

## MUSCULAR SYSTEM

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### INTRODUCTION

- A. Muscular tissue enables the body and its parts to move
  - a. Movement caused by ability of muscle cells (called fibers) to shorten or contract
  - b. Muscle cells shorten by converting chemical energy (obtained from food) into mechanical energy, which causes movement
  - c. Three types of muscle tissue exist in body

### MUSCLE TISSUE

- A. Types of muscle tissue
  - a. Skeletal muscle tissue also called striated or voluntary muscle
    - i. Is 40% to 50% of the body weight ("red meat" attached to bones)
    - ii. Microscope reveals crosswise stripes or striations
    - iii. Contractions can be voluntarily controlled
  - b. Cardiac muscle composes the bulk of the heart
    - i. Cardiac muscle cells branch frequently
    - ii. Characterized by unique dark bands called intercalated disks
    - iii. Interconnected nature of cardiac muscle cells allows heart to contract efficiently as a unit
  - c. Nonstriated muscle or involuntary muscle—also called smooth or visceral muscle
    - i. Lacks cross stripes or striations when seen under a microscope, appears smooth
    - ii. Found in walls of hollow visceral structures such as digestive tract, blood vessels and ureters
    - iii. Contraction not under voluntary control; movement caused by contraction is involuntary
- B. Function—all muscle cells specialize in contraction (shortening)

### STRUCTURE OF SKELETAL MUSCLE

- A. Structure
  - a. Each skeletal muscle is an organ composed mainly of **skeletal muscle cells (fibers)** and **connective tissue**
  - b. Most skeletal muscles extend from one bone across a joint to another bone
  - c. Parts of a skeletal muscle
    - i. **Origin (proximal attachment)**- attachment to the bone that remains relatively stationary or fixed when movement at the joint occurs
    - ii. **Insertion (distal attachment)** – point of attachment to the bone that moves when a muscle contracts
    - iii. **Body** – main part of the muscle (often referred to as the belly)
  - d. Muscles attach to bone by **tendons**—strong cords of fibrous connective tissue; some tendons enclosed in synovial-lined tubes (enveloping membrane) and are lubricated by synovial fluid; tubes are called tendon sheaths
  - e. **Bursae**—small synovial-lined sacs containing a small amount of synovial fluid, located between some tendons and underlying bones

- B. Microscopic structure
  - a. *Contractile cells are called fibers*—grouped into bundles
  - b. Fibers contain thick, myofilaments (containing the protein **myosin**) and thin myofilaments (containing the protein **actin**.)
  - c. Base functional (contractile) unit called **sarcomere**; sarcomeres separated from each other by dark bands called Z lines
    - i. Sliding filament model explains mechanism of contraction
      - 1. Thick and thin myofilaments slide past each other as a muscle contracts
      - 2. Contraction requires calcium and energy-rich ATP molecules

## FUNCTIONING OF SKELETAL MUSCLE

### A. Movement

- a. Muscles produce movement; as a muscle contracts, it pulls the insertion bone closer to the origin bone; movement occurs at the joint between the origin and the insertion
  - i. Groups of muscles usually contract to produce a single movement
    - 1. Prime mover—muscles whose contraction is mainly responsible for producing a given movement
    - 2. Synergists—muscles whose contraction helps the prime mover produce a given movement
    - 3. Antagonist—muscles whose actions oppose the action of a prime mover in any given movement

### B. Posture

- a. A specialized type of muscle contraction called a tonic contraction, enables us to maintain body position
  - i. In tonic contraction only a few of a muscle's fibers shorten at one time
  - ii. Tonic contractions produce no movement of body parts
  - iii. Tonic contractions maintain muscle tone called posture
    - 1. Good posture reduces strain on muscles, tendons, ligaments and bones
    - 2. Poor posture causes fatigue and may lead to deformity

### C. Heat production

- a. Survival depends on the body's ability to maintain a constant body temperature
  - i. Fever—an elevated body temperature, often a sign of illness
  - ii. Hypothermia—a reduced body temperature
- b. Contraction of muscle fibers produces most of the heat required to maintain normal body temperature

## FATIGUE

- A. Reduced strength of muscle contraction
- B. Caused by repeated muscle stimulation without adequate periods of rest
- C. Repeated muscular contraction depletes cellular ATP stores and outstrips the ability of the blood supply to replenish oxygen and nutrients
- D. Contraction in the absence of adequate oxygen produces lactic acid, which some think contributes to muscle soreness

- E. **Oxygen debt**—term used to describe the metabolic effort required to burn excess lactic acid that may accumulate during prolonged periods of exercise; the body is attempting to return the cells energy and oxygen reserves to pre-exercise levels

### ROLE OF OTHER BODY SYSTEMS IN MOVEMENT

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

- A. Stimulation of a muscle by a nerve impulse is required before a muscle can shorten and produce movement
- B. A **motor neuron** is the specialized nerve that transmits an impulse to a muscle, causing contraction
- C. A **neuromuscular junction** is the specialized point of contact between a nerve ending and the muscle fiber it innervates
- D. A **motor unit** is the combination of a motor neuron with the muscle cell or cells it innervates

### MUSCLE STIMULUS

- A. A muscle will contract only if an applied stimulus reaches a certain level of intensity
- A threshold stimulus is the minimal level of stimulation required to cause a muscle fiber to contract
- B. *Once stimulated by a threshold stimulus, a muscle fiber will contract completely, a response called all or none*
- C. Different muscle fibers in a muscle are controlled by different motor (units) neurons 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

- A. Twitch and tetanic contractions
- Twitch contractions are laboratory phenomena* and do not play a significant role in normal muscular activity; they are a single contraction of muscle fibers caused by a single threshold stimulus
  - Tetanic contractions** are sustained and steady muscular contractions caused by a series of stimuli bombarding a muscle in rapid succession
- B. Isotonic contractions
- Contraction of a muscle that produces movement at a joint*

- b. During isotonic contractions, the muscle shortens, causing the insertion end of the muscle to move toward the point of origin
- c. Most types of body movements such as walking and running are caused by isotonic contractions
- C. Isometric contractions
  - a. Isometric contractions are *muscle contractions that do not produce movement*; the muscle as a whole does not shorten
  - b. Although no movement occurs during isometric contractions, tension within the muscle increases

### **EFFECTS OF EXERCISE ON SKELETAL MUSCLES**

- A. Exercise, if regular and properly practiced, improves muscle tone and posture, results in more efficient heart and lung functioning, and reduces fatigue
- B. Effects of exercise on skeletal muscles
  - a. Muscles undergo changes related to the amount of work they normally do
    - i. Regular exercise increases muscle size, called hypertrophy
    - ii. Prolonged inactivity causes disuse atrophy
  - b. Strength training is exercise involving contraction of muscles against heavy resistance
    - i. Strength training increases the numbers of myofilaments in each muscle fiber, and as a result, the total mass of the muscle increases
    - ii. Strength training does not increase the number of muscle fibers
  - c. Endurance training is exercise that increases a muscle's ability to sustain moderate exercise over a long period; it is sometimes called aerobic training.
    - i. Endurance training allows more efficient delivery of oxygen and nutrients to a muscle via increased blood flow
    - ii. Endurance training does not usually result in muscle hypertrophy

### **SKELETAL MUSCLE GROUPS**

- A. Muscles of the head and neck
  - a. Facial muscles
    - i. Orbicularis oculi
    - ii. Orbicularis oris
    - iii. Zygomaticus
  - b. Muscles of mastication
    - i. Masseter
    - ii. Temporalis
  - c. Sternocleidomastoid – flexes head
  - d. Trapezius – elevates shoulders and extends head
- B. Muscles that move the upper extremities
  - a. Pectoralis major – flexes upper arm
  - b. Latissimus dorsi – extends upper arm
  - c. Deltoid – abducts upper arm
  - d. Biceps brachii – flexes forearm
  - e. Triceps brachii – extends forearm

- f. Brachialis – major flexor of forearm
- C. Muscles of the trunk
  - a. Abdominal muscles
    - i. Rectus abdominis
    - ii. External oblique
    - iii. Internal oblique
    - iv. Transversus abdominis
  - b. Respiratory muscles
    - i. Intercostal muscles
    - ii. Diaphragm
- D. Muscles that move the lower extremities
  - a. Iliopsoas – flexes thigh
  - b. Gluteus maximus – extends thigh
  - c. Adductor muscles – adduct thigh
    - i. Adductor magnus, adductor longus, adductor brevis, pectineus, gracilis
  - d. Hamstring muscles – flex lower leg
    - i. Semimembranosus
    - ii. Semitendinosus
    - iii. Biceps femoris
  - e. Quadriceps femoris group – extend the lower leg
    - i. Rectus femoris
    - ii. And the three vastus muscles: Vastus medialis; vastus intermedius; vastus lateralis
  - f. Tibialis anterior – dorsiflexes foot
  - g. Gastrocnemius – plantar flexes foot
  - h. Peroneus group – flex foot
    - i. Peroneus longus, Peroneus brevis, Peroneus tertius
    - ii. Aka as the fibularis group

#### **TYPES OF MOVEMENTS PRODUCED BY SKELETAL MUSCLES CONTRACTIONS**

- A. *Flexion* – movement that decreases the angle between two bones at their joint; bending
- B. *Extension* – movement that increases the angle between two bones at their joint: straightening
- C. *Abduction* – movement of a part away from the midline of the body
- D. *Adduction* – movement of a part toward the midline of the body
- E. *Rotation* – movement around a longitudinal axis
- F. *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
- G. *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 (in other words the toes are pointed)

#### **MAJOR MUSCULAR DISORDERS**

- A. Myopathies: muscle disorders; can range from mild to life threatening

- B. Muscle injury:
  - a. Strain – injury from overexertion or trauma; involves stretching or tearing of muscle fibers
    - i. Often accompanied by Myalgia (muscle pain)
    - ii. May result in inflammation of muscle (myositis) or of a muscle and tendon (fibromyositis)
    - iii. If injury is near a joint and involves ligament damage, it may be called a sprain
  - b. Cramps are painful muscle spasms (involuntary twitches)
  - c. Crush injuries result from severe muscle trauma and may release cell contents that ultimately cause kidney failure
  - d. Stress-induced muscle tension can cause headaches and back pain
- C. Infections
  - a. Several bacteria, viruses and parasite can infect muscles
  - b. Poliomyelitis is a viral infection of motor nerves that ranges from mild to the life threatening
- D. Muscular dystrophy
  - a. A group of genetic disorders characterized by muscle atrophy
  - b. Duchenne (pseudohypertrophic) muscular dystrophy is the most common type
    - i. Characterized by rapid progression of weakness and atrophy; often resulting in death by age 21
    - ii. X-linked inherited disease, affecting mostly boys
- E. Myasthenia gravis – autoimmune muscle disease characterized by weakness and chronic fatigue

**VOCABULARY**

Abduction	fatigue	myosin	rotation
Actin	flexion	neuromuscular	sarcomere
Adduction	hypertrophy	junction	sliding filament theory
All or none	insertion	origin	stimulus
Antagonist	isometric	oxygen debt	supination
Bursa	isotonic	plantar flexion	synergist
Chronic fatigue	motor neuron	posture	tendon
Dorsiflexion	motor unit	prime mover	tetanic contraction
Extension	myofilaments	pronation	tonic contraction

**DISEASES AND OTHER CLINICAL TERMS**

Atrophy	cramps	muscular dystrophy	myositis
Carpal tunnel syndrome	fibromyositis	myalgia	paralysis
	Hypothermia	myasthenia gravis	poliomyelitis
Contusion	muscle strain	myopathy	tenosynovitis

## The Muscular System

### Functions of Muscle Tissue

- a. *Body movement*
- b. *Heat production*
- c. *Posterior and support*

### Arrangement of muscle tissue:

- a. the arrangement of muscle tissue from the largest to the smallest structure is as follows: *muscle* -> *fascicle* (bundles of muscle fibers) -> *muscle fiber* (muscle cell) -> *myofibril* -> *thick and thin myofilaments* -> *actin and myosin proteins*
- b. *Actin* – small, round proteins that form the backbone of the thin myofilaments
- c. *Myosin* – long proteins with globular heads; responsible for binding with the actin molecules and pulling the thin myofilaments closer together
- d. *Motor unit* – one motor neuron and the many muscle fibers it innervates

### Muscle contraction:

- a. Every *muscle fiber (muscle cell)* belongs to a motor unit and therefore receives a branch from an axon terminal. Large muscle groups, such as those in the back or legs concerned with gross motor movements, contain large motor units (approximately 200 to 500 muscle fibers per motor unit.) Small muscle groups, such as those around the eyes or in the hands concerned with fine motor movements, are quite small (sometimes only 10 to 15 muscle fibers per motor unit.) The strength of a muscle contraction is determined by recruitment and the all-or-none law.
- b. *Recruitment* - the number of motor units activated to perform a given task
- c. *All-or-none-law* – (also called Bowditch's law or the staircase phenomenon) when a muscle fiber is stimulated by an action potential from a nerve, the entire muscle fiber contracts; if the stimulus from the nerve is not strong enough, then one of the muscles will contract; motor units also follow this law (when a motor unit is activated, all the muscle fibers in that unit contract or none at all.)
- d. *Muscle twitch* – a single muscle contraction followed by relaxation of the muscle
- e. *Tetanus* – sustained muscle contraction; also called muscle spasm
- f. *Isometric contraction* - [iso – same; metric – length] the muscle contracts but does not change length during the contraction – isometric contraction stabilizes a body part to keep it from moving during an activity.
- g. *Isotonic contraction* - [iso – same; tonic – strength or tone] – the muscle contracts but does not change length during the contraction
- h. *Concentric contraction* – the muscle contracts and shortens. Concentric contraction accelerates a body part to produce a force.
- i. *Eccentric contraction* – the muscle contracts and lengthens. Eccentric contractions slow a body part down or resist a force after it has been produced.

### Muscle Movement –

- a. *Agonist (Prime Mover)* – the muscle that is most responsible for a particular movement when that muscle contracts
- b. *Synergist* – a muscle that helps another muscle (an agonist) perform a movement
- c. *Antagonist* – a muscle that works against the agonist or performs the opposite movement.

**Muscle Attachment –**

- a. *Tendon*- dense fibrous connective tissue that connects muscle to bone (a ligament connects bone to bone)
- b. *Aponeurosis* – a broad, flat, thin tendon
- c. *Origin* – the more stationary attachment site
- d. *Insertion* – the more movable attachment site

**Types of Muscle Tissue –**

- a. *Cardiac*
- b. *Smooth (visceral)*
- c. *Skeletal*

**Diseases of the Muscular System****GENERAL TERMINOLOGY:**

- a. *Atrophy*: a decrease in muscle cell size fronts either disease or disuse
- b. *Hypertrophy*: an increase in muscle cell size
- c. *Myalgia*: muscle pain
- d. Remember, you cannot increase or decrease the number of muscle (or fat) cells in your body, you can only increase or decrease their size.

**DISORDERS:**

- a. **Strain**: occurs when a muscle or tendon is stretched beyond its elastic limits
  - i. Cause: trauma
  - ii. Contraindications/indications: use ice and energy work during the initial 48 to 72 hours, massage proximal to the injury may improve circulation and healing.
- b. **Sprain**: occurs when a ligament or joint capsule becomes stretched beyond its elastic limits. Strains and sprains are graded according to their severity. First degree: stretched condition of fibers, minimal degree of swelling, minimal limitations. Second degree: partially torn condition of fibers, moderate degree of swelling, moderate limitation. Third degree: completely torn condition of fibers, severe degree of swelling, marked limitation.
  - i. Cause: trauma
  - ii. Contraindications/indications: use ice and energy work during the initial 48 to 72 hours; massage proximal to the injury may improve circulation and healing.
- c. **Muscle spasm: (cramp)** – spontaneous, involuntary contraction of skeletal muscle.
  - i. Cause: trauma, water or electrolyte imbalance causing the motor neurons to become hypersensitive and send out spontaneous action potentials
  - ii. Contraindications/indications: short effleurage from tendons to muscle belly can reset proprioceptors; compression, strain-counterstrain, proprioceptive neuromuscular facilitation, and reciprocal inhibition stretching techniques can be effective.
- d. **Fibromyalgia**: a widespread musculoskeletal pain and fatigue disorder; 80 to 90% of cases occur in women; primarily affects the soft fibrous tissues of the body – muscles, ligaments, and tendons; patients describe their pain as deep muscular aching, throbbing, shooting and stabbing; intense burning may also be present as well as abnormal patterns of sleep, diffuse pain and fatigue (particularly in muscles), headaches, irritable bowel, numbness and tingling in the extremities, and tender points

- 18 specific points primarily in the necks, spine, shoulders and hips where tenderness occurs; diagnosis is often based on tenderness or pain in at least 11 of the 18 specific tender points.
  - i. Cause: unknown; theories include injuries or trauma that affects the CNS, changes in muscle metabolism that may decrease blood flow and cause fatigue, or an infectious agent such as a virus.
  - ii. Contraindications/indications: use caution around tender points; kneading, petrissage, and friction should be performed only as a client's tolerance allows.
- e. **Chronic Fatigue Syndrome:** disorder characterized by fatigue that is persistent, relapsing or debilitating and does not improve with bed rest; to be officially diagnosed with this disease, the patient must also have fatigue that reduces or impairs average daily activity levels by more than 50% for a period of at least 6 months and have no previous history of fatigue.
  - i. Cause: unknown; many theories exist, including virus infection, autoimmunity, multiple nutrient deficiencies, food intolerance, or extreme physical or mental stress.
  - ii. Contraindications/indications: massage may reduce associated stress and anxiety and allow the body to relax; avoid any deep tissue work because it could overwork the immune system.
- f. **Torticollis (wryneck):** a deformity of the neck causing tilting or rotation to one side
  - i. Cause: spasm of the sternocleidomastoid muscle because of strain or infection
  - ii. Contraindications/indications: massage to the neck (specifically the sternocleidomastoid muscle) will help relieve tension and anxiety
- g. **Muscular dystrophy:** a group of muscular disorders in which there is considerable muscle degeneration and weakness
  - i. Cause: inherited genetic trait
  - ii. Contraindications/indications: basic massage can relieve tension and related stress and anxiety and could even slow atrophy; stretching can also be effective – if the patient can tolerate it
- h. **Duchenne muscular dystrophy:** the most common form of muscular dystrophy, common signs which usually appear before three years of age include lordosis, muscle contractures, muscle wasting and fat and connective tissue deposition in the muscles; patients are usually confined to a wheelchair by 12 years of age.
  - i. Cause: inherited, sex-linked trait (predominately affects males)
  - ii. Contraindications/indications: basic massage can relieve tension and related stress and anxiety and could even slow atrophy; stretching (if tolerated) can also be effective.
- i. **Myasthenia gravis:** a disease characterized by destruction of acetylcholine receptor sites, producing overall muscle weakness; weakness is made worse by exercise and emotional stress and may lead to death if the respiratory muscles are affected; four times more common in women than in men; incidence rate in the US is about 3 per 100,000.
  - i. Causes: autoimmune disease in which the body produces an immune response against the acetylcholine receptors in the neuromuscular junction; sometimes the cause is unknown.
  - ii. Contraindications/indications: basic massage and range of motion exercises can relax and reduce stress; avoid any deep tissue work, which can release toxins in the body, stressing the kidneys and liver and potentially further complicating the condition.

## The Muscular System SYNOPSIS

This chapter describes the general structure and overall function of muscle tissue. There are three major types of muscle tissue: skeletal or striated, smooth or nonstriated, and cardiac. The muscular system is often referred to as the power system because it provides all of the motion needed for the body to move. Muscle contractions are designed as one of several types: isotonic, isometric, twitch, or tetanic. Muscles must be used to prevent atrophy. Scientific evidence points to the fact that proper exercise affects the entire system.

### LEARNING OBJECTIVES WITH RATIONALE

the student will be able to:

#### 1. List, locate in the body, and compare the structure and function of the three major types of muscle tissue.

There are **three major types of muscle tissue**. *Striated muscle*, also known as *skeletal or voluntary muscle*, appears as bundles of fine threads with many crosswise stripes when observed under a microscope. This type of muscle tissue is always attached to bones in the body, and its contractions are controlled voluntarily. Another type of muscle tissue—called **nonstriated, smooth, or involuntary**—shows no cross-stripes when observed under a microscope. It forms most of the internal body organs, and we have no control over its contractions. The final type of muscle tissue, called **cardiac**, is made up of branching cells with very faint striations. It makes up the heart.

#### 2. Discuss the microscopic structure of a skeletal muscle sarcomere and motor unit.

Skeletal muscle tissue, when observed under a microscope, is made up of fine, threadlike structures called myofilaments: **thick, composed of a protein called myosin**; and **thin, composed of a protein called actin**. These myofilaments are arranged in the form of dark and light stripes that are separated from each other by dark bands called **Z-lines**. Dark stripes are called **A-bands**, and they are *made up of both actin and myosin*. Light bands are called **I-bands**, and they are *made up only of actin*.

The Z-line runs through the I-band region. The *basic unit of muscle contraction, called the sarcomere*, is defined as the area that runs from one Z-line to the next. Shortening the sarcomere or moving thin and thick molecules toward one another serves as the basis of muscle contraction.

Muscle cells are stimulated by a nerve fiber that enters the muscle fiber. This nerve is called the motor neuron. The *motor neuron, together with the muscle cell it innervates, is called the motor unit*.

#### 3. Discuss how a muscle is stimulated, and compare the major types of skeletal muscle contractions.

*The point of contact between a neuron and a muscle fiber is called the neuromuscular junction.*

Chemicals must pass across this junction to initiate contraction.

One type of muscle contraction pattern that can be produced is called *isometric*.

*Isometric contraction does not produce movement.* It causes muscle length to remain the same while tension within the muscle is increased. Pushing against an immovable object is an example of isometric contraction.

Another type of contraction is called *isotonic*. It does produce movement at a joint. *The muscle does shorten, and the insertion end moves toward the point of origin.* Lifting an object is an example of isotonic contraction.

A twitch contraction is a quick, jerky contraction in response to a single stimulus.

*A tetanic contraction is more sustained* than a twitch. It is produced by a series of stimuli bombarding the muscle in rapid succession.

### EXERCISE

4. Name, identify on a model or diagram, and give the function of the major muscles of the body.

The following table lists the major muscles of the body and their functions.

Muscle Function

<b>Pectoralis major</b>	Flexes upper arm, helps adduct upper arm
<b>Latissimus dorsi</b>	Extends upper arm, helps adduct upper arm
<b>Deltoid</b>	Abducts upper arm
<b>Biceps brachii</b>	Flexes lower arm
<b>Triceps brachii</b>	Extends lower arm
<b>Iliopsoas</b>	Flexes trunk or thigh
<b>Sartorius</b>	Flexes thigh and rotates lower leg
<b>Gluteus maximus</b>	Extends thigh
<b>Adductors</b>	Adducts thigh
<b>Hamstring group</b>	Flexes lower leg
<b>Quadriceps group</b>	Extends lower leg
<b>Gastrocnemius</b>	Plantar flexes foot
<b>Rectus abdominis</b>	Flexes trunk
<b>Trapezius</b>	Extends head and neck
<b>Sternocleidomastoid</b>	Rotates and extends head
<b>Orbicularis oculi</b>	Closes eye
<b>Zygomaticus</b>	Elevates corners of mouth and lips
<b>Orbicularis oris</b>	Draws lips together
<b>Masseter</b>	Closes jaw

5. List and explain the most common types of movement produced by skeletal muscles.

Types of movement produced by skeletal muscle contractions include:

- a. **Flexion**—a movement that makes the angle between two bones at their joint smaller than it was at the beginning of the movement.
- b. **Extension**—a movement that makes the angle between two bones at their joint larger than it was at the beginning of the movement.
- c. **Abduction**—a movement that takes a part away from the midline of the body.

- d. **Adduction**—a movement that takes a part toward the midline of the body.
- e. **Rotation**—a movement around a longitudinal axis.

## LECTURE OUTLINE

### I. INTRODUCTION

A. Muscular tissue enables the body and its parts to move.

- 1. Movement caused by ability of muscle cells (called fibers) to shorten or contract.
- 2. Muscle cells shorten by converting chemical energy (obtained from food) into mechanical energy, which causes movement.
- 3. Three types of muscle tissue exist in body.

### II. MUSCLE TISSUE

#### A. Types of muscle tissue

- 1. Skeletal muscle—also called striated or voluntary muscle
  - a. Is 40–50% of body weight (“red meat” attached to bones)
  - b. Microscope reveals cross-stripes or striations
  - c. Contractions can be voluntarily controlled
- 2. Cardiac muscle—composes bulk of heart
  - a. Cardiac muscle cells branch frequently
  - b. Characterized by unique dark bands called intercalated disks
  - c. Interconnected nature of cardiac muscle cells allows heart to contract efficiently as a unit
- 3. Nonstriated muscle or involuntary muscle—also called smooth or visceral muscle
  - a. Lacks cross-stripes or striations when seen under a microscope; appears smooth
  - b. Found in walls of hollow visceral structures such as digestive tract, blood vessels, and ureters
  - c. Contractions not under voluntary control; movement caused by contraction is involuntary

**B. Function**—all muscle cells specialize in contraction (shortening)

### III. STRUCTURE OF SKELETAL MUSCLE

#### A. Structure

- 1. Each skeletal muscle is an organ composed mainly of skeletal muscle cells and connective tissue
- 2. Most skeletal muscles extend from one bone across a joint to another bone
- 3. Parts of a skeletal muscle
  - a. **Origin**—attachment to the bone that remains relatively stationary or fixed when movement at the joint occurs
  - b. **Insertion**—point of attachment to the bone that moves when a muscle contracts
  - c. **Body**—main part of the muscle
- 4. Muscles attach to bone by tendons—strong cords of fibrous connective tissue; some **tendons** enclosed in *synovial-lined tubes* and are lubricated by synovial fluid; tubes called **tendon sheaths**

5. **Bursae**—small synovial-lined sacs containing a small amount of synovial fluid; located between some tendons and underlying bones

#### **B. Microscopic structure**

1. Contractile cells called fibers—grouped into bundles
2. Fibers contain thick myofilaments (containing protein *myosin*) and thin myofilaments (composed of *actin*)
3. *Basic functional (contractile) unit* called **sarcomere**—sarcomeres separated from each other by dark bands called Z-lines
  - a. Sliding filament model explains mechanism of contraction
    - (1) Thick and thin myofilaments slide past each other as a muscle contracts
    - (2) Contraction requires calcium and energy-rich ATP molecules

### **IV. FUNCTIONS OF SKELETAL MUSCLE**

#### **A. Movement**

1. Muscles produce movement—as a muscle contracts, it pulls the insertion bone closer to the origin bone; movement occurs at the joint between the origin and the insertion
  - a. Groups of muscles usually contract to produce a single movement
    - (1) Prime mover—muscle whose contraction is mainly responsible for producing a given movement
    - (2) Synergist—muscle whose contractions help the prime mover produce a given movement
    - (3) Antagonist—muscle whose actions oppose the action of a prime mover in any given movement

#### **B. Posture**

1. A specialized type of muscle contraction, called tonic contraction, enables us to maintain body position
  - a. In tonic contraction, only a few of a muscle's fibers shorten at one time
  - b. Tonic contractions produce no movement of body parts
  - c. Tonic contractions maintain muscle tone called posture
    - (1) Good posture reduces strain on muscles, tendons, ligaments, and bones
    - (2) Poor posture causes fatigue and may lead to deformity

#### **C. Heat production**

1. Survival depends on the body's ability to maintain a constant body temperature
  - a. Fever—an elevated body temperature—often a sign of illness
  - b. Hypothermia—a reduced body temperature
2. Contraction of muscle fibers produces most of the heat required to maintain normal body temperature

### **V. FATIGUE**

A. Reduced strength of muscle contraction

B. Caused by repeated muscle stimulation without adequate periods of rest

C. Repeated muscular contraction depletes cellular ATP stores and outstrips the ability of the blood supply to replenish oxygen and nutrients

D. Contraction in the absence of adequate oxygen produces lactic acid, which contributes to muscle soreness

E. **Oxygen debt**—term used to describe the metabolic effort required to burn excess lactic acid that may accumulate during prolonged periods of exercise; the body is attempting to return the cells' energy and oxygen reserves to pre-exercise levels

## VI. ROLE OF OTHER BODY SYSTEMS IN MOVEMENT

A. Muscle functioning depends on the functioning of many other parts of the body

1. Most muscles cause movements by pulling on bones across movable joints
2. Respiratory, circulatory, nervous, muscular, and skeletal systems play essential roles in producing normal movements
3. Multiple sclerosis, brain hemorrhage, and spinal cord injury are examples of how pathologic conditions in other body organ systems can dramatically affect movement

## VII. MOTOR UNIT

A. **Stimulation** of a muscle by a nerve impulse is required before a muscle can shorten and produce movement

B. A **motor neuron** is the specialized nerve that transmits an impulse to a muscle, causing contraction

C. A **neuromuscular junction** is the specialized point of contact between a nerve ending and the muscle fiber it innervates

D. A **motor unit** is the combination of a motor neuron with the muscle cell or cells it innervates

## VIII. MUSCLE STIMULUS

A. A muscle will contract only if an applied stimulus reaches a certain level of intensity

1. A **threshold stimulus** is the minimal level of stimulation required to cause a muscle fiber to contract

B. Once activated by a threshold stimulus, a muscle fiber will contract completely, a response called **all or none**

C. *Different muscle fibers in a muscle are controlled by different motor units having different threshold-stimulus levels*

1. Although individual muscle fibers always respond all or none to a threshold stimulus, the muscle as a whole does not
2. Different motor units responding to different threshold stimuli permit a muscle as a whole to execute contractions of graded force

## IX. TYPES OF SKELETAL MUSCLE CONTRACTION

A. Twitch and tetanic contractions

1. *Twitch contractions are laboratory phenomena* and do not play a significant role in normal muscular activity; they are a single contraction of muscle fibers caused by a single threshold stimulus
2. **Tetanic contractions are sustained and steady muscular contractions** caused by a series of stimuli bombarding a muscle in rapid succession

B. *Isotonic contractions*

1. Contraction of a muscle that *produces movement at a joint*
2. During isotonic contractions, the muscle shortens, causing the insertion end of the muscle to move toward the point of origin

3. Most types of body movements such as walking and running are caused by isotonic contractions

C. *Isometric contractions*

1. Isometric contractions are muscle *contractions that do not produce movement*; the muscle as a whole does not shorten
2. Although no movement occurs during isometric contractions, tension within the muscle increases

## X. EFFECTS OF EXERCISE ON SKELETAL MUSCLES

A. Exercise, if regular and properly practiced, improves muscle tone and posture, results in more efficient heart and lung functioning, and reduces fatigue

B. Effects of exercise on skeletal muscles

1. Muscles undergo changes related to the amount of work they normally do
  - a. Prolonged inactivity causes disuse atrophy
  - b. Regular exercise increases muscle size, called hypertrophy
2. Strength training is exercise involving contraction of muscles against heavy resistance
  - a. Strength training increases the numbers of myofilaments in each muscle fiber, and as a result, the total mass of the muscle increases
  - b. Strength training does not increase the number of muscle fibers
3. Endurance training is exercise that increases a muscle's ability to sustain moderate exercise over a long period; it is sometimes called aerobic training
  - a. Endurance training allows more efficient delivery of oxygen and nutrients to a muscle via increased blood flow
  - b. Endurance training does not usually result in muscle hypertrophy

## XI. SKELETAL MUSCLE GROUPS

A. Muscles of the head and neck

1. Facial muscles
  - a. Orbicularis oculi
  - b. Orbicularis oris
  - c. Zygomaticus
2. Muscles of mastication
  - a. Masseter
  - b. Temporal
3. Sternocleidomastoid—flexes head
4. Trapezius—elevates shoulders and extends head

B. Muscles that move the upper extremities

1. Pectoralis major—flexes upper arm
2. Latissimus dorsi—extends upper arm
3. Deltoid—abducts upper arm
4. Biceps brachii—flexes forearm
5. Triceps brachii—extends forearm

C. Muscles of the trunk

1. Abdominal muscles
  - a. Rectus abdominis
  - b. External oblique
  - c. Internal oblique
  - d. Transversus abdominis
2. Respiratory muscles
  - a. Intercostal muscles

- b. Diaphragm
- D. Muscles that move the lower extremities
  1. Iliopsoas—flexes thigh
  2. Gluteus maximus—extends thigh
  3. Adductor muscles—adduct thighs
  4. Hamstring muscles—flex lower leg
    - a. Semimembranosus
    - b. Semitendinosus
    - c. Biceps femoris
  5. Quadriceps femoris group—extends lower leg
    - a. Rectus femoris
    - b. Vastus muscles
  6. Tibialis anterior—dorsiflexes foot
  7. Gastrocnemius—plantar flexes foot
  8. Peroneus group—flex foot

## XII. TYPES OF MOVEMENTS PRODUCED BY SKELETAL MUSCLE CONTRACTIONS

- A. Flexion—movement that decreases the angle between two bones at their joint: bending
- B. Extension—movement that increases the angle between two bones at their joint: straightening
- C. Abduction—movement of a part away from the midline of the body
- D. Adduction—movement of a part toward the midline of the body
- E. Rotation—movement around a longitudinal axis
- F. 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
- G. Dorsiflexion and plantar flexion—ankle movements; dorsiflexion results in elevation of the dorsum or top of the foot; during plantar flexion, the bottom of the foot is directed downward

### Review Questions

#### 1. Briefly describe the structure of cardiac muscle.

**Answer:** The bulk of the heart is composed of cardiac muscle with cylindrical cells that branch frequently and combine into an interconnected tissue. The interconnected nature of cardiac muscle fibers helps the tissue to contract as a unit, increasing the efficiency of the heart muscle in pumping blood.

#### 2. Briefly describe the structure of smooth muscle.

**Answer:** Smooth, nonstriated, or visceral muscle lacks cross-stripes, or striation, when seen under a microscope and appears smooth. Smooth, or involuntary, muscle forms an important part of blood vessel walls and many hollow visceral organs, such as the digestive tract, urethra, and ureters.

The muscle contractions are not under voluntary control; movement caused by a contraction is involuntary.

#### 3. Briefly describe the structure and give the function of tendons, bursae, and synovial membranes.

**Answer: Tendons** anchor muscles firmly to bones. They are made of dense, fibrous connective tissue in the shape of strong heavy cords.

**Bursae** are small fluid-filled sacs that lie between some tendons and bones. These small sacs are made of connective tissue and are lined with synovial membranes.

**Synovial membranes** secrete a slippery lubricating fluid called synovial fluid, which fills the bursa, making it easy for tendons to slide over bones.

#### 4. Explain how tonic contractions help maintain posture.

**Answer:** With **tonic contractions**, the muscle as a whole does not shorten and movement does not occur. The contractions *do hold muscles in position by use of muscle tone*. Skeletal muscle tone *maintains posture by counteracting the pull of gravity*, which tends to pull the head and trunk down and forward. The muscle tone in certain back and neck muscles pulls in the opposite direction to overcome the force of gravity, thereby holding the head and neck erect.

#### 5. Give an example of how two other body systems contribute to the movement of the body.

**Answer:** A person with a nervous system disorder may lack nerve impulses to certain skeletal muscles and thus be unable to move. Muscles do not function alone; other structures such as bones and joints must also function in order for movement to occur. Most skeletal muscles cause movement by pulling on bones across moveable joints. Keep in mind that the respiratory, circulatory, nervous, muscular, and skeletal systems all play a role in producing normal movement.

#### 6. Explain twitch and tetanic contractions.

**Answer: Twitch contractions** are a *single, quick, jerky response contraction* of muscle fibers *caused by a single threshold stimulus*.

**Tetanic contractions** are *sustained and steady muscular contractions caused by a series of stimuli* bombarding a muscle in rapid succession. Usually only a few areas of the muscle undergo contraction at any one time.

#### 7. Explain isotonic contractions.

**Answer:** An isotonic contraction is a contraction of a muscle that produces movement at a joint. During isotonic contraction, the muscle shortens, causing the insertion end of the muscle to move toward the point of origin. An example of this is the action of walking or running—the movement is caused by isotonic contractions.

#### 8. Explain isometric contractions.

**Answer: Isometric contractions** are muscle contractions that *do not produce movement*. Although no movement occurs during isometric contractions, tension within the muscle does increase.

#### 9. What is strength training and what are the results?

**Answer: Strength training** is exercise involving *contraction of muscles against heavy resistance*. This type of training increases the numbers of myofilaments in each muscle fiber (not the number of muscle fibers), and as a result, the total mass of muscle increases.

**10. What is endurance training and what are the results?**

**Answer: Endurance training** or aerobic training is exercise that *increases a muscle's ability to sustain moderate exercise over a long time*. It allows more efficient delivery of oxygen and nutrients to a muscle by way of increased blood flow.

**11. Name two muscles of the head and neck and give their origin, insertion, and function.**

**Answer:** Head and neck

(1) (muscle)—**frontal**; (origin)—occipital bone; (insertion)—skin of eyebrow; (function)—raises eyebrow

(2) (muscle)—**orbicularis oculi**; (origin)—maxilla and frontal bone; (insertion)—maxilla and frontal bone; (function)—closes eye

**12. Name two muscles that move the upper extremity and give their origin, insertion, and function.**

**Answer:** Upper extremity

(1) (muscle)—**pectoralis major**; (origin)—sternum, clavicle, and upper rib cartilages; (insertion)—humerus; (function)—flexes and helps adduct upper arms

(2) (muscle)—**latissimus dorsi**; (origin)—vertebrae and ilium; (insertion)—humerus; (function)—extends and helps adduct upper arm

**13. Name two muscles of the trunk and give their origin, insertion, and function.**

**Answer:** Trunk

(1) (muscle)—**external oblique**; (origin)—lower thoracic cage; (insertion)—midline of abdomen; (function)—compresses abdomen

(2) (muscle)—**internal oblique**; (origin)—pelvis; (insertion)—midline of abdomen; (function)—compresses abdomen

**14. Name three muscles that move the lower extremity and give their origin, insertion, and function.**

**Answer:** Lower extremity

(1) (muscle)—iliopsoas; (origin)—ilium and vertebrae; (insertion)—femur; (function)—flexes thigh or trunk

(2) (muscle)—sartorius; (origin)—ilium; (insertion)—tibia; (function)—flexes thigh and rotates

lower leg

(3) (muscle)—gluteus maximus; (origin)—ilium, sacrum, coccyx; (insertion)—femur; (function)—extends thigh

**15. Describe the following movements: flexion, extension, abduction, adduction, and rotation.****Answer:**

- (1) **Flexion**—a movement that decreases the angle between two bones at their joint (bending).
- (2) **Extension**—a movement that increases the angle between two bones at their joint (straightening).
- (3) **Abduction**—a movement of a part away from the midline of the body.
- (4) **Adduction**—a movement of a part toward the midline of the body.
- (5) **Rotation**—a movement around a longitudinal axis.

**Critical Thinking Question:****16. Draw and label a relaxed sarcomere. Include actin, myosin, and Z-lines. Explain the process that causes the sarcomere to contract.**

Answer: The sarcomere contracts when the muscle causes the two types of myofilaments to slide toward each other and shorten the sarcomere and thus the entire muscle. During contraction, the thick myofilaments (myosin) and the thin myofilaments (actin) in a muscle fiber first attach to one another by forming “bridges” that then act as levers to pull the myofilaments past each other.

**17. Explain the interaction of the prime mover, the synergist, and the antagonist in efficient movement.**

Answer: A group of muscles usually contracts to produce a single movement. The contraction of the prime mover muscle is mainly responsible for producing a movement. The synergist is a muscle whose contractions help the prime mover to produce a given movement. When the antagonist muscles contract, they produce a movement opposite to that of the prime movers and their synergist muscles.

**18. Describe the conditions that cause a muscle to develop an “oxygen debt.” How is the oxygen debt paid off?**

Answer: During exercise, the ATP required for muscle contraction becomes depleted. When oxygen supplies run low, the muscle cells switch to a type of energy conversion that does not require oxygen. This process produces lactic acid that may result in muscle soreness after exercise. The term oxygen debt describes the continued increased metabolism that must occur in a cell to remove excess lactic acid that accumulates during prolonged exercise. Labored breathing after the cessation of exercise is required to pay the “debt” of oxygen that is required for cell metabolism.

**CLASSROOM APPLICATION**

The following questions can be used as individual assignments or for small-group discussion. Note: to copy the questions, cover the answers with a blank sheet of paper and print, thus leaving space for answers or note-taking.

**1. One measure of physical fitness is a “step test,” in which a subject steps up on a low platform and then back down (one second for each), and continues this process for 3 minutes. Then the pulse rate and respiration rate of the individual is monitored until they return to the normal rate measured before the test started. Why do breathing and heart rate remain elevated after exercise stops?**

**Answer:** Stored ATP is quickly depleted, and if oxygen supplies are not sufficient, muscle cells switch to energy conversion that does not require oxygen. However, this energy conversion produces lactic acid. The “oxygen debt” is paid when labored breathing and an increased heart rate are required to remove lactic acid and replace depleted energy reserves, even after exercise has ended.

**2. The faster the pulse and respiration rate return to normal, the more “physically fit” the individual is. Why would a physically fit person return to normal breathing and heart rate levels more quickly than an unfit person?**

**Answer:** Benefits of exercise and aerobic training include increased efficiency of the respiratory and circulatory system and an increase in the number of blood vessels in muscles. The increased blood flow to the muscles allows a more efficient delivery of oxygen and glucose to muscle fibers during exercise. The more oxygen that is available, the less the muscle cells will have to switch to energy conversion without oxygen, and the less “oxygen debt” there will be in the muscles.

**3. Aerobic training also increases the number of mitochondria in muscle fibers. Why would this benefit the muscle contraction process?**

**Answer:** Mitochondria are cellular organelles that convert glucose to ATP. Contraction of muscle cells requires ATP, and therefore an increase in the number of mitochondria in a muscle cell increases the speed with which ATP is produced in the cell.

**4. Several years ago, Mr. Harris underwent surgery to remove his right lung. His recovery since that time has been satisfactory. However, he has found it necessary to reduce some physical activities, such as jogging to walking. Explain why the ability to perform as he once was able to do has been modified or eliminated.**

**Answer:** As you know, oxygen is essential for all body functions. With aerobic exercise the respiratory system provides the largest amount of ATP for cells. Due to the removal of his right lung, oxygen availability necessary for muscle cell contraction has been drastically reduced, meaning there will be less ATP produced. So, less oxygen equals less ability of muscles to contract for long periods of time because they run out of ATP.

### **LAB ACTIVITIES**

1. Have students attempt the following movements:
  - a. Abduct the arm and extend the elbow. While the arm is extended, try to adduct the arm as if against resistance. The latissimus dorsi is the muscle in use.
  - b. Abduct and elevate the shoulder as if against resistance. The upper portion of the trapezius is being contracted.

### **PRACTICAL/CREATIVE LEARNING ACTIVITIES**

1. Use a grip tester to demonstrate muscle fatigue.
2. Prepare a list of various body movements. Have students demonstrate various skeletal muscle contractions. Demonstrations with DVD Kinesiology: Joe Muscolino or Trail Guide DVD
3. Have the students prepare a list of various exercises that can be done to develop specific body muscles.

**STUDENT ASSIGNMENT**  
**THE MUSCULAR SYSTEM**

Susan, age 39, is a secretary. She spends most of her working day at a desk. Recently she has complained of feeling tired even though she sleeps 7–8 hours a night. Her doctor has recommended a walking program to counteract her sedentary lifestyle. She is reluctant to begin.

1. What could you tell Susan about the benefits of regular exercise?

(A) \_\_\_\_\_

(B) \_\_\_\_\_

(C) \_\_\_\_\_

(D) \_\_\_\_\_

(E) \_\_\_\_\_

2. Susan asks, "Is there really any danger in not exercising?" She is given the following information. Fill in the missing words.

When muscles are inactive for a period of time, they actually shrink in size and mass, with a reduction in muscle strength making them less efficient. This is technically called (A) \_\_\_\_\_, which is just the opposite of muscles that increase in size, called (B) \_\_\_\_\_.

3. She asks if you are exercising, and you tell her you are running, which is a type of (A) \_\_\_\_\_ training, such as bicycling or walking on a treadmill. What physical benefits are derived from this type of regular exercise?

(B) \_\_\_\_\_

(C) \_\_\_\_\_

(D) \_\_\_\_\_

(E) \_\_\_\_\_

(F) \_\_\_\_\_

4. Susan spends much of her day at work typing. This repetitive motion may in time cause her difficulty.

A common inflammatory problem often caused by such repetitive movement of the wrist and other joints is called (A) \_\_\_\_\_.

What are some of the symptoms present with inflammation of the tendon sheath?

(B) \_\_\_\_\_

(C) \_\_\_\_\_

(D) \_\_\_\_\_

If swelling occurs around the tendons in the area of the wrist, it is called (E) \_\_\_\_\_.

**Definitions**

Define the following vocabulary words:

5. Abduction \_\_\_\_\_

6. Adduction \_\_\_\_\_

7. Atrophy \_\_\_\_\_

8. Flexion \_\_\_\_\_

9. Hypertrophy \_\_\_\_\_

10. Isometric \_\_\_\_\_

11. Motor neuron \_\_\_\_\_

12. Pronation \_\_\_\_\_

13. Supination \_\_\_\_\_

14. Tendon \_\_\_\_\_

**Match the descriptions in Column A to the terms in Column B. Write the corresponding letter in the blank**

provided.

**Column A**

- \_\_\_ 15. Moving parts away from the midline
- \_\_\_ 16. Moving palm from anterior to posterior position
- \_\_\_ 17. Standing on your toes
- \_\_\_ 18. Makes joint angle larger
- \_\_\_ 19. Movement around longitudinal axis
- \_\_\_ 20. Palms turned to anterior position
- \_\_\_ 21. Makes joint angle smaller
- \_\_\_ 22. Moving a part toward the middle

**Column B**

- A. Extension
- B. Flexion
- C. Abduction
- D. Adduction
- E. Rotation
- F. Supination
- G. Pronation
- H. Dorsiflexion

- \_\_\_ 23. Movement to elevate the top of foot  
\_\_\_ 24. Cardiac muscle

- I. Plantar flexion  
J. Involuntary muscle

### Completion

Complete the following statements with the words listed below.

- |                   |                   |
|-------------------|-------------------|
| A. Isometric      | G. Dorsiflexion   |
| B. Hypertrophy    | H. Isotonic       |
| C. Tonic          | I. Visceral       |
| D. Tendons        | J. Atrophy        |
| E. Synovial fluid | K. Tendon sheaths |
| F. Striated       | L. Smooth         |

25. Muscles are attached to bones by \_\_\_\_.
26. Some tendons are enclosed in synovial-lined tubes and lubricated by (a) \_\_\_\_\_. These tubes are called (b) \_\_\_\_\_.
27. The contraction of a muscle that produces movement at a joint is called \_\_\_\_\_.
28. A muscle contraction that does not produce movement is called \_\_\_\_\_.
29. Inactivity can cause muscle tissue to waste away, referred to as \_\_\_\_\_.
30. Skeletal muscle is made up of \_\_\_\_\_ muscle.
31. Regular consistent exercise increases muscle size, referred to as \_\_\_\_\_.
32. Bending the foot up toward the head is \_\_\_\_\_.
33. Nonstriated muscle or involuntary muscle is also called (a) \_\_\_\_\_ or (b) \_\_\_\_\_.
34. A special kind of contraction that assists in maintaining body posture is \_\_\_\_\_.

Identify the choice that best completes the statement or answers the question.

- \_\_\_ 1. Which of the following is NOT a function of the muscular system?
- Exchange of gases
  - External mobility and internal motility
  - Produce heat
  - Maintain posture
- \_\_\_ 2. The sarcoplasmic reticulum stores and releases which ion?
- Phosphorus
  - Potassium
  - Sodium
  - Calcium
- \_\_\_ 3. Which of the following is the term used to describe the opposing muscle that relaxes and stretches or eccentrically contracts to allow the actions of the agonists to occur?
- Agonist
  - Synergist
  - Antagonist
  - Fixator
- \_\_\_ 4. Which is the term used to describe the muscle or muscles that contracts at the same time as prime movers so they can produce more effective movement?
- Antagonist
  - Synergists
  - Fixators
  - Agonist
- \_\_\_ 5. Which of the following athletes typically has a high ratio of slow twitch muscles present in the legs?
- Hurdlers
  - Sprinters
  - World-class long-distance runners
  - Boxers
- \_\_\_ 6. Which of the following best describes a muscle contraction in which the muscle length remains the same while the muscle tension increases?
- Isometric
  - Isotonic
  - Eccentric
  - Concentric

- \_\_\_ 7. What is the term given for the neural phenomenon of when the central nervous system sends a message for the agonist to contract, the tension in the antagonist is inhibited by impulses from motor nerves and is simultaneously relaxed.
  - a. All or none response
  - b. Sliding filament theory
  - c. Reciprocal inhibition
  - d. Recruitment
  
- \_\_\_ 8. What is the theory that explains how filaments within the sarcomere slide past each other in order to create a change in muscle length?
  - a. Gliding filament theory
  - b. Sliding theory of contraction
  - c. Telescoping theory
  - d. Sliding filament theory
  
- \_\_\_ 9. Which of the following is the thin myofilament?
  - a. Actin
  - b. Epimysium
  - c. Myosin
  - d. Fasciculi
  
- \_\_\_ 10. What is a skeletal muscle's contractile unit?
  - a. Fasciculi
  - b. Sarcomere
  - c. Perimysium
  - d. Retinacula
  
- \_\_\_ 11. What are the bandage-like retaining bands of connective tissue found primarily around the elbows, knees, ankles, and wrists?
  - a. Aponeurosis
  - b. Perimysium
  - c. Retinacula
  - d. Epimysium
  
- \_\_\_ 12. Which term describes the ability of a muscle to shorten?
  - a. Contractility
  - b. Extensibility
  - c. Elasticity
  - d. Excitability
  
- \_\_\_ 13. Which is the fascial covering of the entire muscle?
  - a. Perimysium
  - b. Epimysium

- c. Endomysium
- d. Aponeurosis

- \_\_\_ 14. Which of the following is the thick myofilament?
- a. Actin
  - b. Fasciculi
  - c. Myofascial
  - d. Myosin
- \_\_\_ 15. Which of the following are groups of muscle fibers?
- a. Myofibril
  - b. Myofascial
  - c. Fasciculi
  - d. Sarcomere
- \_\_\_ 16. Which of the following is a broad, flat tendon?
- a. Retinacula
  - b. Fasciculi
  - c. Epimysium
  - d. Aponeurosis
- \_\_\_ 17. What is the term used when referring to skeletal muscles and their related fascia within the muscular system?
- a. Myofibril
  - b. Myofascial
  - c. Fibromyalgia
  - d. Neuromuscular
- \_\_\_ 18. Which of the following is a cord-like structure that attaches muscle to bone?
- a. Tendon
  - b. Endomysium
  - c. Appendix
  - d. Cordae tendineae
- \_\_\_ 19. Which term describes the ability of a muscle to lengthen?
- a. Contractility
  - b. Excitability
  - c. Photosynthesis
  - d. Extensibility
- \_\_\_ 20. Which is the tough connective envelope surrounding each fasciculus?
- a. Epimysium

- b. Perimysium
- c. Aponeurosis
- d. Endomysium

- \_\_\_ 21. What are the folded sections of the sarcolemma at which the motor neuron connects called?
- a. Motor end plates
  - b. Muscle spindles
  - c. Sarcoplasmic connections
  - d. Synaptic junctions
- \_\_\_ 22. What is the process of motor unit activation based on need?
- a. All or none response
  - b. Excitability
  - c. Recruitment
  - d. Tonus
- \_\_\_ 23. Which of the following are fatigue-resistant muscle fibers referred to as red muscle?
- a. Fast twitch
  - b. Intermediate
  - c. Moderate twitch
  - d. Slow twitch
- \_\_\_ 24. Which of the following are rapidly fatigable muscle fibers referred to as white muscle?
- a. Fast twitch A
  - b. Fast twitch B
  - c. Moderate twitch
  - d. Slow twitch
- \_\_\_ 25. What part of the muscle is on the more movable bone or attachment during contraction?
- a. Insertion
  - b. Fusiform
  - c. Motor unit
  - d. Origin
- \_\_\_ 26. Which is the muscle most responsible for causing the desired action?
- a. Antagonist
  - b. Fixator
  - c. Synergist
  - d. Agonist
- \_\_\_ 27. Which represents a single motor neuron plus all the muscle fibers to which it attaches?
- a. Muscle spindles

- b. Motor end plate
- c. Motor unit
- d. Tonus

- \_\_\_ 28. Which of the following is stimulated during a stretch and responds by inhibiting muscle contraction, allowing the muscle to relax and stretch?
- a. Neuromuscular junction
  - b. Muscle spindle
  - c. Motor end plate
  - d. Golgi tendon organ
- \_\_\_ 29. Which of the following is stimulated when a muscle is stretched too rapidly and responds by reflexively contracting the muscle, safeguarding it from overstretching?
- a. Neuromuscular junction
  - b. Muscle spindle
  - c. Golgi tendon organ
  - d. Motor end plates
- \_\_\_ 30. Which is the tendinous attachment of the muscle on the less movable bone or attachment during contraction?
- a. Origin
  - b. Insertion
  - c. Fixator
  - d. Agonist
- \_\_\_ 31. Which term is used to describe a type of isotonic contraction that results in shortening of the muscle?
- a. Isometric contractions
  - b. Concentric contractions
  - c. Eccentric contractions
  - d. Synergistic contractions
- \_\_\_ 32. Which is the term used to indicate the cell membrane of a muscle?
- a. Sarcoplasm
  - b. Perimysium
  - c. Sarcolemma
  - d. Epimysium
- \_\_\_ 33. What phrase is used to describe an individual muscle fiber that, sufficiently stimulated, will contract to its fullest extent or not at all is
- a. All or none response
  - b. Motor unit activation
  - c. Recruitment
  - d. Troponin/tropomyosin response

- \_\_\_ 34. Which term is used to describe an isotonic contraction that results in lengthening of the muscle?
- Stretch contraction
  - Eccentric contraction
  - Concentric contraction
  - Isometric contraction
- \_\_\_ 35. Which are the regulatory proteins positioned on the actin filaments?
- Myosin and lysosin
  - Fasciculi and epimysium
  - Myosin and ribosin
  - Troponin and tropomyosin
- \_\_\_ 36. A state of continuous, partial contraction of many skeletal muscles is known as
- Atrophy
  - Hypertrophy
  - Tonus
  - Muscle soreness
- \_\_\_ 37. What is the opposite of muscular contraction?
- Stretching
  - Hypertrophy
  - Reciprocal tightening
  - Atrophy
- \_\_\_ 38. What are muscles called that cross two joints and act on both joints?
- Uniarticular
  - Biarticular
  - Multiarticular
  - Twicearticular
- \_\_\_ 39. Which are the two ends of a sarcomere?
- A-bands
  - Z-lines
  - S-lines
  - H-bands
- \_\_\_ 40. What is the principal neurotransmitter involved in muscle contraction?
- Dopamine
  - Epinephrine
  - Acetylcholine
  - Catecholamines

**Answer Section****MULTIPLE CHOICE**

1. ANS: A                   PTS: 1
2. ANS: D                   PTS: 1
3. ANS: C                   PTS: 1
4. ANS: B                   PTS: 1
5. ANS: C                   PTS: 1
6. ANS: A                   PTS: 1
7. ANS: C                   PTS: 1
8. ANS: D                   PTS: 1
9. ANS: A                   PTS: 1
10. ANS: B                   PTS: 1
11. ANS: C                   PTS: 1
12. ANS: A                   PTS: 1
13. ANS: B                   PTS: 1
14. ANS: D                   PTS: 1
15. ANS: C                   PTS: 1
16. ANS: D                   PTS: 1
17. ANS: B                   PTS: 1
18. ANS: A                   PTS: 1
19. ANS: D                   PTS: 1
20. ANS: B                   PTS: 1
21. ANS: A                   PTS: 1
22. ANS: C                   PTS: 1
23. ANS: D                   PTS: 1
24. ANS: B                   PTS: 1
25. ANS: A                   PTS: 1
26. ANS: D                   PTS: 1
27. ANS: C                   PTS: 1
28. ANS: D                   PTS: 1
29. ANS: B                   PTS: 1
30. ANS: A                   PTS: 1
31. ANS: B                   PTS: 1
32. ANS: C                   PTS: 1
33. ANS: A                   PTS: 1
34. ANS: B                   PTS: 1
35. ANS: D                   PTS: 1
36. ANS: C                   PTS: 1
37. ANS: A                   PTS: 1
38. ANS: B                   PTS: 1
39. ANS: B                   PTS: 1
40. ANS: C                   PTS: 1