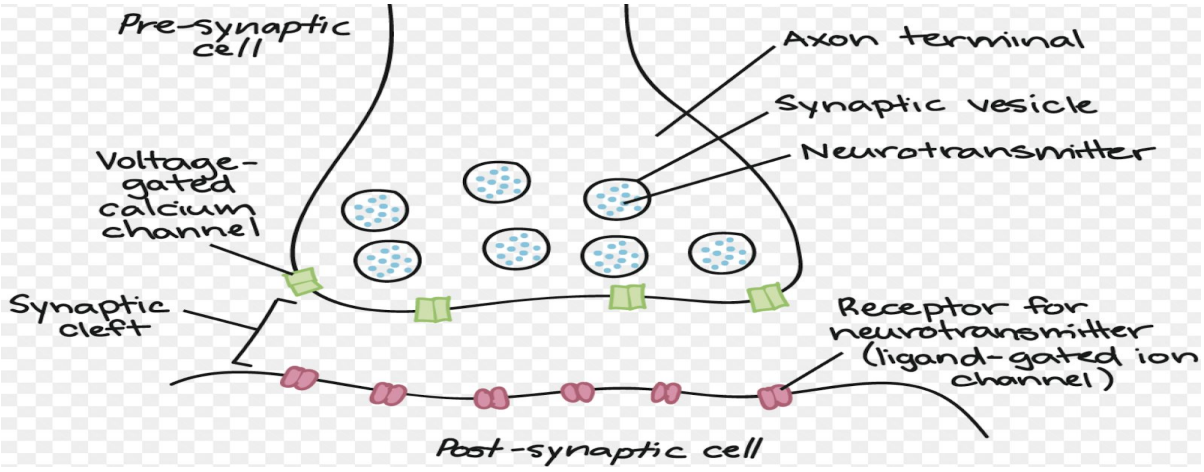
Russell Lee

Musculoskeletal System

- Dental Relevance of the musculoskeletal system
    - The Musculoskeletal system allows for contractions of muscles, having an understanding of this aids in diagnosis of patients with problems with chewing/closing/opening the jaw
    - Knowing how Local Anaesthetic (LA) takes effect

Neuromuscular Transmission

- Conduction sequence which results in Action potentials



    - Pre-synaptic depolarisation → AP travels down axon to the pre-synaptic terminal
    - AP activates the voltage gated calcium channels, opening them, allowing for an influx of calcium into the cytosol, increasing the concentration of calcium inside.
    - Calcium binds to synaptic vesicles which contain neurotransmitter, this allows the synaptic vesicles to undergo exocytosis by binding to the cell membrane and releasing the neurotransmitter into the synaptic cleft
    - NT (ACh) binds with postsynaptic receptors/Ligand gated channels (nicotinic acetylcholine receptors nAChR)
    - Bound receptors regulate ion conductances (e.g 3d conformational change in shape, resulting in an open pore, Na+ influx)
    - Transmitter is cleared,taken back into presynaptic terminal or by glia (ACh unbinds from receptors when there is a Ca2+ deficit). This step occurs by a myriad of processes
        - Diffusion
        - Enzymatic breakdown (acetylcholinesterase→ breaks it down into acetate and choline for reuptake)
        - Transport (re-uptake)

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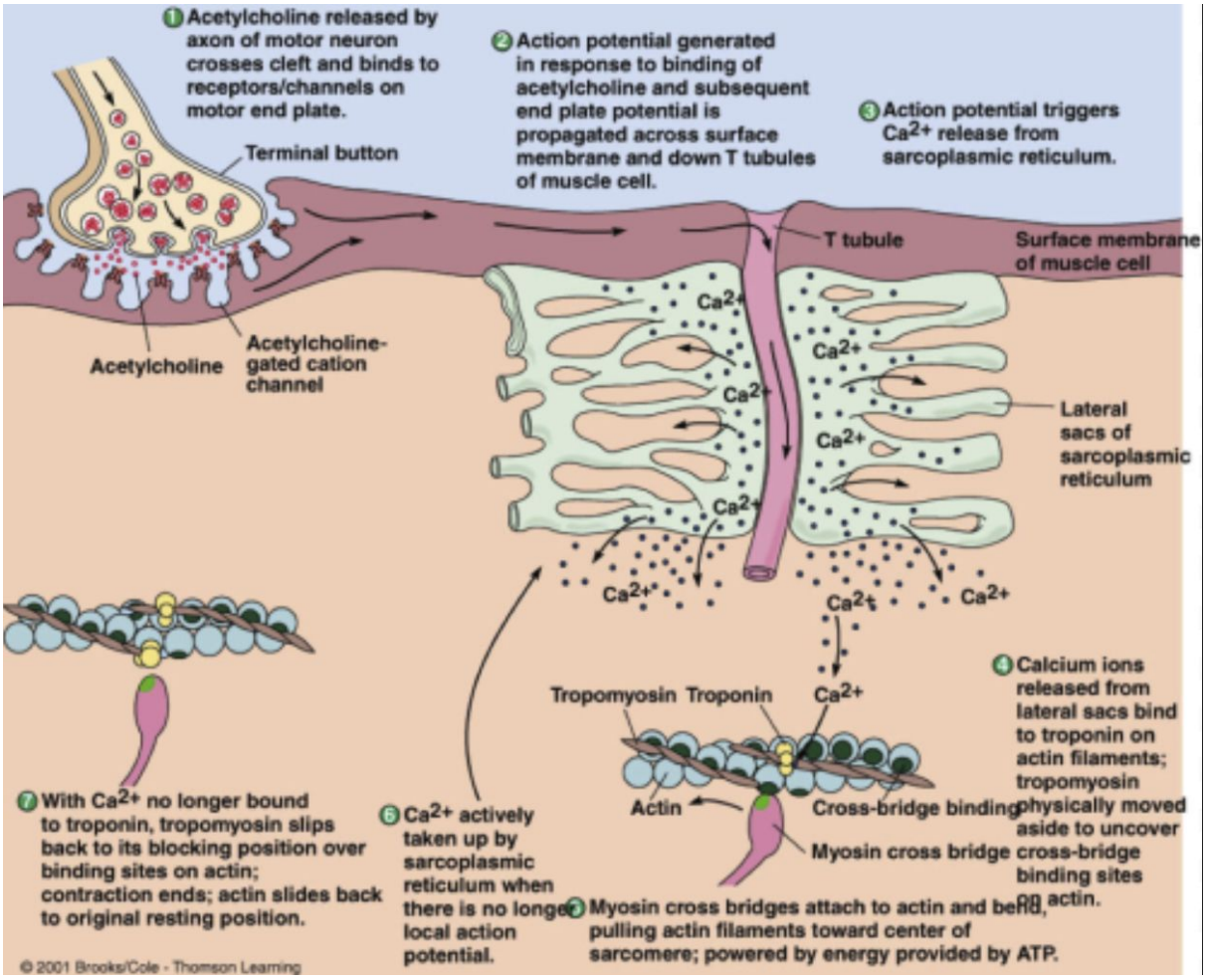
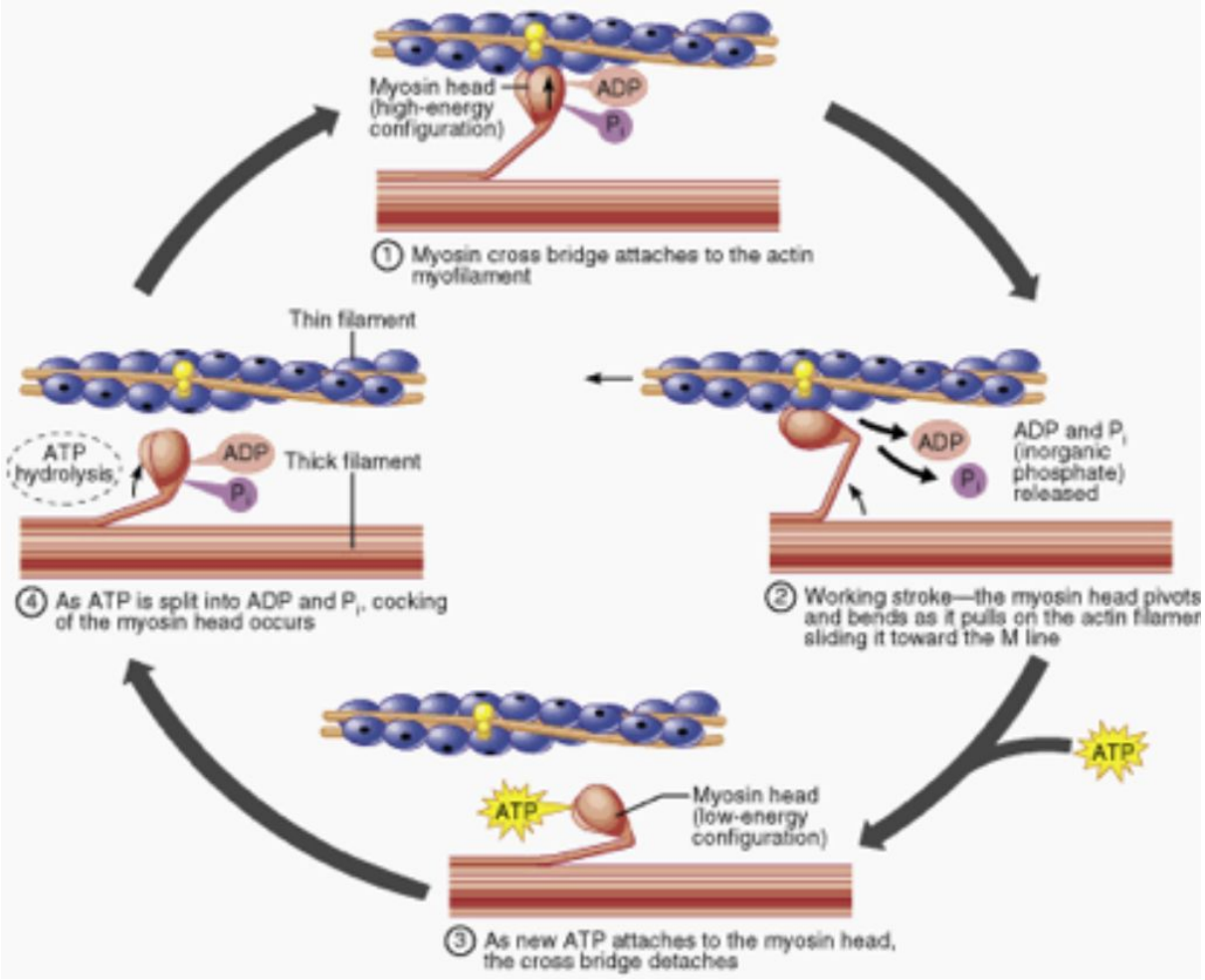
- Post-synaptic muscular characteristics
    - Only contain nicotinic acetylcholine receptors, but in high concentrations
        - Results in high safety factor (EPP - threshold)
    - Allows it to respond dependably to stimulus
    - End plate potential experienced by muscle → An above threshold depolarisation triggers an AP (usually 50mv or more in magnitude)

- Post-synaptic muscular response/Excitation-contraction coupling



    - ACh released by pre-synaptic terminal into synaptic cleft
    - ACh Binds to nAChR at the end plate, resulting in an EPP
    - AP is generated and travels along the surface of membrane and down t-tubules of muscle cell
    - Action potential causes Dihydropyradine receptors on the T-tubule interact with ryanodine/foot receptors on the sarcoplasmic reticulum, Causing voltage gated calcium channels to open, releasing calcium into the cytosol
    - Before calcium binds to troponin, ATP on the myosin motorhead splits into inorganic phosphate and ADP, producing energy and resetting/cocking the motor head.
    - Calcium ions bind to troponin on actin filaments, causing a conformational shape change in the molecule as tropomyosin shifts, unmasking the binding sites

- Actin and myosin motorhead bind, forming a cross bridge
- Upon formation of cross bridge, motorhead undergoes powerstroke, consuming energy. Inorganic phosphate released during powerstroke and ADP released at the end of powerstroke
- New ATP molecule attaches to myosin motorhead, This allows actin and myosin to unbind
- Cycle repeats



- Ending muscular contractions
  - Ca2+ is pumped into SR from cytosol via CaATPase pump
  - Ca2+ levels in cytosol fall, calcium unbinds from troponin
  - Tropomyosin returns to original state and mask binding sites

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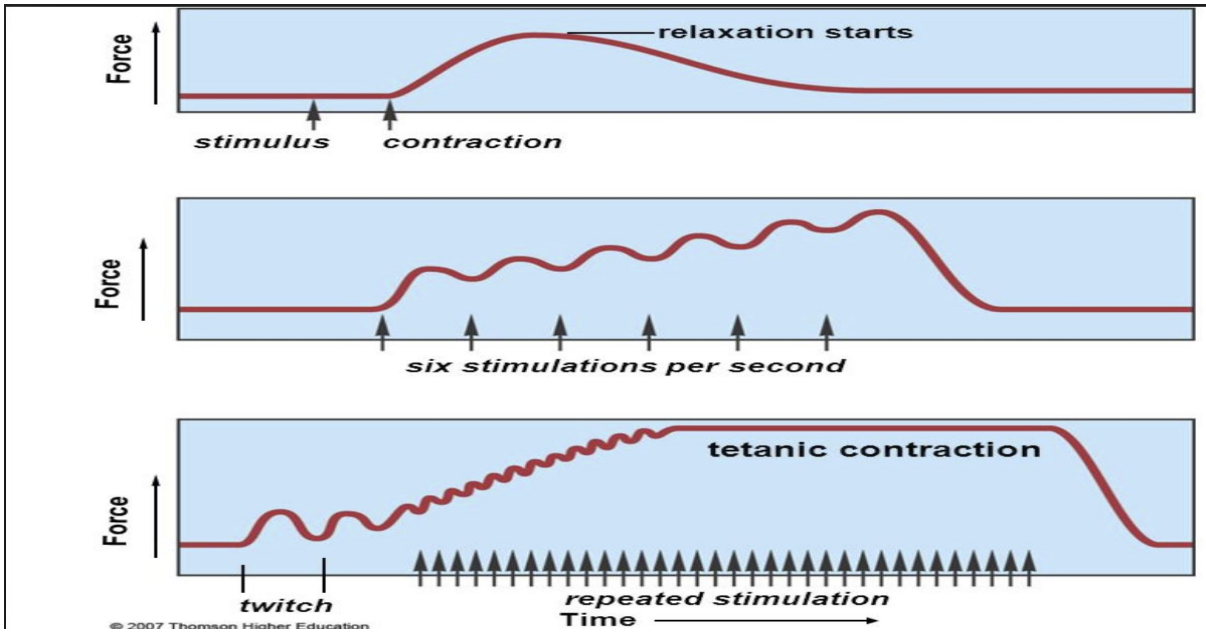
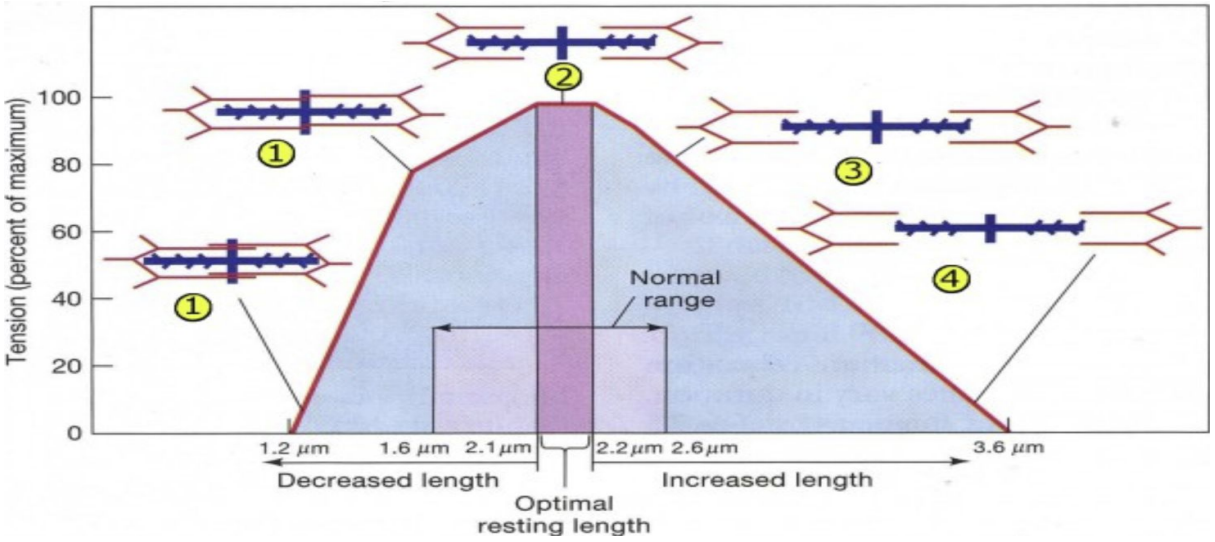
- Twitch Summation and Tetanus
  - 

  - Twitch Summation
    - If muscle fiber is restimulated before it is completely relaxed, second twitch is an addition to it, resulting in summation, resulting in greater force
  - Tetanus
    - Muscle fiber undergoes rapid stimulation, such that no time opportunity for relaxation, a maximal sustained contraction is obtained, known as tetanus
    - prolonged contraction without relaxation
    - Muscle eventually undergoes fatigue at which it has to relax

- Length-Tension Relationship

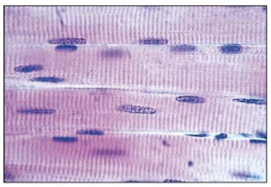
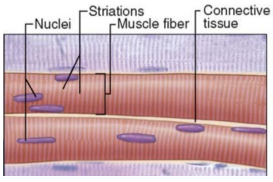
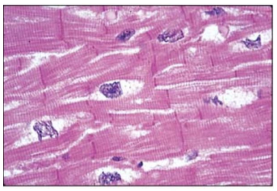
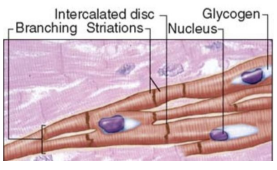
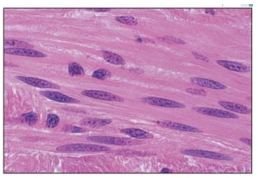


  - Greatest force can be generated when muscle is at a length with an optimal amount of overlap of actin and myosin filaments

- When there is excessive overlap of actin and myosin, no more space for titin to contract, no space for myosin to pull z disk any closer, results in no contraction when sarcomere is excessively short due to structural impingement
- When there is a minor overlap of actin and actin, Some of the motorheads are blocked from contracting, resulting in sub-optimal contractile force
- When There is little overlap, fewer myosin heads can interact with actin as they get further apart from the M line, resulting in fewer number of power-strokes occuring causing less force
- When there is too little overlap, no myosin heads can interact with actin, resulting in no power-strokes being able to occur, hence no contractile force/tension

Muscle

- The 3 types of muscles

	Skeletal Muscle	**Cardiac Muscle**	**Smooth Muscle**
Nuclei?	Multinucleated, 2-4	1 or 2	1
Striations?	Striated	Striated	No striations
Intercalated Disks?	No IC disk	Contain IC disk	No IC disk
Voluntary?	Voluntary	Involuntary	involuntary
Shape?	Fibrilar  	Fibrilar  	Spindle/fusiform shape  

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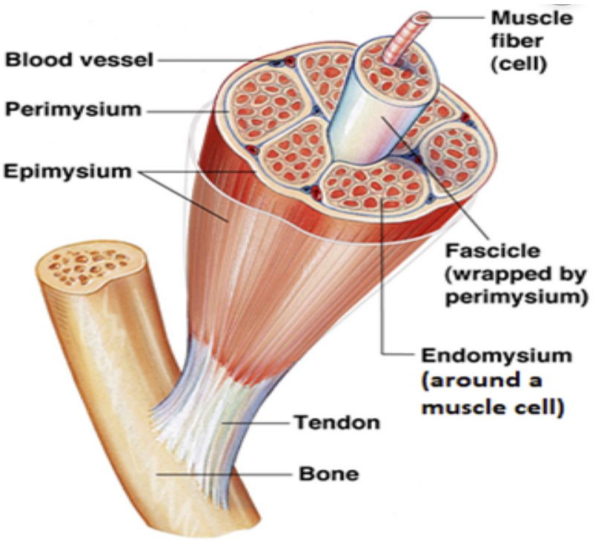
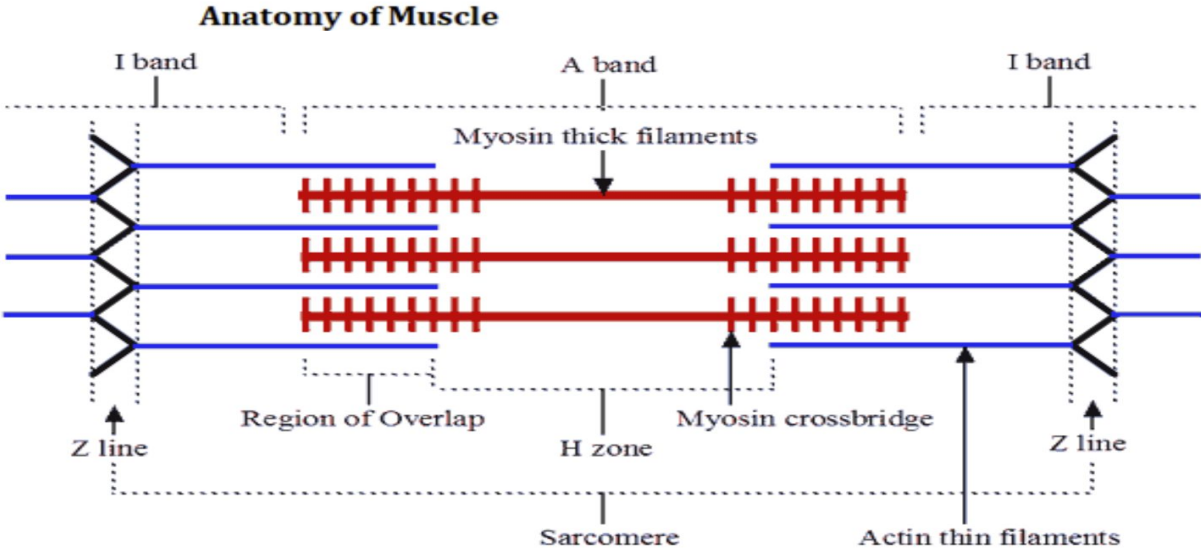
- Skeletal Muscle
    - 1 muscle fibre → 1 myocyte
    - Made up of bundles of myofibrils, myofibrils made of myofilaments
    - Muscle fibre encapsulated by **ENDOMYSIUM**
    - A fascicle, which is a bundle of muscle fibres is encapsulated by **PERIMYSIUM**
    - Multiple fascicles are encapsulated by **EPIMYSIUM**
        - These are protective layers of CT that help to dissipate force/tension evenly amongst the muscle → passive tensile force transmission

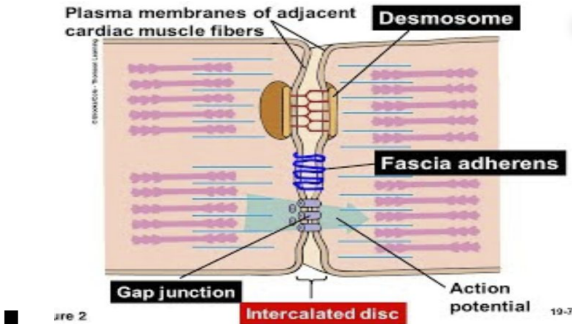




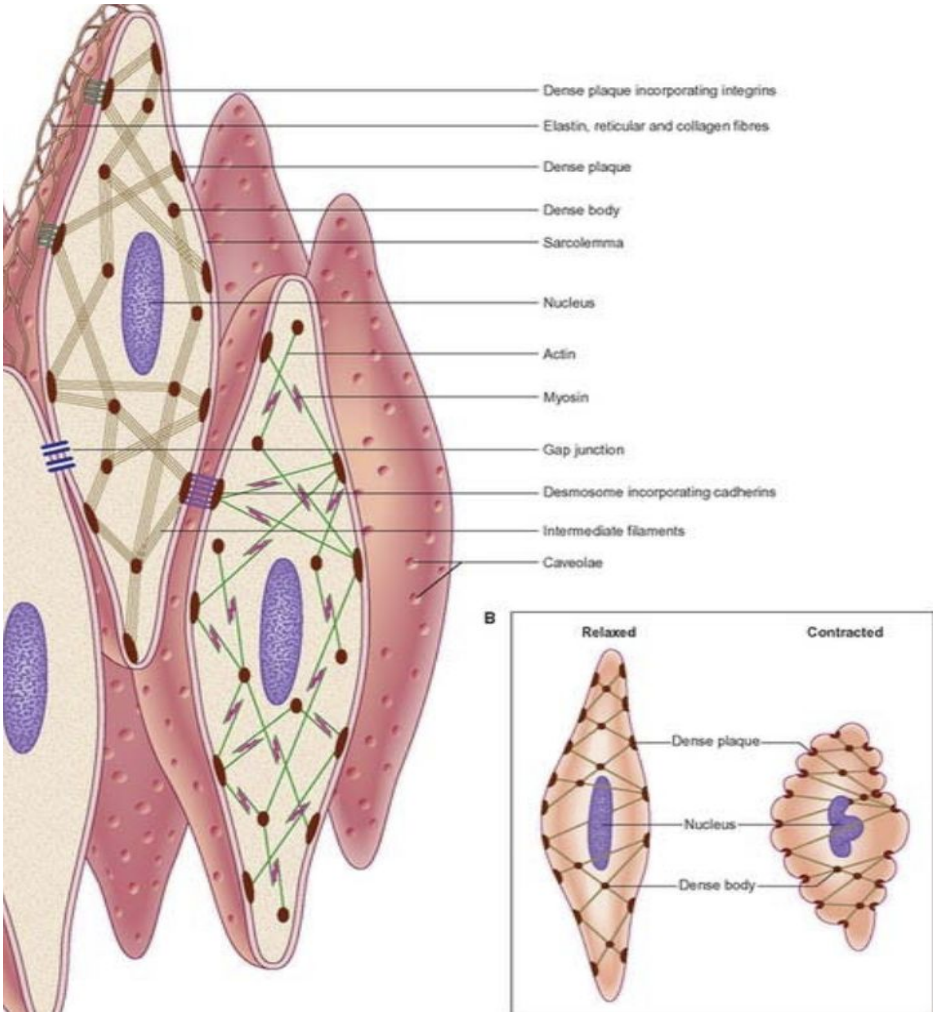
    - Striations
        - Are due to the A Band and I band
            - A band = dark zone
            - I band = light zone

- Cardiac Muscle
    - Intercalated disks
        - Consists of
            - Desmosomes→ strong adhesion

- Fascia adherens → strong adhesion + actin anchoring sites
- Gap Junctions → quick communication between cardio myocytes and allow them to function in syncytium via electrical transmission



- Smooth muscle
  - Actin and myosin bundles not organized in a regular fashion like other myocytes
  - Actin attached to dense bodies
  - Myosin attached between actins



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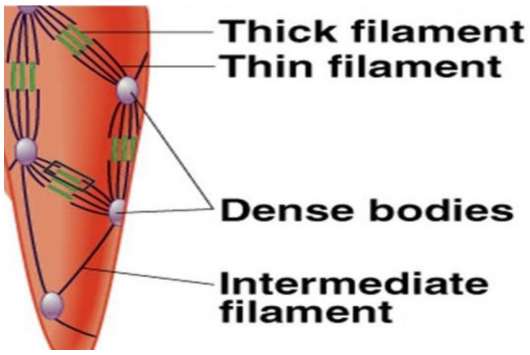
- 
Thick filament
Thin filament
Dense bodies
Intermediate filament