

## Bio 103 Muscular System

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### Lecture Outline: **MUSCULAR SYSTEM** [Chapter 9]

#### **A. Functions of Skeletal Muscle**

1. Movement
2. Maintain posture
3. Support
4. Guard openings
5. Maintain body temperature (thermogenesis)

#### **B. Muscle Tissue Types**

1. Skeletal
2. Smooth
3. Cardiac

#### **C. Structure of a Skeletal Muscle**

Skeletal Muscle: organ of the muscular system

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- 
- 

– dense connective tissue, separates adjacent muscles, holds muscles in position

– collagen fibers of endomysium, perimysium, and epimysium

Aponeuroses –

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### D. Connective Tissue Coverings

1. Epimysium
2. Perimysium  
Fascicle
3. Endomysium

### Skeletal Muscle Organization

- 1.
- 2.
- 3.
- 4.
5.  
= thick and thin filaments

### E. Skeletal Muscle fiber = muscle cell

Sarcolemma

Sarcoplasm

Sarcoplasmic reticulum (SR)

Transverse tubules (T-tubules)

Myofibrils

### Myofilaments

#### Thin filaments

Actin -

Troponin -

Tropomyosin -

#### Thick filaments

Myosin -

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**Sarcomere** = functional unit

- I bands –
- A bands –
- H zone –
- Z lines –
- M line -

### F. Sliding Filament Theory

\* thin filaments slide past the thick filaments ==>

- H zones and I bands narrow
- Z lines move closer together
- A band width does not change

### Muscle Contraction

Nervous system controls muscle contraction

#### **Neuromuscular Junction (NMJ)** or Myoneural Junction

Motor neuron -

Synapse -

Synaptic cleft -

Motor end plate -

Synaptic vesicles -

Acetylcholine (ACh) - neurotransmitter

### Motor Unit

= all muscle fibers associated with single motor neuron

Precise movements

Less precise control

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### A. Stimulus for Contraction

1. Nerve impulse (AP) travels along axon
2. ACh released from \_\_\_\_\_
3. ACh diffuses across \_\_\_\_\_
4. ACh binds to ACh receptors on \_\_\_\_\_
5. Na<sup>+</sup> influx into sarcoplasm generating a muscle impulse
6. Muscle impulse travels along T-tubules to \_\_\_\_\_

### B. Excitation Contraction Coupling

1. SR releases Ca<sup>+2</sup> into \_\_\_\_\_
2. Ca<sup>+2</sup> binds to \_\_\_\_\_ to change its shape
3. Position of tropomyosin is altered
4. Binding sites on actin are exposed
5. Actin and myosin molecules bind forming a cross-bridge

### C. Cross-bridge Cycling

1. Myosin cross-bridge pulls \_\_\_\_\_ filament
2. ADP and P are released from myosin
3. New \_\_\_\_\_ binds to myosin causing the cross-bridge to detach
- 4.
5. Myosin head is reset to original position

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### D. Relaxation

1. Acetylcholinesterase ( ) breaks down ACh
  2. ATP breaks cross-bridge attachments
  3.  $\text{Ca}^{+2} \rightarrow \text{SR}$  (via AT)
  4. Troponin is reactivated preventing myosin and actin from binding
- \*

### Rigor Mortis

In living, resting muscle, normally ATP sits on head of myosin.

ATP  $\rightarrow$  ADP + P + E in order for the power stroke to occur.

If no ATP available (as in death)  $\rightarrow$  cross-bridges cannot break.

### A. What Supplies the Energy?

- 1.
- 2.



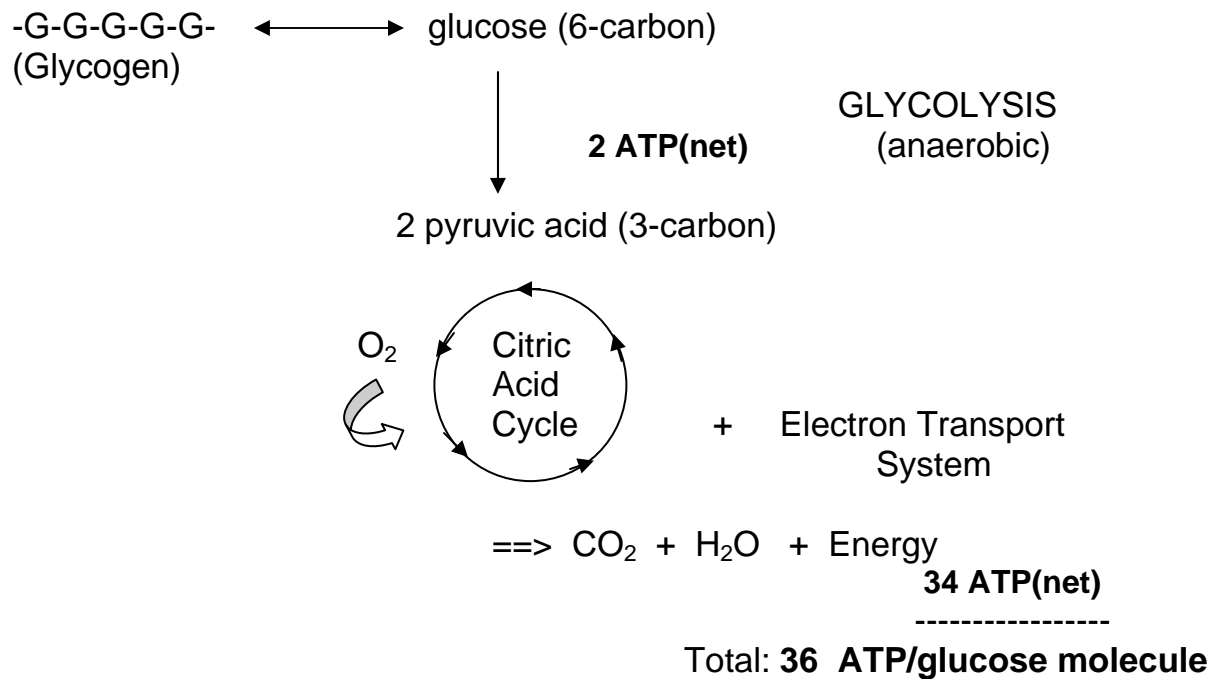
Creatine phosphate -

### B. Cellular Respiration

1. Anaerobic Phase
  - 
  - 
  - produces 2 ATP
2. Aerobic Phase
  - citric acid cycle
  - 
  - 
  - produces 34 ATP
  - myoglobin stores extra oxygen

Anaerobic and aerobic respiration produces a total of \_\_\_\_\_

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### C. Oxygen Debt

= amount of oxygen needed by liver cells to use the accumulated lactic acid to produce glucose

-  
-  
-

### Anaerobic Respiration Drawbacks

Glycolysis –  
Accumulation of lactic acid

### Muscle Fatigue

- inability to contract

Caused from:

-  
-  
-

Cramp – sustained, involuntary muscle contraction

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### D. Energy Use

1. Resting muscle
  - low energy demands
  - O<sub>2</sub> available
  - buildup of CP and glycogen
2. Moderate activity
  - energy demand increases
  - incr. O<sub>2</sub> use and incr. ATP output
  - no surplus of ATP
3. Peak activity levels
  - max. mitochondrial ATP production (produces 1/3 of ATP)
  - rate limited by O<sub>2</sub> available
  - 2/3 ATP produced via

#### Heat Production

- by-product of cellular respiration
- muscle cells are major source of body heat
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### A. Muscular Responses

Threshold stimulus –

Twitch – single stimulus → contraction followed by relaxation

1. Latent period – time needed for AP → sarcolemma; Ca<sup>+2</sup> released from SR
2. Contraction phase –
3. Relaxation phase –

### B. Summation

- process by which individual twitches combine
- produces sustained contractions
- can lead to \_\_\_\_\_ contractions

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1. Treppe
2. Wave Summation
3. Incomplete Tetanus
4. Complete Tetanus

Infectious disease: Tetanus (“lockjaw”)  
- *Clostridium tetani*

### **A. Recruitment of Motor Units**

Recruitment -

- Whole muscle composed of many motor units
- An intensity of stimulation increases, recruitment of motor units continues until all motor units are activated

### **B. Sustained Contractions**

Smaller motor units –

Larger motor units -

Muscle tone – continuous state of partial contraction =

### **C. Types of Contractions**

1. Isotonic -

a. Eccentric -

b. Concentric –

2. Isometric -



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### Fast and Slow Twitch Muscle Fibers

Slow-twitch fibers

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- 
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Fast-twitch glycolytic fibers

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Fast-twitch fatigue resistant fibers

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### Muscle hypertrophy and atrophy

Hypertrophy –

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Atrophy –

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### A. Smooth Muscle Tissue

1. Structural differences

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- 
- filaments: actin & myosin but no sarcomeres
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- lacks T-tubules
- SR not well developed

2. Functional differences

- control mechanism:
- contraction:

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### 3. Types of Smooth Muscle

#### Visceral Smooth Muscle

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- fibers held together by gap junctions
- exhibit rhythmicity
- 
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#### Multiunit Smooth Muscle

- less organized
- function as separate units
- fibers function separately
- 
- 

### 4. Smooth Muscle Contraction

#### Resembles skeletal muscle contraction:

- 
- 
- 

#### Different from skeletal muscle contraction

- 
- 
- 
- 
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### **B. Cardiac Muscle Tissue**

- located only in the heart
- muscle fibers joined together by \_\_\_\_\_
- fibers branch
- 
- 
- longer refractory period than skeletal muscle
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### **Skeletal Muscle Actions**

Origin:

Insertion:

- prime mover (agonist) – primarily responsible for movement
- synergists – assist prime mover
- antagonist – resists prime mover's action and cause movement in the opposite direction

Ex. **Pectoralis major**

**Biceps brachii**

Origin:

Insertion:

Action:

### **Life Span Changes**

### **Clinical Disorders**

Myasthenia gravis

Botulism

Polio

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### Whole Muscle Anatomy

#### A. Parts of muscle

Naming of muscle actions:

flexion                      extension

adduction                  abduction

#### B. Naming of Muscles:

1. action:

2. direction:

3. location:

4. divisions:

5. shape:

6. attachment:

7. Latin meanings: platysma, buccinators, serratus, masseter, vastus

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### Exercise A: Muscle Function Prentice-Hall Video Tutor

1. Bundles of muscle fibers, blood vessels, and nerves within a CT sheath are called \_\_\_\_\_.
2. The cell membrane of a muscle cell is the \_\_\_\_\_.
3. Each muscle fiber is composed of \_\_\_\_\_ which run the entire length of the muscle cell.
4. Bundles of thick and thin filaments are organized into repeating units called \_\_\_\_\_.
5. The repeating units (in #4) are joined at junctions called \_\_\_\_\_.
6. Each thin filament is composed mostly of the protein \_\_\_\_\_.
7. Thin filaments have the appearance of \_\_\_\_\_.
8. Thin filaments also contain 2 proteins \_\_\_\_\_ and \_\_\_\_\_ that are important in the control of muscle contraction.
9. Thick filaments are composed of the protein \_\_\_\_\_.
10. Each myosin is shaped like \_\_\_\_\_.
11. To make up a thick filament, the \_\_\_\_\_ of the myosin molecules are bundled together and the \_\_\_\_\_ project outward in a spiral.
12. The region where an axon communicates with a muscle cell is called \_\_\_\_\_.
13. The terminal process of the axon and the muscle fiber are separated by a small gap called \_\_\_\_\_.
14. A neuron can control a muscle fiber by releasing a chemical called a \_\_\_\_\_ into the gap between the neuron and the muscle fiber.
15. The \_\_\_\_\_ stores the calcium ions.
16. When a muscle is at rest, \_\_\_\_\_ molecules hold \_\_\_\_\_ molecules against the actin strands.

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17. The molecules (in #16) block the \_\_\_\_\_ binding sites on the thin filaments.
18. When \_\_\_\_\_ are released from the SR, they attach to \_\_\_\_\_.
19. The \_\_\_\_\_ molecules rotate, moving the \_\_\_\_\_ molecules, and exposing the \_\_\_\_\_ binding sites.
20. A \_\_\_\_\_ forms when the head of a myosin molecule attaches to a binding site on the actin molecule.
21. When the muscle contracts, the two ends of the sarcomere move \_\_\_\_\_.

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### Exercise B:

### Naming of Muscles:

1. Action:
2. Direction:
3. Location:
4. Divisions:
5. Shape:
6. Attachment:
7. Latin name:

Levator scapulae

Gluteus maximus

Tranversus abdominis

Internal Oblique

Rectus abdominis

Flexor carpi ulnaris

Adductor longus

Brachialis

Biceps brachii

Buccinator

Triceps brachii

Quadriceps femoris

Sternocleidomastoid

Extensor carpi radialis

Pectoralis major

Deltoid

Trapezius

External oblique

Platysma

Vastus medialis

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### Exercise C: More muscle tissue review

1. Muscle tissue is made up of specialized cells for the function of \_\_\_\_\_.
2. The three types of muscle tissue: \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_.
3. Skeletal muscles are called voluntary muscles because:
  - a. ATP activates skeletal muscle for contraction.
  - b. Skeletal muscle contains the myoneural junction.
  - c. They contract when stimulated by motor neurons of the CNS.
  - d. CT harnesses generated forces voluntarily.
4. The smallest functional unit of the muscle fiber is \_\_\_\_\_.
5. Thin filaments consist of:
6. Thick filaments consist of :
7. All of the muscle fibers controlled by a single motor neuron make up a \_\_\_\_\_.
8. Tension in a muscle fiber will vary depending on:
  - a. Structure of individual sarcomeres.
  - b. Initial length of muscle fibers.
  - c. The number of cross-bridges formed within a fiber.
9. The reason there is less precise control over leg muscles compared to muscles of the eye is:
  - a. Single muscle fibers are controlled by many motor neurons.
  - b. Many muscle fibers are controlled by many motor neurons.
  - c. A single muscle fiber is controlled by a single motor neuron.
  - d. Many muscle fibers are controlled by a single motor neuron.
10. The sliding filament mechanism explains the *physical change* that takes place during contraction is:
  - a. Thick filaments slide toward center of sarcomere alongside the thin filaments.
  - b. Thick and thin filaments slide toward the center of the sarcomere together.
  - c. The thin filaments slide toward the center of the sarcomere alongside the thick filaments.

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