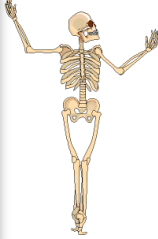


Chapter 47

Muscles and Bones



Animal Locomotion

What are the advantages of locomotion?

sessile

motile



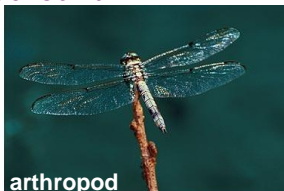
Lots of ways to get around...



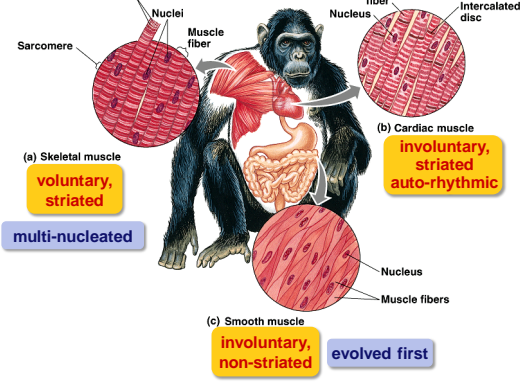
Lots of ways to get around...

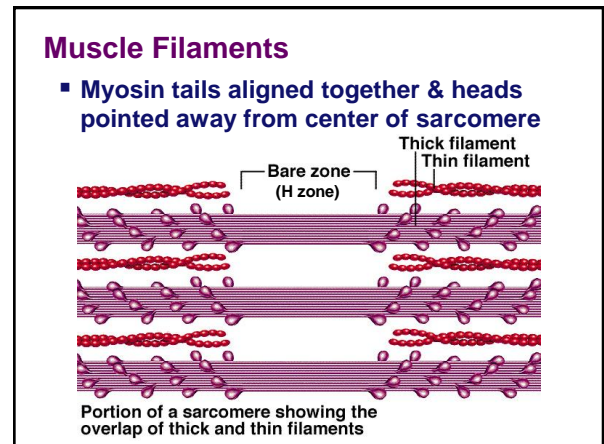
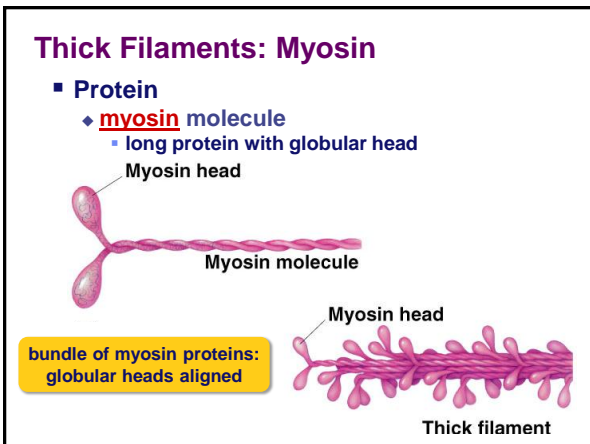
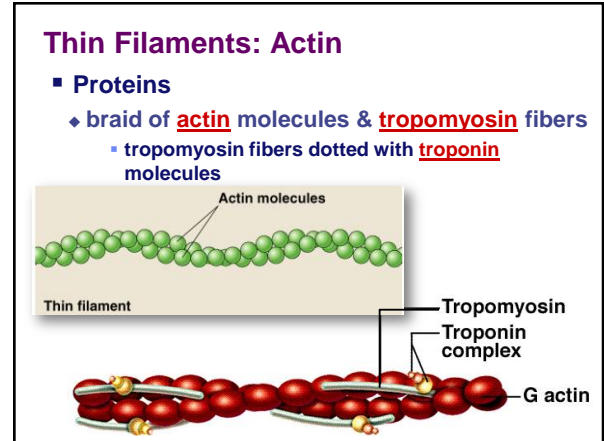
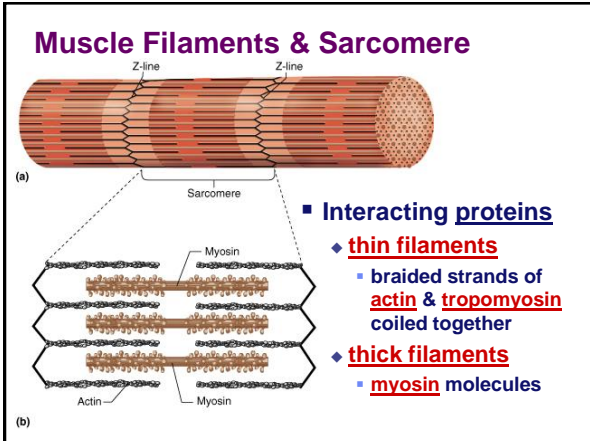
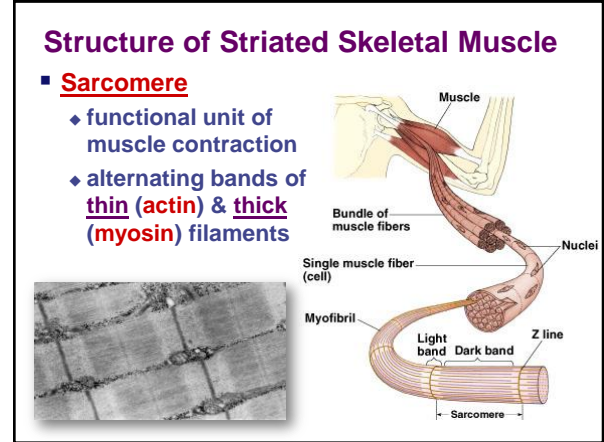
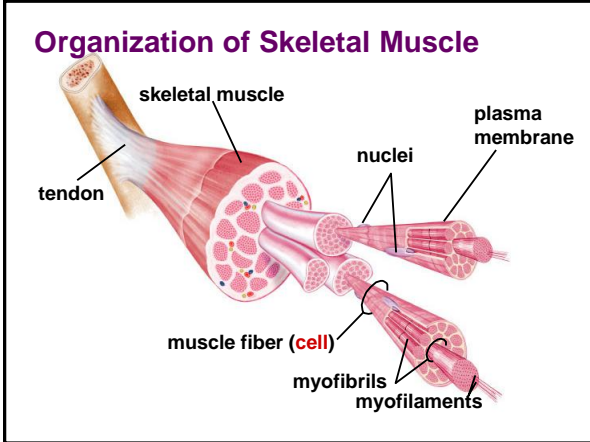


Lots of ways to get around...



Muscle





Interaction of Muscle Filaments

- Cross bridges**
 - connections formed between **myosin heads** (thick filaments) & **actin** (thin filaments)
 - cause the muscle to shorten (contract)

Where is ATP needed?

Shortening Sarcomere

- Myosin pulls actin chain along toward center of sarcomere
- Sarcomere **shortens** (Z lines move closer together)
- Muscle contracts
 - energy from:
 - ATP**
 - glycogen**

Closer Look at Muscle Cell

Muscle Cell Organelles

- Sarcoplasm**
 - muscle cell **cytoplasm**
 - contains many mitochondria
- Sarcoplasmic reticulum (SR)**
 - organelle similar to **ER**
 - network of tubes
 - stores Ca²⁺**
 - Ca²⁺ released from SR through channels
 - Ca²⁺ pumps** then restore Ca²⁺ to SR
 - remove Ca²⁺ from cytosol
 - pumps use ATP

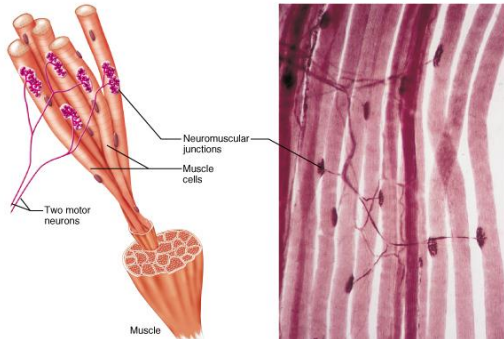
Muscle at Rest

- Interacting proteins**
 - at rest, **tropomyosin** molecules hold **tropomyosin** fibers so that they cover the **myosin-binding sites** on **actin**

(a) Myosin binding sites blocked; muscle cannot contract

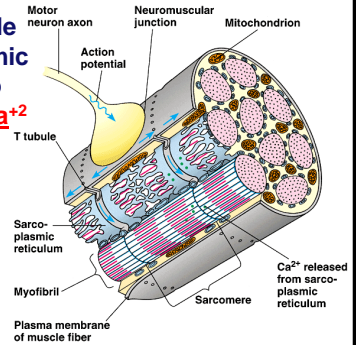
The Trigger: Motor Neurons

- Motor neuron triggers muscle contraction



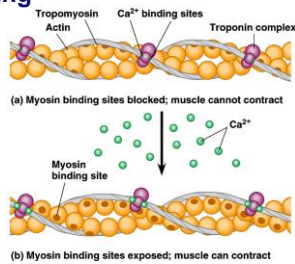
The Trigger: Motor Neurons

- Nerve signal stimulates muscle cell's sarcoplasmic reticulum (SR) to release stored Ca^{+2}



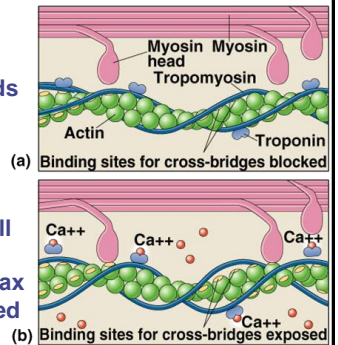
Ca²⁺ Triggers Muscle Action

- At rest, **tropomyosin** blocks myosin-binding sites on actin
- Ca²⁺ binds to **troponin complex**
 - shape change causes movement of tropomyosin-troponin complex
 - exposes myosin-binding sites on actin

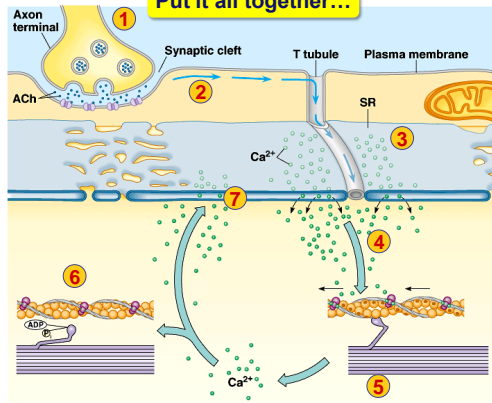


How Ca²⁺ Controls Muscle

- Sliding filament model
 - exposed actin binds to myosin
 - fibers slide past each other
 - ratchet system
 - shorten muscle cell
 - muscle contraction
 - muscle doesn't relax until Ca²⁺ is pumped back into SR
 - requires ATP



Put it all together...



How it all works...

- Action potential causes **Ca²⁺** release from SR
 - Ca²⁺ binds to **troponin**
- Troponin moves **tropomyosin** uncovering **myosin binding site** on actin
- Myosin binds **actin**
 - uses **ATP** to "ratchet" each time
 - releases, "unratchets" & binds to next actin
- Myosin pulls actin chain along
- Sarcomere **shortens**
 - Z lines move closer together
- Whole fiber shortens → **contraction!**
- Ca²⁺ pumps restore Ca²⁺ to SR → **relaxation!**
 - pumps use **ATP**

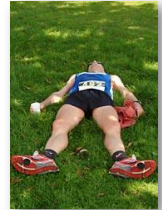
Fast v. Slow Twitch Muscles

- **Slow twitch muscle fibers**
 - ◆ contract slowly, but keep going for a long time
 - more mitochondria for aerobic respiration
 - less SR → Ca²⁺ remains in cytosol longer
 - ◆ long distance runner
 - ◆ “dark” meat = more blood vessels
- **Fast twitch muscle fibers**
 - ◆ contract quickly, but get tired rapidly
 - store more glycogen for anaerobic respiration
 - ◆ sprinter
 - ◆ “white” meat



Muscle Limits

- **Muscle fatigue**
 - ◆ lack of sugar
 - lack of ATP to restore Ca²⁺ gradient
 - ◆ low O₂
 - lactic acid drops pH which interferes with protein function
 - ◆ synaptic fatigue
 - loss of acetylcholine
- **Muscle cramps**
 - ◆ build up of lactic acid
 - ◆ ATP depletion
 - ◆ ion imbalance
 - massage or stretching increases circulation



Diseases of Muscle Tissue

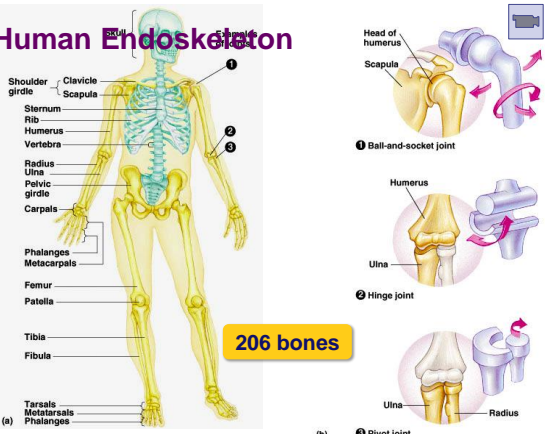
- **ALS**
 - ◆ amyotrophic lateral sclerosis
 - ◆ Lou Gehrig’s disease
 - ◆ motor neurons degenerate
- **Myasthenia gravis**
 - ◆ auto-immune
 - ◆ antibodies to acetylcholine receptors



Rigor Mortis

- **So why are dead people “stiffs”?**
 - ◆ no life, no breathing
 - ◆ no breathing, no O₂
 - ◆ no O₂, no aerobic respiration
 - ◆ no aerobic respiration, no ATP
 - ◆ no ATP, no Ca²⁺ pumps
 - ◆ Ca²⁺ remains in cytoplasm
 - ◆ muscle fibers continually contract
 - tetany or rigor mortis
 - ◆ eventually tissues breakdown & relax
 - measure of time of death

Human Endoskeleton



Muscles and Movement

- **Muscles do work by contracting**
 - ◆ skeletal muscles come in antagonistic pairs
 - flexor vs. extensor
 - ◆ contracting = shortening
 - move skeletal parts
 - ◆ tendons
 - connect bone to muscle
 - ◆ ligaments
 - connect bone to bone

