Chapter 8

The Muscular System
What do we want to learn in chapter 8?

• List, locate, and compare the structure and function of the three major types of muscle tissue
• Discuss the microscopic structure of a skeletal muscle sarcomere and motor unit
• Discuss how a muscle is stimulated and compare the major types of skeletal muscle contractions
What do we want to learn in chapter 8?

- Name, identify, and give the function of the major muscles of the body
- List and explain the most common types of movement produced by skeletal muscles
- Name and describe the major disorders of skeletal muscles
Introduction

• Muscular tissue enables the body and its parts to move
  – Movement caused by ability of muscle cells (called fibers) to shorten or contract
  – Muscle cells shorten by converting chemical energy (obtained from food) into mechanical energy, which causes movement
  – Three types of muscle tissue in body- skeletal, muscle, smooth
Muscle Tissue

• Skeletal muscle—also called striated or voluntary muscle
  – Is 40% to 50% of body weight (“red meat” attached to bones)
  – Microscope reveals crosswise stripes or striations
  – Contractions can be voluntarily controlled
Muscle Tissue

• Cardiac muscle—comprises bulk of heart
  – Cardiac muscle cells branch frequently
  – Characterized by unique dark bands called intercalated disks
  – Interconnected nature of cardiac muscle cells allows heart to contract efficiently as a unit
Muscle Tissue

- Smooth muscle—also called *nonstriated, involuntary, or visceral* muscle
  - Lacks cross stripes or striations when seen under a microscope; appears smooth
  - Found in walls of hollow visceral structures such as digestive tract, blood vessels, and ureters
  - Contractions not under voluntary control; movement caused by contraction is involuntary
Muscle Tissue

• Function—all muscle cells specialize in contraction (shortening)
Structure of Skeletal Muscle

- Major structures
  - Each skeletal muscle is an organ composed mainly of skeletal muscle cells and connective tissue
  - Most skeletal muscles extend from one bone across a joint to another bone
Structure of Skeletal Muscle

• Structure
  – Parts of a skeletal muscle
    • Origin—attachment to the bone that remains relatively stationary or fixed when movement at the joint occurs
    • Insertion—point of attachment to the bone that moves when a muscle contracts
    • Body—main part of the muscle
Structure of Skeletal Muscle

• Structure
  – Muscles attach to bone by tendons—strong cords of fibrous connective tissue; tendons lubricated by synovial fluid
  – Bursae—small synovial-lined sacs containing a small amount of synovial fluid; located between some tendons and underlying bones
Structure of Skeletal Muscle

• Microscopic structure and function
  – Muscle fibers—grouped into bundles
  1. Fibers contain thick myofilaments (containing the protein myosin) and thin myofilaments (composed of actin)
  2. Together, the thick and thin myofilaments make a sarcomere
  3. Fiber→filaments----→sarcomere
Basic functional (contractile) unit called a sarcomere

- **Sliding filament model** explains mechanism of contraction
  - Thick and thin myofilaments slide past each other as a muscle contracts
  - Contraction requires calcium and energy-rich ATP molecules
1. A nerve impulse travels to a muscle fiber through a motor neuron, triggering an electrical impulse that travels along the muscle fiber membrane.

2. The impulse triggers the release of calcium ions ($\text{Ca}^{++}$) from the endoplasmic reticulum and into the cytoplasm.

3. The $\text{Ca}^{++}$ ions bind to thin filaments and release actin to react with myosin. Myosin heads form ratcheting cross-bridges with actin, which pull the thin filaments toward the middle of the sarcomere—thus producing a contraction.
Functions of Skeletal Muscle

- Movement occurs at insertion
  - Muscles produce movement by pulling on bones as a muscle contracts
    - The insertion bone is pulled closer to the origin bone
    - Movement occurs at the joint between the origin and the insertion
Functions of Skeletal Muscle

- Movement
  - Groups of muscles usually contract to produce a single movement
    - Prime mover—muscle whose contraction is mainly responsible for producing a given movement
    - Synergist—muscle whose contractions help the prime mover produce a given movement
    - Antagonist—muscle whose actions oppose the action of a prime mover in any given movement
Functions of Skeletal Muscle

• Posture
  – A type of muscle contraction called *tonic contraction* enables us to maintain body position
    • In tonic contraction, only a few of a muscle’s fibers shorten at one time
    • Tonic contractions produce no movement of body parts
Functions of Skeletal Muscle

• Posture
  – Good posture (optimum body positioning) favors best body functioning
  – Skeletal muscle tone maintains posture by counteracting the pull of gravity
Functions of Skeletal Muscle

• Heat production
  – Survival depends on the body’s ability to maintain a constant body temperature
    • Fever—an elevated body temperature—often a sign of illness
    • Hypothermia—body temperature below normal
  – Contraction of muscle fibers produces most of the heat required to maintain normal body temperature
Fatigue

• Reduced strength of muscle contraction
• Caused by repeated muscle stimulation without adequate periods of rest
• Repeated muscular contraction depletes cellular ATP stores and outstrips the ability of the blood supply to replenish oxygen and nutrients
Fatigue

• Contraction in the absence of adequate oxygen produces lactic acid, which contributes to muscle burning

• *Oxygen debt*—the metabolic effort required to burn excess lactic acid that may accumulate during prolonged periods of exercise
  – Labored breathing after strenuous exercise is required to “pay the debt”
  – This increased metabolism helps restore energy and oxygen reserves to pre-exercise levels
Role of Other Body Systems in Movement

- Muscle functioning depends on the functioning of many other parts of the body
  - Most muscles cause movements by pulling on bones across movable joints
  - Respiratory, circulatory, nervous, muscular, and skeletal systems play essential roles in producing normal movements
Role of Other Body Systems in Movement

• Muscle functioning depends on the functioning of many other parts of the body
  – Multiple sclerosis, brain hemorrhage, and spinal cord injury are examples of how pathological conditions in other body organ systems can dramatically affect movement
Motor Unit

- Stimulation of a muscle by a nerve impulse is required before a muscle can shorten and produce movement.
- A motor neuron is the nerve cell that transmits an impulse to a muscle, causing contraction.
- A motor unit is the combination of a motor neuron and the muscle cell or cells it innervates.
Motor Unit

• A neuromuscular junction is the point of contact between a nerve ending and the muscle fiber it innervates
Muscle Stimulus

• A muscle will contract only if an applied stimulus reaches a certain minimal level of intensity—called a threshold stimulus.

• Once stimulated by a threshold stimulus, a muscle fiber will contract completely, a response called *all or none*. 
Muscle Stimulus

• Different muscle fibers in a muscle are controlled by different motor units having different threshold-stimulus levels
  – Although individual muscle fibers always respond all or none to a threshold stimulus, the muscle as a whole does not
  – Different motor units responding to different threshold stimuli permit a muscle as a whole to execute contractions of graded force
Types of Skeletal Muscle Contraction

• Twitch and tetanic contractions
  – Twitch contractions—quick, jerky responses to a stimulus—are laboratory phenomena and do not play a significant role in normal muscular activity
  – Tetanic contractions are sustained and steady muscular contractions caused by a series of stimuli bombarding a muscle in rapid succession..most daily tasks
Types of Skeletal Muscle Contraction

- Isotonic contractions
  - Produce *movement* at a joint
  - During isotonic contractions, the muscle changes length, causing the insertion end of the muscle to move relative to the point of origin
  - Concentric contractions shorten muscles
  - Eccentric contractions allow muscles to increase in length
  - Most types of body movements such as walking and running are caused by isotonic contractions
Types of Skeletal Muscle Contraction

• Isometric contractions
  – Isometric contractions are muscle contractions that do not produce movement; the muscle as a whole does not shorten
  – Although no movement occurs during isometric contractions, tension within the muscle increases
  – Muscles grow larger
**Isotonic**
Same tension; changing length

- Eccentric contraction
  - Muscle shortens
- Concentric contraction
  - Muscle lengthens

**Isometric**
Same length; changing tension

- Relaxed
- Contracting
Effects of Exercise on Skeletal Muscles

• Exercise, if done regularly and practiced properly, improves muscle tone and posture, results in more efficient heart and lung functioning, and reduces fatigue

• Specific effects of exercise on skeletal muscles
  – Muscles undergo changes related to the amount of work they normally do
    • Prolonged inactivity causes disuse atrophy
    • Regular exercise increases muscle size, called hypertrophy
Effects of Exercise on Skeletal Muscles

• Effects of exercise on skeletal muscles
  – Strength training involves contraction of muscles against heavy resistance
    • Strength training increases the number of myofilaments in each muscle fiber, and as a result, the total mass of the muscle increases
    • Strength training does not increase the number of muscle fibers
Effects of Exercise on Skeletal Muscles

- Effects of exercise on skeletal muscles
  - Endurance training increases a muscle’s ability to sustain moderate exercise over a long period; sometimes called *aerobic training*
    - Endurance training allows more efficient delivery of oxygen and nutrients to a muscle via increased blood flow
    - Endurance training does not usually result in muscle hypertrophy
Types of Movements Produced by Skeletal Muscle Contractions

- Flexion—movement that decreases the angle between two bones at their joint: bending
- Extension—movement that increases the angle between two bones at their joint: straightening
Types of Movements Produced by Skeletal Muscle Contractions

- Abduction—movement of a part away from the midline of the body
- Adduction—movement of a part toward the midline of the body
- Rotation and circumduction—movement around a longitudinal axis
Types of Movements Produced by Skeletal Muscle Contractions

• Supination and pronation—hand positions that result from rotation of the forearm; supination results in a hand position with the palm turned to the anterior position; pronation occurs when the palm faces posteriorly.
Types of Movements Produced by Skeletal Muscle Contractions

• Dorsiflexion and plantar flexion—foot movements; dorsiflexion results in elevation of the dorsum or top of the foot; during plantar flexion, the bottom of the foot is directed downward
rotation

A. Abduction
B. Rotation
C. Pronation
D. Dorsiflexion

Plantar flexion
Major Muscular Disorders

• Myopathies—muscle disorders; can range from mild to life threatening

• Muscle injury
  – Strain—injury from overexertion or trauma; involves stretching or tearing of muscle fibers
    • Often accompanied by myalgia (muscle pain)
    • May result in inflammation of muscle (myositis) or of muscle and tendon (fibromyositis)
    • If injury is near a joint and involves ligament damage, it may be called a sprain
Muscle Strain

Cold compress

Muscle raised
Major Muscular Disorders

• Muscle injury
  – Cramps are painful muscle spasms (involuntary twitches)
  – Crush injuries result from severe muscle trauma and may release cell contents that ultimately cause kidney failure
  – Stress-induced muscle tension can cause headaches and back pain
IT Band

- Iliac crest
- Gluteus medius m. covered by fascia
- Tensor fascia latae m.
- Gluteus maximus m.
- Vastus lateralis m.
- Iliotibial tract
- Lateral condyle of the tibia
- Patella
- Lateral patellar retinaculum
Stress and Muscle Pain
Major Muscular Disorders

• Infections
  – Several bacteria, viruses, and parasites can infect muscles
  – Poliomyelitis is a viral infection of motor nerves that ranges from mild to life threatening
Poliomelitis
Major Muscular Disorders

- Muscular dystrophy
  - A group of genetic disorders characterized by muscle atrophy
  - Duchenne (pseudohypertrophic) muscular dystrophy is the most common type
    - Characterized by rapid progression of weakness and atrophy, resulting in death by age 21
    - X-linked inherited disease, affecting mostly boys
Major Muscular Disorders

- **Myasthenia gravis**—autoimmune muscle disease characterized by weakness and chronic fatigue