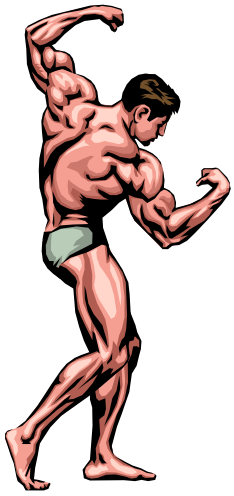
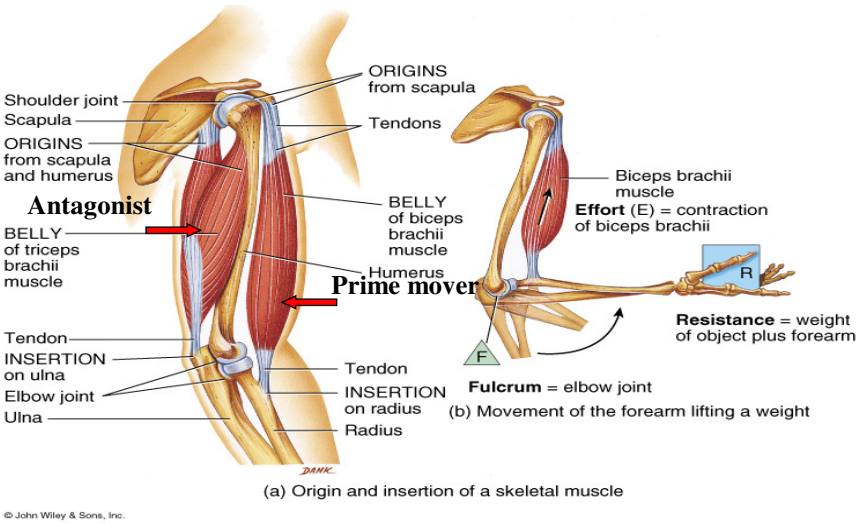
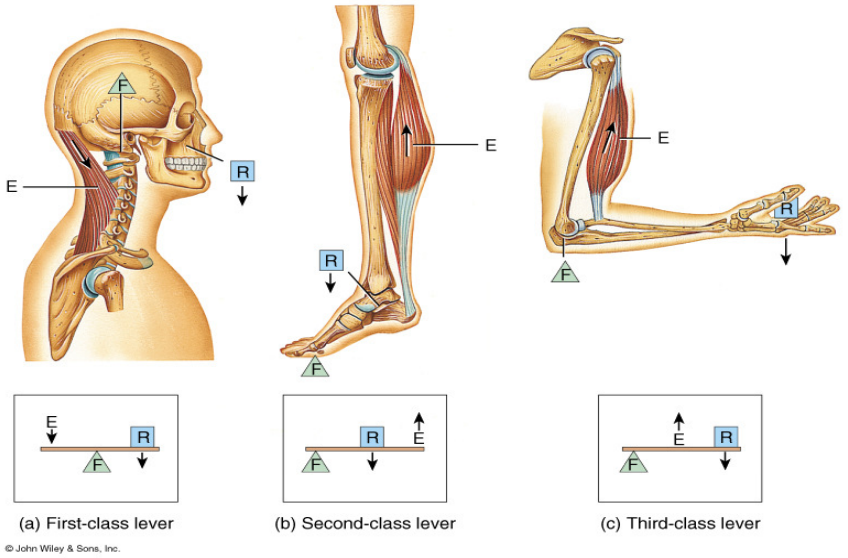
Bio& 241 A&P 1
Unit 3 Lecture 3



Actions of Antagonistic Muscles

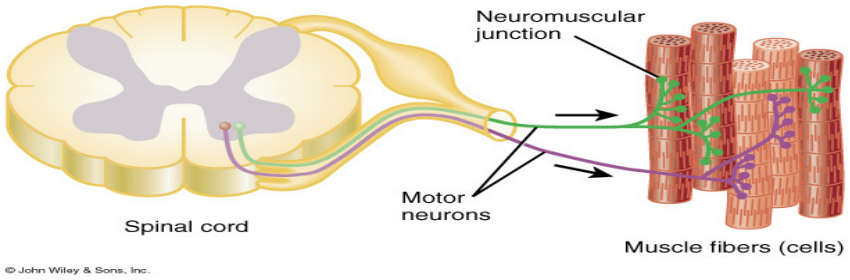


Properties of Muscle Contraction



Motor Unit

All the muscle fibers (cells) innervated by the same motor neuron



All-or-None Principle: All muscle fibers that make up a motor unit contract fully together. This principle holds true at the sarcomere, myofibril, and muscle fiber levels as well. Partial contraction occurs at the muscle level because all motor units are not contracting at the same time.

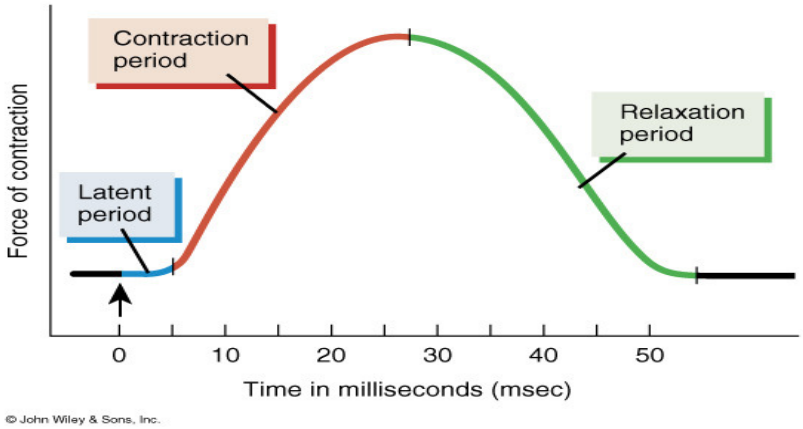
Recruitment: The process by which the number of actively contracting motor units is increased.

Types of Muscle Contraction

1. **Isotonic contraction:**
   a. Concentric isotonic contraction: Overall length of a muscle decreases during contraction to produce movement.
   b. Eccentric isotonic contraction: Overall length of a muscle increases during muscle contraction, i.e., when an antagonistic muscle contracts against its agonist.

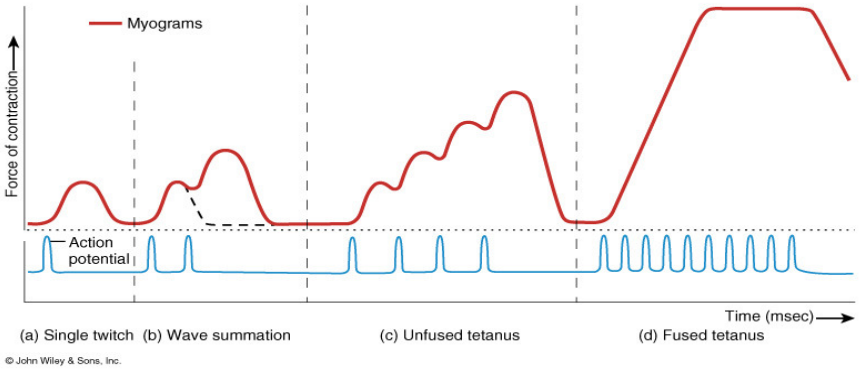
2. **Isometric contraction: a contraction where considerable muscle tension is generated without shortening of the muscle.**

Myogram of a Simple Twitch



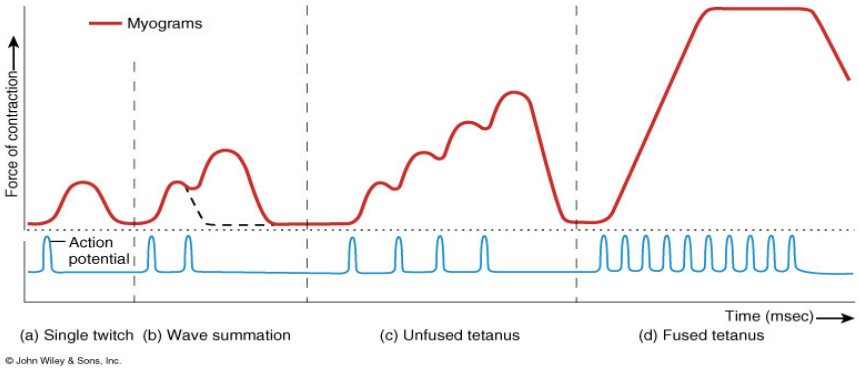
Simple twitch: Brief contraction of all fibers in a motor unit in response to a single stimulus.

Myograms Created by Multiple Stimuli



Wave Summation: Two stimuli that occur close together so that the second stimulus occurs before the the muscle can completely relax. Increased force of contraction is due to recruitment of motor units.

Unfused or Incomplete Tetanus: Due multiple stimuli that cause repeated wave summations that increase force of contraction due to recruitment.

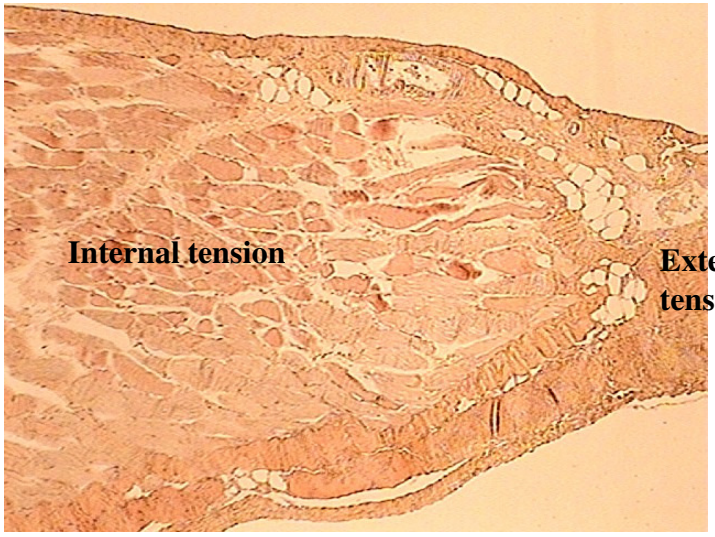


Fused or Complete Tetanus: A sustained maximum contraction in which individual contractions are not discernable. In fused tetanus, multiple stimuli are occurring so fast, the muscle does not undergo any relaxation.

Tension Produced by Contracting Skeletal Muscles

- **Internal tension: The force created by the shortening of sarcomeres and myofibrils within a muscle cell or fiber.**
- **External tension: The force transferred from contracting muscle cells to their connective tissues (epimysium, perimysium, and endomysium) and tendons they become part of.**
- **Because of the "series elastic elements" within this connective tissue, external tension builds slowly during early contraction periods and then builds more rapidly, transferring the tension to the force that moves bones at joints.**

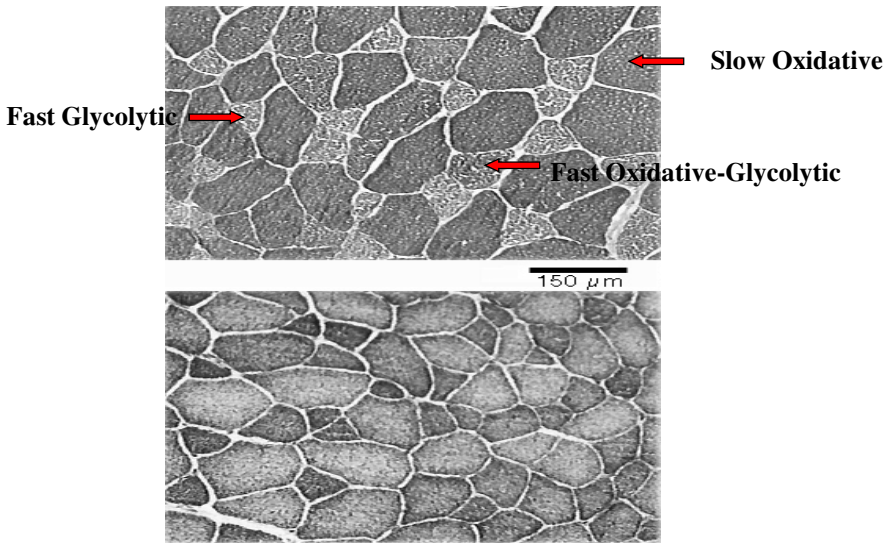
Tension Produced by Contracting Skeletal Muscles



Receptors in Muscle

- Muscle spindle
  - Detect dynamic and static changes in muscle length
  - Stretch reflex
    - Stretch on muscle causes reflex contraction
- Golgi tendon organ (GTO)
  - Monitor tension developed in muscle
  - Prevents damage during excessive force generation
    - Stimulation results in reflex relaxation of muscle

Three Types of Skeletal Muscle Fibers

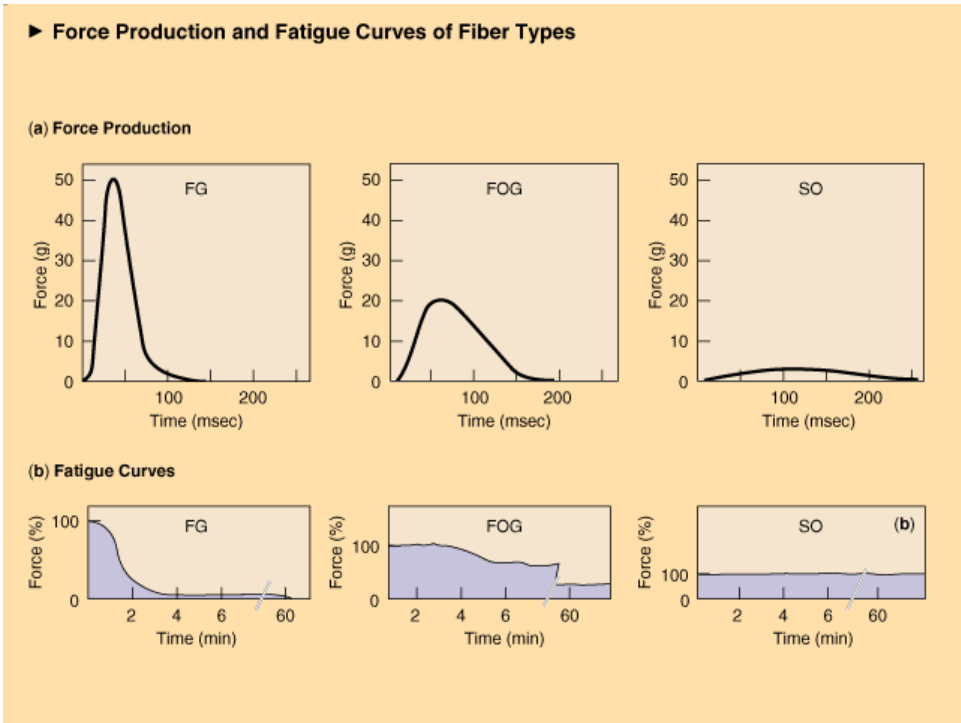


Structural Characteristics of the Three Fibers

Slow Oxidative (Type 1, ST, SO)	**Fast Oxidative (Type 2a, FOG)**	**Fast Glycolytic Type 2b, FG)**
High Myoglobin	High Myoglobin	Low Myoglobin
Many Mitochondria	Many Mitochondria	Few Mitochondria
Many Capillaries	Many Capillaries	Few Capillaries
Red in Color	Red-pink in Color	White (Pale pink) in color

Functional Characteristics of the Three Fibers

Slow Oxidative	**Fast Oxidative**	**Fast Glycolytic**
Slow rate of ATP hydrolysis	Fast rate of ATP hydrolysis	Fast rate of ATP hydrolysis
Slow contraction speed	Fast contraction speed	Fast contraction speed
High fatigue resistance	Intermediate fatigue resistance	Low fatigue resistance
Low glycogen stores	Intermediate glycogen stores	High glycogen stores



Functional Characteristics of the Three Fibers

Slow Oxidative	Fast Oxidative	Fast Glycolytic
1st recruitment	2nd recruitment	3rd recruitment
Most abundant in postural muscles	Most abundant in leg muscles	Most abundant in arm muscles
Involved in endurance activities	Involved in walking or sprinting	Involved in rapid, intense, short duration activities

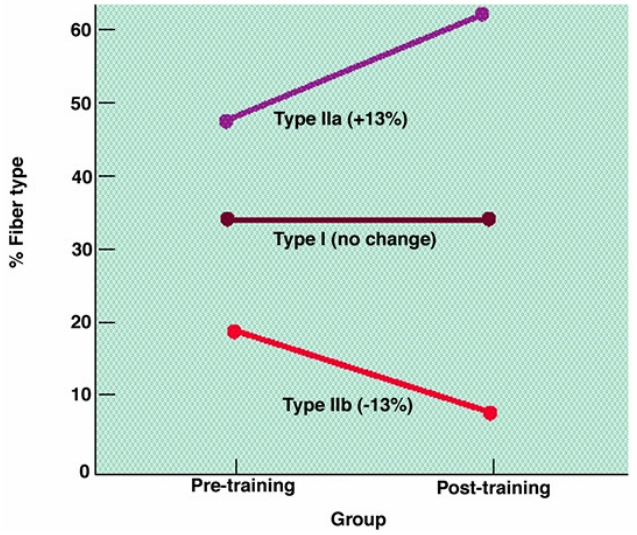
Fiber Types and Performance

- Power athletes
  - Sprinters
  - Possess high percentage of fast fibers
- Endurance athletes
  - Distance runners
  - Have high percentage of slow fibers
- Others
  - Weight lifters and nonathletes
  - Have about 50% slow and 50% fast fibers

Alteration of Fiber Type by Training

- Endurance and resistance training
  - Cannot change fast fibers to slow fibers
  - Can result in shift from Type IIb to IIa fibers
    - Toward more oxidative properties

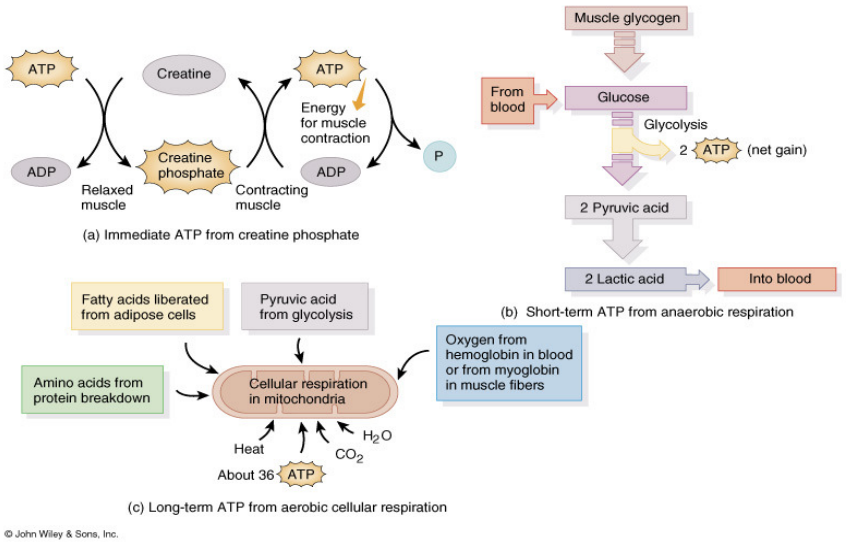
Training-Induced Changes in Muscle Fiber Type



Age-Related Changes in Skeletal Muscle

- Aging is associated with a loss of muscle mass
  - Rate increases after 50 years of age
- Regular exercise training can improve strength and endurance
  - Cannot completely eliminate the age-related loss in muscle mass

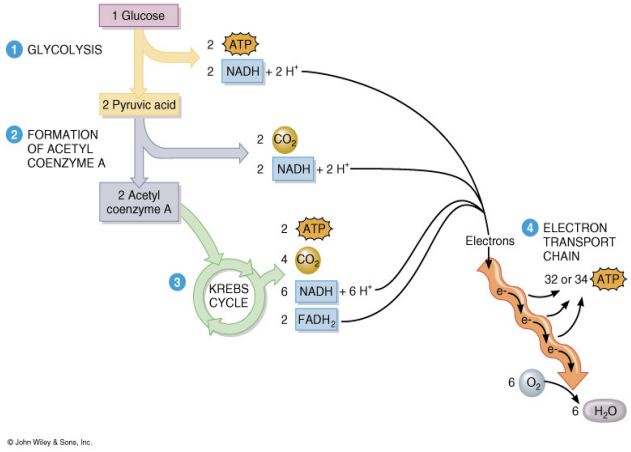
ATP Production for Muscle Contraction



Overview of Cellular Respiration

ATP generation

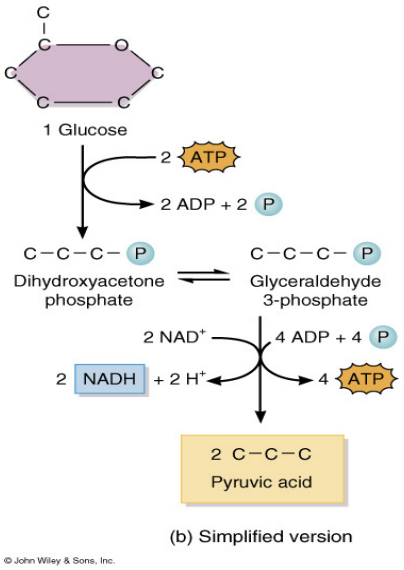
Glycolysis:	
Total	**4**
Used	**2**
Net gain	**2**
Krebs Cycle:	
Net gain	**2**
ETC:	
Net gain	
	32 or 34
Total	**36 or 38**



Glycolysis

1. Converting glucose to glyceraldehyde 3-phosphate require the use of two ATP.
2. Converting glyceraldehyde 3-phosphate to pyruvic acid produces 4 ATP.

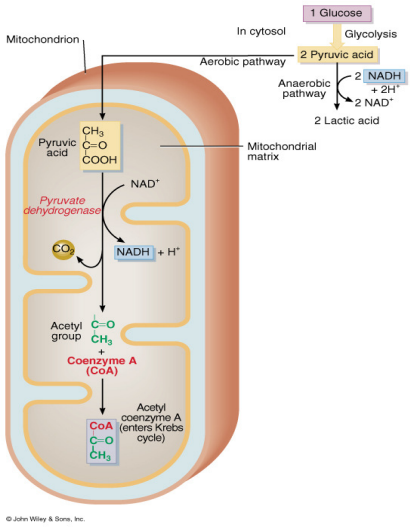
Products: **2 molecules of Pyruvic Acid**
2 ATP
2 NADH



Formation of Acetyl Coenzyme-A

The conversion of Pyruvic acid into Acetyl Coenzyme-A produces no ATP directly

Products:
2 Acetyl-CoA
2 NADH
2 CO2

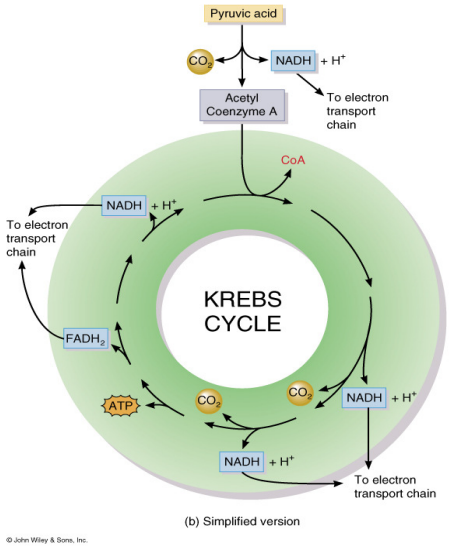


Kreb's Cycle

Produces one GTP per molecule of Acteyl-COA for a net gain of two per glucose molecule. This GTP is rapidly converted to ATP

Products:

NADH	**6**
FADH2	**2**
GTP	**2**
CO2	**4**



Chemiosmotic generation of ATP

Electron Transport Chain

A series of Oxidative Phosphorylation reactions

Oxidation = the removal of electrons from a molecule and results in a decrease in the energy content of the molecule. Because most biological reactions involve the loss of hydrogen atoms, they are called dehydrogenation reactions.

Reduction = the opposite of oxidation; the addition of electrons to a molecule, and results in an increase in the energy content of the molecule.

Chemiosmotic generation of ATP

ATP production:

NADH from Glycolysis
2 NADH= 6 ATP or 4ATP

NADH from Acetyl-COA
2 NADH= 6 ATP

NADH from Kreb's Cycle:
6 NADH= 18 ATP

FADH2 from Kreb's
2 FADH2= 4 ATP

TOTAL 32 or 34