CHAPTER 9
MUSCULAR SYSTEM

OVERVIEW
This chapter presents the muscular system. In conjunction with the skeletal system, the muscular system serves to move the body. The chapter introduces the three types of muscle; the major events in contraction of skeletal, smooth, and cardiac muscles; the energy supply to muscle fiber for contraction; the occurrence of oxygen debt; and the process of muscle fatigue (objectives 1, 3, 4, and 10). The chapter describes the structure and function of a skeletal muscle, distinguishes between a twitch and a sustained contraction, explains how various kinds of muscle contraction produce body movements and maintain posture, shows how the location and interaction of muscles produce body movements, identifies the location and action of major skeletal muscles, and differentiates the structure and function of a multiunit smooth muscle and a visceral smooth muscle (objectives 2, 5–9, 11, and 12).

The skeletal system can be thought of as the passive partner in producing movement; the muscular system can be thought of as the active partner. This chapter explains how muscles interact with bones to maintain posture and produce movement. In addition, it tells the characteristics and functions of skeletal, smooth, and cardiac muscles. This knowledge is a foundation for the study of other organ systems, such as the digestive system, the respiratory system, and the cardiovascular system.

CHAPTER OBJECTIVES
After you have studied this chapter, you should be able to:
1. Describe how connective tissue is part of the structure of a skeletal muscle.
2. Name the major parts of a skeletal muscle fiber and describe the function of each part.
3. Explain the major events that occur during muscle fiber contraction.
4. Explain how energy is supplied to muscle fiber contraction, how oxygen debt develops, and how a muscle may become fatigued.
5. Distinguish between fast and slow muscle fibers.
6. Distinguish between a twitch and a sustained contraction.
7. Describe how exercise affects skeletal muscles.
8. Explain how various types of muscular contractions produce body movements and help maintain posture.
9. Distinguish between the structures and functions of a multiunit smooth muscle and a visceral smooth muscle.
10. Compare the contraction mechanisms of skeletal, smooth, and cardiac muscle fibers.
11. Explain how the locations of skeletal muscles help produce movements and how muscles interact.
12. Identify and locate the major skeletal muscles of each body region and describe the action of each muscle.

FOCUS QUESTION
How do muscle cells utilize energy and interact with bones to accomplish such diverse movements as playing a piano and playing a basketball game?

MASTERY TEST
Now take the mastery test. Do not guess. Some questions may have more than one correct answer. As soon as you complete the test, correct it. Note your successes and failures so that you can read the chapter to meet your learning needs.

1. A skeletal muscle is separated from adjacent muscles and kept in place by layers of dense connective tissue called:
   a. fascia.
   b. aponeuroses.
   c. perimysium.
   d. sarcolemma.
Connective tissue that attaches muscle to the periosteum is called
a. ligaments. c. aponeuroses.
b. tendons. d. elastin.

3. Bundles of muscle fibers are called ________________.

4. Each bundle is covered by layers of connective tissue called ________________.

5. The connective tissue that penetrates and divides the individual muscles into compartments is the
a. deep fascia. c. epimysium.
b. superficial fascia. d. perimysium.

A surgical procedure to relieve pressure within a muscle compartment is a ________________.

The characteristic striated appearance of skeletal muscle is due to the arrangement of alternating protein filaments composed of ________________ and ________________.

The units that form the repeating pattern along each muscle fiber are called
a. transverse tubules. c. actin filaments.
b. sarcomeres. d. myosin filaments.

9. The muscle protein found in A bands is (actin/myosin)

10. Membranous channels formed by invaginations into the sarcolemma are known as ________________

11. In addition to actin and myosin, two other proteins associated with actin filaments are ________________ and ________________

12. When muscle fibers are overstretched, the injury sustained is a ________________

13. The union between a nerve fiber and a muscle fiber is the
a. motor neuron. c. neuromuscular junction.
b. motor end plate. d. neurotransmitter.

14. The axon of a motor nerve (does/does not) connect physically with the muscle fiber it stimulates.

15. Contraction of skeletal muscle is made possible by _____________ in the synaptic cleft.

16. The substance used by motor neurons to transmit stimuli to skeletal muscle is
a. norepinephrine. c. acetylcholine.
b. dopamine. d. serotonin.

17. When the filaments of actin and myosin slide past each other within the myofibril, the result is
a. shortening of the muscle fiber. c. release of acetylcholine.
b. membrane polarization.

18. What ion is necessary in relatively high concentrations to allow the formation of cross-bridges between actin and myosin?

19. When a muscle fiber is at rest, the protein ________________ prevents the formation of cross-bridges between actin and myosin.

20. Contraction of skeletal muscle after death is ________________.

21. The energy used in muscle contraction is supplied by the decomposition of ________________.

22. The substance that halts stimulation of muscle tissue is
a. acetylcholine. c. acetylcholinesterase.
b. calcium. d. sodium.

23. A disease caused by a decreased amount of acetylcholine is ________________

24. The primary source of energy to reconstruct ATP from ADP and phosphate is a substance called ________________

25. The substance stored in large quantities in muscle that can store oxygen is ________________
A person feels out of breath after vigorous exercise because of oxygen debt. Which of the following statements helps explain this phenomenon?

a. Anaerobic respiration increases during strenuous activity.

b. Lactic acid is metabolized more efficiently when the body is at rest.

c. Conversion of lactic acid to glycogen occurs in the liver and requires energy.

d. Priority in energy use is given to ATP synthesis.

After prolonged muscle use, muscle fatigue occurs due to an accumulation of ________________

Muscle tissue is a major source of

a. glycogen.

b. glucose.

c. water.

d. heat.

The minimal strength stimulus needed to elicit contraction of a single muscle fiber is called a ________________

A record of a muscle’s response to stimulation is called a ________________

The period of time following a muscle response to a stimulus when it will not respond to a second stimulus is called the

a. latent period.

b. contraction.

c. refractory period.

d. state of sustained, partial contraction of muscles that is necessary to maintain posture.

e. the ability of a muscle to maintain contraction against an outside force.

g. the condition athletes attain after intensive training.

e. number of motor units stimulated.

d. diameter of the muscle fibers.

A contraction in which muscle shortens is an ________________ contraction.

A contraction in which tension within the muscle increases without a change in muscle length is an ________________ contraction.

When exercise activates primarily the slow, red fibers, the result is

a. increased muscle strength.

b. increased muscle size.

c. increased resistance to fatigue.

d. increased anaerobic tolerance.

The muscles that move the eye are (fast/slow) twitch fibers.

The precision of movement produced by a muscle is due to

a. the size of the muscle fiber, small fibers being more precise.

b. the small muscle fiber-to-neuron ratio within a motor unit.

c. many muscle fibers being present for each neuron in a motor unit.

d. the number of branches in the neuron, many branches being associated with diffuse stimulation.

The finer and more precise the movement produced by a particular muscle, the (fewer/greater) the number of muscle fibers in the motor unit.

40. Smooth muscle contracts (more slowly/more rapidly) than skeletal muscle following stimulation.

41. Two types of smooth muscle are ________________ muscle and ________________ muscle.

42. The protein that binds to calcium in smooth muscle is ________________.
43. Peristalsis is due to which of the following characteristics of smooth muscle?
   a. the capacity of smooth muscle fibers to c. rhythmicity
      excite each other d. sympathetic innervation
   b. automaticity

44. The neurotransmitter(s) in smooth muscle is/are
   a. norepinephrine. c. acetylcholine.
   b. dopamine. d. serotonin.

45. The self-exciting property of cardiac muscle is probably due to
   a. the presence of intercalated disks between c. a cell membrane more permeable to sodium
      muscle cells. ions.
   b. a well-developed sarcoplasmic reticulum.

46. In the following statements, does statement a explain statement b? _____________
   a. Cardiac muscle remains refractory until a contraction is completed.
   b. Sustained tetanic contraction is not possible in heart muscle.

47. Drugs that stop spasms in cardiac muscle by interfering with the movement of calcium ions across the cardiac muscle
cell membranes are called _______________ _______________.

48. In producing movement of body parts, muscles and bones interact in mechanical devices known as _______________.

49. The attachment of a muscle to a relatively fixed part is called the _______________; the attachment to a relatively
movable part is called the _______________.

50. Smooth body movements depend on _______________ giving way to prime movers.

51. The muscle that compresses the cheeks inward when it contracts is the
   a. orbicularis oris. c. platysma.
   b. epicranius. d. buccinator.

52. Excessive use of jaw muscles to clench the jaw may lead to _______________ _______________ syndrome.

53. The muscle that moves the head so that the face turns to the opposite side when one side contracts is the
   a. sternocleidomastoid. c. semispinalis capitis.
   b. splenius capitis. d. longissimus capitis.

54. The large triangular muscle that extends horizontally from the base of the skull and the cervical and thoracic vertebrae
to the shoulder is the _______________ muscle.

55. The muscle that abducts the upper arm and can both flex and extend the humerus is the
   a. biceps brachii. c. infraspinatus.
   b. deltoid. d. triceps brachii.

56. The muscle that extends the arm at the elbow is the
   a. biceps brachii. c. supinator.
   b. brachialis. d. triceps brachii.

57. The band of tough connective tissue that extends from the xiphoid process to the symphysis pubis and serves as an
attachment for muscles of the abdominal wall is the _______________ _______________.

58. The heaviest muscle in the body, which serves to straighten the leg at the hip during walking, is the
   a. psoas major. c. adductor longus.
   b. gluteus maximus. d. gracilis.

59. The tendon that connects the gastrocnemius muscle with the calcaneus is the _______________ tendon, or the
    _______________ tendon.
50. thoracic vertebrae, sternum  
51. d  
52. angle of Louis or sternal angle  
53. clavicles, scapulae  
54. b  
55. a  
56. metacarpal  
57. a  
58. c  
59. b  
60. calcaneus  
61. a  
62. compression

8 Mastery Test Answers  
1. d  
2. immovable, slightly movable,  
   freely movable, fibrous,  
   cartilaginous, synovial  
3. b, c  
4. fibrous  
5. synchondrosis, cartilaginous  
   joint  
6. is  
7. c  
8. subchondral plate  
9. b, c  
10. d  
11. b  
12. synovial membrane  
13. a, c  
14. menisci  
15. bursa  
16. synovial fluid  
17. d  
18. 1, c, 2, e, 3, b, 4, a  
19. a  
20. c  
21. humerus and scapula  
22. is not  
23. dislocation  
24. humerus, ulna  
25. pronation and supination of the  
   hand  
26. arthroscope  
27. acetabulum, coxal  
28. extension, flexion, abduction,  
   adduction, rotation, and  
   circumduction  
29. knee  
30. a  
31. sprain  
32. b

9 Mastery Test Answers  
1. a  
2. b  
3. fasciculi or fascicles  
4. perimysium

10 Mastery Test Answers  
1. neurons and neuroglia  
2. a  
3. synapses

11 Mastery Test Answers  
1. brain, spinal cord  
2. a  
3. subdural hematoma  
4. c  
5. b, c  
6. b  
7. choroid plexus  
8. c  
9. 31  
10. b, d  
11. a  
12. b  
13. d  
14. b  
15. b  
16. b  
17. a  
18. b  
19. a  
20. cerebrum, cerebellum,  
   brainstem  
21. spina bifida  
22. a  
23. c  
24. b, c  
25. 1, c, 2, d, 3, c, 4, a, 5, b, 6, a  
26. frontal  
27. b, c  
28. c