problems. Manic behavior in which the users undergo Jekyll-and-Hyde personality swings and become extremely violent (the so-called 'roid rage) is common; so, too, are depression and delusions.

A recent arrival on the scene, sold over the counter as a "nutritional performance enhancer," is androstenedione, which is converted to testosterone in the body. It is taken orally, and much of it is destroyed by the liver soon after ingestion, but the few milligrams that survive temporarily boost testosterone levels. Reports of "wannabe" athletes from the fifth grade up sweeping the supplement off the drugstore shelves are troubling. Androstenedione is not regulated by the U.S. Food and Drug Administration (FDA), and its long-term effects are unpredictable. Ongoing studies have found that boys and men who took the supplement developed elevated levels of the female hormone estrogen as well as testosterone (raising their risk of feminizing effects such as enlarged breasts), early puberty, and stunted bone growth leading to shorter than normal adult height.

The question of why athletes use these drugs is easy to answer. Some say they are willing to do almost anything to win, short of killing themselves. Are they unwittingly doing this as well?

DID YOU GET IT?

18. Based on their names, deduce some characteristics of the following muscles: tibialis anterior, erector spinae, rectus abdominis.

19. What is the fascicle arrangement of the orbicularis oris muscle?

For answers, see Appendix D.

Gross Anatomy of Skeletal Muscles

✓ Name and locate the major muscles of the human body (on a torso model, muscle chart, or diagram), and state the action of each.

It is beyond the scope of this book to describe the hundreds of skeletal muscles of the human body. We describe only the most important muscles here. All the superficial muscles we consider are summarized in Tables 6.3 and 6.4 and illustrated in overall body views in Figures 6.22 and 6.23, which accompany the tables (pp. 216–219).

Head and Neck Muscles

The head muscles (**Figure 6.16**) are an interesting group. They have many specific functions but are usually grouped into two large categories—facial muscles and chewing muscles. Facial muscles are unique because they are inserted into soft tissues such as other muscles or skin. When they pull on the skin of the face, they permit us to smile faintly, grin widely, frown, pout, deliver a kiss, and so forth. The chewing muscles begin to break down food for the body. All head and neck muscles we describe are paired except for the platysma, the orbicularis oris, the frontalis, and the occipitalis.

Facial Muscles

Frontalis The frontalis, which covers the frontal bone, runs from the cranial aponeurosis to the skin of the eyebrows, where it inserts. This muscle allows you to raise your eyebrows, as in surprise, and to wrinkle your forehead. At the posterior end of the cranial aponeurosis is the small **occipitalis** muscle, which covers the posterior aspect of the skull and pulls the scalp posteriorly.*

Orbicularis Oculi The orbicularis oculi (or-bik″u-la′ris ok′u-li) has fibers that run in circles around the eyes. It allows you to close your eyes, squint, blink, and wink.

Orbicularis Oris The orbicularis oris is the circular muscle of the lips. Because it closes the mouth and protrudes the lips, it is often called the "kissing" muscle.

*Although the current references on anatomic terminology refer to the frontalis and occipitalis as the *frontal* and *occipital bellies* of the *epicranius* ("over the cranium") muscle, we will continue to use the terms frontalis and occipitalis here.

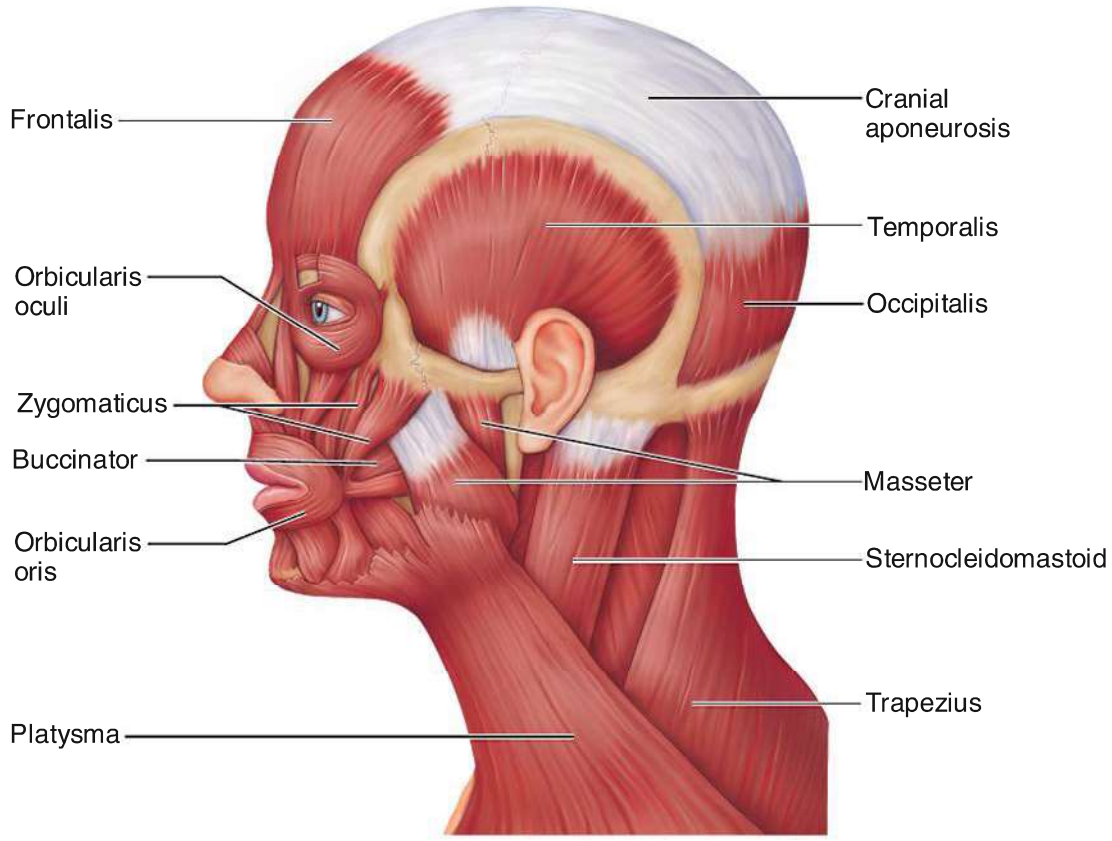

Figure 6.16 **Superficial muscles of the face and neck.**

Buccinator The fleshy buccinator (bu′sĭ-na″tor) muscle runs horizontally across the cheek and inserts into the orbicularis oris. It flattens the cheek (as in whistling or blowing a trumpet). It is also listed as a chewing muscle because it compresses the cheek to hold the food between the teeth during chewing.

Zygomaticus The zygomaticus (zi″go-mat′i-kus) extends from the corner of the mouth to the cheekbone. It is often referred to as the "smiling" muscle because it raises the corners of the mouth upward.

Chewing Muscles

The buccinator muscle, which is a member of this group, is described with the facial muscles.

Masseter As it runs from the zygomatic process of the temporal bone to the mandible, the masseter (mă-se′ter) covers the angle of the lower jaw. This muscle closes the jaw by elevating the mandible.

Temporalis The temporalis is a fan-shaped muscle overlying the temporal bone. It inserts into the mandible and acts as a synergist of the masseter in closing the jaw.

Neck Muscles

For the most part, the neck muscles, which move the head and shoulder girdle, are small and straplike. We consider only two neck muscles here.

Platysma The platysma is a single sheetlike muscle that covers the anterolateral neck (see Figure 6.16). It originates from the connective tissue covering of the chest muscles and inserts into the area around the mouth. Its action is to pull the corners of the mouth inferiorly, producing a downward sag of the mouth (the "sad clown" face).

Sternocleidomastoid The paired sternocleidomastoid (ster″no-kli″do-mas′toid) muscles are two-headed muscles, one found on each side of the neck. Of the two heads of each muscle, one arises from the sternum and the other arises from the clavicle (see Figure 6.22, p. 216). The heads fuse before inserting into the mastoid process of the temporal bone. When both sternocleidomastoid muscles contract together, they flex your neck. (It is this action of bowing the head that has led some people to call these muscles the "prayer"

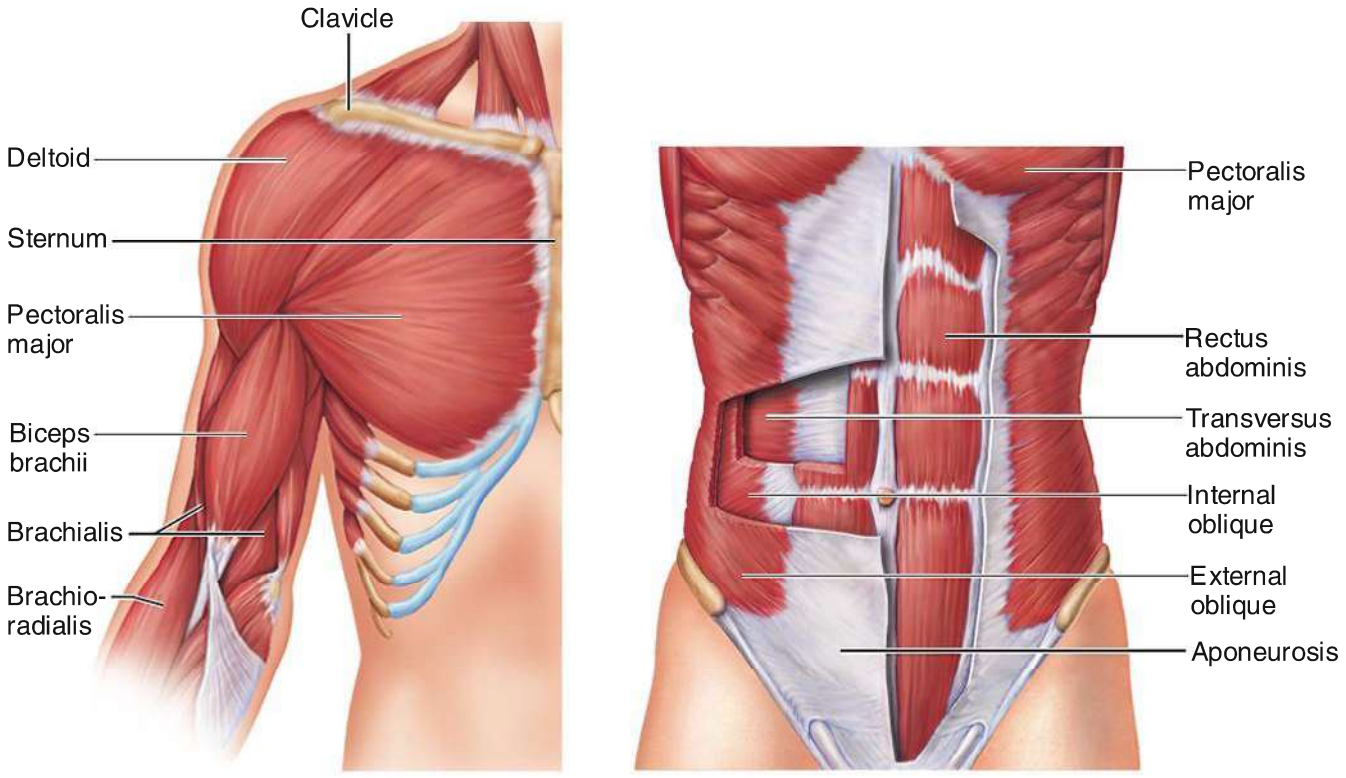

Figure 6.17 **Muscles of the anterior trunk, shoulder, and arm.** **(a)** Muscles crossing the shoulder joint, causing movements of the arm. The platysma of the neck is removed. **(b)** Muscles of the abdominal wall. Portions of the superficial muscles of the right side of the abdomen are cut away to reveal the deeper muscles.

muscles.) If just one muscle contracts, the head is rotated toward the shoulder on the opposite side and tilts the head to its own side.

HOMEOSTATIC IMBALANCE

In some difficult births, one of the sternocleidomastoid muscles may be injured and develop spasms. A baby injured in this way has **torticollis** (tor″ti-kol′is), or wryneck.

DID YOU GET IT?

20. Which muscle raises your eyebrow?

21. Which two muscles are synergists in jaw closure?

For answers, see Appendix D.

Trunk Muscles

The trunk muscles include (1) those that move the vertebral column (most of which are posterior antigravity muscles); (2) anterior thorax muscles, which move the ribs, head, and arms; and (3) muscles of the abdominal wall, which help to move the vertebral column and, most important, form the muscular "natural girdle" of the abdominal body wall.

Anterior Muscles (Figure 6.17)

Pectoralis Major The pectoralis (pek″to-ra′lis) major is a large fan-shaped muscle covering the upper part of the chest. Its origin is from the sternum, shoulder girdle, and the first six ribs. It inserts on the proximal end of the humerus. This muscle forms the anterior wall of the axilla and acts to adduct and flex the arm.

Intercostal Muscles The intercostal muscles are deep muscles found between the ribs. (Although they are not shown in Figure 6.17, which shows only superficial muscles, they are illustrated in Figure 6.22, p. 216.) The external intercostals are important in breathing because they help to raise the rib cage when you inhale. The internal intercostals, which lie deep to the external intercostals,

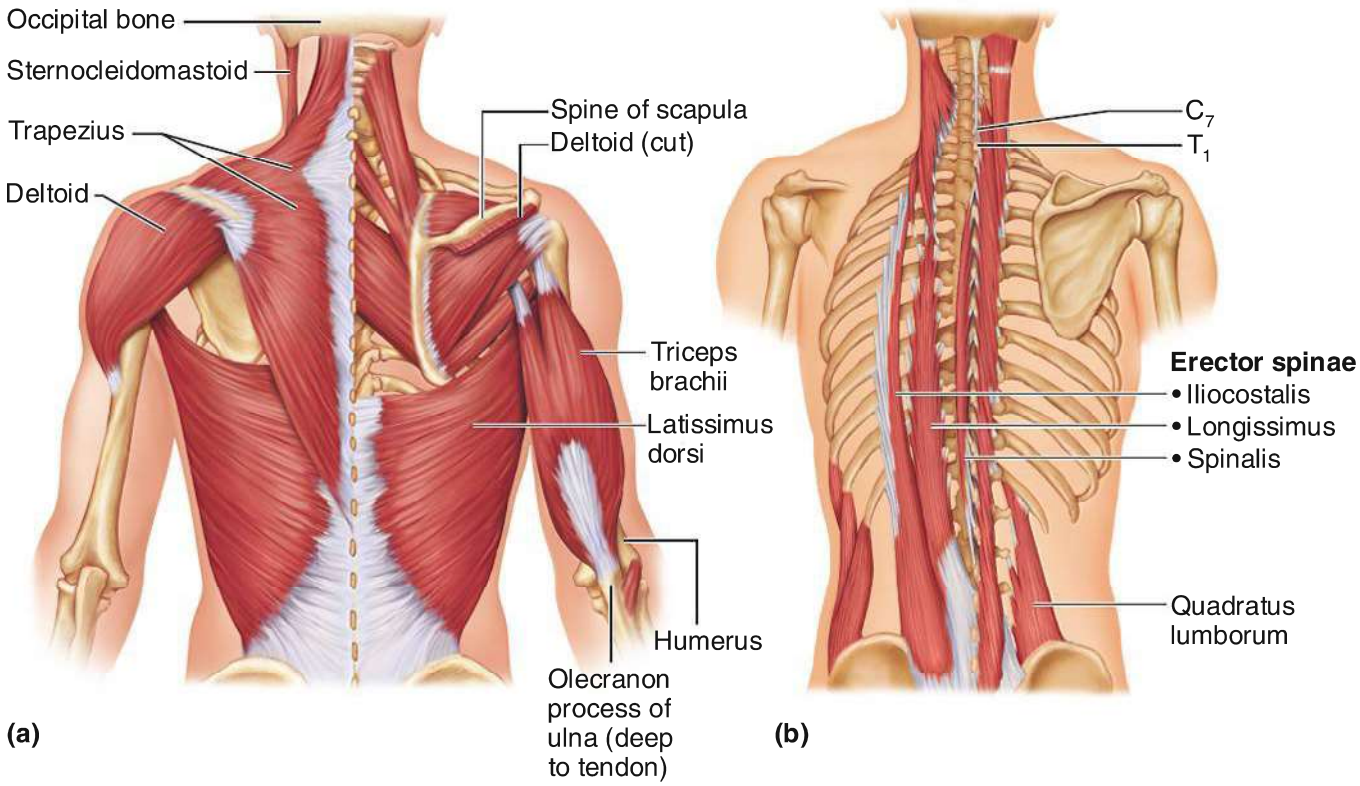

Figure 6.18 **Muscles of the posterior neck, trunk, and arm.** **(a)** Superficial muscles. **(b)** The erector spinae muscles (longissimus, iliocostalis, and spinalis), deep muscles of the back.

depress the rib cage, which helps to move air out of the lungs when you exhale forcibly.

Muscles of the Abdominal Girdle The anterior abdominal muscles (rectus abdominis, external and internal obliques, and transversus abdominis) form a natural "girdle" that reinforces the body trunk. Taken together, they resemble the structure of plywood because the fibers of each muscle or muscle pair run in a different direction. Just as plywood is exceptionally strong for its thickness, the abdominal muscles form a muscular wall that is well suited for its job of containing and protecting the abdominal contents.

- **Rectus abdominis.** The paired straplike rectus abdominis muscles are the most superficial muscles of the abdomen. They run from the pubis to the rib cage, enclosed in an aponeurosis. Their main function is to flex the vertebral column. They also compress the abdominal contents during defecation and childbirth and are involved in forced breathing.
- **External oblique.** The external oblique muscles are paired superficial muscles that make up the lateral walls of the abdomen. Their fibers run downward and medially from the last eight ribs and insert into the ilium. Like the rectus abdominis, they flex the vertebral column, but they also rotate the trunk and bend it laterally.
- **Internal oblique.** The internal oblique muscles are paired muscles deep to the external obliques. Their fibers run at right angles to those of the external obliques. They arise from the iliac crest and insert into the last three ribs. Their functions are the same as those of the external obliques.
- **Transversus abdominis.** The transversus abdominis is the deepest muscle of the abdominal wall and has fibers that run horizontally across the abdomen. It arises from the lower ribs and iliac crest and inserts into the pubis. This muscle compresses the abdominal contents.

Posterior Muscles (Figure 6.18)

Trapezius The trapezius (trah-pe′ze-us) muscles are the most superficial muscles of the posterior

neck and upper trunk. When seen together, they form a diamond- or kite-shaped muscle mass. Their origin is very broad. Each muscle runs from the occipital bone of the skull down the vertebral column to the end of the thoracic vertebrae. They then flare laterally to insert on the scapular spine and clavicle. The trapezius muscles extend the head (thus they are antagonists of the sternocleidomastoids). They also can elevate, depress, adduct, and stabilize the scapula.

Latissimus Dorsi The latissimus (lah-tis′ĭ-mus) dorsi muscles are the two large, flat muscles that cover the lower back. They originate on the lower spine and ilium and then sweep superiorly to insert into the proximal end of the humerus. Each latissimus dorsi extends and adducts the humerus. These are very important muscles when the arm must be brought down in a power stroke, as when swimming or striking a blow.

Erector Spinae The erector spinae (e-rek′tor spi′ne) group is the prime mover of back extension. These paired muscles are deep muscles of the back; they are shown in Figure 6.18b. Each erector spinae is a composite muscle consisting of three muscle columns (longissimus, iliocostalis, and spinalis) that collectively span the entire length of the vertebral column. These muscles not only act as powerful back extensors ("erectors") but also provide resistance that helps control the action of bending over at the waist. Following injury to back structures, these muscles go into spasms, a common source of lower back pain.

Quadratus Lumborum The fleshy quadratus lumborum (qwad-ra′tus lum-bor′um) muscles form part of the posterior abdominal wall. Acting separately, each muscle of the pair flexes the spine laterally. Acting together, they extend the lumbar spine. These muscles arise from the iliac crests and insert into the upper lumbar vertebrae (Figure 6.18b).

Deltoid The deltoids are fleshy, triangle-shaped muscles that form the rounded shape of your shoulders (see Figure 6.18a). Because they are so bulky, they are a favorite injection site (**Figure 6.19**) when relatively small amounts of medication (less than 5 ml) must be given intramuscularly (into muscle). The origin of each deltoid winds across the shoulder girdle from the spine of the scapula to the clavicle. It inserts into the proximal humerus. The deltoids are the prime movers of arm abduction.

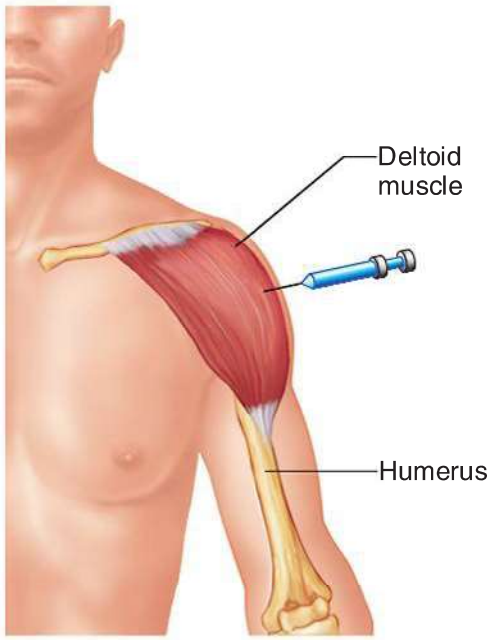

Figure 6.19 The fleshy deltoid muscle is a favored site for administering intramuscular injections.

DID YOU GET IT?

22. Which muscle group is the prime mover of back extension?

23. What structural feature makes the abdominal musculature especially strong for its thickness?

24. Which muscle of the posterior trunk is the synergist of the pectoralis major muscle in arm adduction?

For answers, see Appendix D.

Muscles of the Upper Limb

The upper limb muscles fall into three groups. The first group includes muscles that arise from the shoulder girdle and cross the shoulder joint to insert into the humerus (see Figures 6.17 and 6.18a). We have already considered these muscles, which move the arm—they are the pectoralis major, latissimus dorsi, and deltoid.

The second group causes movement at the elbow joint. These muscles enclose the humerus and insert on the forearm bones. We describe only the muscles of this second group in this section.

The third group includes the muscles of the forearm, which insert on the hand bones and cause their movement. The muscles of this last group are thin and spindle-shaped, and there are many of them. We will not consider them here except to

mention their general naming and function. As a rule, the forearm muscles have names that reflect their activities. For example, the flexor carpi and flexor digitorum muscles, found on the anterior aspect of the forearm, cause flexion of the wrist and fingers, respectively. The extensor carpi and extensor digitorum muscles, found on the lateral and posterior aspect of the forearm, extend the same structures. (Some of these muscles are described briefly in Table 6.4 and illustrated in Figure 6.23.)

Muscles of the Humerus That Act on the Forearm

All *anterior* arm muscles cause elbow flexion. In order of decreasing strength these are the brachialis, biceps brachii, and brachioradialis (Figures 6.17a and 6.22).

Biceps Brachii The biceps brachii (bra′ke-i) is the most familiar muscle of the arm because it bulges when the elbow is flexed (see Figure 6.17a). It originates by two heads from the shoulder girdle and inserts into the radial tuberosity. This muscle is the powerful prime mover for flexion of the forearm and acts to supinate the forearm. The best way to remember its action is to think of opening a bottle of wine. The biceps supinates the forearm to turn the corkscrew *and* then flexes the elbow to pull the cork.

Brachialis The brachialis lies deep to the biceps muscle and is as important as the biceps in elbow flexion. The brachialis lifts the ulna as the biceps lifts the radius.

Brachioradialis The brachioradialis is a fairly weak muscle that arises on the humerus and inserts into the distal forearm (see Figure 6.22, p. 216). Hence, it resides mainly in the forearm.

Triceps Brachii The triceps brachii is the only muscle fleshing out the posterior humerus (see Figure 6.18a). Its three heads arise from the shoulder girdle and proximal humerus, and it inserts into the olecranon process of the ulna. Being the powerful prime mover of elbow extension, it is the antagonist of the biceps brachii. This muscle is often called the "boxer's" muscle because it can deliver a straight-arm knockout punch.

Muscles of the Lower Limb

Muscles that act on the lower limb cause movement at the hip, knee, and foot joints. They are among the largest, strongest muscles in the body and are specialized for walking and balancing the body. Because the pelvic girdle is composed of heavy, fused bones that allow little movement, no special group of muscles is necessary to stabilize it. This is very different from the shoulder girdle, which requires several fixator muscles.

Many muscles of the lower limb span two joints and can cause movement at both of them. Therefore, the terms *origin* and *insertion* are often interchangeable in referring to these muscles.

Muscles acting on the thigh are massive muscles that help hold the body upright against the pull of gravity and cause various movements at the hip joint. Muscles acting on the leg form the flesh of the thigh. (Recall that in common usage the term *leg* refers to the whole lower limb, but anatomically the term refers only to that part between the knee and the ankle.) The thigh muscles cross the knee and cause its flexion or extension. Because many of the thigh muscles also have attachments on the pelvic girdle, they can cause movement at the hip joint as well.

Muscles originating on the leg cause assorted movements of the ankle and foot. We will consider only three muscles of this group, but there are many others that act to extend and flex the ankle and toe joints.

Muscles Causing Movement at the Hip Joint (Figure 6.20)

Gluteus Maximus The gluteus maximus (gloo′te-us max′ĭ-mus) is a superficial muscle of the hip that forms most of the flesh of the buttock (Figure 6.20a). It is a powerful hip extensor that acts to bring the thigh in a straight line with the pelvis. Although it is not very important in walking, it is probably the most important muscle for extending the hip when power is needed, as when climbing stairs and when jumping. It originates from the sacrum and iliac bones and inserts on the gluteal tuberosity of the femur and into the large tendinous *iliotibial* tract.

Gluteus Medius The gluteus medius runs from the ilium to the femur, beneath the gluteus maximus for most of its length. The gluteus medius is a hip abductor and is important in steadying the pelvis during walking. The gluteus medius is an important site for giving intramuscular injections,

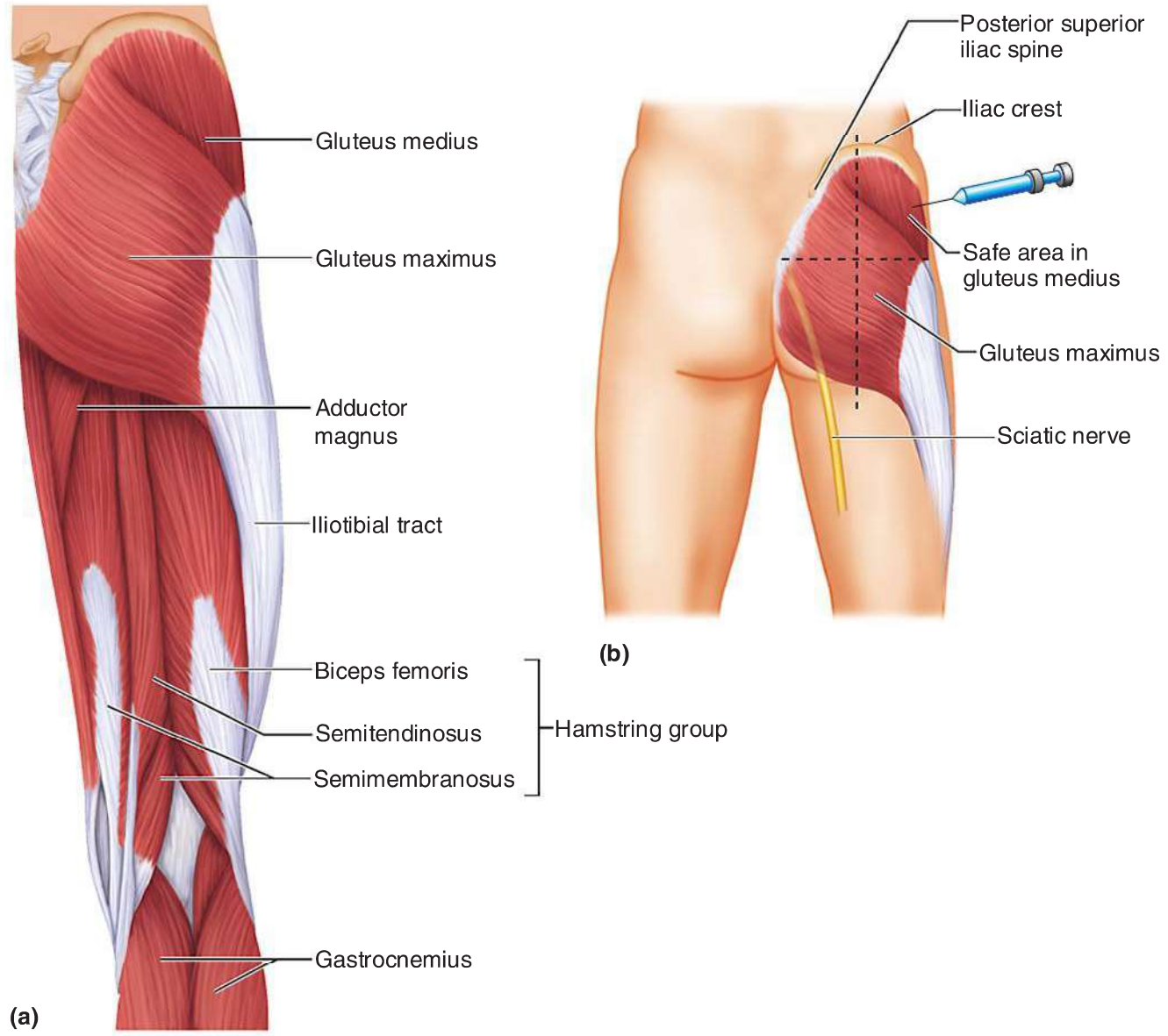

Figure 6.20 **Pelvic, hip, and thigh muscles of the right side of the body.** **(a)** Posterior view of hip and thigh muscles. **(b)** Diagram showing deep structures of the gluteal region and the proper site for administering an injection into the gluteus medius muscle.

particularly when more than 5 ml is administered (see Figure 6.20b). Although it might appear that the large, fleshy gluteus maximus that forms the bulk of the buttock mass would be a better choice, notice that the medial part of each buttock overlies the large *sciatic nerve;* hence this area must be carefully avoided. This can be accomplished by *mentally* dividing the buttock into four equal quadrants (shown by the division lines on Figure 6.20b). The superolateral quadrant then overlies the gluteus medius muscle, which is usually a very safe site for an intramuscular injection.

Iliopsoas The iliopsoas (il″e-o-so′as; the *p* is silent) is a fused muscle composed of two muscles, the *iliacus* and the *psoas major* (Figure 6.20c). It runs from the iliac bone and lower vertebrae deep inside the pelvis to insert on the lesser trochanter of the femur. It is a prime mover of hip flexion. It also acts to keep the upper body from falling backward when we are standing erect.

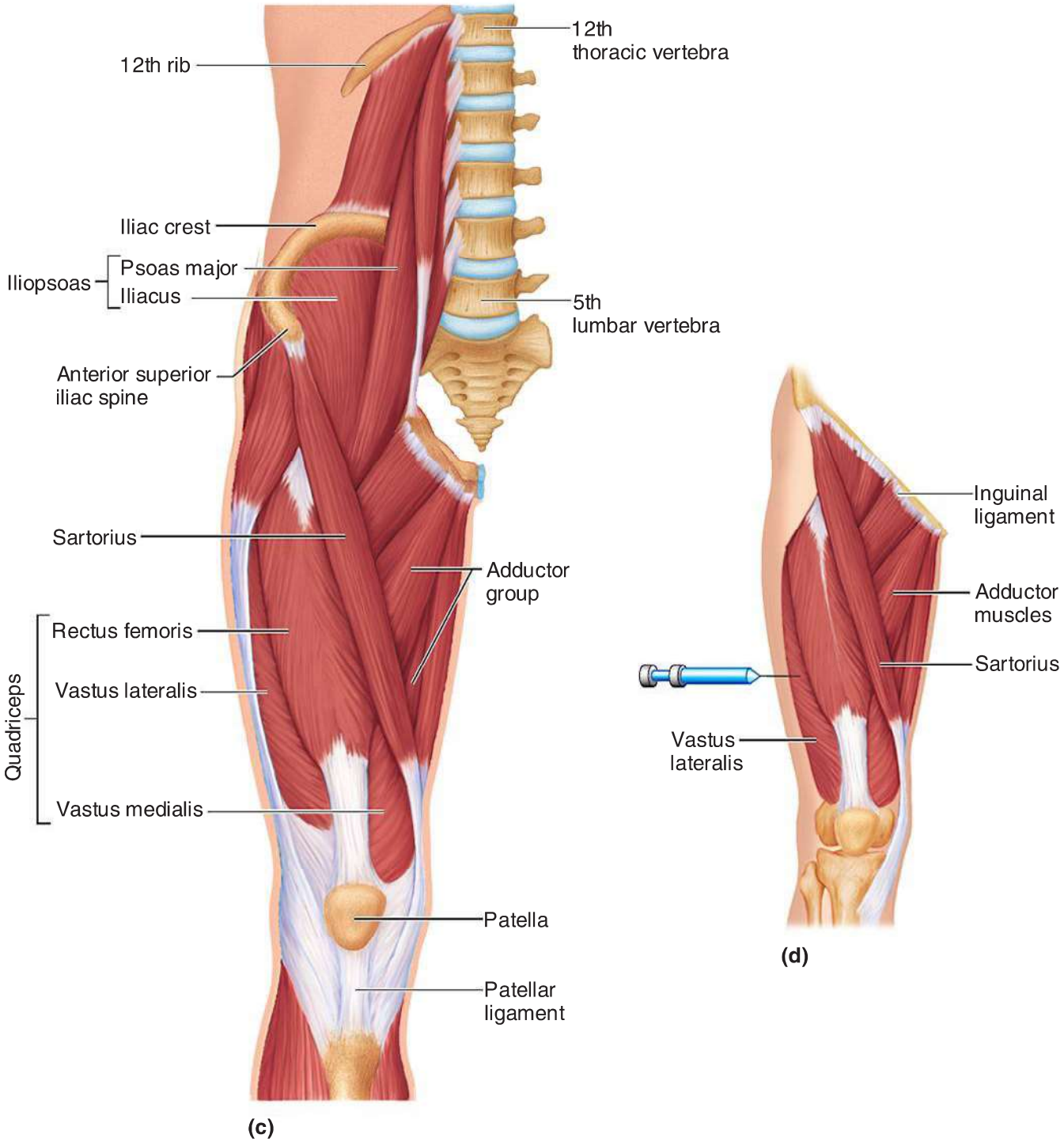

Figure 6.20 *(continued)* **Pelvic, hip, and thigh muscles of the right side of the body. (c)** Anterior view of pelvic and thigh muscles. **(d)** Diagram showing the proper site for administration of an injection into the lateral thigh (vastus lateralis muscle).

Adductor Muscles The muscles of the adductor group form the muscle mass at the medial side of each thigh (Figure 6.20c). As their name indicates, they adduct, or press, the thighs together. However, because gravity does most of the work for them, they tend to become flabby very easily. Special exercises are usually needed to keep them toned. The adductors have their origin on the pelvis and insert on the proximal aspect of the femur.

Muscles Causing Movement at the Knee Joint (Figure 6.20)

Hamstring Group The muscles forming the muscle mass of the posterior thigh are the hamstrings (Figure 6.20a). The group consists of three muscles, the **biceps femoris, semimembranosus,** and **semitendinosus,** which originate on the ischial tuberosity and run down the thigh to insert on both sides of the proximal tibia. They are prime movers of thigh extension and knee flexion. Their name comes from the fact that butchers use their tendons to hang hams (consisting of thigh and hip muscles) for smoking. These tendons can be felt at the back of the knee.

Sartorius Compared with other thigh muscles described here, the thin, straplike sartorius (sar-to′re-us) muscle is not too important. However, it is the most superficial muscle of the thigh and so is rather hard to miss (Figure 6.20c). It runs obliquely across the thigh from the anterior iliac crest to the medial side of the tibia. It is a weak thigh flexor. The sartorius is commonly referred to as the "tailor's" muscle because it acts as a synergist to bring about the cross-legged position in which old-time tailors are often shown.

Quadriceps Group The quadriceps (kwod′rĭ-seps) group consists of four muscles—the **rectus femoris** and three **vastus muscles**—that flesh out the anterior thigh. (Only two vastus muscles are visible in Figure 6.20c. The third, the vastus intermedius, is obscured by the rectus femoris muscle, which lies over it.) The vastus muscles originate from the femur; the rectus femoris originates on the pelvis. All four muscles insert into the tibial tuberosity via the patellar ligament. The group as a whole acts to extend the knee powerfully, as when kicking a football. Because the rectus femoris crosses two joints, the hip and the knee, it can also help to flex the hip. The vastus lateralis and rectus femoris are sometimes used as intramuscular injection sites (Figure 6.20d), particularly in infants, who have poorly developed gluteus muscles.

Muscles Causing Movement at the Ankle and Foot (Figure 6.21)

Tibialis Anterior The tibialis anterior is a superficial muscle on the anterior leg. It arises from the upper tibia and then parallels the anterior crest as it runs to the tarsal bones, where it inserts by a long tendon. It acts to dorsiflex and invert the foot.

Extensor Digitorum Longus Lateral to the tibialis anterior, the extensor digitorum longus muscle arises from the lateral tibial condyle and proximal three-quarters of the fibula and inserts into the phalanges of toes 2 to 5. It is a prime mover of toe extension.

Fibularis Muscles The three fibularis muscles—**longus, brevis,** and **tertius**—are found on the lateral part of the leg. They arise from the fibula and insert into the metatarsal bones of the foot. The group as a whole plantar flexes and everts the foot.

Gastrocnemius The gastrocnemius (gas″trok-ne′-me-us) muscle is a two-bellied muscle that forms the curved calf of the posterior leg. It arises by two heads, one from each side of the distal femur, and inserts through the large *calcaneal (Achilles) tendon* into the heel of the foot. It is a prime mover for plantar flexion of the foot; for this reason it is often called the "toe dancer's" muscle. If its insertion tendon is cut, walking is very difficult. The foot drags because the heel cannot be lifted.

Soleus Deep to the gastrocnemius is the fleshy soleus muscle. Because it arises on the tibia and fibula (rather than the femur), it does not affect knee movement, but like the gastrocnemius, it inserts into the calcaneal tendon and is a strong plantar flexor of the foot.

Remember that most of the superficial muscles previously described are shown in anterior and posterior views of the body as a whole in Figures 6.22 and 6.23 and are summarized in Tables 6.3 and 6.4 (pp. 216–219). Take the time to review these muscles again before continuing with this chapter.