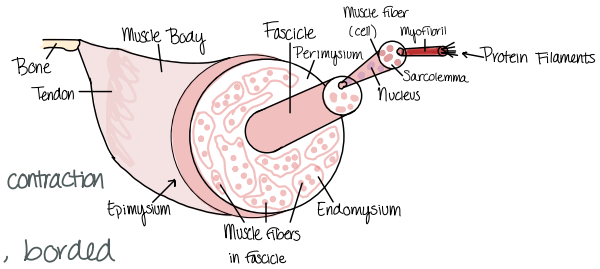
Skeletal Muscle Structure

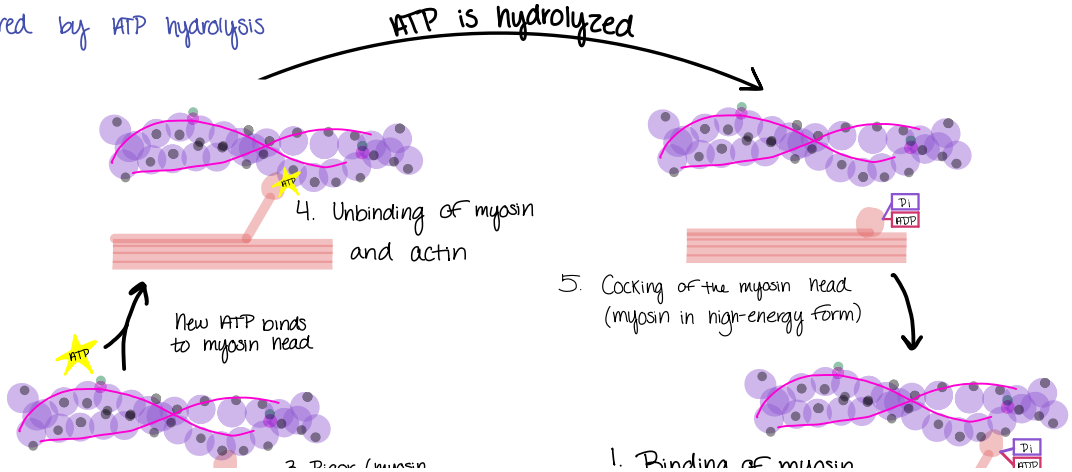
- Skeletal muscles are connected to at least two bones by tendons (cords of elastic connective tissue)
- Muscle fibers have many nuclei b/c they are formed during embryonic life from fusion of cells

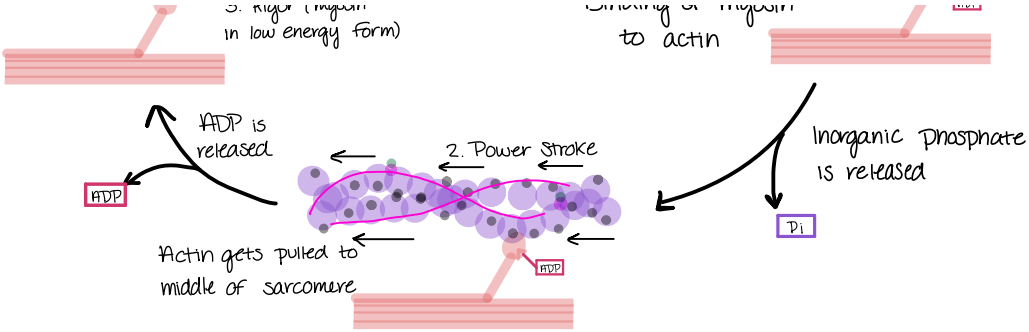


- Sarcoplasmic reticulum: surrounds each myofibers → activates contraction
- Sarcomere: makes up myofibrils, repeat over + over, borded by Z lines; M lines connect thick filaments (both run perpendicular to the long axis
  - ↳ filaments are made up of actin (thin) + myosin (thick) proteins
    - two regulatory proteins that enable contraction: tropomyosin → blocks myosin-binding sites in muscles at rest; troponin → 3-protein complex
    - the head of the myosin molecule actively generates mechanical force → actin-binding site + ATPase binding site (enzymatic activity + hydrolyzes ATP)

Mechanism of Force

- The sliding-filament model: contractions are caused when the I bands and H zones shorten → I band shortening occurs when they slide past thick filaments, deeper into the H zone (decreasing its width) → A bands move closer together (decreasing I band width) → Z lines move closer + sarcomere is shortened
- Crossbridge cycle: what drives thick+thin filaments past one another → oscillating motion of myosin crossbridges, powered by ATP hydrolysis





- excitation-contraction coupling: muscle cell recieves input from motor neuron → cell depolarizes + fires action potential to stimulate contraction
- neuromuscular junction: motor neuron's terminal boutons fan out in the sarcolemma, acetylcholine is released, end-plate potential is produced
  - ↳ if an action potential occurs in a motor neuron, it's always followed by an AP in the muscle cell it innervates

Skeletal Muscle Contraction

- Twitch: an AP triggers contraction in all the muscle cells connected to a motor neuron (motor unit)
  - latent period → delay between AP and contraction; contraction phase → muscular tension/force peaks, cytosolic calcium levels increase; relaxation phase → longest, cytosolic calcium levels and # of active crossbridges decrease
- Isotonic contraction: muscle generates constant tension (concentric → shortening of the muscle, eccentric → lengthening - lowering an object)
- Isometric contraction: muscle creates tension but maintains the same length b/c the load is greater than the force exerted by the muscle
- Contractile component → sarcomeres, series elastic component → parts of a muscle that don't actively generate force, but passively transmit force to the ends of muscles
- Factors affecting force
  - Frequency of stimulation: as frequency increases, muscles move from twitch contractions
    - Treppe: independent twitches follow each other closely → peak tension rises until it reaches constant
    - summation: repeated stimulation, twitches are superimposed to yield a force greater than a single twitch

- tetanus: highest frequencies, in unfused tetanus (incomplete), brief periods of relaxation occur; fused tetanus complete

- Fiber diameter: a muscle w/ more sarcomeres arranged in parallel can generate more force → fiber's diameter ∝ force generating capacity ∝ cross-sectional area

- changes in fiber length: optimum length, when its not in that range, force-generating capacity decreases

- Regulation of Force

- recruitment: an increase in # of active motor units

- size principle: correspondence between size of motor units + order of recruitment

- velocity of shortening: the rate of change of the distance shortened

Skeletal Muscle Metabolism

- to ensure steady supply of ATP, muscles use creatine phosphate → donates phosphate to ADP → ATP

- fast myosin (in fast-twitch fibers) hydrolyzes ATP fast + has a fast ATPase rate → can complete more crossbridge cycles / second → sarcomeres shorten faster

- Glycolytic Fibers: high cytosolic concentrations of glycolytic enzymes

- Oxidative Fibers: rich in mitochondria + high capacity for producing ATP via oxidative phosphorylation → generally smaller diameter + lots of capillaries, contain myoglobin (oxygen-binding protein)

Control of Skeletal Muscles

- muscle activity across joints

- origin → where muscle attaches to stationary bone; insertion → attatchment to moveable bone

- muscle spindles: detect muscle length, consist of intrafusal fibers

- Golgi tendon organs: connective tissue intertwined with collagen fibers of tendons, detect muscle tension

- Smooth muscle

- found in internal organs, blood vessels + stuctures not under voluntary control

- thin + thick filaments, generates force through the crossbridge cycle

↳ dense bodies: points of attachment between filaments + connective tissue inside cells

- regulated by autonomic neurons. Synchronized activity is promoted by Gap Junctions → allow ions to move between cells + electrical signals spread to neighboring cells

- Cardiac Muscle

- connected by gap junctions → action potentials travel throughout the entire cell network
- summation cannot occur so the heart can relax + fill w/ blood