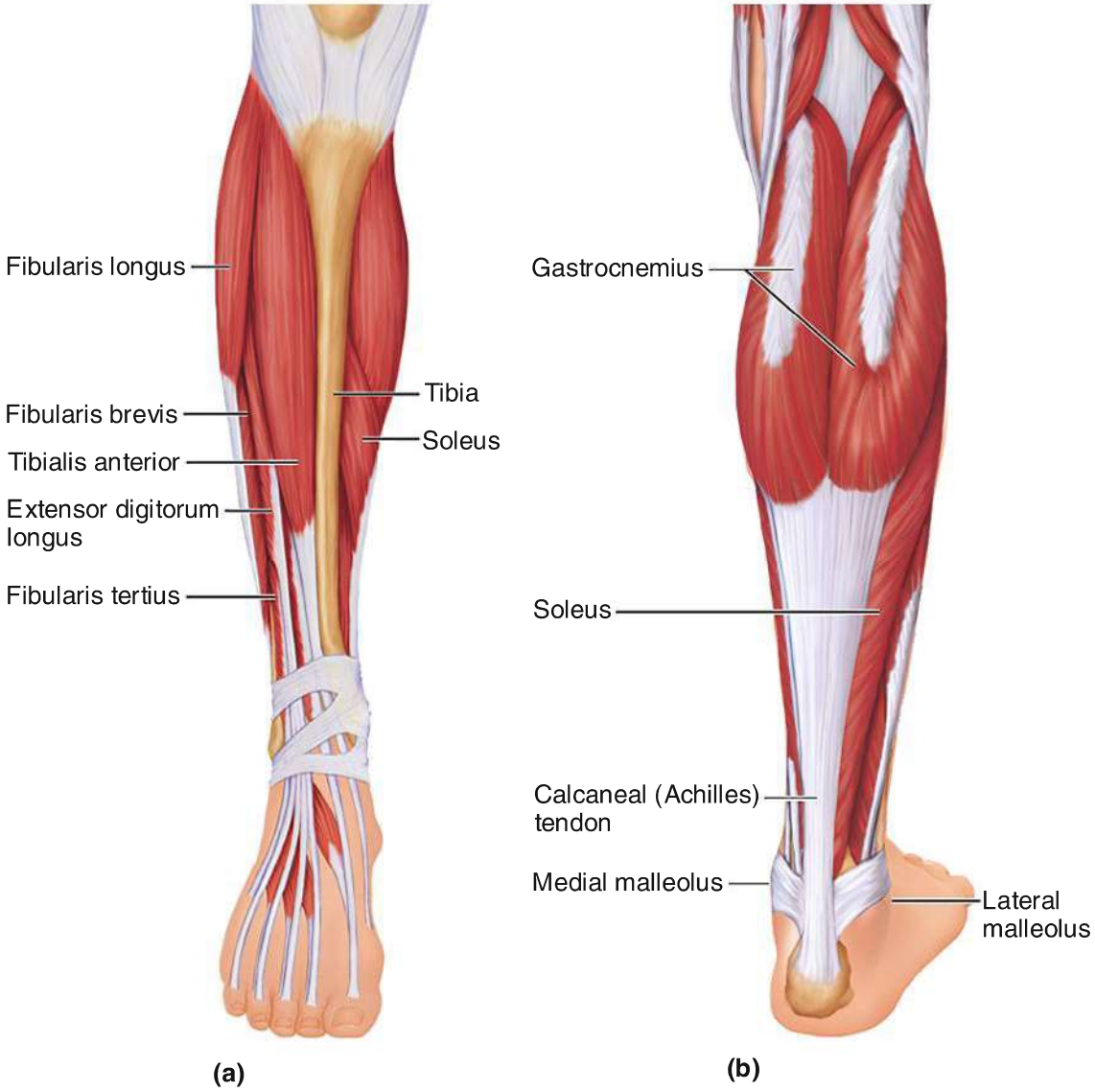


Figure 6.21 **Superficial muscles of the right leg.** **(a)** Anterior view. **(b)** Posterior view.

DID YOU GET IT?

25. Which muscle is the antagonist of the biceps brachii when the biceps flexes the elbow?

26. Which muscle group is the antagonist of the hamstring muscles?

27. What are two good sites for intramuscular injections in adults?

28. Which two muscles insert into the calcaneal tendon? What movement do they effect?

For answers, see Appendix D.

Developmental Aspects of the Muscular System

- ✓ Explain the importance of a nerve supply and exercise in keeping muscles healthy.
- ✓ Describe the changes that occur in aging muscles.

In the developing embryo, the muscular system is laid down in segments (much like the structural plan of an earthworm), and then each segment is invaded by nerves. The muscles of the thoracic and

lumbar regions become very extensive because they must cover and move the bones of the limbs. The muscles and their control by the nervous system develop rather early in pregnancy. The expectant mother is often astonished by the first movements (called the *quickening*) of the fetus, which usually occur by the sixteenth week of pregnancy.

HOMEOSTATIC IMBALANCE

Very few congenital muscular problems occur. The exception to this is **muscular dystrophy**—a group of inherited muscle-destroying diseases that affect specific muscle groups. The muscles enlarge due to fat and connective tissue deposit, but the muscle fibers degenerate and atrophy.

The most common and serious form is **Duchenne's muscular dystrophy,** which is expressed almost exclusively in boys. This tragic disease is usually diagnosed between the ages of 2 and 7 years. Active, normal-appearing children become clumsy and fall frequently as their muscles weaken. The disease progresses from the extremities upward, finally affecting the head and chest muscles. Children with this disease rarely live beyond their early twenties and generally die of respiratory failure. Although the cause of muscular dystrophy has been pinned down—the diseased muscle fibers lack a protein (called dystrophin) that helps maintain the sarcolemma—a cure is still elusive.

Initially after birth, a baby's movements are all gross reflex types of movements. Because the nervous system must mature before the baby can control muscles, we can trace the increasing efficiency of the nervous system by observing a baby's development of muscle control. This development proceeds in a cephalic/caudal direction, and gross muscular movements precede fine ones. Babies can raise their heads before they can sit up and can sit up before they can walk. Muscular control also proceeds in a proximal/distal direction; that is, babies can perform the gross movements like waving "bye-bye" and pulling objects to themselves before they can use the pincer grasp to pick up a pin. All through childhood, the nervous system's control of the skeletal muscles becomes more and more precise. By midadolescence, we have reached the peak level of development of this natural control and can simply accept it or bring it to a fine edge by athletic training.

Because of its rich blood supply, skeletal muscle is amazingly resistant to infection throughout life, and given good nutrition, relatively few problems afflict skeletal muscles. We repeat, however, that muscles, like bones, *will* atrophy, even with normal tone, if they are not used continually. A lifelong program of regular exercise keeps the whole body operating at its best possible level.

HOMEOSTATIC IMBALANCE

One rare disease that can affect muscles during adulthood is **myasthenia gravis** (mi″as-the′ne-ah gra′vis; *asthen* = weakness; *gravi* = heavy), a disease characterized by drooping of the upper eyelids, difficulty in swallowing and talking, and generalized muscle weakness and fatigability. The disease involves a shortage of acetylcholine receptors at neuromuscular junctions. The blood of many of these patients contains antibodies to acetylcholine receptors, which suggests that myasthenia gravis is an autoimmune disease. Although the receptors may initially be present in normal numbers, they appear to be destroyed as the disease progresses. Whatever the case, the muscle cells are not stimulated properly and get progressively weaker. Death usually occurs as a result of the inability of the respiratory muscles to function **(respiratory failure).**

As we age, the amount of connective tissue in the muscles increases, and the amount of muscle tissue decreases; thus the muscles become stringier, or more sinewy. Because the skeletal muscles represent so much of the body mass, body weight begins to decline in the older person as this natural loss in muscle mass occurs. Another result of the loss in muscle mass is a decrease in muscle strength; strength decreases by about 50 percent by the age of 80. Regular exercise can help offset the effects of aging on the muscular system, and frail older people who begin to "pump iron" (use leg and hand weights) can rebuild muscle mass and dramatically increase their strength.

DID YOU GET IT?

29. What must happen before babies can control their muscles?

30. How does lifelong exercise affect our skeletal muscles and muscle mass in old age?

For answers, see Appendix D.

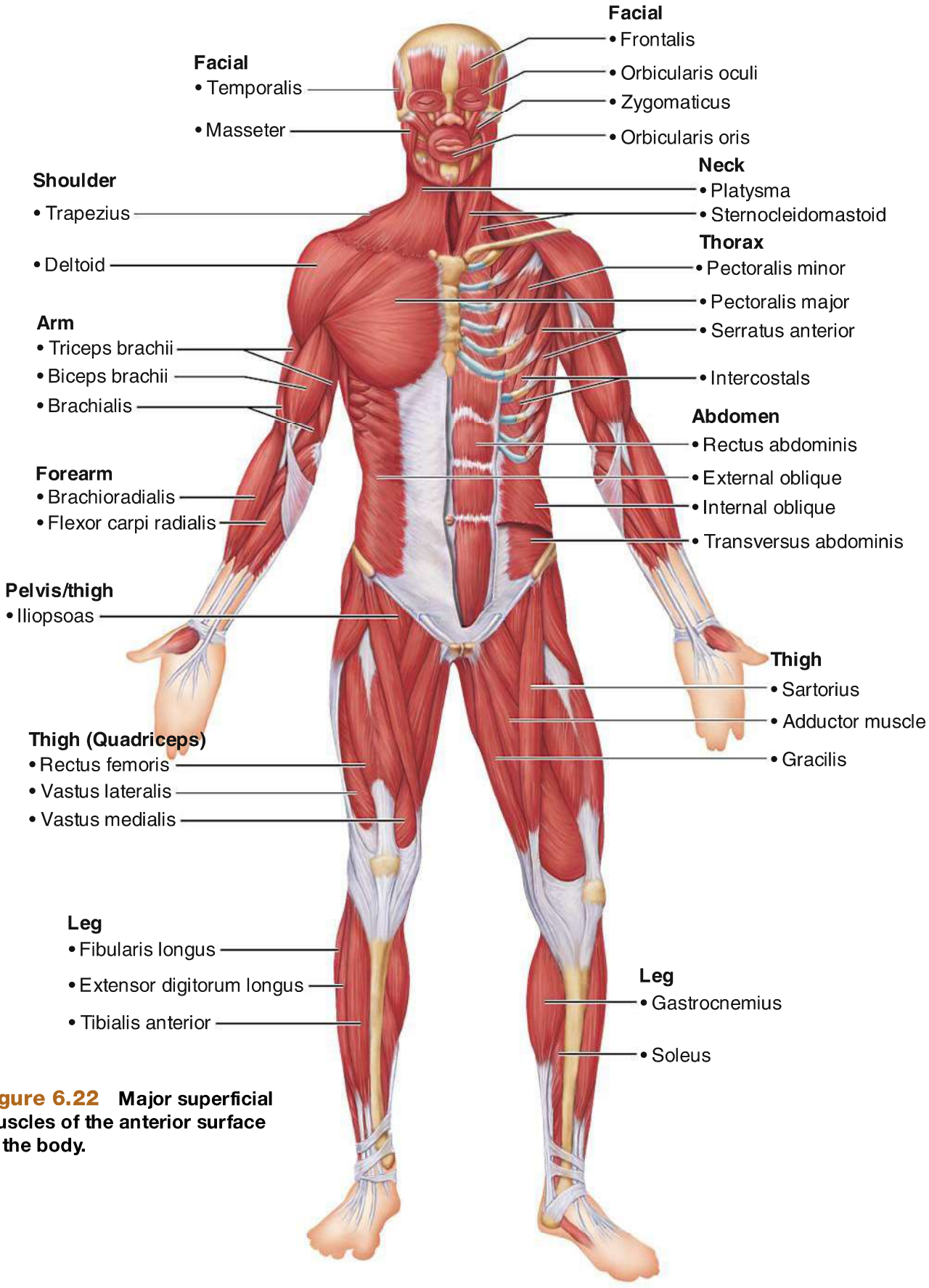


Figure 6.22 **Major superficial muscles of the anterior surface of the body.**

Table 6.3 **Superficial Anterior Muscles of the Body** (See Figure 6.22)

Name	Origin	Insertion	Primary action(s)
Head/Neck Muscles			
Frontalis	Cranial aponeurosis	Skin of eyebrows	Raises eyebrows
Orbicularis oculi	Frontal bone and maxilla	Tissue around eyes	Blinks and closes eye
Orbicularis oris	Mandible and maxilla	Skin and muscle around mouth	Closes and protrudes lips
Temporalis	Temporal bone	Mandible	Closes jaw
Zygomaticus	Zygomatic bone	Skin and muscle at corner of lips	Raises corner of mouth
Masseter	Temporal bone	Mandible	Closes jaw
Buccinator	Maxilla and mandible near molars	Orbicularis oris	Compresses cheek (as in sucking), holds food between teeth during chewing
Sternocleidomastoid	Sternum and clavicle	Temporal bone (mastoid process)	Flexes neck; laterally rotates head
Platysma	Connective tissue covering of superior chest muscles	Tissue around mouth	Tenses skin of neck (as in shaving)
Trunk Muscles			
Pectoralis major	Sternum, clavicle, and first to sixth ribs	Proximal humerus	Adducts and flexes humerus
Rectus abdominis	Pubis	Sternum and fifth to seventh ribs	Flexes vertebral column
External oblique	Lower eight ribs	Iliac crest	Flexes and rotates vertebral column
Arm/Shoulder Muscles			
Biceps brachii	Scapula of shoulder girdle	Proximal radius	Flexes elbow and supinates forearm
Brachialis	Distal humerus	Proximal ulna	Flexes elbow
Deltoid	See Table 6.4		Abducts arm
Hip/Thigh/Leg Muscles			
Iliopsoas	Ilium and lumbar vertebrae	Femur (lesser trochanter)	Flexes hip
Adductor muscles	Pelvis	Proximal femur	Adduct and medially rotate thigh
Sartorius	Ilium	Proximal tibia	Flexes thigh on hip
Quadriceps group (vastus medialis, intermedius, and lateralis; and the rectus femoris)	Vasti: Femur	Tibial tuberosity via patellar ligament	All extend knee; rectus femoris also flexes hip on thigh
	Rectus femoris: Pelvis	Tibial tuberosity via patellar ligament	
Tibialis anterior	Proximal tibia	First cuneiform (tarsal) and first metatarsal of foot	Dorsiflexes and inverts foot
Extensor digitorum longus	Proximal tibia and radius	Distal toes 2–5	Extends toes
Fibularis muscles	Fibula	Metatarsals of foot	Plantar flex and evert foot

Figure 6.23 **Major superficial muscles of the posterior surface of the body.**

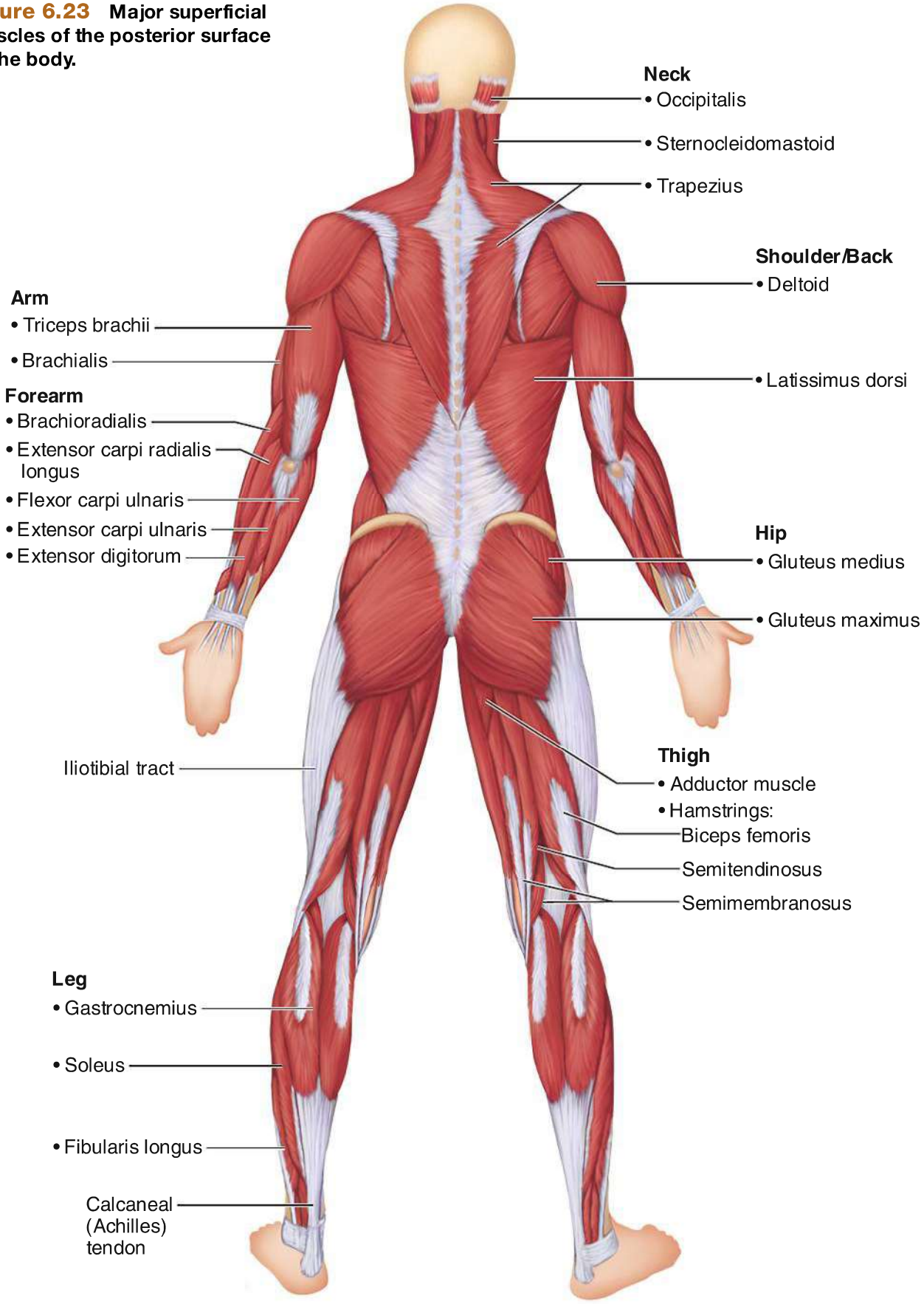


Table 6.4 Superficial Posterior Muscles of the Body (Some Forearm Muscles Also Shown) (See Figure 6.23)

Name	Origin	Insertion	Primary action(s)
Neck/Trunk/Shoulder Muscles			
Trapezius	Occipital bone and all cervical and thoracic vertebrae	Scapular spine and clavicle	Raises, retracts, and rotates scapula
Latissimus dorsi	Lower spine and iliac crest	Proximal humerus	Extends and adducts humerus
Erector spinae*	Iliac crests, ribs 3–12, and vertebrae	Ribs, thoracic and cervical vertebrae	Extends and laterally flexes spine
Quadratus lumborum*	Iliac crest, lumbar fascia	Transverse processes of upper lumbar vertebrae	Flexes spine laterally; extends spine
Deltoid	Scapular spine and clavicle	Humerus (deltoid tuberosity)	Abducts humerus
Arm/Forearm Muscles			
Triceps brachii	Shoulder girdle and proximal humerus	Olecranon process of ulna	Extends elbow
Flexor carpi radialis	Distal humerus	Second and third metacarpals	Flexes wrist and abducts hand (see Figure 6.22)
Flexor carpi ulnaris	Distal humerus and posterior ulna	Carpals of wrist and fifth metacarpal	Flexes wrist and adducts hand
Flexor digitorum superficialis†	Distal humerus, ulna and radius	Middle phalanges of second to fifth fingers	Flexes wrist and fingers
Extensor carpi radialis	Humerus	Base of second and third metacarpals	Extends wrist and abducts hand
Extensor digitorum	Distal humerus	Distal phalanges of second to fifth fingers	Extends fingers
Hip/Thigh/Leg Muscles			
Gluteus maximus	Sacrum and ilium	Proximal femur (gluteal tuberosity)	Extends hip (when forceful extension is required)
Gluteus medius	Ilium	Proximal femur	Abducts thigh; steadies pelvis during walking
Hamstring muscles (semitendinosus, semimembranosus, biceps femoris)	Ischial tuberosity	Proximal tibia (head of fibula in the case of biceps femoris)	Flex knee and extend hip
Gastrocnemius	Distal femur	Calcaneus (heel via calcaneal tendon)	Plantar flexes foot and flexes knee
Soleus	Proximal tibia and fibula	Calcaneus	Plantar flexes foot

*Erector spinae and quadratus lumborum are deep muscles and not shown in Figure 6.23; see Figure 6.18b.

†Although its name indicates that it is a superficial muscle, the flexor digitorum superficialis lies deep to the flexor carpi radialis and is not visible in a superficial view.

Focus on CAREERS

Massage Therapist

To be effective, a massage therapist needs a thorough understanding of anatomy and physiology.

Many of us think of massage simply as something that feels good. Although this is certainly true, there's a lot of skill involved in massaging the body correctly.

Diana Syverud, part-owner of the Berkeley Massage and Self-Healing Center in Berkeley, California, doesn't just make her clients feel good; she helps them recover from injuries and prevent further problems. Many of them suffer from pain due to overusing certain muscles. "Most often, I see people who spend hours at the computer," she explains. "This can lead to trouble with the flexor carpi ulnaris, and muscles in the neck and back. I also treat musicians who are sore from spending hours playing the violin and waitresses who have painful wrists from carrying heavy trays."

"When I was studying anatomy and physiology, sometimes I wondered why I had to learn all that information" she admits. "But today, I'm glad I did. I need to know where muscles are located in the body and where they attach. For instance, a muscle may contract and pinch the sciatic nerve, causing excruciating pain. I check to determine which muscle is contracted and use various massage techniques to release it. I also help clients who have no specific muscular problems stretch and strengthen their muscles, increasing their range of motion." She notes that "It's important to know the areas of the body where massage is contraindicated, such as in the area of the esophagus or hyoid bone."

Anatomy and physiology are fascinating—you're learning how your own body works.

"Anatomy and physiology classes are fascinating because you're really learning how your own body works," she comments. "This knowledge is valuable, for your clients' sake and for your own welfare."

Syverud's favorite aspect of her work is the one-on-one contact. "Typically I meet with a client for at least an hour at a time, often over a period of several months," she says. "Many initially come for a specific reason, then stay with me for years, long after we've resolved their original problem. We might meet weekly while they're in pain, then switch to monthly appointments to help prevent future problems." Some customers are referred to her by chiropractors, but most come on their own. If she feels their problems require more than massage, she refers them to appropriate healthcare practitioners such as chiropractors, psychiatrists, or internists.

Training for massage therapists varies widely. State requirements for training vary from 200 to 500 hours or more, and licensing and accreditation procedures vary from state to state. Regardless of their length, all effective massage programs require an understanding of anatomy and physiology; Syverud estimates it made up more than one-third of her course work.

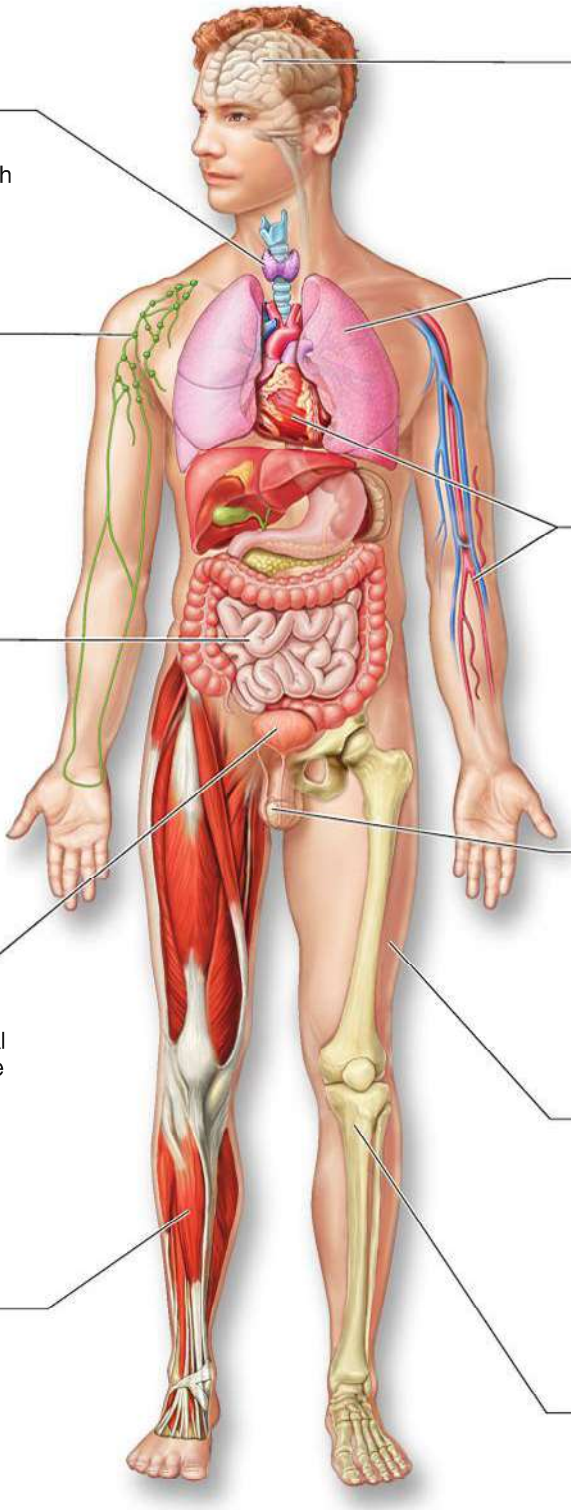
Syverud is in private practice, but many massage therapists work in spas, health clubs, or chiropractic offices. Often employers prefer to hire graduates of programs accredited by the American Massage Therapy Association (AMTA). For more information contact

AMTA
500 Davis Street, Suite 900
Evanston, IL 60201
(847) 864-0123
http://www.amtamassage.org

For additional information on this career, click the Focus on Careers link at **www.anatomyandphysiology.com**.

SYSTEMS IN SYNC

Homeostatic Relationships between the **Muscular System** and Other Body Systems



Endocrine System
- Growth hormone and androgens influence skeletal muscle strength and mass

Lymphatic System/Immunity
- Physical exercise may enhance or depress immunity depending on its intensity
- Lymphatic vessels drain leaked tissue fluids; immune system protects muscles from disease

Digestive System
- Physical activity increases gastrointestinal mobility when at rest
- Digestive system provides nutrients needed for muscle health; liver metabolizes lactic acid

Urinary System
- Physical activity promotes normal voiding behavior; skeletal muscle forms the voluntary sphincter of the urethra
- Urinary system disposes of nitrogen-containing wastes

Muscular System

Nervous System
- Facial muscle activity allows emotions to be expressed
- Nervous system stimulates and regulates muscle activity

Respiratory System
- Muscular exercise increases respiratory capacity
- Respiratory system provides oxygen and disposes of carbon dioxide

Cardiovascular System
- Skeletal muscle activity increases efficiency of cardiovascular functioning; helps prevent atherosclerosis and causes cardiac hypertrophy
- Cardiovascular system delivers oxygen and nutrients to muscles; carries away wastes

Reproductive System
- Skeletal muscle helps support pelvic organs (e.g., uterus in females); assists erection of penis and clitoris
- Testicular androgen promotes increased skeletal muscle size

Integumentary System
- Muscular exercise enhances circulation to skin and improves skin health; exercise also increases body heat, which the skin helps dissipate
- Skin protects the muscles by external enclosure

Skeletal System
- Skeletal muscle activity maintains bone health and strength
- Bones provide levers for muscle activity

Summary

Access more review material and fun learning activities online—visit **www.anatomyandphysiology.com** and select Essentials of Human Anatomy & Physiology, 10th edition. In addition, references to Interactive Physiology are included below.

iP = Interactive Physiology

Overview of Muscle Tissues (pp. 181–185)

1. Skeletal muscle forms the muscles attached to the skeleton, which move the limbs and other body parts. Its cells are long, striated and multinucleate, and they are subject to voluntary control. Connective tissue coverings (endomysium, perimysium, and epimysium) enclose and protect the muscle fibers and increase the strength of skeletal muscles. Skeletal muscles make up the muscular system.
2. Smooth muscle cells are uninucleate, spindle-shaped, and arranged in opposing layers in the walls of hollow organs. When they contract, substances (food, urine, a baby) are moved along internal pathways. Smooth muscle control is involuntary.
3. Cardiac muscle cells are striated, branching cells that fit closely together and are arranged in spiral bundles in the heart. Their contraction pumps blood through the blood vessels. Control is involuntary.
4. The sole function of muscle tissue is to contract or shorten. As it contracts, it causes movement, maintains posture, stabilizes joints, and generates heat.

Microscopic Anatomy of Skeletal Muscle (pp. 185–187)

1. The multinucleate cylindrical skeletal muscle fibers are packed with unique organelles called myofibrils. The banding pattern (striations) of the myofibrils and the cell as a whole reflects the regular arrangement of thin (actin-containing) and thick (myosin) filaments within the sarcomeres, the contractile units composing the myofibrils.

   iP Muscular System Topic: Anatomy Review: Skeletal Muscle Tissue, pp. 7–9.

2. Each myofibril is loosely enclosed by a specialized ER, called the sarcoplasmic reticulum (SR), which plays an important role in storing and releasing calcium ions. Calcium ions are the final trigger for muscle fiber contraction.

Skeletal Muscle Activity (pp. 187–196)

1. All skeletal muscle cells are stimulated by motor neurons. When the neuron releases a neurotransmitter (acetylcholine), the permeability of the sarcolemma changes, allowing sodium ions to enter the muscle cell. This produces an electrical current (action potential), which flows across the entire sarcolemma, resulting in release of calcium ions from the SR.

   iP Muscular System Topic: The Neuromuscular Junction, pp. 3–6.

2. Calcium binds to regulatory proteins on the thin filaments and exposes myosin-binding sites, allowing the myosin heads on the thick filaments to attach. The attached heads pivot, sliding the thin filaments toward the center of the sarcomere, and contraction occurs. ATP provides the energy for the sliding process, which continues as long as ionic calcium is present.

   iP Muscular System Topic: Sliding Filament Theory, pp. 3–28.

3. Although individual muscle cells contract completely when adequately stimulated, a muscle (an organ) responds to stimuli to different degrees, that is, it exhibits graded responses.
4. Most skeletal muscle contractions are tetanic (smooth and sustained) because rapid nerve impulses are reaching the muscle, and the muscle cannot relax completely between contractions. The strength of muscle contraction reflects the relative number of muscle cells contracting (more = stronger).
5. ATP, the immediate source of energy for muscle contraction, is stored in muscle fibers in small amounts that are quickly used up. ATP is regenerated via three routes. From the fastest to the slowest, these are via a coupled reaction of creatine phosphate with ADP, via anaerobic glycolysis and lactic acid formation, and via aerobic respiration. Only aerobic respiration requires oxygen.

   iP Muscular System Topic: Muscle Metabolism, pp. 6–13.

6. If muscle activity is strenuous and prolonged, muscle fatigue occurs because lactic acid accumulates in the muscle and the energy (ATP) supply decreases. After exercise, the oxygen deficit is repaid by rapid, deep breathing.
7. Muscle contractions are isotonic (the muscle shortens, and movement occurs) or isometric (the muscle does not shorten, but its tension increases).

8. Muscle tone keeps muscles healthy and ready to react. It is a result of a staggered series of nerve impulses delivered to different cells within the muscle. If the nerve supply is destroyed, the muscle loses tone, becomes paralyzed, and atrophies.
9. Inactive muscles atrophy. Muscles challenged almost beyond their ability by resistance exercise will increase in size and strength. Muscles subjected to regular aerobic exercise become more efficient and stronger and can work longer without tiring. Aerobic exercise also benefits other body organ systems.

Muscle Movements, Types, and Names (pp. 196–205)

1. All muscles are attached to bones at two points. The origin is the immovable attachment; the insertion is the movable bony attachment. When contraction occurs, the insertion moves toward the origin.
2. Body movements include flexion, extension, abduction, adduction, circumduction, rotation, pronation, supination, inversion, eversion, dorsiflexion, plantar flexion, and opposition.
3. On the basis of their general functions in the body, muscles are classified as prime movers, antagonists, synergists, and fixators.
4. Muscles are named according to several criteria, including muscle size, shape, number and location of origins, associated bones, and action of the muscle.
5. Muscles have several fascicle arrangements that influence their force and degree of shortening.

Gross Anatomy of Skeletal Muscles (pp. 205–214)

1. Muscles of the head fall into two groups. The muscles of facial expression include the frontalis, orbicularis oris and oculi, and zygomaticus. The chewing muscles are the masseter, temporalis, and buccinator (which is also a muscle of facial expression).
2. Muscles of the trunk and neck move the head, shoulder girdle, and trunk and form the abdominal girdle. Anterior neck and trunk muscles include the sternocleidomastoid, pectoralis major, intercostals, rectus abdominis, external and internal obliques, and transversus abdominis. Posterior trunk and neck muscles include the trapezius, latissimus dorsi, and deltoid. Deep muscles of the back are the erector spinae muscles.
3. Muscles of the upper limb include muscles that cause movement at the shoulder joint, elbow, and hand. Muscles causing movement at the elbow include the brachialis, biceps brachii, brachioradialis, and triceps brachii.
4. Muscles of the lower extremity cause movement at the hip, knee, and foot. They include the iliopsoas, gluteus maximus and medius, adductors, quadriceps and hamstring groups, gastrocnemius, tibialis anterior, fibularis muscles, soleus, and extensor digitorum longus.

Developmental Aspects of the Muscular System (pp. 214–215)

1. Increasing muscular control reflects the maturation of the nervous system. Muscle control is achieved in a cephalic/caudal and proximal/distal direction.
2. To remain healthy, muscles must be regularly exercised. Without exercise, they atrophy; with extremely vigorous exercise, they hypertrophy.
3. As we age, muscle mass decreases, and the muscles become more sinewy. Exercise helps to retain muscle mass and strength.

Review Questions

Multiple Choice

More than one choice may apply.

1. If you compare electron micrographs of a relaxed skeletal muscle fiber and a fully contracted muscle fiber, which would you see only in the *relaxed* fiber?
   a. Z discs
   b. Triads
   c. I bands
   d. A bands
   e. H zones
2. After ACh attaches to its receptors at the neuromuscular junction, what is the next step?
   a. Sodium channels open.
   b. Calcium binds to regulatory proteins on the thin filaments.
   c. Cross bridges attach.
   d. ATP is hydrolyzed.
3. Your ability to lift that heavy couch would be increased by which type of exercise?
   a. Aerobic
   b. Endurance
   c. Resistance
   d. Swimming

4. Doing the pincer grasp is an _____ movement.
   a. extending
   b. abducting
   c. adducting
   d. opposing
5. Which are ways in which muscle names have been derived?
   a. Attachments
   b. Size
   c. Function
   d. Location
6. Which of the following muscles attach to the hip bones?
   a. Rectus abdominis
   b. Rectus femoris
   c. Vastus medialis
   d. Vastus lateralis
7. Which of these thigh muscles causes movement at the hip joint?
   a. Rectus femoris
   b. Biceps femoris
   c. Vastus lateralis
   d. Semitendinosus
8. Which of the following insert on the arm?
   a. Biceps brachii
   b. Triceps brachii
   c. Trapezius
   d. Latissimus dorsi

Short Answer Essay

9. What is the major function of muscle?
10. Compare skeletal, smooth, and cardiac muscles as to their microscopic anatomy, location and arrangement in body organs, and function in the body.
11. What two types of muscle tissue are striated?
12. Why are the connective tissue wrappings of skeletal muscles important? Name these connective tissue coverings, beginning with the finest and ending with the most coarse.
13. What is the function of tendons?
14. Define *neuromuscular junction, motor unit, tetanus, graded response, aerobic respiration, anaerobic glycolysis, muscle fatigue,* and *neurotransmitter.*
15. Describe the events that occur from the time a motor neuron releases acetylcholine at the neuromuscular junction until muscle cell contraction occurs.
16. How do isotonic and isometric contractions differ?
17. Muscle tone keeps muscles healthy. What is muscle tone, and what causes it? What happens to a muscle that loses its tone?
18. A skeletal muscle is attached to bones at two points. Name each of these attachment points, and indicate which is movable and which is immovable.
19. List the 12 body movements studied in this chapter and demonstrate each.
20. How is a prime mover different from a synergist muscle? How can a prime mover also be considered an antagonist?
21. If you were alternately contracting and relaxing your masseter muscle, what would you be doing? Name three other muscles of the face, and give the location and function of each.
22. The sternocleidomastoid muscles help to flex the neck. What are their antagonists?
23. Name two muscles that reverse the movement of the deltoid muscle.
24. Name the prime mover of elbow flexion. Name its antagonist.
25. Other than acting to flex the spine and compress the abdominal contents, the abdominal muscles are extremely important in protecting and containing the abdominal viscera. What is it about the arrangement of these muscles that makes them so well suited for their job?
26. The hamstring and quadriceps muscle groups are antagonists of each other, and each group is a prime mover in its own right. What action does each muscle group perform?
27. What two-bellied muscle makes up the calf region of the leg? What is its function?
28. What happens to muscles when they are exercised regularly? Exercised vigorously as in weight lifting? Not used?
29. What is the effect of aging on skeletal muscles?
30. Should a triathlete engage in aerobic or resistance training? Explain.

Critical Thinking and Clinical Application Questions

31. Name three muscles or muscle groups used as sites for intramuscular injections. Which is most often used in babies?

32. Mr. Ahmadi was advised by his physician to lose weight and start jogging. He began to jog daily. On the sixth day, he was forced to jump out of the way of a speeding car. He heard a snapping sound that was immediately followed by pain in his right lower calf. A gap was visible between his swollen calf and his heel, and he was unable to plantar flex that foot. What do you think happened?

33. While painting her house, Sally fell off the ladder and fractured her right clavicle. Treatment prescribed by the emergency room physician included using a sling for her right arm to immobilize the clavicle and speed its healing. What muscles are temporarily "put out of business" by the sling?

34. When Eric returned from jogging, he was breathing heavily and sweating profusely, and he complained that his legs ached and felt weak. His wife poured him a sport drink and urged him to take it easy until he could "catch his breath." On the basis of what you have learned about muscle energy metabolism, respond to the following questions:
    a. Why is Eric breathing heavily?
    b. What ATP-harvesting pathway have his working muscles been using that leads to such a breathing pattern?
    c. What metabolic product(s) might account for his sore muscles and his feeling of muscle weakness?

35. Chemical A binds and blocks acetylcholine receptors of muscle cells. Chemical B floods the cytoplasm of muscle cells with calcium ions. Which chemical would make the best muscle relaxant and why?

36. Mr. Posibo has had colon surgery. Now he is experiencing weakness of the muscles on his right side only, the side in which the incision was made through the abdominal musculature. Consequently, the abdominal muscles on his left side contract more strongly, throwing his torso into a lateral flexion. Mr. Posibo needs physical therapy. What abnormal spinal curvature will result if he doesn't get it, and why?

37. When a person dies, rigor mortis sets in as ATP synthesis ceases. Explain why the lack of ATP in muscle cells would cause the muscles to become rigid rather than limp soon after death.

38. Harry was pondering an exam question that said, "What muscle type has elongated cells and is found in the walls of the urinary bladder?" What should he have responded?