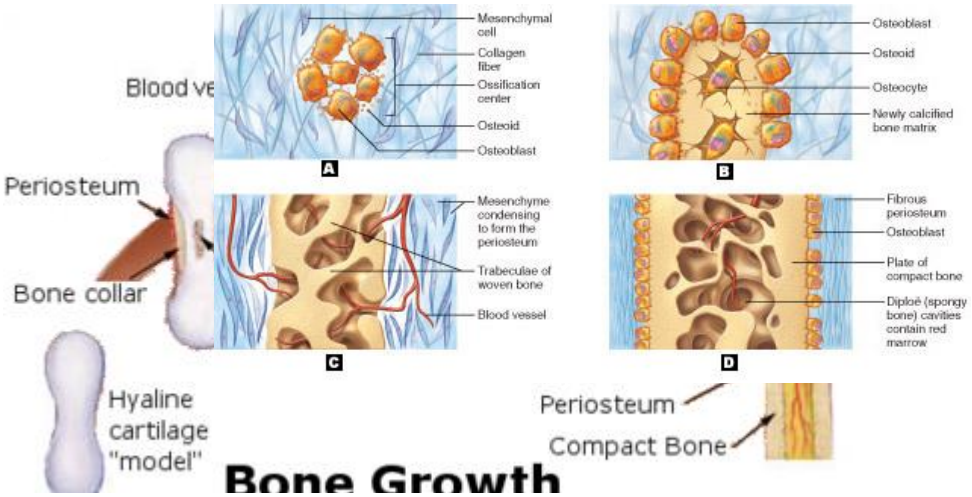


Figure 1 Endochondral ossification

	mineralised and the mineralised tissue	

Fluorosis occurs when excess fluoride is digested by people during tooth development and can lead to hypomineralisation or hypoplastic (incomplete development of) enamel. The mechanism of this is unsure but F has been shown to convert hydroxyapatite crystals into fluorapatite. Teeth appear to be mottled or simply have faint flecking in the enamel.

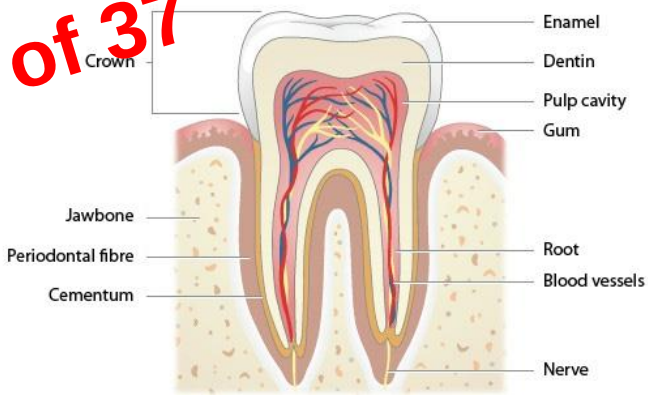
Osteoporosis is the reduction in bone mass of an individual leading to bone weakening due to bone loss exceeding new bone formation. This results in sufferers being more likely to have skeletal deformities and bone pains.

Osteogenesis imperfecta is caused by mutations in the gene coding for type I collagen. This results in similar symptoms to osteoporosis with bone loss, leading to the patient having bone imperfections and being more susceptible to fractures.

Dentinogenesis imperfecta there are 3 types of the disease: type I is associated with osteogenesis imperfecta, type II only affects the teeth and type III is an autosomal dominant disorder which affects a small population in America and causes a mutation in a gene which codes for two important proteins within dentine. Hypomineralised teeth have normal appearing enamel however it is very weak and is worn away easily and so people are left with little enamel at a young age. Hypoplastic teeth do not have sufficient enamel in the first place.m

Teeth

- **Enamel**



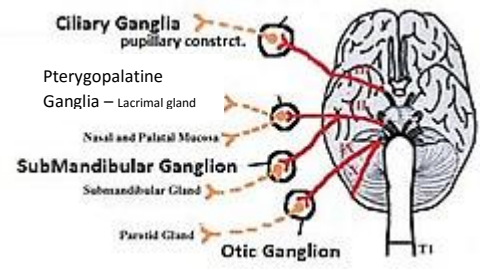
  - Has a prismatic structure (full of prisms) of hydroxyapatite crystals packed together – hydroxyapatite has the general structure $Ca_5(PO_4)_3(OH,F,Cl)$ with the last group being optional and each has different properties:
    - F improves resistance to caries
    - CO_3 makes more susceptible to caries
    Ion substitutions can occur if the ions are the same size
  - The hardest and most highly mineralised tissue in the body as 96% of the tissue is inorganic component
  - The organic component consists of proteins exclusive to dentine: amelogenins and non-amelogenins.
  - Avascular, Acellular, non-vital, insensitive and possesses no capacity for repair
  - Formed from **Ameloblasts** in a process where 1 crystal is formed by one cell, however these disappear on tooth eruption.
  - The mineralisation of enamel does not use matrix vesicles and only utilises heterogeneous nucleation, however the site of nucleation is not associated with collagen and the nucleation instead occurs within the matrix
  - Some nucleation is able to occur immediately when the matrix is secreted by the ameloblasts

the Adrenal medulla causing it to secrete adrenaline and noradrenaline (Epinephrine and Norepinephrine) into the blood stream. Adrenaline is particularly useful in the excitation of non-innervated tissues such as the smooth muscle of bronchioles.

- Parasympathetic nervous system

The parasympathetic nerve fibres originate from the brainstem and sacral region in the craniosacral outflow. Unlike the sympathetic nervous system the preganglionic fibres are long and they synapse in ganglia proximal to the target tissue.

Preganglionic Cell body	Nerve	Ganglion	Target
Edinger westphal	Occulomotor (CN III)	Ciliary ganglion	Pupillary constrictor
Superior salivatory	Facial (CN VII	Pterygopalatine	Nose and eyes
		submandibular	S/M and S/L glands
Inferior salivatory	Glossopharyngeal (CN IX)	Otic ganglion	Parotid gland
Dorsal nucleus of Vagus nerve	Vagus (CN X)	Cardiac, Pulmonary and Enteric	Heart, lungs, intestines
S2-S4	Pelvic splanchnic nerve	Renal, rectal, genitalia…	

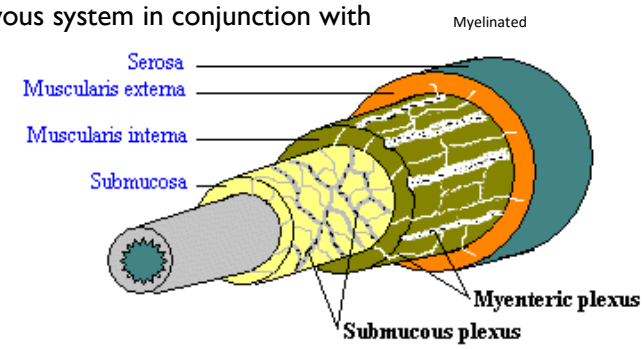


Afferent nerves of the parasympathetic nervous system travel to the cranial nerve sensory nuclei, through the dorsal root ganglion and to the dorsal horn.

As the visceral (the not consciously perceived information) and somatic fibres pass through the same spinal nerve, organ pain can often be misinterpreted by the patient as cutaneous pain from a different part of the body. Also the pain described from autonomic nerves is often diffuse and poorly localised.

- Enteric Nervous system

Makes up the 3rd division of the Autonomic Nervous system in conjunction with the sympathetic and parasympathetic nerves. It controls the gastrointestinal tracts contractions, blood flow and secretions and the plexuses that make up the ENS are intrinsic. Although the ENS can operate on its own it receives innervation from the central nervous system as well, with the level of integration varying at different locations, it interacts with the central nervous system by communicating with the sympathetic and parasympathetic nervous systems which in turn connect to the CNS. It is found within the wall of the GIT and comprises of 2 major plexuses:



- The **Submucosal Plexus**
  Located between the submucosa of the small intestine and the first ring of circular smooth muscle, found primarily in the intestines and some in the stomach
- The **Myenteric Plexus**
  Located between the outer longitudinal smooth muscle and the inner circular smooth muscle, of the whole gastrointestinal tract

The Myenteric plexus can carry out a reflex arc for peristalsis and segmentation by receiving afferent information from the mucosa of the gut when a bolus passes and causes distention in the gut wall