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 –

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

<u>Thin filaments</u>
Actin -
Troponin -
Tropomyosin -

<u>Thick filaments</u>
Myosin -

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

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

D. Relaxation

1. Acetylcholinesterase ( ) breaks down ACh
2. ATP breaks cross-bridge attachments
3. Ca^{+2} → 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 ---> ADP + P + E in order for the power stroke to occur.

If no ATP available (as in death) → cross-bridges cannot break.

A. What Supplies the Energy?

1.
2.

$$ADP + CP \xrightarrow{CPK} ATP + \text{creatine}$$

Creatine phosphate -

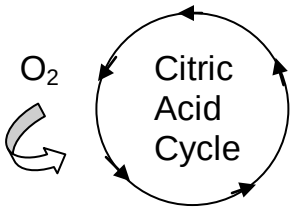
B. Cellular Respiration

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 _____

-G-G-G-G-G- ←→ glucose (6-carbon)
(Glycogen)

I GLYCOLYSIS
I **2 ATP(net)** (anaerobic)
V
2 pyruvic acid (3-carbon)



\+ Electron Transport System

==> CO_2 + H_2O + Energy
34 ATP(net)

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
   - O_2 available
   - buildup of CP and glycogen

2. Moderate activity
   - energy demand increases
   - incr. O_2 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_2 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*

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 (type I)

-
-
-
-
-

Fast-twitch glycolytic fibers (type IIa)

-
-
-

Fast-twitch fatigue resistant fibers (type IIb)

-
-
-
-
-

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
-

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

Bio 103 Muscular System

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 and 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

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.