CHAPTER 9: MUSCULAR SYSTEM

OBJECTIVES:

1. Compare and contrast the types of muscle tissues in terms of structure, control, location, and type of contraction, and function.

2. Describe three similarities among the three muscle tissues.

3. Identify the terms used for a muscle fiber's cell membrane and cytoplasm.

4. Describe the functions of muscle tissue.

5. Compare and contrast the functional characteristics of muscle tissue (i.e. excitability, contractility, extensibility, and elasticity).

6. Illustrate how a skeletal muscle is wrapped in four layers of connective tissue.

7. Define the terms *tendon, aponeurosis, raphe,* and *syncytium.*

8. Illustrate how the myofibrils that compose skeletal muscle fibers are composed of sarcomeres. Label the thick filaments, thin filaments, A-Band, I-Band and Z-line.

9. Compare and contrast the ultrastructure of thick and thin filaments.

10. Explain the significance of the special membranous organelles found in skeletal muscle tissue.

11. Explain what happens to sarcomere structure when a muscle contracts.

12. Explain the role that calcium plays in contraction.

13. Name the organelle that contains a high concentration of calcium due to the action of a calcium pump.

14. List the sequence of events involved in the power stroke of muscle contraction.

15. Define the terms *neuromuscular junction (NMJ), motor unit, motor end plate* and *neurotransmitter*.

16. Identify the neurotransmitter involved in muscle contraction.

17. List the sequence of events involved in skeletal muscle fiber contraction beginning with the necessary motor impulse initiated by the brain.

18. Explain how and why a contracted muscle relaxes.

19. Name the three pathways that regenerate energy/ATP in muscle cells.

20. Outline a general overview of cellular respiration, denoting its two major parts and where each occurs in the cell. Be sure to include starting products, end products, and any additional requirements. Then discuss the significance of this pathway in skeletal muscle contraction (don't forget that the midpoint product can take one of two pathways!!!).

21. Explain how lactic acid is produced and what its accumulation causes.

22. Define the term *oxygen debt*.

23. Demonstrate the negative feedback mechanisms that maintain thermal homeostasis.

24. Define the term *threshold stimulus*, and give the numerical value in skeletal muscle cells.

25. A myogram measures a muscle contraction as a *twitch*. What does this term mean?

26. Describe what is meant by "all or nothing" response in skeletal muscle fibers.

27. Define the term used to describe a myogram that shows a series of twitches with increasing strength.

28. Name the term when a myogram illustrates a sustained contraction that lacks even slight relaxation between twitches.

29. Compare and contrast isometric and isotonic muscle contractions.

30. List the differences between fast and slow muscle fibers, and explain why they are also called white and red fibers, respectively.

31. Distinguish between multi-unit and visceral smooth muscle and give examples of each type.

32. Define *peristalsis*.

33. List the characteristics of cardiac muscle tissue.

34. Define the terms *origin* and *insertion* as they relate to a skeletal muscle.

35. Define the terms *prime mover, antagonist, synergists*, and *fixator* as they relate to muscle actions, and use the thigh muscles as an example.

36. For every skeletal muscle listed in this outline, be able to complete the following:

    A. locate the muscle on a diagram or human muscle model.
    B. describe the shape and/or fascicle arrangement of the muscle.
    C. identify key origin and insertion sites.
    D. describe the action.

CHAPTER 9: MUSCULAR SYSTEM

I. OVERVIEW OF MUSCLE TISSUES: Review from Chapter 5.

A. Muscle Types: Skeletal
Smooth
Cardiac

B. **Similarities**:
1. All muscle cells are elongated = **muscle fibers**;
2. Muscle contraction depends on two kinds of myofilaments (**actin and myosin**);
3. The cell membrane of a muscle cell is called **"sarcolemma"**, while the cytoplasm of a muscle cell is called **"sarcoplasm"**.

C. **Skeletal Muscle Characteristics**:
1. long, thin and multi-nucleated fibers;
2. striations;
3. voluntary control;
4. arranged into packages called muscles that attach to and cover the bony skeleton;
5. contracts rapidly & vigorously, but tired easily; may exert great force.

D. **Cardiac Muscle Characteristics**:
1. network of branched fibers connected by gap junctions (intercalated disks);
2. only in heart;
3. striations;
4. involuntary control;
5. contracts at rhythmic, steady rate set by "pacemaker".

E. **Smooth Muscle Characteristics**:
1. lacks striations;
2. walls of hollow visceral organs and blood vessels;
3. involuntary control;
4. contractions are slow & sustained.

F. **Functions**:
1. **Movement** = locomotion & manipulation, vision, facial expression (skeletal), blood pumping (cardiac), food digesting, urination (smooth);
2. **Posture Maintenance** (skeletal)
3. **Joint Stability (**skeletal)
4. **Heat Generation** (skeletal)

G**.** **Functional Characteristics** of Muscle:
1. **Excitability** = the ability to receive and respond to stimuli;
2. **Contractility** = the ability to shorten forcibly when stimulated;
3. **Extensibility** = the ability to be stretched or extended;
4. **Elasticity** = the ability to bounce back to original length

II. SKELETAL MUSCLE

Introduction: Each skeletal muscle is an organ made up of skeletal muscle fibers, connective tissue coverings, blood vessels, and nerve fibers.

A. Structure of a Skeletal Muscle:

1. Connective Tissue Coverings:

a. Each muscle fiber (cell) is wrapped in a thin, delicate layer of CT called **endomysium**.

b. Many muscle fibers are bundled together into groups called **fascicles**;

- Each fascicle is wrapped in a second layer of CT made of collagen called **perimysium**.

c. Many fascicles are bundled together to form a **skeletal muscle**.

- Each skeletal muscle is covered by a third layer of dense, fibrous CT called **epimysium**.

d. Each skeletal muscle is then covered by a fourth, very tough fibrous layer of CT called **deep fascia**.

- The deep fascia may extend past the length of the muscle (**tendon** or **aponeurosis)**, and attach that muscle to a bone, cartilage or muscle.

B. Skeletal Muscle Fibers

Recall that skeletal muscle tissue possesses **striations**:

1. A muscle fiber is a long, thin cell;

a. Each muscle fiber is composed of **myofibrils**;

- Each myofibril is composed of two types of **protein filaments** (cytoskeletal elements):
  1. **Thick** filaments primarily composed of the protein myosin;
  2. **Thin** filaments primarily composed of the protein actin.
- Striations are caused by the arrangement of thick and thin filaments within the myofibrils:
  1. **A-Band** = dark area = overlapping of thick and thin filaments;
  2. **I-Band** = light area = thin filaments alone.
- The length of each myofibril is divided into **sarcomeres**:
  1. Sarcomeres meet one another at an area called the **Z-line**.

II. SKELETAL MUSCLE

B. Skeletal Muscle Fibers

2. **Thick filaments** = protein **myosin**.
   a. rod-like **tail** (axis) that terminates in two globular **heads or cross bridges**;
   b. Cross bridges interact with active sites on thin filaments;
3. **Thin filaments** = protein **actin**.
   a. coiled helical structure (resembles twisted strands of pearls):
   b. **Tropomyosin** = rod-shaped protein spiraling around actin backbone to stabilize it;
   c. **Troponin** = complex of polypeptides:
      - one binds to actin,
      - one that binds to tropomyosin,
      - one that binds to calcium ions;
   d. Both tropomyosin and troponin help control actin's interaction with myosin during contraction.

4. Within the sarcoplasm of a muscle fiber, there are two specialized membranous organelles:
   a. **Sarcoplasmic reticulum (SR)**
      - Network of membranous channels that surrounds each myofibril and runs parallel to it.
      - Same as endoplasmic reticulum in other cells.
      - SR has high concentrations of calcium ions compared to the sarcoplasm (maintained by active transport calcium pump).
      - When stimulated by muscle impulse, membranes become more permeable to calcium ions and calcium diffuses out of SR and into sarcoplasm.
   b. **Transverse tubules (TT)**
      - set of membranous channels that extends into the sarcoplasm as invaginations continuous with muscle cell membrane (sarcolemma).
      - TTs are filled with extracellular fluid and extend deep into the cell.
      - Each TT runs between two enlarged portions of SR called cisternae.
        - These structures form a triad near the region where actin and myosin overlap.
   c. SR and TT are involved in activating the muscle contraction mechanism (discussed in greater detail later).
   d. Because one TT is associated with two SR they are termed the **Triad**

II. SKELETAL MUSCLE

C. Skeletal Muscle Contraction:

1. **Neuromuscular Junction** - Stimulation of Skeletal Muscle Cell:

   a. **Neuromuscular Junction (NMJ)** = the site where a motor nerve fiber and a skeletal muscle fiber meet; (also called a synapse or synaptic cleft)
   b. In order for a skeletal muscle to contract, its fibers must first be **stimulated by a motor neuron**.
   c. **Motor Unit** = one motor neuron and many skeletal muscle fibers; See Fig 9.9, page 283.
   d. **Motor End Plate** = the specific part of a skeletal muscle fiber's sarcolemma directly beneath the NMJ.
   e. **Neurotransmitter** = chemical substance released from a motor end fiber, causing stimulation of the sarcolemma of muscle fiber; **acetylcholine (ACh)**.
   f. **Synaptic cleft** – small space between neuron and muscle

2. **Stimulus for Contraction**

   a. Introduction: The function of skeletal muscle is to move bones of the skeleton under voluntary control. Contraction of a skeletal muscle fiber is a complex interaction of several cellular and chemical constituents. The final result is a movement whereby actin and myosin filaments slide past one another. Accordingly, the muscle fiber shortens and pulls on its attachments.
   b. The process begins when a motor impulse is initiated by the brain, travels down the spinal cord, into a motor neuron, which branches into many motor nerve fibers/endings;
      - Each motor nerve fiber extends to the motor end-plate of a skeletal muscle fiber forming a neuromuscular junction (NMJ);
   c. When the motor impulse reaches the end of the motor nerve fiber/ending, the membrane is depolarized (-70mV to -55mV);
      - calcium ions rush into motor nerve fiber, and
      - neurotransmitter (Acetylcholine) is released into the NMJ (via exocytosis).
   d. Acetylcholine diffuses across the NMJ & stimulates/depolarizes the motor end-plate **(**sarcolemma) of a skeletal muscle fiber from -100mV to –70mV;
   e. The muscle impulse travels over the surface of the skeletal muscle fiber and deep into the muscle fiber by means of the TT

II. SKELETAL MUSCLE

C. Skeletal Muscle Contraction:

3. Excitation Contraction Coupling

a. The muscle impulse reaches the sarcoplasmic reticulum, which releases calcium ions into the sarcoplasm of the muscle fiber;
b. Calcium binds to troponin, moving tropomyosin and exposing myosin binding sites on actin filament;
c. Cross-bridges (linkages) form between actin and myosin;
d. Actin filaments are pulled inward by myosin cross-bridges;
e. The muscle fiber shortens as contraction occurs.

4. Sliding Filament Theory:

a. most popular theory concerning muscle contraction;
b. first proposed by Hugh Huxley in 1954;
c. states that muscle contraction involves the **sliding movement of the thin filaments (actin) past the thick filaments (myosin)**;
d. Sliding continues until the overlapping between the thin & thick filaments is complete.

*Remember that in a relaxed muscle cell, overlapping of thick and thin filaments is only slight.

e. **Changes in muscle during contraction:**

The distance between the Z-lines of the sarcomeres decreases;

- The I-Bands (light bands) shorten;
- The A-Bands move closer together, but do not diminish in length.

f. **The Role of Calcium in Contraction Mechanism**:

- In a resting muscle cell (i.e. in the absence of calcium ions):
  - Tropomyosin blocks or inhibits the myosin binding sites on actin.
- When **calcium ions (Ca^{++})** are present:
  - Ca^{++} binds to troponin causing a conformational change in the troponin-complex, which causes:
    1. Tropomyosin to move
    2. which "opens" or exposes the myosin binding sites on actin;
    3. This results in interaction between the active sites on actin and the heads (or cross bridges) of myosin.

II. SKELETAL MUSCLE

C. Skeletal Muscle Contraction:

5. **Cross-Bridge Cycling**

When calcium ions are present, the myosin binding sites on actin are exposed:

a. Cross-bridge attaches.
   - ATP breakdown provides energy to "cock" myosin head.
   - **"**Cocked**"** myosin attaches to exposed actin binding site

b. Cross-bridge (myosin head) springs from cocked position and pulls on actin filament.

c. Cross bridges break**.**
   - ATP binds to cross-bridge (but is not yet broken down)
   - Myosin heads are released from actin.

* As long as calcium ions and ATP are present, this walking continues until the muscle fiber is fully contracted.

6. **Relaxation**:

a. **Acetylcholinesterase** is an enzyme present in the NMJ;

b. It immediately destroys acetylcholine, so the motor end-plate is no longer stimulated (i.e. it cannot cause continuous muscle contraction).

c. Calcium ions are transported from sarcoplasm back into sarcoplasmic reticulum.

d. Linkages between actin and myosin are broken.

e. The muscle fiber relaxes.

7. **Energy Sources for Contraction**:

a. Introduction: The energy used to power the interaction between actin and myosin comes from ATP.

b. ATP stored in skeletal muscle lasts only about six seconds.
   - **ATP** must be regenerated continuously if contraction is to continue.
   - There are **three pathways in which ATP is regenerated**:
     1. Coupled Reaction with Creatine Phosphate (CP)
     2. Anaerobic Cellular Respiration
     3. Aerobic Cellular Respiration

c. **Coupled Reaction with Creatine Phosphate (CP)**

   - CP + ADP <------> creatine + **ATP**
   - Muscle stores a lot of CP,
   - This coupling reaction allows for about 10 seconds worth of ATP.

II. SKELETAL MUSCLE

C. Skeletal Muscle Contraction:

8. Oxygen Supply and Cellular Respiration:

Review from Chapter 4.

a. **Anaerobic Respiration**
   - Steps are called glycolysis.
   - Steps occur in the cytoplasm of the cell.
   - Results in production of pyruvic acid and **2 ATP**.

b. **Aerobic Respiration**
   - Steps are called citric acid cycle and electron transport chain.
   - Oxygen is required.
   - Steps occur in the mitochondrion of the cell.
   - Results in CO_2, water and **36ATP**.

9. Muscle Fatigue

a. Muscle fatigue is a state of physiological inability to contract;
b. If no oxygen is available in muscle cells to complete aerobic respiration, pyruvic acid is converted to **lactic acid,** which causes muscle fatigue and soreness
c. Results from a relative deficit of ATP and/or accumulation of lactic acid (which decreases pH).

10. Oxygen Debt:

a. The oxygen debt is the amount of oxygen necessary to support the conversion of lactic acid to glycogen.
b. needed to replenish spent glycogen stores.

11. Heat Production

a. Almost half of the energy released during muscle contraction is lost to heat, which helps maintain our body temperature at 37^{o} C.
b. Excessive heat is lost through many negative feedback mechanisms (discussed in chapter 1) including sweating, dilation of superficial blood vessels, increased breathing rate, and increased heart rate.

II. SKELETAL MUSCLE

D. MUSCULAR RESPONSES

1. **Threshold Stimulus**
   a. The minimal strength of stimulation required to cause contraction.
   b. A skeletal muscle fiber's resting membrane potential must be depolarized from –100mV to –70mv before an impulse begins; Therefore the threshold stimulus is +30mV.
2. **Recording a Muscle Contraction:**
   a. A myogram is a recording of a muscle contraction.
   b. A twitch is a single contraction that lasts a fraction of a second, followed by relaxation.
   c. The delay between stimulation and contraction is called the **latent period.**
   d. A muscle fiber must return to its resting state (-100mV) before it can be stimulated again. This is called the **refractory period**.
   e. **All-or-Nothing Response**
      - If a muscle fiber is brought to threshold or above, it responds with a complete twitch.
      - If the stimulus is sub-threshold, the muscle fiber will not respond.
   f. **Staircase Effect (treppe):**
      - Most muscle fiber contraction is "all-or-nothing".
      - However a muscle fiber that has been inactive can be subjected to a series of stimuli and:
        - the fiber undergoes a series of twitches with relaxation between, and
        - the strength of each successive contraction increases slightly.
      - This phenomenon is small and brief and involves excess calcium in sarcoplasm.

3. **Summation:**
   a. When several stimuli are delivered in succession to a muscle fiber, it cannot completely relax between contractions.
   b. The individual twitches begin to combine and the muscle contraction becomes sustained.
      - In a sustained contraction, the force of individual twitches combines in a process called summation.
      - When the resulting sustained contraction lacks even slight relaxation, it is called titanic contraction;

II. SKELETAL MUSCLE

D. MUSCULAR RESPONSES

4. **Motor Units:**
   a. Definition: A motor unit is a motor neuron and the many skeletal muscle fibers it stimulates.
   b. Because the motor neuron branches into several motor nerve endings, it can stimulate many skeletal muscles fibers simultaneously, which then contract simultaneously.
   c. The number of muscle fibers in a motor unit varies from 10-hundreds.
5. **Recruitment of Motor Units**
   a. Because a whole muscle is composed of many motor units, controlled by many different motor neurons, simultaneous contraction of all units does not necessarily occur.
   b. As the intensity of stimulation increases, recruitment of motor units increases, until all contract simultaneously.
6. **Sustained Contractions**
   a. Even when a muscle is at rest, a certain amount of sustained contraction is occurring in its fibers. This is called muscle tone.
      - **Muscle tone** is very important in maintaining posture.
7. **Types of Contractions:**
   a. **Isotonic contractions**
      - The muscle shortens and its attachment(s) move(s).
   b. **Isometric contraction**,
      - The muscle becomes taut, but the attachment(s) do not move; tensing a muscle;
   c. Most muscular movements involve both isotonic and isometric contractions.

8. **Fast and Slow Muscle Fibers**
   a. Muscle fibers vary in contraction speed (i.e. slow or fast twitch).
   b. Slow-Twitch Fibers are also called red fibers.
      - contain oxygen carrying pigment, myoglobin, receive a rich blood supply, and contain many mitochondria
      - can generate ATP fast enough to keep up with breakdown.
      - These fibers contract for long periods without fatiguing.
   c. Fast-twitch fibers are also called white fibers.
      - contain less myoglobin, blood, and fewer mitochondria.
      - contain extensive sarcoplasmic reticulum to store and reabsorb calcium.
      - These fibers contract rapidly, but fatigue easily due to lactic acid accumulation.

III. SMOOTH MUSCLE:

A. Introduction: The contraction mechanism of smooth muscle is similar to that of skeletal muscle in that interaction occurs between actin and myosin, however the transverse tubules and sarcoplasmic reticula are greatly reduced, and troponin is absent.

B. **Smooth Muscle Fibers** - Two types:

1. **Multi-unit smooth muscle**
   a. location:
      - irises of eyes
      - walls of blood vessels
   b. Contraction is rapid and vigorous (similar to skeletal muscle tissue).

2. **Visceral smooth muscle**
   a. Location = the walls of hollow organs
   b. Contraction is slow and sustained.
      - Rhythmicity = pattern of repeated contractions;
      - **Peristalsis** = wave-like motion that helps push substances through passageways.
   c. Structure:
      - random arrangement of actin and myosin filaments.
      - Two layers of muscle surround the passageway.
        1. inner circular layer
        2. outer longitudinal layer

C. **Smooth Muscle Contraction:**

1. A protein, **calmodulin** binds to calcium ions (no troponin) and activates the contraction mechanism.
2. Most calcium diffuses in to smooth muscle cells from the extracellular fluid (reduced SR).
3. Norepinephrine and acetylcholine are smooth muscle neurotransmitters.
4. Contraction is slow and sustained.

IV. **CARDIAC MUSCLE**: (Will be studied in greater detail at a later date.)

A. Location:
   1. Only in heart.

B. Anatomy:
   1. Striated uninuclear cells joined end-to-end forming a network.
      a. Cell junctions are called intercalated discs.
         - gap junctions
   2. Arrangement of actin and myosin not as organized as skeletal muscle.
   3. Contains sarcoplasmic reticula, transverse tubules, and numerous mitochondria:
      a. Sarcoplasmic reticulum is less developed than SR in skeletal muscle and stores much less calcium.

C. Physiology
   1. Self-exciting tissue (i.e. “Pacemaker”);
   2. Rhythmic contractions (60-100 beats/minute);
   3. Involuntary, all-or-nothing contractions
      a. Function as a “syncytium” (all-or-nothing)
   4. Pumps blood to:
      a. Lungs for oxygenation;
      b. Body for distribution of oxygen and nutrients.

V. SKELETAL MUSCLE ACTIONS

A. Introduction: Skeletal muscles generate a great variety of body movements. The action of a muscle primarily depends upon the joint associated with it and the manner in which the muscle is attached on either side of that joint.

B. **Origin and Insertion:** Recall that skeletal muscles are usually attached to a fixed body part and a movable body part:
   1. The **origin** of a muscle is its immovable (anchored) end.
   2. The **insertion** of a muscle is the movable end of a muscle.

   *When a muscle contracts and shortens, its insertion is pulled toward its origin.

C. Review of **Skeletal Muscle Actions**:
   1. **Flexion** = decreasing the angle between 2 bones;
      a. Dorsiflexion = decreasing the angle between the foot and shin;
      b. Plantar flexion = pointing toes;
   2. **Extension** = increasing the angle between 2 bones;
   3. **Abduction** = moving a body part away from the midline;
   4. **Adduction** = moving a body part toward the midline;
   5. **Circumduction** = movement in a circular (cone-shaped) motion;
   6. **Rotation** = turning movement of a bone about its long axis; (i.e. atlas/axis);
   7. **Supination** = thumbs up;
   8. **Pronation** = thumbs down;
   9. **Inversion** = sole of foot in;
   10. **Eversion** = sole of foot out;
   11. **Elevation** = lifting a body part; (i.e. shoulder shrug);
   12. **Depression** = returning a body part to pre-elevated position.

D. **Interactions of Skeletal Muscles**
   1. **Prime Mover (agonist)** = the primary muscle responsible for a movement.
      - The biceps brachii in flexing the arm at the elbow,
   2. **Antagonist(s)** = the muscle(s) in opposition to the action of the prime mover. The antagonist relaxes (or stretches) during the prime movement.
      - The triceps brachii is the antagonist of the biceps brachii when we flex the arm at the elbow.
   3. **Synergist(s)** = muscles that assist the prime mover.
      - The brachialis helps the biceps brachii during elbow flexion.
   4. **Fixators** = muscle groups that stabilize the origin of the prime mover (i.e. hold it in place) so that the prime mover can act more efficiently.
      - The scapula is the origin for many arm muscles, but it must be held in place by fixator muscles in order to function in this way.
        a. serratus anterior
        b. pectoralis minor

VI. MAJOR SKELETAL MUSCLES - Naming

CHARACTERISTIC	EXAMPLES	EXAMPLES IN HUMANS
Direction of fascicles relative to midline	rectus = parallel transverse = perpendicular oblique = at 45^{o} angle	Rectus abdominis Transversus abdominis External Oblique
Location (i.e. the bone or body part that a muscle covers)	frontal bone tibia	Frontalis Tibialis Anterior
Relative Size	maximus = largest longus = longest brevis = shortest	Gluteus maximus Palmaris longus Peroneus longus
Number of Origins (Heads)	biceps = 2 origins triceps = 3 origins	Biceps brachii Triceps brachii
Shape	deltoid = triangle trapezius = trapezoid serratus = saw-toothed orbicularis = circular	Deltoid Trapezius Serratus anterior Orbicularis oris
Location of Origin and/or Insertion	origin = sternum insertion = mastoid process	Sternocleidomastoid
Action of Muscle	flexion extension adduction	Flexor carpi radialis Extensor digitorum Adductor longus

VII. **MAJOR SKELETAL MUSCLES** (Keyed at the end of this outline)

Use the figures and tables in your text to complete the following information. If a muscle is starred (*), please include its origin and insertion.

A. Muscles of Facial Expression:

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Epicranius **Frontalis** **Occipitalis**		
Orbicularis oris		
Zygomaticus (*)		
Buccinator		
Platysma		
Orbicularis oculi		

B. Muscles of Mastication:

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Masseter(*)		
Temporalis		

VII. MAJOR SKELETAL MUSCLES (continued)

C. Muscles that move the Head and Vertebral Column:

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Sternocleidomastoid (*)		
Erector Spinae		

D. Muscles that move the Pectoral Girdle:

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Trapezius (*)		
Pectoralis minor		
Serratus anterior		

E. Muscles that move the Arm (Humerus):

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Pectoralis major (*)		
Latissimus dorsi		
Deltoid		

VII. **MAJOR SKELETAL MUSCLES** (continued)

F. **Muscles that move the Forearm (radius & ulna):**

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Biceps Brachii (*)		
Brachialis		
Brachioradialis		
Triceps brachii		

G. **Muscles that move the Hand**

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Flexor carpi radialis		
Flexor carpi ulnaris		
Palmaris longus		
Extensor digitorum		

VII. **MAJOR SKELETAL MUSCLES** (continued)

H. **Muscles of the Abdominal Wall:**

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Rectus abdominis (*)		
External Oblique		
Internal Oblique		
Transversus abdominis		

I. **Muscles of the Pelvic Outlet**

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Levator ani		
Coccygeus		
Superficial transversus perinei		
Bulbospongiosus		
Ischiocavernosus		
Sphincter urethrae		

VII. **MAJOR SKELETAL MUSCLES** (continued)

J. **Muscles that move the Thigh (Femur):**

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Gluteus Maximus (*)		
Gluteus Medius		
Adductor Longus		

K. **Muscles that move the Leg (Tibia & Fibula):**

NAME OF MUSCLE	**LOCATION/ DESCRIPTION**	**ACTION**
Rectus femoris		
Vastus lateralis		
Vastus Medialis		
Vastus intermedius		
Sartorius (*)		
Biceps femoris		
Semitendinosus		
Semimembranosus		

VII. **MAJOR SKELETAL MUSCLES** (continued)

L**. Muscles that move the Foot & Toes**

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Tibialis anterior		
Fibularis longus		
Gastrocnemius (*)		
Soleus		

Note the location of the Calcaneal Tendon.

VIII. **LIFE SPAN CHANGES**

A. Supplies of ATP, myoglobin, and creatine phosphate in muscle fibers begin to decline in one's forties.
B. Half of one's muscle mass has been replaced by connective and adipose tissue by age 80, and reflexes are reduced.
C. Exercise is the best way to maintain muscle function.

IX. **Homeostatic Imbalances/Disorders**

A. Tendinitis
B. Compartment Syndrome
C. Muscle Strain
D. Poliomyelitis
E. Myasthenia Gravis
F. Duchenne Muscular Dystrophy
G. Rigor Mortis
H. Botulism
I. Use and Disuse of Skeletal Muscles
J. TMJ
K. Parkinson's Disease

SKELETAL MUSCLE SUMMARY TABLES

A. Muscles of Facial Expression

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Epicranius **Frontalis** **Occipitalis**	Covers cranium over forehead over occipital	elevates eyebrow
Orbicularis oris	circular muscle around the mouth	closes lips ("kissing muscle")
Zygomaticus (*) Origin: zygomatic arch Insertion: corners of orbicularis oris	muscle that connects zygomatic arch to corner of mouth	elevates corners of mouth ("smiling muscle")
Buccinator	hollow of cheek	compresses cheeks "trumpeter's muscle"
Platysma	over lower jaw to neck	depresses mandible
Orbicularis oculi	circular muscle around eye	closes eye

B. Muscles of Mastication

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Masseter(*) Origin: Zygomatic Arch Insertion: Lateral Mandible	over lateral mandible	elevates mandible
Temporalis	convergent muscle over temporal bone	elevates mandible

SKELETAL MUSCLE SUMMARY TABLES

C. Muscles that move the Head and Vertebral Column:

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Sternocleidomastoid(*) Origin: sternoclavicular region Insertion: mastoid process of temporal	Major neck muscle	flexion of head toward chest (both contracted) rotation/abduction of head (as antagonists)
Erector Spinae	Group of midline dorsum muscles	Maintain posture

D. Muscles that move the Pectoral Girdle

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Trapezius (*) Origin: occipital bone & spines of C7-T12 Insertion: clavicle and acromion process of scapulae	Trapezoid shaped muscle in posterior neck and upper back	elevates pectoral girdle ("shoulder shrug")
Pectoralis minor	Muscle deep to Pectoralis major	scapula fixator
Serratus anterior	Saw-toothed lateral thoracic muscle	scapula fixator

E. Muscles that move the Arm (Humerus)

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Pectoralis major (*) Origin: clavicle, sternum, & costal cartilages of ribs 1-6 Insertion: Greater tubercle of humerus	Large, convergent chest muscle	flexes arm medially (pull arms forward and together)
Latissimus dorsi	Large, back muscle	adduction of humerus
Deltoid	Triangular shaped shoulder muscle	abduction of humerus

SKELETAL MUSCLE SUMMARY TABLES

F. Muscles that move the Forearm (radius & ulna)

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Biceps Brachii (*) Origin: Coracoid process Insertion: Radial tuberosity	fusiform, parallel, anterior upper arm muscle (two origins)	flexion of arm at elbow (prime mover)
Brachialis	muscle beneath biceps brachii	flexion of arm at elbow (synergist)
Brachioradialis	lateral muscle between upper and forearm	flexion of arm at elbow (synergist)
Triceps brachii	posterior upper arm muscle (three heads)	extension of arm at elbow

G. Muscles that move the Hand

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Flexor carpi Radialis	anterior, lateral forearm muscle	flexion of wrist
Flexor carpi Ulnaris	anterior, medial forearm muscle	flexion of wrist
Palmaris longus	anterior forearm muscle located between two above	flexion of wrist
Extensor digitorum	posterior forearm muscle	extension of wrist/fingers

SKELETAL MUSCLE SUMMARY TABLES

H. Muscles of the Abdominal Wall

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Rectus abdominis (*) Origin: pubic crest & symphysis Insertion: xiphoid process & costal cartilages of 5-7th ribs	strap like muscle from costal cartilages to ilium	tenses abdominal wall
External Oblique	superficial/lateral oblique abdominal muscle	tenses abdominal wall
Internal Oblique	deep oblique abdominal muscle	tenses abdominal wall
Transversus abdominis	deep abdominal muscle that runs perpendicular to rectus abdominis	tenses abdominal wall

I. Muscles of the Pelvic Outlet

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Levator ani	Thin sheet surrounding anus, urethra and vagina	Supports viscera and aids sphincters
Coccygeus	Fan shaped, posterior to levator ani	Same as above
Superficial transversus perinei	Band of muscle anterior to levator ani	Supports viscera
Bulbospongiosus	Surrounds base of penis or vagina	Male – assists ejaculation Female – constricts vaginal orifice
Ischiocavernosus	Band of muscle lateral to bulbospongiosus	Same as above
Sphincter urethrae	Surround urethra	Opens and closes urethral orifice

SKELETAL MUSCLE SUMMARY TABLES

J. Muscles that move the Thigh (Femur)

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Gluteus Maximus (*) Origin: dorsal ilium, sacrum, coccyx Insertion: posterior femur	buttocks, largest muscle in body	extension of hip at thigh (as in walking or climbing stairs)
Gluteus Medius	lateral hip muscle	abduction of femur
Adductor Longus	medial thigh muscle	adduction of femur

K. Muscles that move the Tibia & Fibula

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Rectus femoris	anterior thigh; quadriceps	extension of leg at knee
Vastus lateralis	lateral anterior thigh; quadriceps	extension of leg at knee
Vastus Medialis	medial anterior thigh; quadriceps	extension of leg at knee
Vastus intermedius	deep anterior thigh; quadriceps	extension of leg at knee
Sartorius (*) Origin: iliac spine Insertion: medial tibia	parallel strap-like muscle that crosses thigh	flexion of knee forward
Biceps femoris	posterior thigh; hamstring	flexion of leg at knee
Semitendinosus	posterior thigh; hamstring	flexion of leg at knee
Semimembranosus	posterior thigh; hamstring	flexion of leg at knee

SKELETAL MUSCLE SUMMARY TABLES

L. Muscles that move the Foot & Toes

NAME OF MUSCLE	LOCATION/ DESCRIPTION	ACTION
Tibialis anterior	anterior to tibia	dorsiflexion
Peroneus longus	lateral to fibula	eversion
Gastrocnemius (*) Origin: condyles of femur Insertion: calcaneus	posterior lower leg (i.e. calf muscle); two origins	plantar flexion (prime mover)
Soleus	deep to gastrocnemius	plantar flexion (synergist)