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  
-  
-  
-  
-  
- 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⁺ influx into sarcoplasm generating a muscle impulse
6. Muscle impulse travels along T-tubules to __________

B. Excitation Contraction Coupling

1. SR releases Ca⁺² into __________
2. Ca⁺² 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. Ca\(^{2+}\) \(\rightarrow\) 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. 

\[ \text{CPK} \quad \text{ADP} + \text{CP} \xleftrightarrow{\text{CPK}} \text{ATP} + \text{creatine} \]

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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\[ -G\text{-G-G-G-G-} \quad \rightarrow \quad \text{glucose (6-carbon)} \]

\[ \text{GLYCOLOGYSIS} \quad \rightarrow \quad 2 \text{ ATP(net)} \]

\[ \rightarrow \quad 2 \text{ pyruvic acid (3-carbon)} \]

\[ \text{O}_2 \text{ Citric Acid Cycle} \quad + \quad \text{Electron Transport System} \]

\[ \Rightarrow \quad \text{CO}_2 + \text{H}_2\text{O} + \text{Energy} \]

\[ \text{34 ATP(net)} \]

\[ \text{Total: 36 ATP/glucose molecule} \]

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
D. Energy Use
   1. Resting muscle
      - low energy demands
      - O₂ available
      - buildup of CP and glycogen

   2. Moderate activity
      - energy demand increases
      - incr. O₂ 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 O₂ available
      - 2/3 ATP produced via

Heat Production
   - by-product of cellular respiration
   - muscle cells are major source of body heat

A. Muscular Responses
   Threshold stimulus –

   Twitch – single stimulus → contraction followed by relaxation

   1. Latent period – time needed for AP → sarcolemma; Ca⁺² released from SR

   2. Contraction phase –

   3. Relaxation phase –

B. Summation
   - process by which individual twitches combine

   - produces sustained contractions

   - can lead to ________ contractions
1. Treppe

2. Wave Summation

3. Incomplete Tetanus

4. Complete Tetanus

Infectious disease: Tetanus ("lockjaw")
   - *Clostridium tetani*

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**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 -
Fast and Slow Twitch Muscle Fibers
Slow-twitch fibers
- 
- 
- 
- 
- 

Fast-twitch glycolytic fibers
- 
- 
- 
- 
- 

Fast-twitch fatigue resistant fibers
- 
- 
- 
- 
- 

Muscle hypertrophy and atrophy
Hypertrophy –
- 
- 
Atrophy –
- 

A. Smooth Muscle Tissue
1. Structural differences
- 
- 
- 
- filaments: actin & myosin but no sarcomeres
- 
- lacks T-tubules
- SR not well developed

2. Functional differences
- control mechanism:
- contraction:
3. Types of Smooth Muscle
   Visceral Smooth Muscle
   -
   -
   - fibers held together by gap junctions
   - exhibit rhythm city
   -
   -

   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
   -
   -
   -
   -

B. Cardiac Muscle Tissue
   - located only in the heart
   - muscle fibers jointed 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
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: platymsa, buccinators, serratus, masseter, vastus
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.
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 ________.

Exercise B: Naming of Muscles:

1. Action:
2. Direction:
3. Location:
4. Divisions:
5. Shape:
6. Attachment:
7. Latin name:
   
   Levator scapulae    Triceps brachii
   Gluteus maximus    Quadriceps femoris
   Tranversus abdominis    Sternocleidomastoid
   Internal Oblique    Extensor carpi radialis
   Rectus abdominis    Pectoralis major
   Flexor carpi ulnaris    Deltoid
   Adductor longus    Trapezius
   Brachialis    External oblique
   Biceps brachii    Platysma
   Buccinator    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.