Muscles & Muscle Tissue

Chapter 6

I. Overview of Muscle

A. MUSCLE TYPES

- SKELETAL: striated, voluntary
- CARDIAC: only in heart
  - involuntary
  - striated
- SMOOTH: walls of organs
  - involuntary
  - nonstriated

All Muscle Cells are

- Elongated
- Can Shorten & Contract
- Prefixes
  - Myo- & Mys – muscle
  - Sarco - flesh

1. Skeletal Muscle

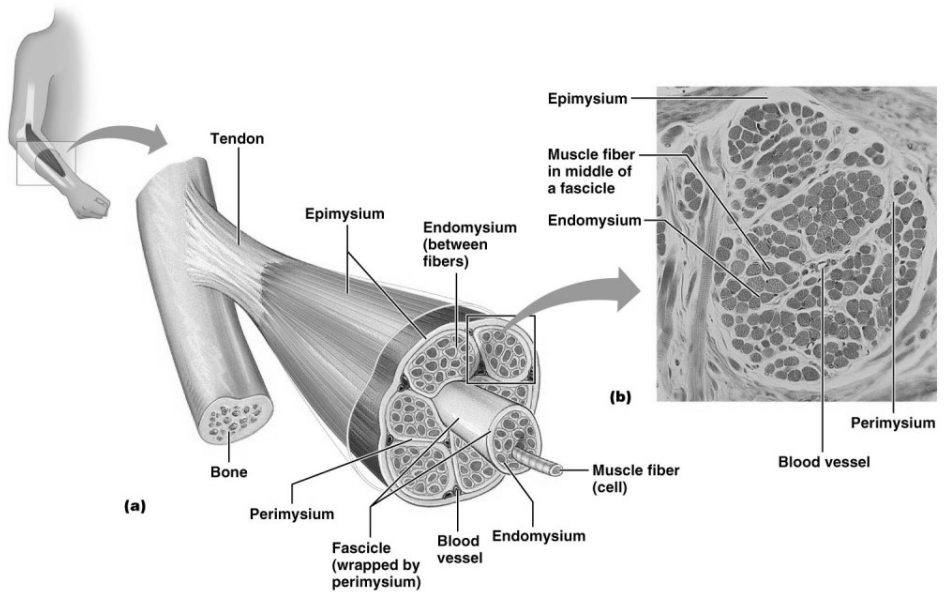
- Skeletal muscle fibers: packaged into organs called skeletal muscles that attach to skeleton
- Fibers are cigar-shaped, multinucleate cells, up to 1ft in length
- Striated: fibers appear to be striped
- Voluntary: conscious control

- Can be activated by reflexes
- Tires easily
- Held together by connective tissue

a. Gross Anatomy

- **Muscle: organ (fig. 6.1 p.164)**
  - **consists of hundreds to thousands of muscle cells**
  - **covered by epimysium (CT)**
    - **binds muscles into functional groups**
    - **Blend into strong, cordlike tendons or into sheetlike sponeuroses**
  - **blood vessels & nerve fibers**

- **fascicle: portion of muscle**
  - **bundle of muscle cells**
  - **surrounded by perimysium (CT)**



2. Smooth Muscle

- No striations, involuntary
- Found in walls of hollow organs
- Spindle shaped, single nucleus
- Arranged in two sheets or layers
- Figure 6.2a p. 165
- Alternately contract & relax
- Food through digestive system

3. Cardiac Muscle

- Found only in heart
- Striated, involuntary
- Arranged in spiral or figure 8-shaped bundes
- Fig. 6.2b p. 165
- Branching cells joined by intercalated discs that allow for communication

B. Muscle Functions

1. Producing Movement

- Mobility of body
- Forces fluids & other substances through internal body channels

2. Maintaining Posture

- Skeletal muscles maintain an erect or seated posture despite gravity

3. Stabilizing Joints

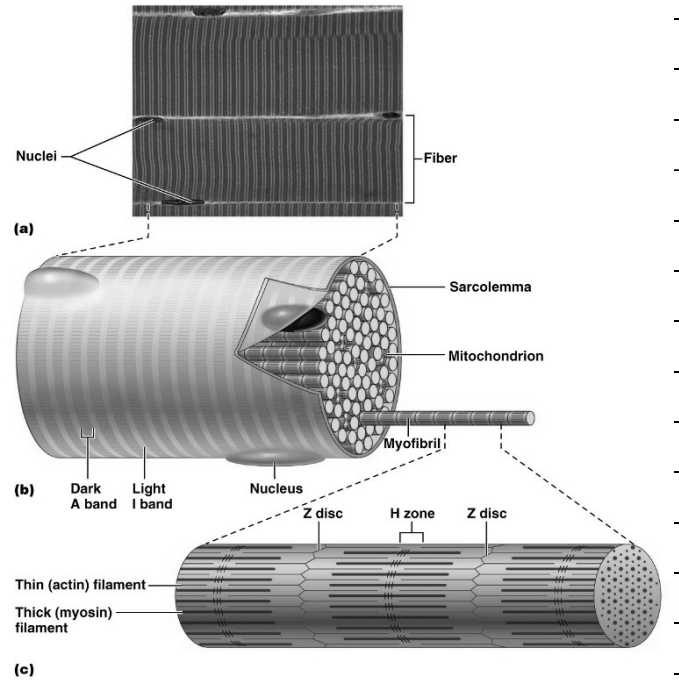
- As skeletal muscles pull on bones to cause movement, they also stabilize joints of skeleton

4. Generating Heat

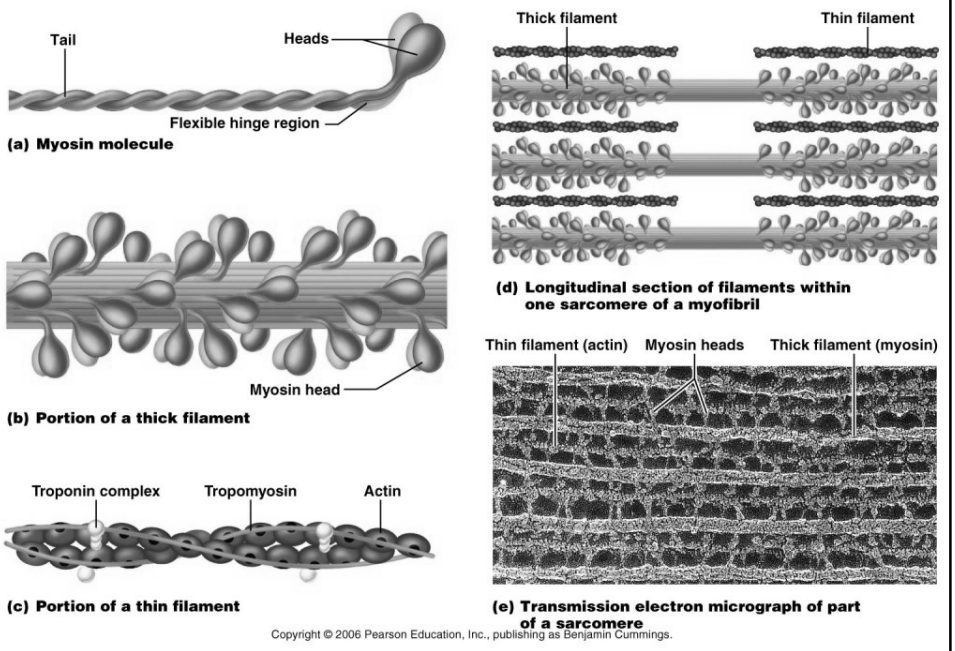
- By-product of muscle activity
- ATP powers muscle contraction, ¾ of energy is lost as heat
- Vital in maintaining normal body temperature - 40%

II. Microscopic Anatomy Of Skeletal Muscle

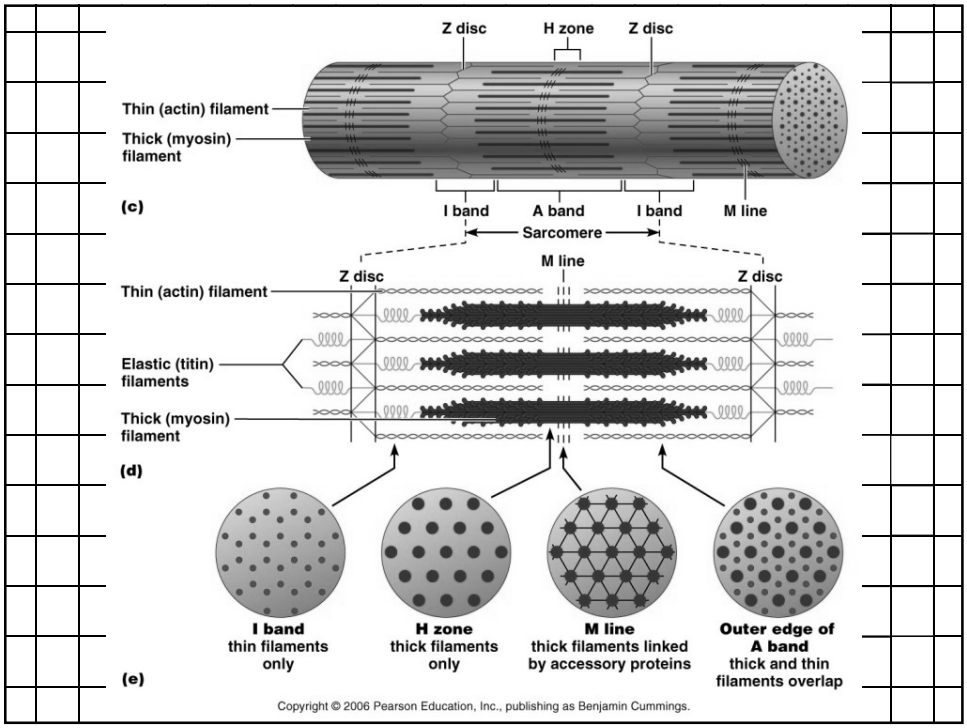
- Sarcolemma: muscle fiber plasma membrane
- myofibril: complex organelle composed of bundles of myofilaments
  - banded
- sarcomere: contractile unit
  - composed of myofilaments made of contractile proteins



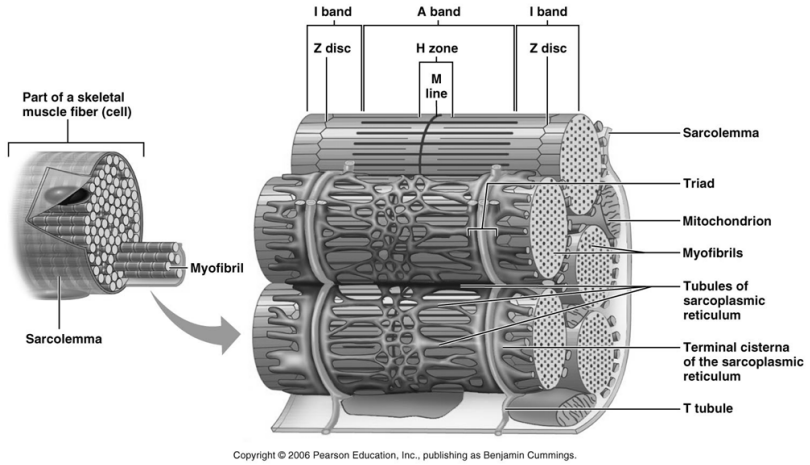
- **myofilament: two types**
  - **thin (actin) filament**
    - **long bead-like strands (twisted double strand of pearls)**
    - **tropomyosin & troponin also on beaded strand**
  - **thick (myosin) filament**
    - **rodlike tail with two globular heads**



- p. 167 fig. 6.3
- A bands
  - Contain actin & myosin
- 1 sarcomere
  - extends from Z line to next Z line
  - contain both actin & myosin
- I bands
  - contain actin



- **Sarcoplasmic reticulum (SR)**
  - **Interconnecting tubules that surround each myofirbril**
  - **Store calcium**

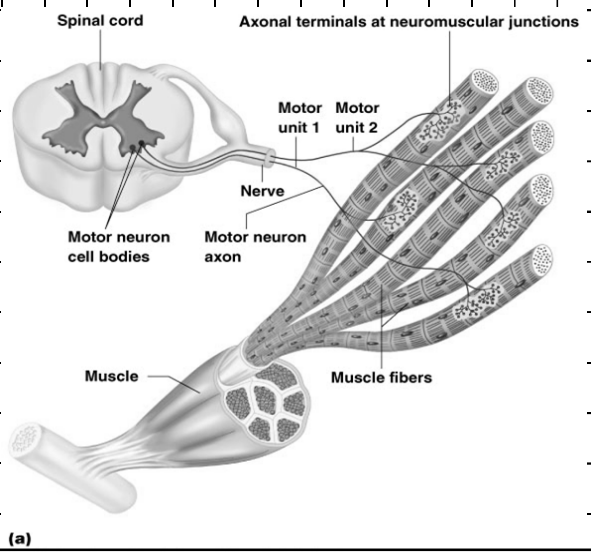


III. Skeletal Muscle Activity

A. Stimulation & Contraction of Single Skeletal Muscle Cells

- Special functional properties
  - Irritability: ability to receive & respond to a stimulus
  - Contractility: ability to shorten when an adequate stimulus received
  - Extensibility – ability to lengthen
  - Elasticity – ability to stretch and return to normal lengths

1. Nerve Stimulus & Action Potential



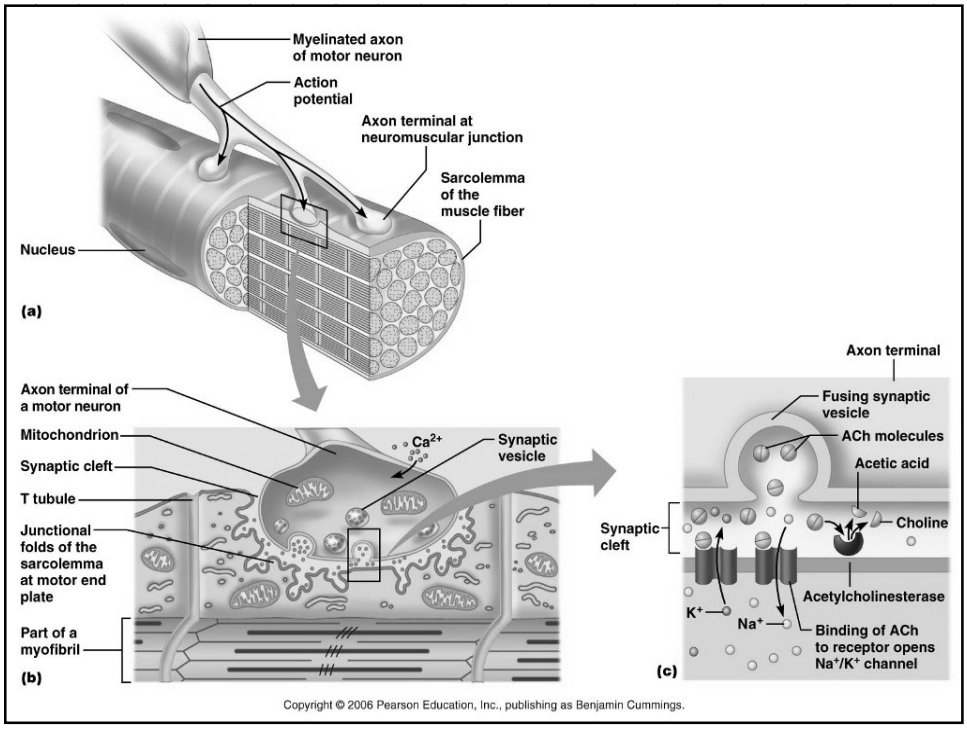
Motor Unit

- motor neuron & all the muscle fibers it supplies
- fine control: fingers & eyes
  - < 150 muscle fibers / motor neuron
- less precise: hips & legs
  - > 150 muscle fibers / motor neuron

Neuromuscular Junctions

- Where axonal terminals forms junctions with sarcolemma
- Synaptic cleft: gap between axonal terminal & sarcolemma
  - Filled with interstitial fluid

- Nerve impulse reaches axonal terminals
- Neurotransmitter acetylcholine (Ach) released
- Diffuses across synaptic cleft & attaches to receptors on sarcolemma
- Membrane become permeable to Na^+ which rush into muscle cell
- Upsets normal balance & generates electrical current called action potential



Contraction of Fiber

- sarcomeres shorten ⇨ myofibrils shorten .....
- sliding filament theory of contraction
  1. Cross bridge attachment: activated myosin heads are strongly attracted to exposed binding sites on actin & cross bridge binding occurs

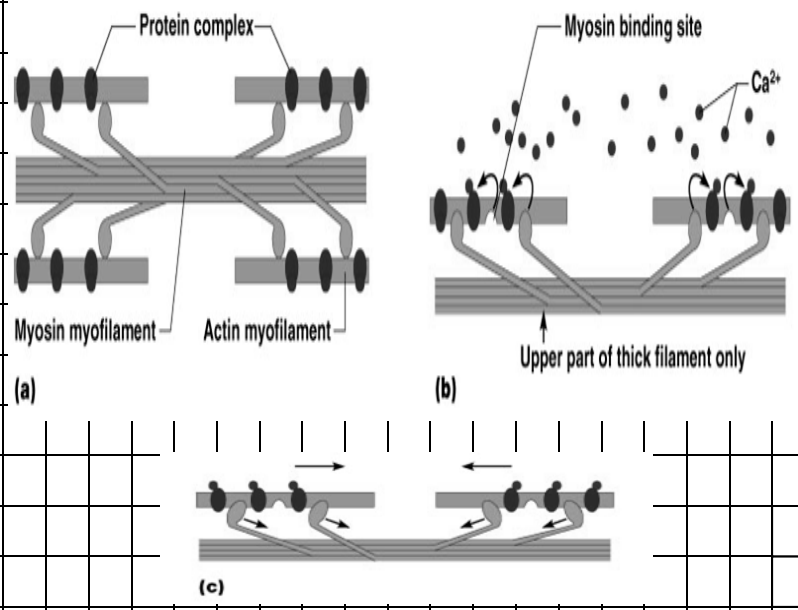
2. Power Stroke: as myosin head binds, it changes from high-energy configuration to its bent, low-energy shape, which causes head to pull on thin filament, sliding it toward center of sarcomere
   - ADP & P_i generated during prior contraction cycle are released from myosin head

3. Cross bridge detachment

- as new ATP molecule binds to myosin head, myosin cross bridge is released from actin

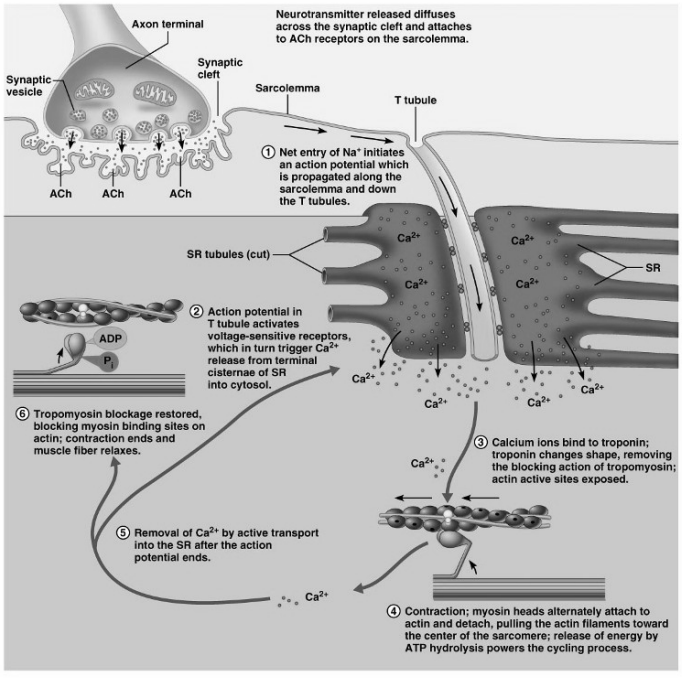
4. Cocking of myosin head

- hydrolysis of ATP to ADP and P_i provides energy needed to return myosin head to its high-energy or cocked position, which gives it potential energy needed for next attachment
- figure 6.8 p. 171



Role of Ca^{+2} in contraction

- low Ca^{+2} concentrations, blocks binding sites on actin & prevents cross bridge attachment - relaxed muscle
- high Ca^{+2} concentrations, binding site open
  - myosin head binds - contraction
  - warm-up for athletes increases Ca^{+2} levels



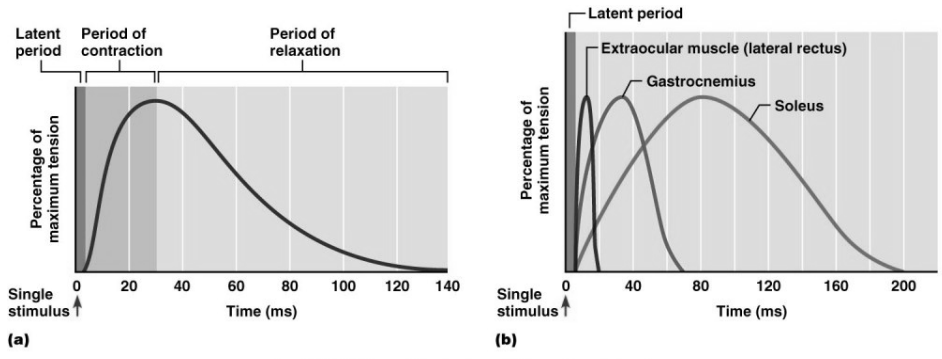
Rigor mortis

- death rigor
- illustrates that cross bridge detachment is ATP-driven
- muscles stiffen 3-4 hours after death
- rigidity peaks at 12 hours then gradually decreases next 48-60 hours due to breakdown of biological molecules

B. Contraction of a Skeletal Muscle as a Whole

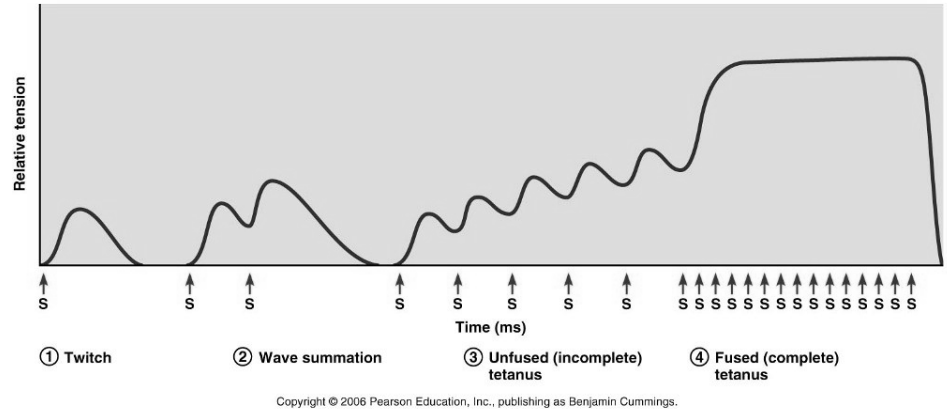
1. Graded Responses

- All-or-none law: muscle cell will contract to fullest when stimulated never partially
- Skeletal muscles react to stimuli with graded response
  - Change frequency of muscle stimulation
  - Change # of muscle cells being stimulated



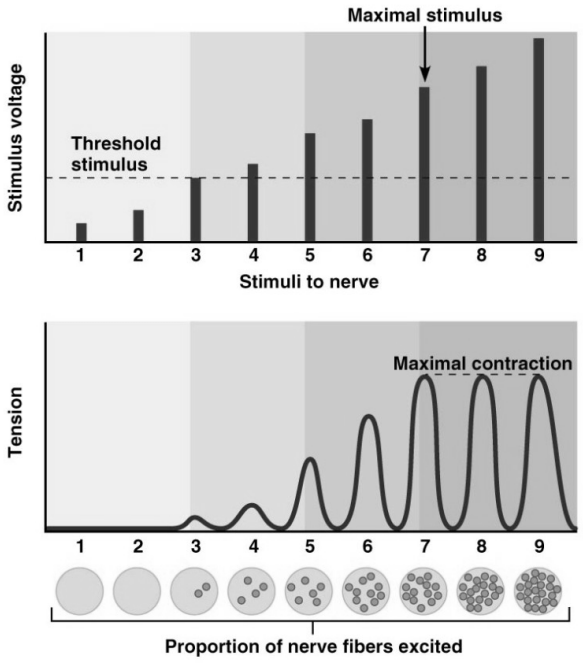
a. Muscle Response to Increasingly Rapid Stimulation

- Figure 6.9 p. 172
- Fused or complete tetanus: muscle is stimulated so rapidly that no evidence of relaxation is seen, contractions are completely smooth and sustained



b. Muscle Response to Stronger Stimuli

- Force of muscle contraction depends on how many cells are stimulated



2. Providing Energy for Muscle Contraction

- Bonds of ATP are hydrolyzed to release energy
- Muscle only store 4-6 sec of energy
- ATP must be regenerated continuously

a. Phosphorylatin of ADP by creatine phosphate

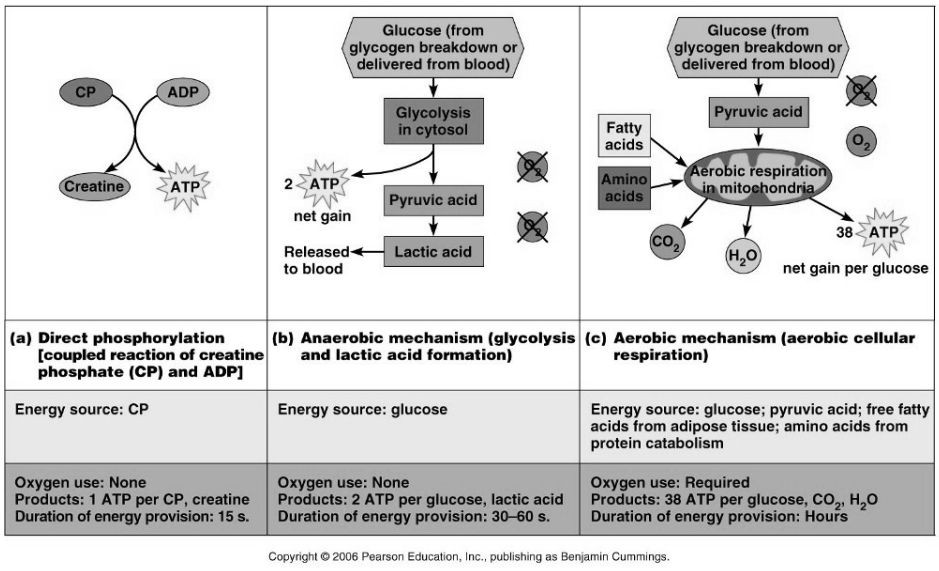
- Figure 6.10a
- Creatine phosphate found in muscle cells but not other cells

b. Aerobic respiration

- Figure 6.10c
- Produces 95% of ATP at rest & light exercise
- Mitochondria
- 36 ATP per 1 glucose molecule
- Requires oxygen

c. Anaerobic glycolysis

- Figure 6.10b
- Only 5% as much ATP from each glucose molecule as aerobic respiration
- 2.5 time faster
- Can provide most of ATP for 30-60 s
- Uses huge amounts of glucose for small ATP harvest
- Accumulates lactic acid that promotes muscles fatigue & soreness

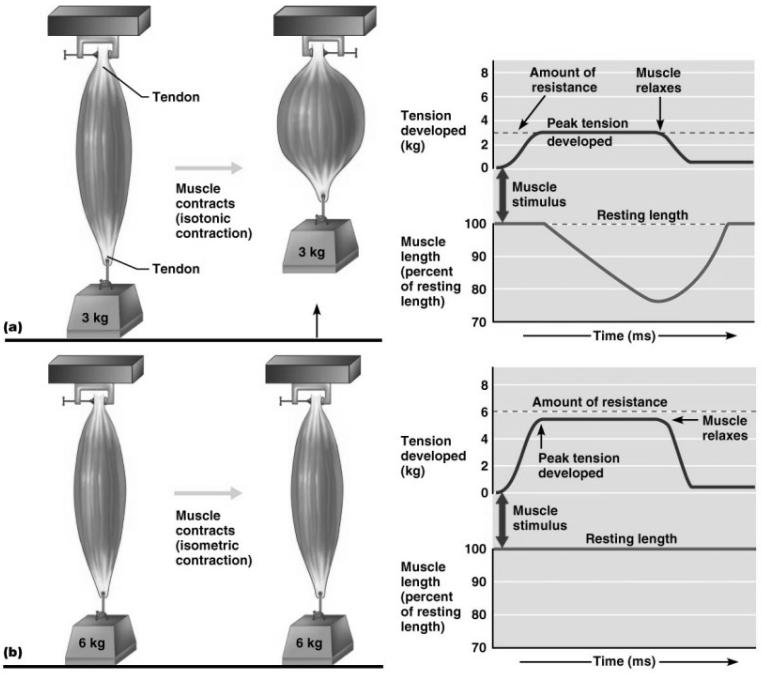


3. Muscle Fatigue & Oxygen Debt

- Strenuous & prolonged activity causes fatigue due to accumulation of lactic acid in muscle & decrease in ATP
- After exercise oxygen debt is repaid by rapid deep breathing

4. Types of Muscle Contractions

- Isotonic: muscle shortens & movement occurs
- Isometric: muscle tries to shorten but cannot
  - Try to push over a brick wall



5. Muscle Tone

- Not consciously controlled
- Some fibers are always contracted while other relax

6. Effect of Exercise on Muscles

- Use it or lose it

TABLE 9.2 Structural and Functional Characteristics of the Three Types of Skeletal Muscle Fibers

	SLOW OXIDATIVE FIBERS	FAST OXIDATIVE FIBERS	FAST GLYCOLYTIC FIBERS
METABOLIC CHARACTERISTICS			
Speed of contraction	Slow	Fast	Fast
Myosin ATPase activity	Slow	Fast	Fast
Primary pathway for ATP synthesis	Aerobic	Aerobic (some anaerobic glycolysis)	Anaerobic glycolysis
Myoglobin content	High	High	Low
Glycogen stores	Low	Intermediate	High
Recruitment order	First	Second	Third
Rate of fatigue	Slow (fatigue-resistant)	Intermediate (moderately fatigue-resistant)	Fast (fatigable)
ACTIVITIES BEST SUITED FOR			
	Endurance-type activities—e.g., running a marathon; maintaining posture (antigravity muscles)	Sprinting, walking	Short-term intense or powerful movements, e.g., hitting a baseball
STRUCTURAL CHARACTERISTICS			
Color	Red	Red to pink	White (pale)
Fiber diameter	Small	Intermediate	Large
Mitochondria	Many	Many	Few
Capillaries	Many	Many	Few

IV. Muscle Movements, Types, & Names

A. Types of Body Movements

- **Origin: attached to immovable or less movable bone**
- **Insertion: attached to movable bone**
- **Figure 6.13 p. 177-178**

B. Types of Muscles

- Prime mover: major responsibility for movement
- Antagonists: oppose or reverse a movement
- Synergists: help prime movers by producing same movement or by reducing undesirable movements
- Fixators: hold a bone still or stabilize origin of prime mover

C. NAMING OF SKELETAL MUSCLES

1. Location of muscle

- indicate the bone or body region where muscle in located

2. Shape of muscle

- deltoid: triangular
- trapezius: form trapezoid

3. Size of muscle

- maximus: largest
- minimus: smallest
- longus: long

4. Direction of muscle fibers

- rectus: fibers run parallel
- transverse: horizontally
- oblique: diagonally

5. Number of origins

- biceps: two origins
- triceps: three origins
- quadriceps: four origins

6. Location origin / insertion

- name according to attachment point
- sternocleidomastoid
  - sterno- origin on sternum
  - cleido- origin on clavicle
  - mastoid inserts on mastoid process of temporal bone

7. Action of muscle

- flexor
- extensor
- abductor
- adductor

V. MUSCLE LIST

KNOW THOSE FROM WORKSHEET