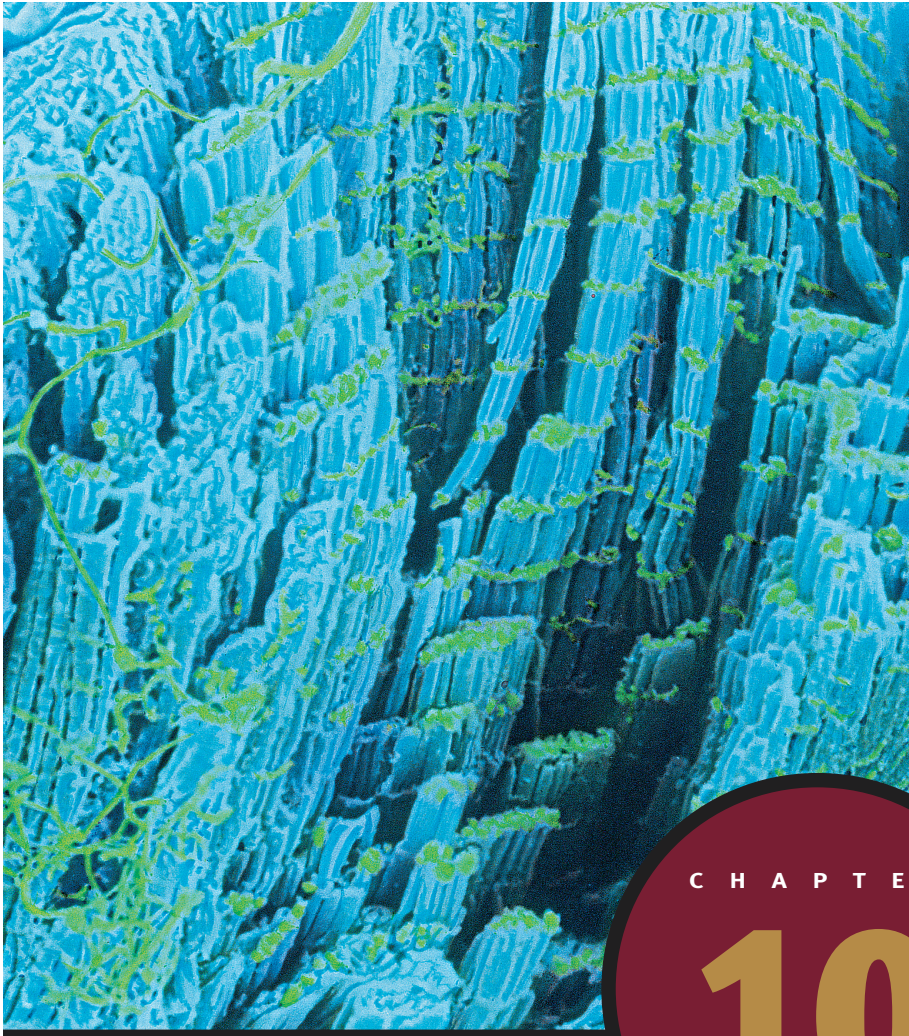




Colorized SEM of skeletal muscle.

C H A P T E R

10

# Muscular System

## Gross Anatomy

Mannequins are rigid, expressionless, immobile re-creations of the human form. They cannot walk or talk. One of the major characteristics of a living human being is our ability to move about. Without muscles, humans would be little more than mannequins. We wouldn't be able to hold this book. We wouldn't be able to blink, so our eyes would dry out. None of these inconveniences would bother us for long because we wouldn't be able to breathe either.

We use our skeletal muscles all the time—even when we aren't "moving." Postural muscles are constantly contracting to keep us sitting or standing upright. Respiratory muscles are constantly functioning to keep us breathing, even when we sleep. Communication of any kind requires skeletal muscles, whether we are writing, typing, or speaking. Even silent communication with hand signals or facial expression requires skeletal muscle function.

This chapter explains the *general principles* (314) of the muscular system and describes in detail the *head muscles* (319), *trunk muscles* (332), *upper limb muscles* (338), and *lower limb muscles* (349).

## General Principles

### Objectives

- As they pertain to muscles, define **origin**, **insertion**, **synergist**, **antagonist**, **prime mover**, and **fixator**.
- List the major muscle shapes, and relate them to function.
- Describe and give examples of the three classes of levers.

This chapter is devoted to the description of the major named skeletal muscles. The structure and function of cardiac and smooth muscle are considered in other chapters. Most skeletal muscles extend from one bone to another and cross at least one joint. Muscle contractions usually cause movement by pulling one bone toward another across a movable joint. Some muscles of the face are not attached to bone at both ends but attach to the connective tissue of skin and move the skin when they contract.

**Tendons** attach muscles to bones and other connective tissue. A very broad tendon is called an **aponeurosis** (ap'ō-noo-rō'sis). The points of attachment for each muscle are the origin and insertion. The **origin**, also called the **head**, is normally that end of the muscle attached to the more stationary of the two bones, and the **insertion** is the end of the muscle attached to the bone undergoing the greatest movement. The largest portion of the muscle, between the origin and the insertion, is the **belly**. Some muscles have multiple origins and a common insertion and are said to have multiple heads (such as a biceps, with two heads).

A muscle causing an action when it contracts is called an **agonist** (ag'on-ist). A muscle working in opposition to the agonist, moving a structure in the opposite direction, is an **antagonist**. Most muscles function as members of a functional group to accomplish specific movements. Furthermore, many muscles are

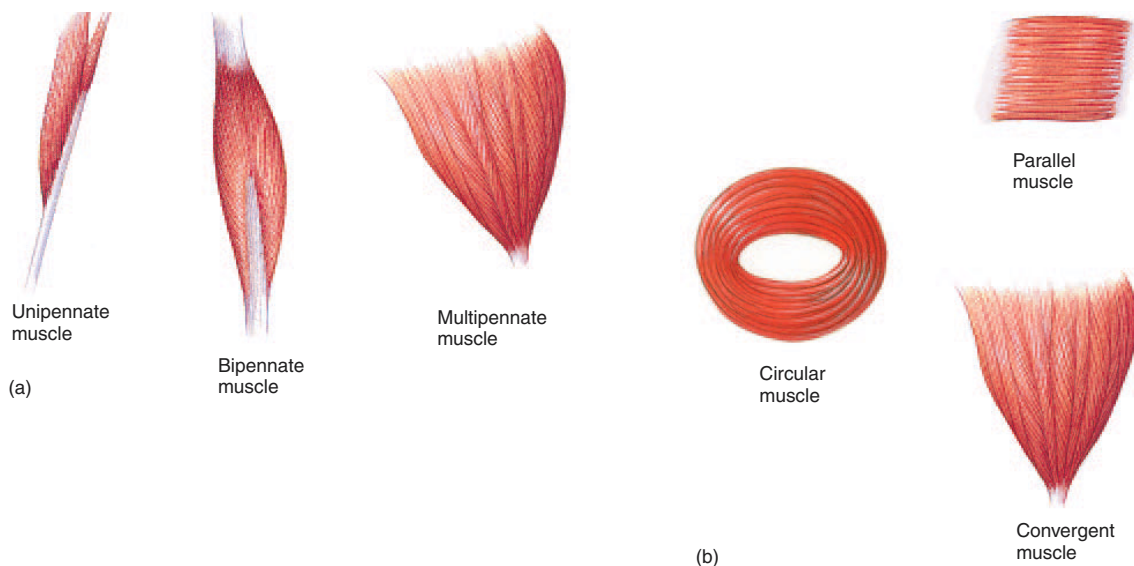
members of more than one group, depending on the type of movement being considered. For example, the anterior part of the deltoid muscle functions with the flexors of the arm, whereas the posterior part functions with the extensors of the arm. Muscles that work together to cause a movement are **synergists** (sin'er-jists). Among a group of synergists, if one muscle plays the major role in accomplishing the desired movement, it is called the **prime mover**. The brachialis and biceps brachii are synergists in flexing the elbow, with the brachialis as the prime mover; the triceps brachii is the antagonist to the brachialis and extends the elbow.

Other muscles, called **fixators** (fik-sā'ters), may stabilize one or more joints crossed by the prime mover. The extensor digitorum is the prime mover in finger extension. The flexor carpi radialis and flexor carpi ulnaris are fixators that keep the wrist from extending as the fingers are extended.

## Muscle Shapes

Muscles come in a wide variety of shapes. The shape and size of any given muscle greatly influences the degree to which it can contract and the amount of force it can generate. The large number of muscular shapes are grouped into four classes according to the orientation of the muscle fasciculi: pennate, parallel, convergent, and circular.

Some muscles have their fasciculi arranged like the barbs of a feather along a common tendon and therefore are called **pennate** (pen'āt; *pennatus* is Latin, meaning feather) muscles. A muscle with fasciculi on one side of the tendon only is **unipennate**, one with fasciculi on both sides is **bipennate**, and a muscle with fasciculi arranged at many places around the central tendon is **multipennate** (figure 10.1a). The pennate arrangement allows a large number of



**Figure 10.1** Examples of Muscle Types

(a) Muscles with various pennate arrangements. (b) Muscles with various fascicular orientations.



fasciculi to attach to a single tendon with the force of contraction concentrated at the tendon. The muscles that extend the leg are examples of multipennate muscles (see table 10.20).

In other muscles, called **parallel** muscles, fasciculi are organized parallel to the long axis of the muscle (figure 10.1*b*). As a consequence, the muscles shorten to a greater degree than do pennate muscles because the fasciculi are in a direct line with the tendon; however, they contract with less force because fewer total fascicles are attached to the tendon. The hyoid muscles are an example of parallel muscles (see figure 10.10).

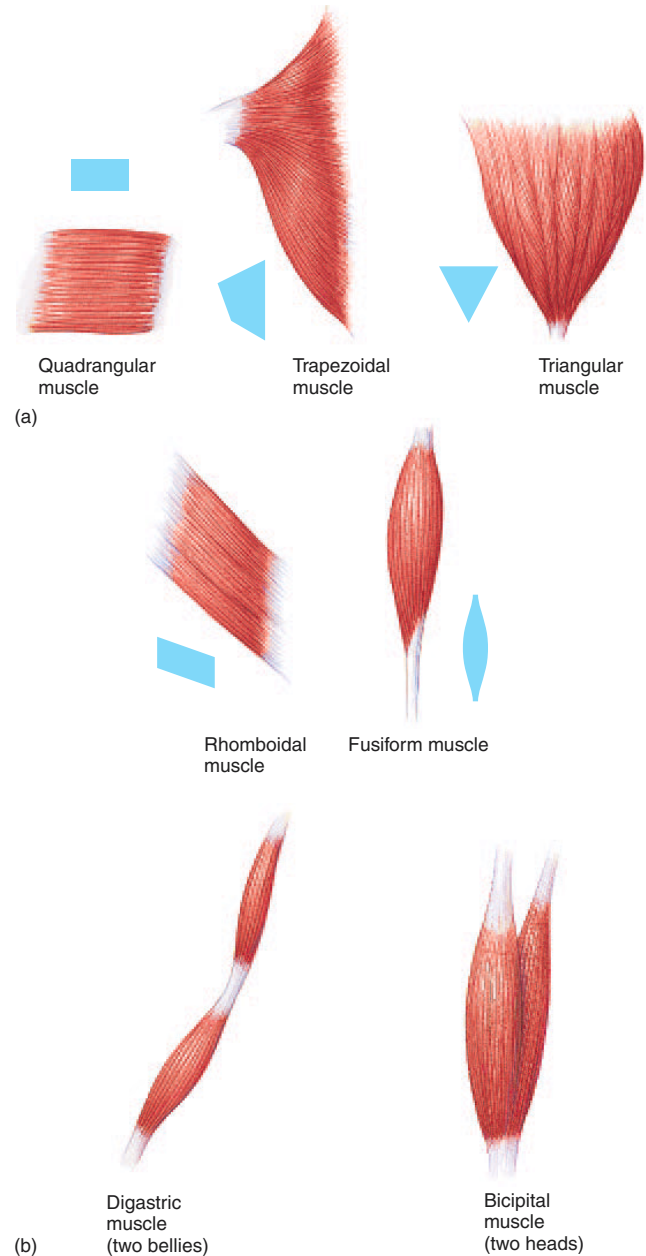
In **convergent** muscles, such as the deltoid muscle (see figure 10.23*a*), the base is much wider than the insertion, giving the muscle a triangular shape and allowing it to contract with more force than could occur in a parallel muscle. **Circular** muscles, such as the orbicularis oris and orbicularis oculi (see figure 10.7) have their fasciculi arranged in a circle around an opening and act as sphincters to close the opening.

Muscles may have specific shapes, such as quadrangular, triangular, rhomboidal, or fusiform (figure 10.2*a*). Muscles also may have multiple components, such as two bellies or two heads. A digastric muscle has two bellies separated by a tendon, whereas a bicipital muscle has two origins (heads) and a single insertion (figure 10.2*b*).

## Nomenclature

Muscles are named according to their location, size, shape, orientation of fasciculi, origin and insertion, number of heads, or function. Recognizing the descriptive nature of muscle names makes learning those names much easier.

1. **Location.** Some muscles are named according to their location. For example, a pectoralis (chest) muscle is located in the chest, a gluteus (buttock) muscle is located in the buttock, and a brachial (arm) muscle is located in the arm.
2. **Size.** Muscle names may also refer to the relative size of the muscle. For example, the gluteus maximus (large) is the largest muscle of the buttock, and the gluteus minimus (small) is the smallest. A longus (long) muscle is longer than a brevis (short) muscle.
3. **Shape.** Some muscles are named according to their shape. The deltoid (triangular) muscle is triangular, a quadratus (quadrangular) muscle is rectangular, and a teres (round) muscle is round.
4. **Orientation.** Muscles are also named according to their fascicular orientation. A rectus (straight) muscle has muscle fasciculi running straight with the axis of the structure to which the muscle is associated, whereas the fasciculi of an oblique muscle lie oblique to the longitudinal axis of the structure.
5. **Origin and insertion.** Muscles may be named according to their origin and insertion. The sternocleidomastoid originates on the sternum and clavicle and inserts onto the mastoid process of the temporal bone. The brachioradialis originates in the arm (brachium) and inserts onto the radius.



**Figure 10.2** Examples of Muscle Shapes

(a) Muscles with various shapes. (b) Muscles with various components.

6. **Number of heads.** The number of heads (origins) a muscle has may also be used in naming it. A biceps muscle has two heads, and a triceps muscle has three heads.
7. **Function.** Muscles are also named according to their function. An abductor moves a structure away from the midline, and an adductor moves a structure toward the midline. The masseter (a chewer) is a chewing muscle.

## Movements Accomplished by Muscles

When muscles contract, the **pull** ( $P$ ), or force, of muscle contraction is applied to levers, such as bones, resulting in movement of the levers (figure 10.3). A **lever** is a rigid shaft capable of turning about a pivot point called a **fulcrum** ( $F$ ) and transferring a force applied at one point along the lever to a **weight** ( $W$ ), or resistance, placed at some other point along the lever. The joints function as fulcrums, the bones function as levers, and the muscles provide the pull to move the levers. Three classes of levers exist based on the relative positions of the levers, weights, fulcrums, and forces.

### Class I Lever

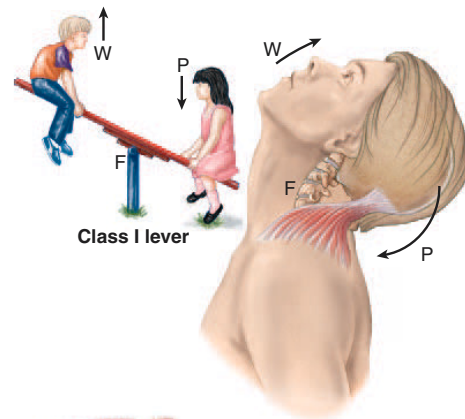
In a **class I lever system**, the fulcrum is located between the force and the weight (figure 10.3a). A child's seesaw is an example of this type of lever. The children on the seesaw alternate between being the weight and the pull across a fulcrum in the center of the board. The head is an example of this type of lever in the body. The atlanto-occipital joint is the fulcrum, the posterior neck muscles provide the pull depressing the back of the head, and the face, which is elevated, is the weight. With the weight balanced over the fulcrum, only a small amount of pull is required to lift a weight. For example, only a very small shift in weight is needed for one child to lift the other on a seesaw. This system is quite limited, however, as to how much weight can be lifted and how high it can be lifted. For example, consider what happens when the child on one end of the seesaw is much larger than the child on the other end.

### Class II Lever

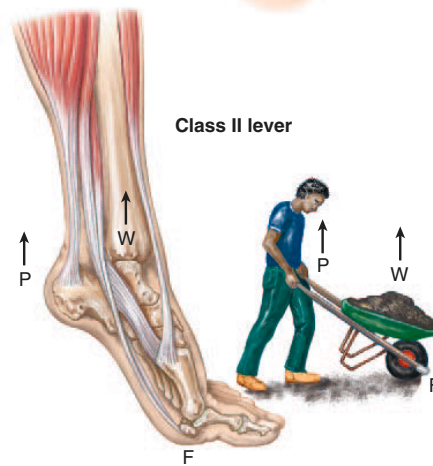
In a **class II lever system**, the weight is located between the fulcrum and the pull (figure 10.3b). An example is a wheelbarrow, where the wheel is the fulcrum and the person lifting on the handles provides the pull. The weight, or load, carried in the wheelbarrow is placed between the wheel and the operator. In the body, an example of a class II lever is the foot of a person standing on the toes. The calf muscles pulling (force) on the calcaneus (end of the lever) elevate the foot and the weight of the entire body, with the ball of the foot acting as the fulcrum. A considerable amount of weight can be lifted by using this type of lever system, but the weight usually isn't lifted very high.

### Class III Lever

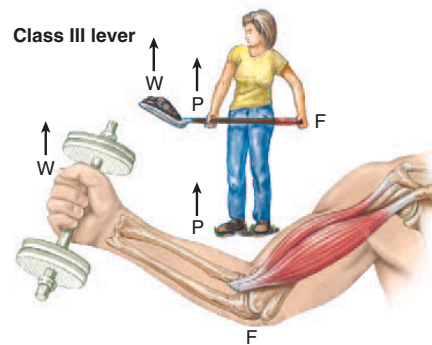
In a **class III lever system**, the most common type in the body, the pull is located between the fulcrum and the weight (figure 10.3c). An example is a person using a shovel. The hand placed on the part of the handle closest to the blade provides the pull to lift the weight, such as a shovel full of dirt, and the hand placed near the end of the handle acts as the fulcrum. In the body, the action of the biceps brachii muscle (force) pulling on the radius (lever) to flex the elbow (fulcrum) and elevate the hand (weight) is an example of a class III lever. This type of lever system doesn't allow as great a weight to be lifted, but the weight can be lifted a greater distance.



(a)



(b)



(c)

**Figure 10.3 Lever Classes**

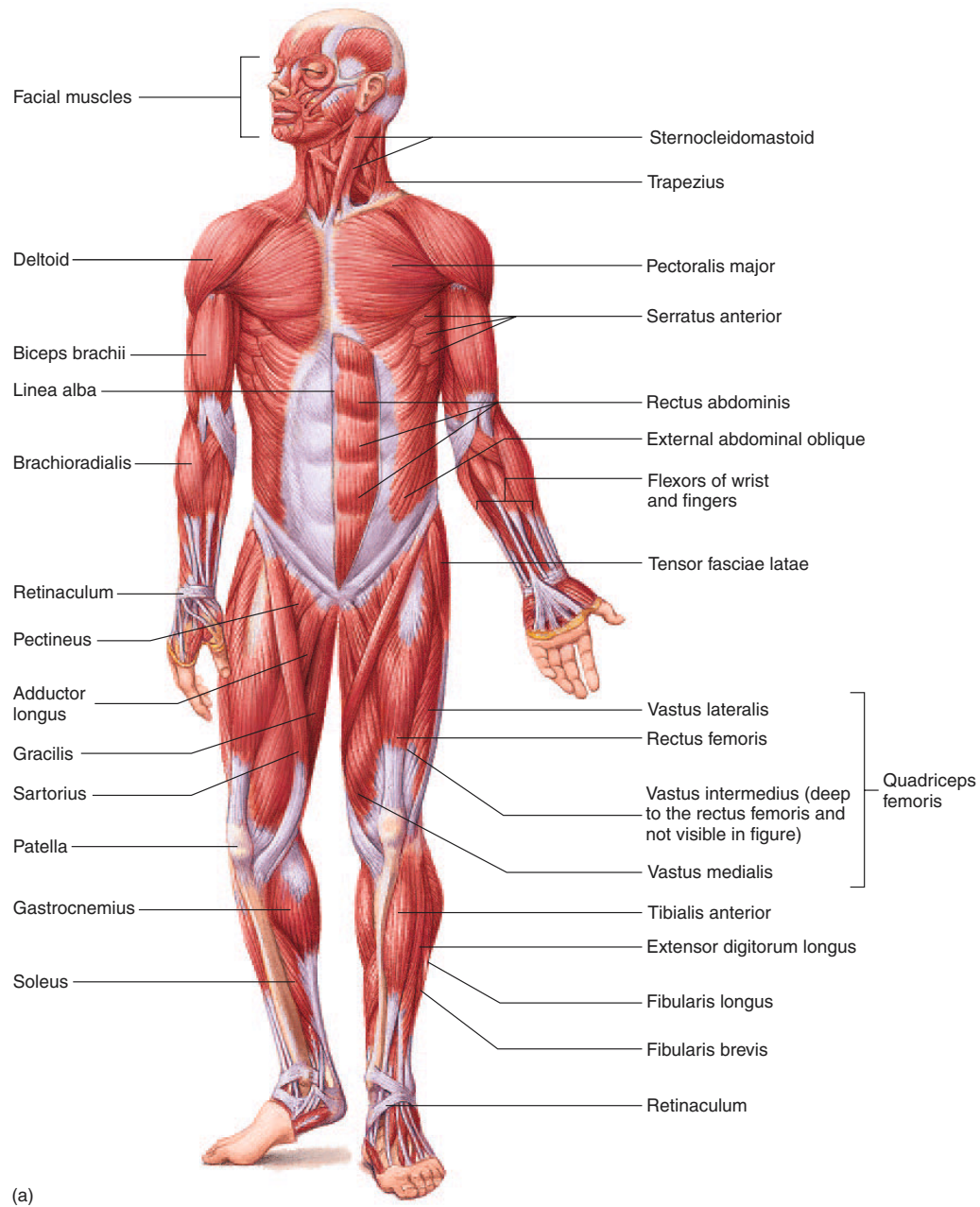
(a) **Class I:** The fulcrum ( $F$ ) is located between the weight ( $W$ ) and the force or pull ( $P$ ). The pull is directed downward, and the weight, on the opposite side of the fulcrum, is lifted. (b) **Class II:** The weight ( $W$ ) is located between the fulcrum ( $F$ ) and the force or pull ( $P$ ). The upward pull lifts the weight. (c) **Class III:** The force or pull ( $P$ ) is located between the fulcrum ( $F$ ) and the weight ( $W$ ). The upward pull lifts the weight.

1. Define the terms **origin** and **insertion**; **agonist** and **antagonist**; and **synergist**, **prime mover**, and **fixator**.
2. Describe the different shapes of muscles. How are the shapes related to the force of contraction of the muscle and the range of movement the contraction produces?

3. List the different criteria used to name muscles, and give an example of each.
4. Using the terms **fulcrum**, **lever**, and **force**, explain how contraction of a muscle results in movement. Define the three classes of levers, and give an example of each in the body.

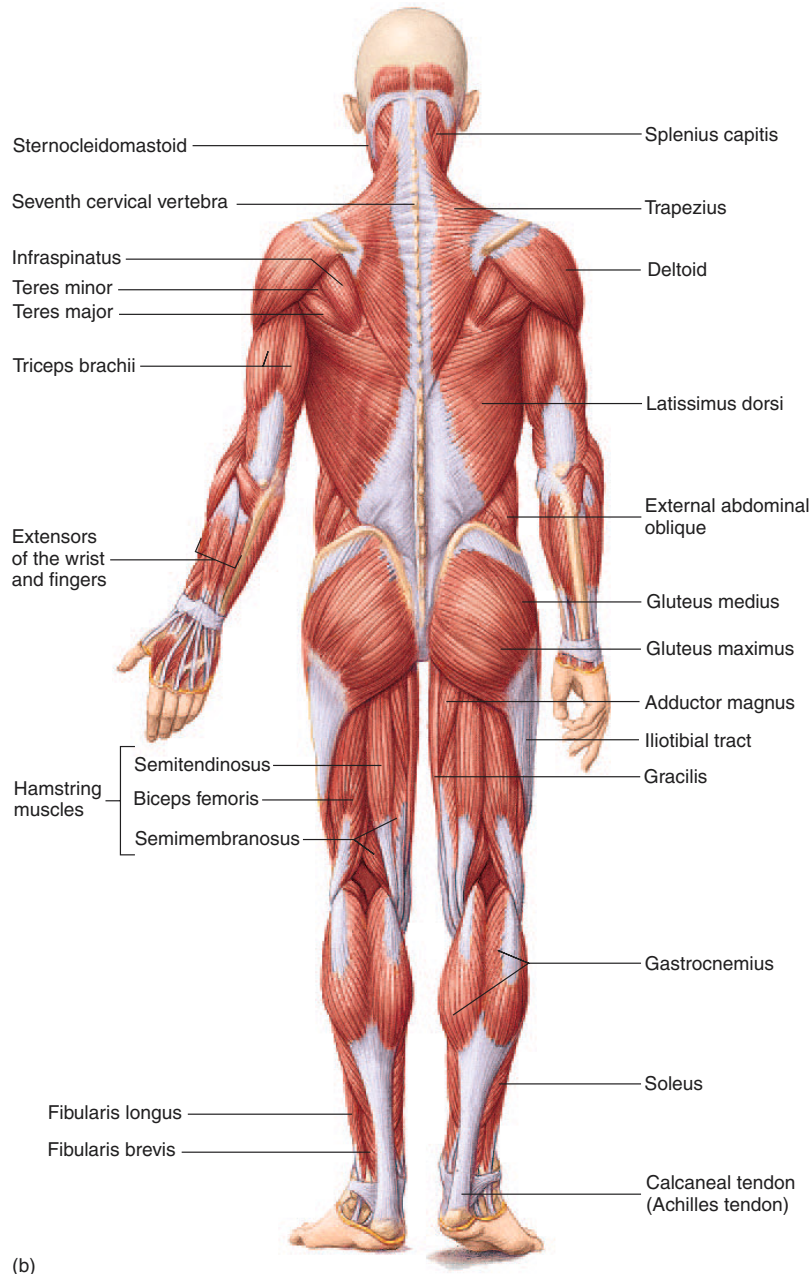
## Muscle Anatomy

An overview of the superficial skeletal muscles is presented in figure 10.4.



**Figure 10.4** General Overview of the Superficial Body Musculature

(a) Anterior view.



(b)

**Figure 10.4** (continued)

(b) Posterior view.



## Head Muscles

### Objectives

- Describe the action of the muscles involved in major movements of the head.
- List various facial expressions, and name the muscles that produce them.
- List and give the actions for the muscles of mastication.
- Describe the tongue movements caused by contraction of extrinsic and intrinsic tongue muscles.
- Describe the actions of the muscles involved in swallowing.
- Describe and give the actions for the muscles that move the eye.

## Head and Neck Muscles

Most of the flexors of the head and neck (table 10.1 and figure 10.5a) lie deep within the neck along the anterior margins of the vertebral bodies. Extension of the head is accomplished by posterior neck muscles that attach to the occipital bone (figure 10.5b and c) and function as the force of a class I lever system.

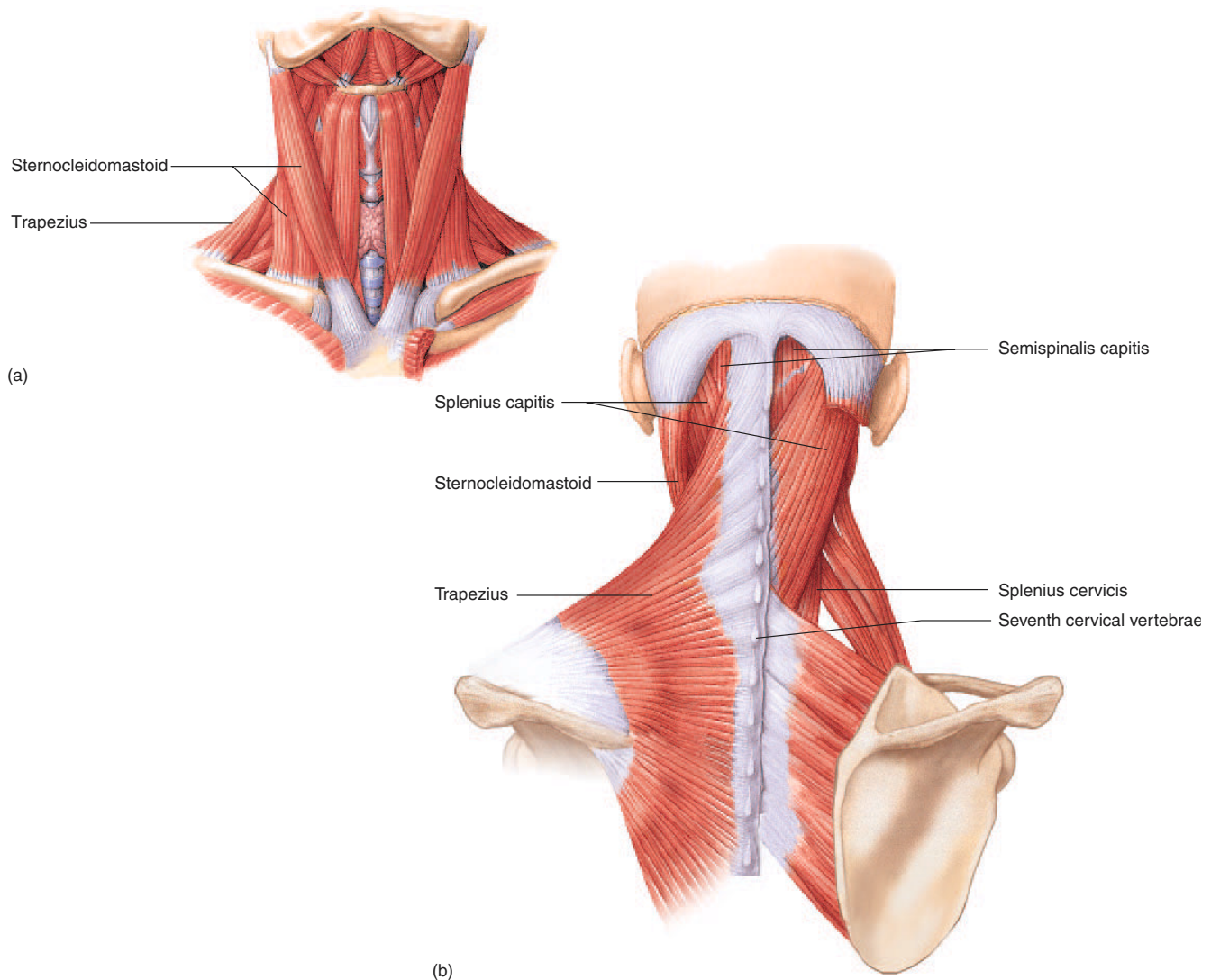
The muscular ridge seen superficially in the posterior part of the neck and lateral to the midline is composed of the trapezius muscle overlying the splenius capitis (figure 10.6). The fasciculi of the trapezius muscles are shorter at the base of the neck and leave a diamond-shaped area over the inferior cervical and superior thoracic vertebral spines.

**Table 10.1** Muscles Moving the Head (see figure 10.5)

| Muscle                                                              | Origin                                                                        | Insertion                                         | Nerve                             | Action                                                                                           |
|---------------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------|-----------------------------------|--------------------------------------------------------------------------------------------------|
| <b>Anterior</b>                                                     |                                                                               |                                                   |                                   |                                                                                                  |
| Longus capitis<br>(lon'gūs ka'pi-tis)<br>(not illustrated)          | C3–C6                                                                         | Occipital bone                                    | C1–C3                             | Flexes head                                                                                      |
| Rectus capitis anterior<br>(rek'tūs ka'pi-tis)<br>(not illustrated) | Atlas                                                                         | Occipital bone                                    | C1–C2                             | Flexes head                                                                                      |
| <b>Posterior</b>                                                    |                                                                               |                                                   |                                   |                                                                                                  |
| Longissimus capitis<br>(lon-gis'ŭmūs<br>kă'pi-tis)                  | Upper thoracic and lower<br>cervical vertebrae                                | Mastoid process                                   | Dorsal rami of cervical<br>nerves | Extends, rotates, and<br>laterally flexes head                                                   |
| Oblique capitis superior<br>(ka'pi-tis)                             | Atlas                                                                         | Occipital bone (inferior<br>nuchal line)          | Dorsal ramus of C1                | Extends and laterally<br>flexes head                                                             |
| Rectus capitis posterior<br>(rek'tūs ka'pi-tis)                     | Axis, atlas                                                                   | Occipital bone                                    | Dorsal ramus of C1                | Extends and rotates<br>head                                                                      |
| Semispinalis capitis                                                | C4–T6                                                                         | Occipital bone                                    | Dorsal rami of cervical<br>nerves | Extends and rotates<br>head                                                                      |
| Splenius capitis                                                    | C4–T6                                                                         | Superior nuchal line and<br>mastoid process       | Dorsal rami of cervical<br>nerves | Extends, rotates, and<br>laterally flexes head                                                   |
| Trapezius                                                           | Occipital protuberance,<br>nuchal ligament,<br>spinous processes of<br>C7–T12 | Clavicle, acromion process,<br>and scapular spine | Accessory                         | Extends and laterally<br>flexes head                                                             |
| <b>Lateral</b>                                                      |                                                                               |                                                   |                                   |                                                                                                  |
| Rectus capitis lateralis<br>(not illustrated)                       | Atlas                                                                         | Occipital bone                                    | C1                                | Laterally flexes head                                                                            |
| Sternocleidomastoid                                                 | Manubrium and medial<br>clavicle                                              | Mastoid process and<br>superior nuchal line       | Accessory                         | One contracting alone:<br>rotates and extends<br>head<br>Both contracting<br>together: flex head |

Rotation and abduction of the head are accomplished by muscles of both the lateral and posterior groups (see table 10.1). The **sternocleidomastoid** (ster'nō-klī'dō-mas'toyd) muscle is the prime mover of the lateral group. It's easily seen on the anterior and lateral sides of the neck, especially if the head is extended slightly and rotated to one side (figure 10.6b). If the

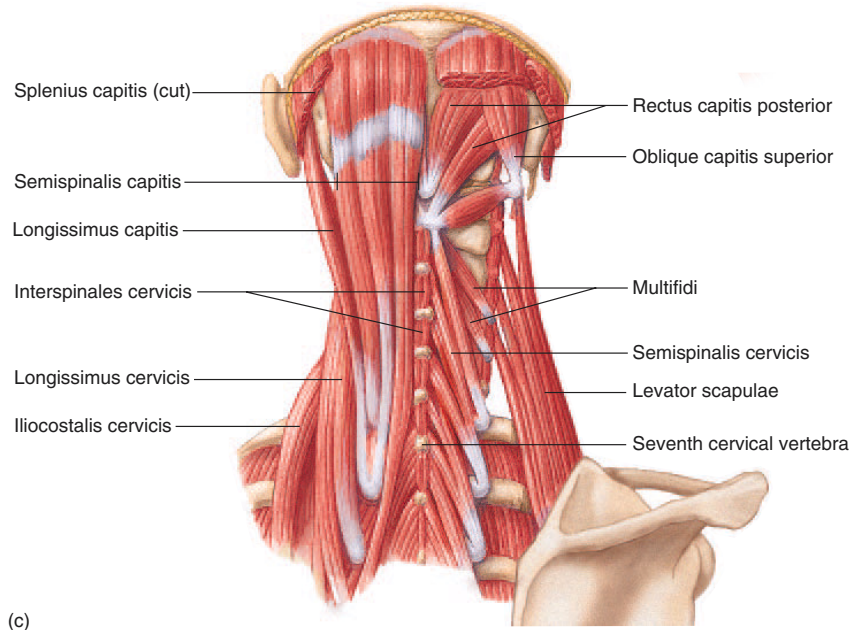
sternocleidomastoid muscle on only one side of the neck contracts, the head is rotated toward the opposite side. If both contract together, they flex the neck. Lateral flexion of the head (moving the head back to the midline after it has been tilted to one side or the other) is accomplished by the lateral flexors of the opposite side.



**Figure 10.5** Muscles of the Neck

(a) Anterior superficial. (b) Posterior superficial.

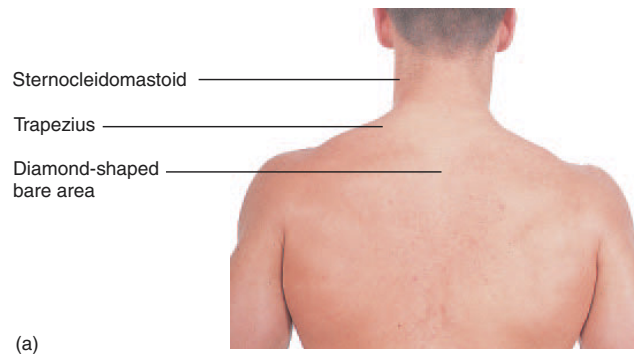




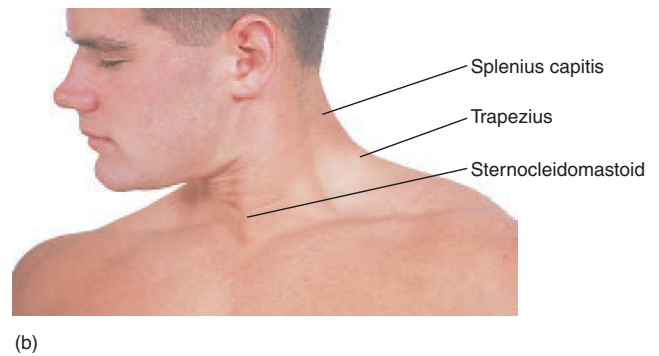
(c)

**Figure 10.5** (continued)

(c) Posterior deep.



(a)



(b)

**Figure 10.6** Surface Anatomy, Muscles of the Neck

(a) Posterior view. (b) Lateral view.

### Torticollis



**Torticollis** (tōr-ti-kol'is; twisted neck, or wry neck), may result from injury to one of the sternocleidomastoid muscles. Damage to an infant's neck muscles during a difficult birth sometimes causes torticollis and can usually be corrected by exercising the muscle.

### PREDICT 1

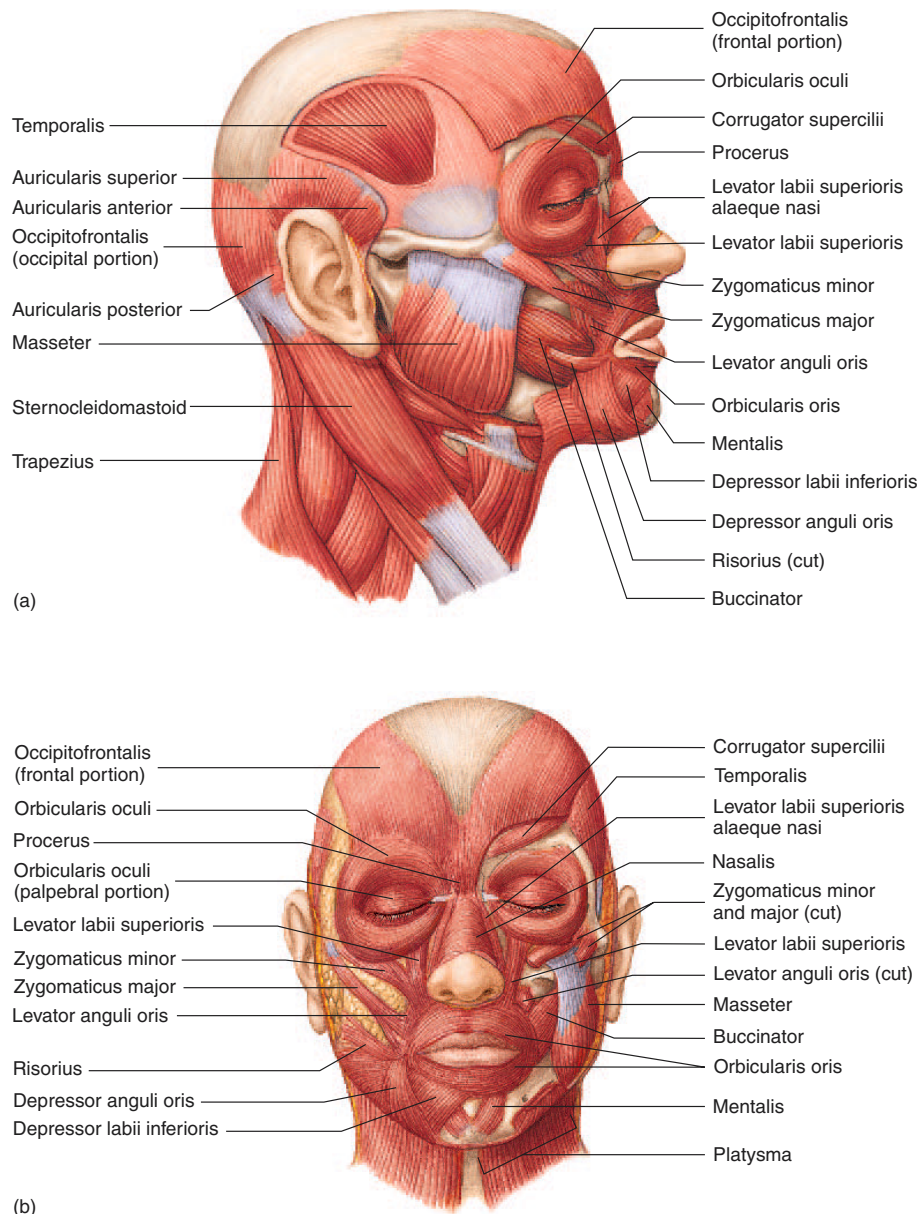
Shortening of the right sternocleidomastoid muscle rotates the head in which direction?

## Facial Expression

The skeletal muscles of the face (table 10.2 and figure 10.7) are cutaneous muscles attached to the skin. Many animals have cutaneous muscles over the trunk that allow the skin to twitch to remove irritants such as insects. In humans, facial expressions are important components of nonverbal communication, and the cutaneous muscles are confined primarily to the face and neck.

Several muscles act on the skin around the eyes and eyebrows (figure 10.8 and see figure 10.7). The **occipitofrontalis** (ok-sip'i-tō-frūn-tā'lis) raises the eyebrows and furrows the skin of the fore-

head. The **orbicularis oculi** (ōr-bik'ū-lā'ris ok'ū-lī) closes the eyelids and causes “crow’s-feet” wrinkles in the skin at the lateral corners of the eyes. The **levator palpebrae** (le-vā'ter, lē-vā'tōr pal-pē'brē; the palpebral fissure is the opening between the eyelids) **superioris** raises the upper lids (figure 10.8a). A droopy eyelid on one side, called **ptosis** (tō'sis), usually indicates that the nerve to the levator palpebrae superioris has been damaged. The **corrugator supercilii** (kōr'ū-gā'ter, kōr'ū-gā'tōr soo'per-sil'ē-ī) draws the eyebrows inferiorly and medially, producing vertical corrugations (furrows) in the skin between the eyes (see figures 10.7 and 10.8c).



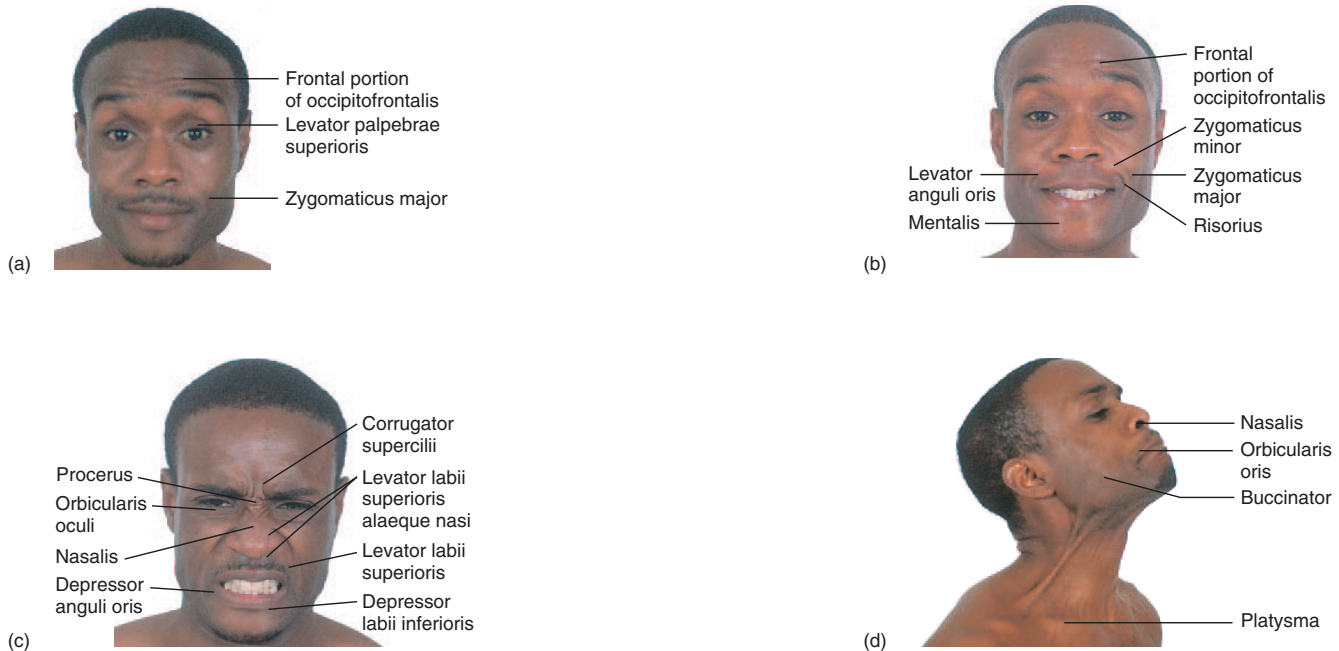
**Figure 10.7** Muscles of Facial Expression

(a) Lateral view. (b) Anterior view.

**Table 10.2** Muscles of Facial Expression (see figure 10.7)

| Muscle                                                                                               | Origin                                 | Insertion                                    | Nerve      | Action                                                                         |
|------------------------------------------------------------------------------------------------------|----------------------------------------|----------------------------------------------|------------|--------------------------------------------------------------------------------|
| Auricularis<br>(aw-rik'ū-lār'is)                                                                     |                                        |                                              |            |                                                                                |
| Anterior                                                                                             | Aponeurosis over head                  | Cartilage of auricle                         | Facial     | Draws auricle superiorly and anteriorly                                        |
| Posterior                                                                                            | Mastoid process                        | Posterior root of auricle                    | Facial     | Draws auricle posteriorly                                                      |
| Superior                                                                                             | Aponeurosis over head                  | Cartilage of auricle                         | Facial     | Draws auricle superiorly and posteriorly                                       |
| Buccinator (buk'sī-nā'tōr)                                                                           | Mandible and maxilla                   | Orbicularis at angle of mouth                | Facial     | Retracts angle of mouth; flattens cheek                                        |
| Corrugator supercilii<br>(kōr'ū'gā'ter, soo'per-sil'ē-i)                                             | Nasal bridge and orbicularis oculi     | Skin of eyebrow                              | Facial     | Depresses medial portion of eyebrow and draws eyebrows together as in frowning |
| Depressor anguli oris<br>(dē-pres'ōr ang'gū-lī ōr'ūs)                                                | Lower border of mandible               | Lip near angle of mouth                      | Facial     | Depresses angle of mouth                                                       |
| Depressor labii inferioris<br>(dē-pres'ōr lā'bē-i in-fer'ē-ōr-is)                                    | Lower border of mandible               | Skin of lower lip and orbicularis oris       | Facial     | Depresses lower lip                                                            |
| Levator anguli oris<br>(lē-vā'tor, le-vā'ter ang'gū-lī ōr'ūs)                                        | Maxilla                                | Skin at angle of mouth and orbicularis oris  | Facial     | Elevates angle of mouth                                                        |
| Levator labii superioris<br>(lē-vā'tor, le-vā'ter lā'bē-i sū-pēr'ē-ōr-is)                            | Maxilla                                | Skin and orbicularis oris of upper lip       | Facial     | Elevates upper lip                                                             |
| Levator labii superioris alaeque nasi<br>(lē-vā'tor, le-vā'ter lā'bē-i sū-pēr'ē-ōr-is ā-lak'ā nā'zī) | Maxilla                                | Ala at nose and upper lip                    | Facial     | Elevates ala of nose and upper lip                                             |
| Levator palpebrae superioris<br>(lē-vā'tor, le-vā'ter pal-pē'brē sū-pēr'ē-ōr-is)                     | Lesser wing of sphenoid                | Skin of eyelid                               | Oculomotor | Elevates upper eyelid                                                          |
| Mentalis<br>(men-tā'lis)                                                                             | Mandible                               | Skin of chin                                 | Facial     | Elevates and wrinkles skin over chin; elevates lower lip                       |
| Nasalis<br>(nā'zā-lis)                                                                               | Maxilla                                | Bridge and ala of nose                       | Facial     | Dilates nostril                                                                |
| Occipitofrontalis<br>(ok-sip'i-tō-frūn'tā'lis)                                                       | Occipital bone                         | Skin of eyebrow and nose                     | Facial     | Moves scalp; elevates eyebrows                                                 |
| Orbicularis oculi<br>(ōr-bik'ū-lā'ris ok'ū-lī)                                                       | Maxilla and frontal bones              | Circles orbit and inserts near origin        | Facial     | Closes eye                                                                     |
| Orbicularis oris<br>(ōr-bik'ū-lā'ris ōr'is)                                                          | Nasal septum, maxilla, and mandible    | Fascia and other muscles of lips             | Facial     | Closes lip                                                                     |
| Platysma<br>(plā-tiz'mā)                                                                             | Fascia of deltoid and pectoralis major | Skin over inferior border of mandible        | Facial     | Depresses lower lip; wrinkles skin of neck and upper chest                     |
| Procerus<br>(prō-sē'rūs)                                                                             | Bridge of nose                         | Frontalis                                    | Facial     | Creates horizontal wrinkle between eyes, as in frowning                        |
| Risorius<br>(ri-sōr'ē-ūs)                                                                            | Platysma and masseter fascia           | Orbicularis oris and skin at corner of mouth | Facial     | Abducts angle of mouth                                                         |
| Zygomaticus major<br>(zī'gō-mat'i-kūs)                                                               | Zygomatic bone                         | Angle of mouth                               | Facial     | Elevates and abducts upper lip                                                 |
| Zygomaticus minor<br>(zī'gō-mat'i-kūs)                                                               | Zygomatic bone                         | Orbicularis oris of upper lip                | Facial     | Elevates and abducts upper lip                                                 |





**Figure 10.8** Surface Anatomy, Muscles of Facial Expression

Several muscles function in moving the lips and the skin surrounding the mouth (see figures 10.7 and 10.8). The **orbicularis oris** (ōr-bik'ū-lā'ris ōr'is) and **buccinator** (buk'si-nā-tōr), the kissing muscles, pucker the mouth. Smiling is accomplished by the **zygomaticus** (zī'gō-mat'i-kūs) **major** and **minor**, the **levator anguli** (ang'gū-li) **oris**, and the **risorius** (rī-sōr'ē-ūs). Sneering is accomplished by the **levator labii superioris** and frowning or pouting by the **depressor anguli oris**, the **depressor labii inferioris**, and the **mentalis** (men-tā'lis). If the mentalis muscles are well developed on each side of the chin, a chin dimple may appear between the two muscles.

5. Name the major movements of the head caused by contraction of the anterior, posterior, and lateral neck muscles.
6. Name the movements of the head and neck caused by contraction of the sternocleidomastoid muscle. What is torticollis (wry neck)?
7. What is unusual about the insertion (and sometimes the origin) of facial muscles?
8. Which muscles are responsible for moving the ears, the eyebrows, the eyelids, and the nose? For puckering the lips, smiling, sneering, and frowning? What causes a dimple on the chin? What usually causes ptosis on one side?

## PREDICT 2

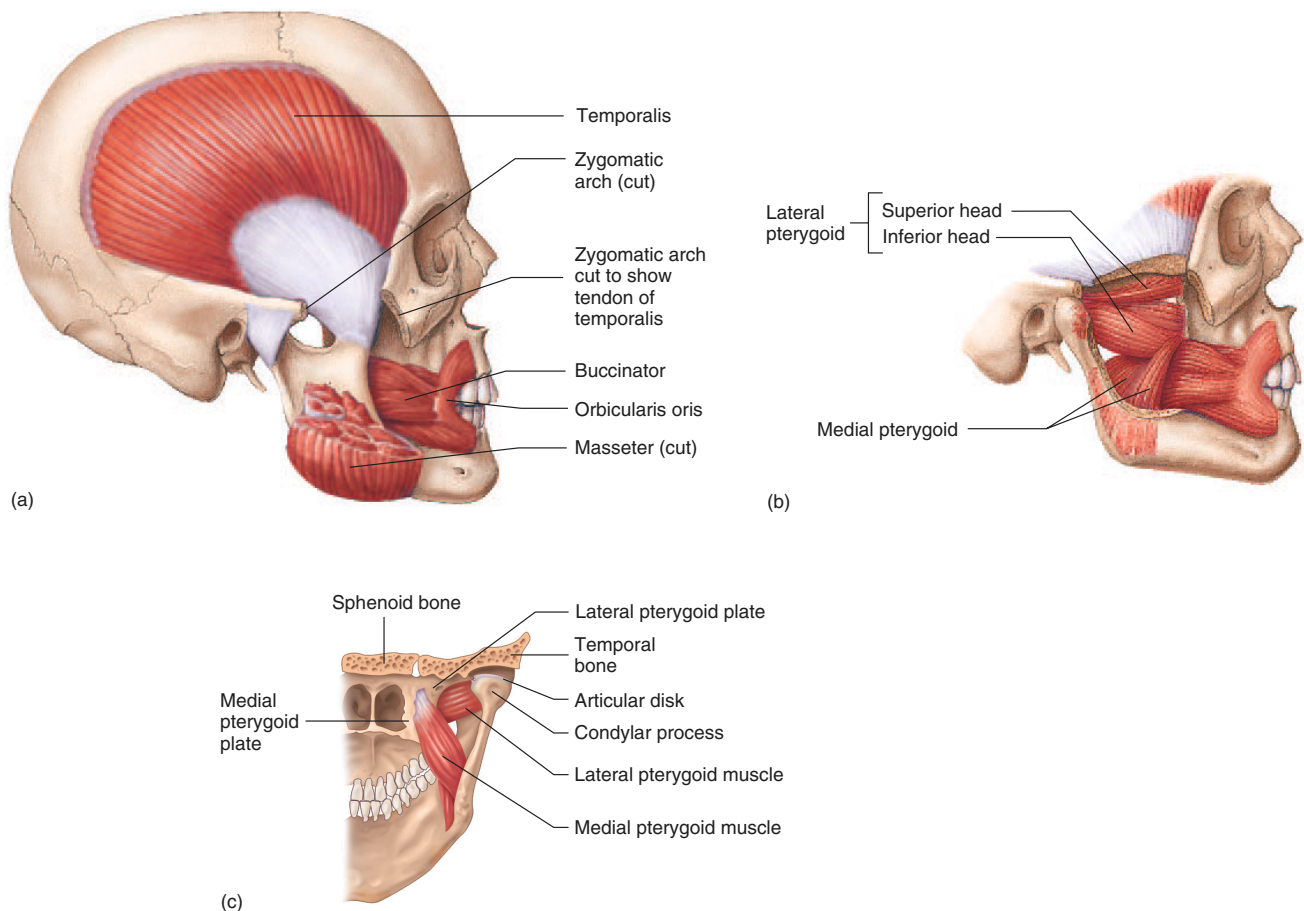
Harry Wolf, a notorious flirt, on seeing Sally Gorgeous raises his eyebrows, winks, whistles, and smiles. Name the facial muscles he uses to carry out this communication. Sally, thoroughly displeased with this exhibition, frowns and flares her nostrils in disgust. What muscles does she use?

## Mastication

Chewing, or **mastication** (mas-ti-kā'shūn), involves forcefully closing the mouth (elevating the mandible) and grinding food between the teeth (medial and lateral excursion of the mandible). The **muscles of mastication** and the **hyoid muscles** move the mandible (tables 10.3 and 10.4; figures 10.9 and 10.10). The elevators of the mandible are some of the strongest muscles of the body and bring the mandibular teeth forcefully against the maxillary teeth to crush food. Slight mandibular depression involves relaxation of the mandibular elevators and the pull of gravity. Opening the mouth wide requires the action of the depressors of the mandible; and even though the muscles of the tongue and the buccinator (see tables 10.2 and 10.5) are not involved in the actual process of chewing, they help move the food in the mouth and hold it in place between the teeth.

**Table 10.3** Muscles of Mastication (see figures 10.7 and 10.9)

| Muscle                             | Origin                                                                     | Insertion                                                       | Nerve                                | Action                                                        |
|------------------------------------|----------------------------------------------------------------------------|-----------------------------------------------------------------|--------------------------------------|---------------------------------------------------------------|
| Temporalis<br>(tem-pō-rā'lis)      | Temporal fossa                                                             | Anterior portion of<br>mandibular ramus<br>and coronoid process | Mandibular division<br>of trigeminal | Elevates and retracts<br>mandible; involved in<br>excursion   |
| Masseter<br>(ma'se-ter)            | Zygomatic arch                                                             | Lateral side of<br>mandibular ramus                             | Mandibular division<br>of trigeminal | Elevates and protracts<br>mandible; involved in<br>excursion  |
| <b>Pterygoids</b><br>(ter'i-goydz) |                                                                            |                                                                 |                                      |                                                               |
| Lateral                            | Lateral side of lateral<br>pterygoid plate and greater wing<br>of sphenoid | Condylar process of<br>mandible and<br>articular disk           | Mandibular division<br>of trigeminal | Protracts and depresses<br>mandible; involved in<br>excursion |
| Medial                             | Medial side of lateral<br>pterygoid plate and tuberosity<br>of maxilla     | Medial surface of<br>mandible                                   | Mandibular division<br>of trigeminal | Protracts and elevates<br>mandible; involved in<br>excursion  |

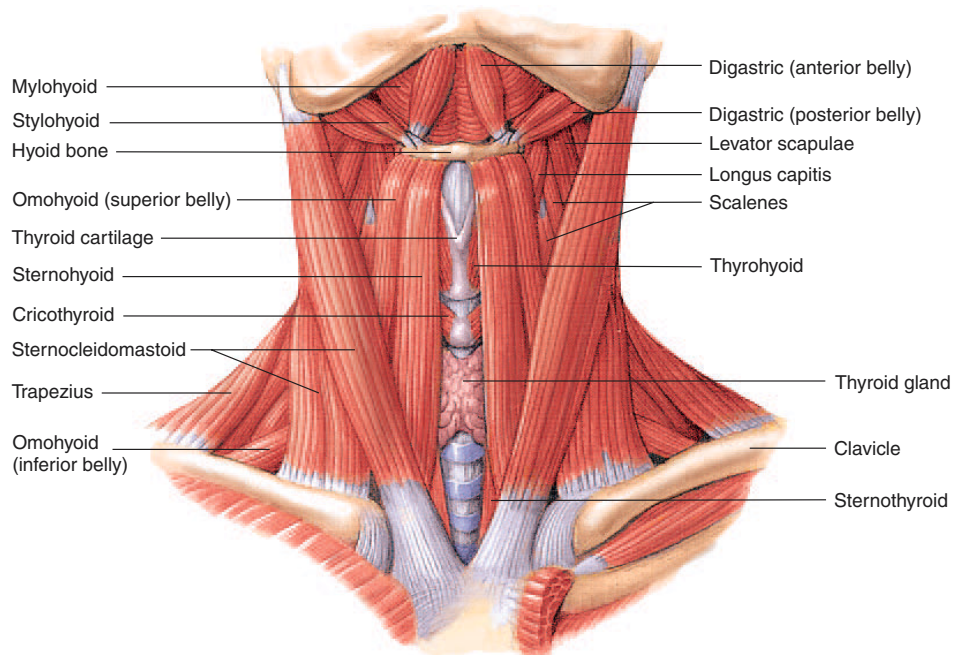


**Figure 10.9** Muscles of Mastication

(a) Lateral (superficial) view. Masseter and zygomatic arch are removed, and the zygomatic arch and part of the mandible are cut away to reveal the deeper muscles. (b) Lateral (deep) view. Masseter and temporalis muscles are removed, and the zygomatic arch and part of the mandible are cut away to reveal the deeper muscles. (c) Frontal section of the head showing the pterygoid muscles from a posterior view.

**Table 10.4** Hyoid Muscles (see figures 10.10 and 10.11)

| Muscle                              | Origin                                               | Insertion                                 | Nerve                                                                                 | Action                                                                                                  |
|-------------------------------------|------------------------------------------------------|-------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| <b>Suprahyoid Muscles</b>           |                                                      |                                           |                                                                                       |                                                                                                         |
| Digastric<br>(dī-gas'trik)          | Mastoid process<br>(posterior belly)                 | Mandible near midline<br>(anterior belly) | Posterior belly—<br>facial; anterior<br>belly—mandibular<br>division of<br>trigeminal | Depresses and retracts<br>mandible; elevates hyoid                                                      |
| Geniohyoid<br>(jē-nī-ō-hī'oyd)      | Genu of mandible                                     | Body of hyoid                             | Fibers of C1 and C2<br>with hypoglossal                                               | Protracts hyoid; depresses<br>mandible                                                                  |
| Mylohyoid<br>(mī'lō-hī'oyd)         | Body of mandible                                     | Hyoid                                     | Mandibular division<br>of trigeminal                                                  | Elevates floor of mouth and<br>tongue; depresses mandible<br>when hyoid is fixed                        |
| Stylohyoid<br>(stī-lō-hī'oyd)       | Styloid process                                      | Hyoid                                     | Facial                                                                                | Elevates hyoid                                                                                          |
| <b>Infrahyoid Muscles</b>           |                                                      |                                           |                                                                                       |                                                                                                         |
| Omoxyoid<br>(ō-mō-hī'oyd)           | Superior border of<br>scapula                        | Hyoid                                     | Upper cervical<br>through ansa<br>cervicalis                                          | Depresses hyoid; fixes hyoid<br>in mandibular depression                                                |
| Sternohyoid<br>(ster'nō-hī'oyd)     | Manubrium and first<br>costal cartilage              | Hyoid                                     | Upper cervical<br>through ansa<br>cervicalis                                          | Depresses hyoid; fixes hyoid<br>in mandibular depression                                                |
| Sternothyroid<br>(ster'nō-thī'royd) | Manubrium and first or<br>second costal<br>cartilage | Thyroid cartilage                         | Upper cervical<br>through ansa<br>cervicalis                                          | Depresses larynx; fixes hyoid<br>in mandibular depression                                               |
| Thyrohyoid<br>(thī-rō-hī'oyd)       | Thyroid cartilage                                    | Hyoid                                     | Upper cervical,<br>passing with<br>hypoglossal                                        | Depresses hyoid and elevates<br>thyroid cartilage of<br>larynx; fixes hyoid in<br>mandibular depression |



**Figure 10.10** Hyoid Muscles

Anterior superficial view.

## Tongue Movements

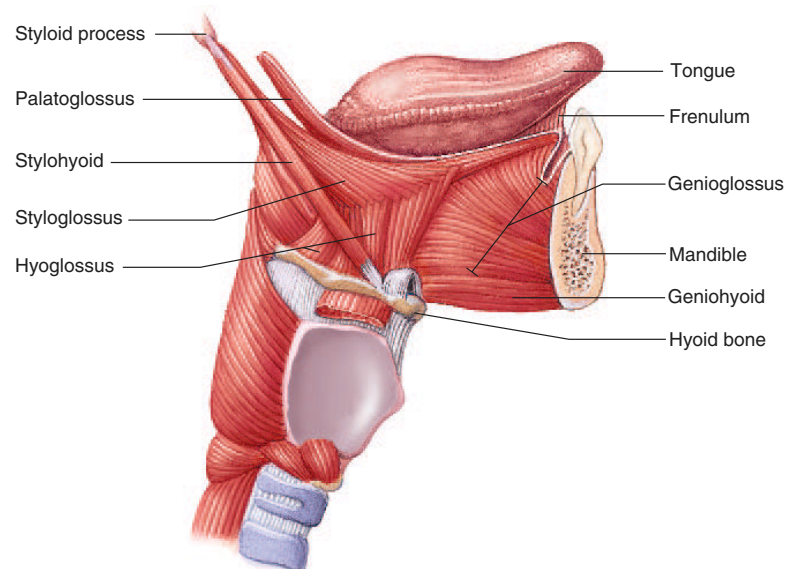
The tongue is very important in mastication and speech: (1) it moves food around in the mouth; (2) with the buccinator it holds food in place while the teeth grind it; (3) it pushes food up to the palate and back toward the pharynx to initiate swallowing; and (4) it changes shape to modify sound during speech. The tongue consists of a mass of **intrinsic muscles** (entirely within the tongue) which are involved in changing the shape of the tongue, and **extrinsic muscles** (outside of the tongue but attached to it) which help change the shape and move the tongue (table 10.5; figure 10.11). The intrinsic muscles are named for their fiber orientation in the tongue. The extrinsic muscles are named for their origin and insertion.

### Tongue Rolling

Everyone can change the shape of the tongue, but not everyone can roll the tongue into the shape of a tube. The ability to accomplish such movements apparently is partially controlled genetically, but other factors are involved. In some cases one of a pair of identical twins can roll the tongue but the other twin cannot. It's not known exactly what tongue muscles are involved in **tongue rolling**, and no anatomic differences are reported to exist between tongue rollers and nonrollers.

**Table 10.5** Tongue Muscles (see figure 10.11)

| Muscle                                                   | Origin                           | Insertion                     | Nerve             | Action                                |
|----------------------------------------------------------|----------------------------------|-------------------------------|-------------------|---------------------------------------|
| <b>Intrinsic Muscles</b>                                 |                                  |                               |                   |                                       |
| Longitudinal, transverse, and vertical (not illustrated) | Within tongue                    | Within tongue                 | Hypoglossal       | Change tongue shape                   |
| <b>Extrinsic Muscles</b>                                 |                                  |                               |                   |                                       |
| Genioglossus (jĕ'nĭ-ō-glos'ŭs)                           | Genu of mandible                 | Tongue                        | Hypoglossal       | Depresses and protrudes tongue        |
| Hyoglossus (hĭ'ō-glos'ŭs)                                | Hyoid                            | Side of tongue                | Hypoglossal       | Retracts and depresses side of tongue |
| Styloglossus (stĭ'lō-glos'ŭs)                            | Styloid process of temporal bone | Tongue (lateral and inferior) | Hypoglossal       | Retracts tongue                       |
| Palatoglossus (pal-ă-tō-glos'ŭs)                         | Soft palate                      | Tongue                        | Pharyngeal plexus | Elevates posterior tongue             |



**Figure 10.11** Muscles of the Tongue

As seen from the right side.



## Swallowing and the Larynx

The hyoid muscles (see table 10.4 and figure 10.10) are divided into a **suprahyoid group** superior to the hyoid bone and an **infrahyoid group** inferior to it. When the hyoid bone is fixed by the infrahyoid muscles so that the bone is stabilized from below, the suprahyoid muscles can help depress the mandible. If the suprahyoid muscles fix the hyoid and thus stabilize it from above, the thyrohyoid muscle (an infrahyoid muscle) can elevate the larynx. To observe this effect, place your hand on your larynx (Adam's apple) and swallow.

The soft palate, pharynx, and larynx contain several muscles involved in swallowing and speech (table 10.6 and figure 10.12). The muscles of the soft palate close the posterior opening to the nasal cavity during swallowing.

Swallowing (see chapter 24) is accomplished by elevation of the pharynx, which in turn is accomplished by elevation of the larynx, to which the pharynx is attached, and constriction of the **palatopharyngeus** (pal'ă-tō-far-in-jē'ūs) and **salpingopharyngeus** (sal-pin'gō-far-in-jē'ūs; *salpingo* means trumpet and refers to the trumpet-shaped opening of the auditory, or eustachian, tube). The pharyngeal constrictor muscles then constrict from superior to inferior, forcing food into the esophagus.

The salpingopharyngeus also opens the auditory tube, which connects the middle ear with the pharynx. Opening the auditory tube equalizes the pressure between the middle ear and the atmosphere; this is why it's sometimes helpful to chew gum or swallow when ascending or descending a mountain in a car or when changing altitudes in an airplane.

The muscles of the larynx are listed in table 10.6 and are illustrated in figure 10.12*b*. Most of the laryngeal muscles help to narrow or close the laryngeal opening so food does not enter the larynx when a person swallows. The remaining muscles shorten the vocal cords to raise the pitch of the voice.



### Snoring and Laryngospasm

**Snoring** is a rough, raspy noise that can occur when a sleeping person inhales through the mouth and nose. The noise usually is made by vibration of the soft palate but also may occur as a result of vocal cord vibration.

**Laryngospasm** is a tetanic contraction of the muscles around the opening of the larynx. In severe cases, the opening is closed completely, air no longer can pass through the larynx into the lungs, and the victim may die of asphyxiation. Laryngospasm can develop as a result of, for example, severe allergic reactions, tetanus infections, or hypocalcemia.

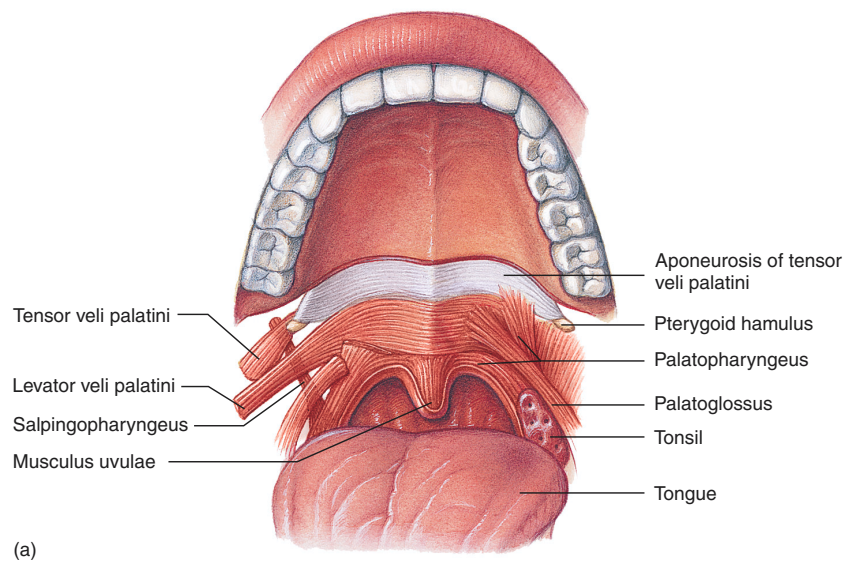
**Table 10.6** Muscles of Swallowing and the Larynx (see figure 10.12)

| Muscle                                                               | Origin                              | Insertion                    | Nerve               | Action                                    |
|----------------------------------------------------------------------|-------------------------------------|------------------------------|---------------------|-------------------------------------------|
| <b>Larynx</b>                                                        |                                     |                              |                     |                                           |
| Arytenoids<br>(ar-i-tē'noydz)                                        |                                     |                              |                     |                                           |
| Oblique<br>(not illustrated)                                         | Arytenoid cartilage                 | Opposite arytenoid cartilage | Recurrent laryngeal | Narrows opening to larynx                 |
| Transverse<br>(not illustrated)                                      | Arytenoid cartilage                 | Opposite arytenoid cartilage | Recurrent laryngeal | Narrows opening to larynx                 |
| Cricoarytenoids<br>(krī'kō-ar-i-tē'noydz)                            |                                     |                              |                     |                                           |
| Lateral<br>(not illustrated)                                         | Lateral side of cricoid cartilage   | Arytenoid cartilage          | Recurrent laryngeal | Narrows opening to larynx                 |
| Posterior<br>(not illustrated)                                       | Posterior side of cricoid cartilage | Arytenoid cartilage          | Recurrent laryngeal | Widens opening of larynx                  |
| Cricothyroid<br>(krī'kō-thī'royd)                                    | Anterior cricoid cartilage          | Thyroid cartilage            | Superior laryngeal  | Tenses vocal cords                        |
| Thyroarytenoid<br>(thī'rō-ar'i-tē'noydz)<br>(not illustrated)        | Thyroid cartilage                   | Arytenoid cartilage          | Recurrent laryngeal | Shortens vocal cords                      |
| Vocalis<br>(vō-kal'is)<br>(not illustrated)                          | Thyroid cartilage                   | Arytenoid cartilage          | Recurrent laryngeal | Shortens vocal cords                      |
| <b>Soft Palate</b>                                                   |                                     |                              |                     |                                           |
| Levator veli palatini<br>(lē-vā'tor, le-vā'ter vel'ī<br>pal'ă-tē'nī) | Temporal bone and auditory tube     | Soft palate                  | Pharyngeal plexus   | Elevates soft palate                      |
| Palatoglossus<br>(pal'ă-tō-glos'ūs)                                  | Soft palate                         | Tongue                       | Pharyngeal plexus   | Narrows fauces; elevates posterior tongue |

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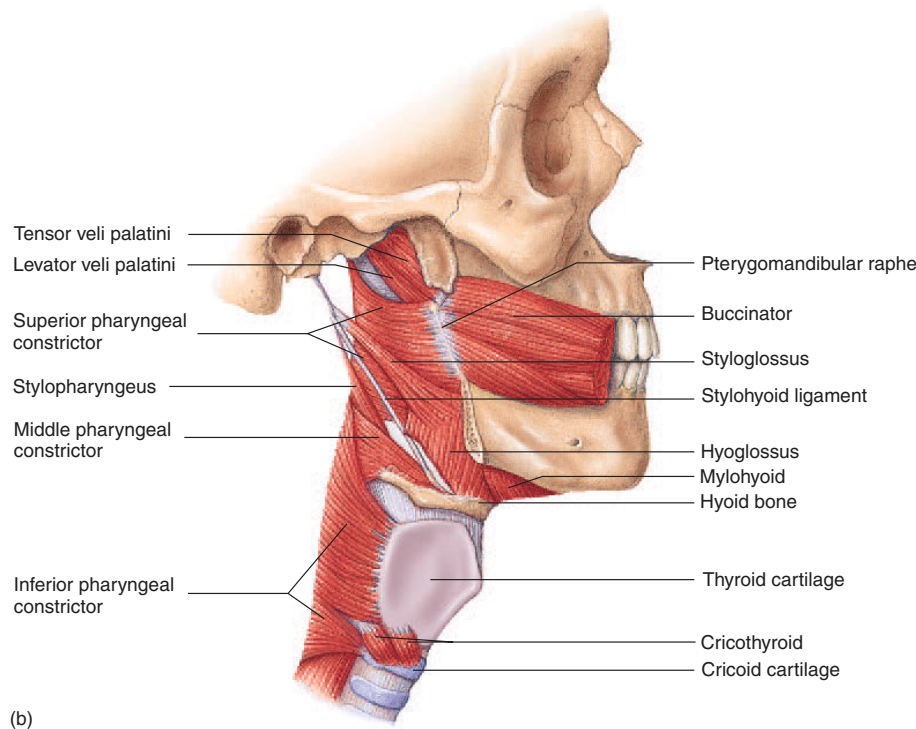
**Table 10.6** *continued*

| Muscle                                              | Origin                                                               | Insertion                                | Nerve                                          | Action                                              |
|-----------------------------------------------------|----------------------------------------------------------------------|------------------------------------------|------------------------------------------------|-----------------------------------------------------|
| <b>Soft Palate—cont'd</b>                           |                                                                      |                                          |                                                |                                                     |
| Palatopharyngeus<br>(pal'ă-tō-far-in-jē'ūs)         | Soft palate                                                          | Pharynx                                  | Pharyngeal plexus                              | Narrows fauces; depresses palate; elevates pharynx  |
| Tensor veli palatini<br>(ten'sōr vel'ī pal'ă-tē'nī) | Sphenoid and auditory tube                                           | Soft palate<br>division of auditory tube | Mandibular, division of trigeminal             | Tenses soft palate; opens auditory tube             |
| Uvulae<br>(ū'vū-lē)                                 | Posterior nasal spine                                                | Uvula                                    | Pharyngeal plexus                              | Elevates uvula                                      |
| <b>Pharynx</b>                                      |                                                                      |                                          |                                                |                                                     |
| Pharyngeal constrictors<br>(fă-rin'jē-ăl)           |                                                                      |                                          |                                                |                                                     |
| Inferior                                            | Thyroid and cricoid cartilages                                       | Pharyngeal raphe                         | Pharyngeal plexus and external laryngeal nerve | Narrows lower pharynx in swallowing                 |
| Middle                                              | Stylohyoid ligament and hyoid                                        | Pharyngeal raphe                         | Pharyngeal plexus                              | Narrows pharynx in swallowing                       |
| Superior                                            | Medial pterygoid plate, mandible, floor of mouth, and side of tongue | Pharyngeal raphe                         | Pharyngeal plexus                              | Narrows pharynx in swallowing                       |
| Salpingopharyngeus<br>(sal-ping'gō-far-in-jē'ūs)    | Auditory tube                                                        | Pharynx                                  | Pharyngeal plexus                              | Elevates pharynx; opens auditory tube in swallowing |
| Stylopharyngeus<br>(stī'lō-far-in-jē'ūs)            | Styloid process                                                      | Pharynx                                  | Glossopharyngeus                               | Elevates pharynx                                    |



**Figure 10.12** Muscles of the Palate, Pharynx, and Larynx

(a) Inferior view of the palate. Palatoglossus and part of the palatopharyngeus muscles are cut on one side to reveal the deeper muscles.



**Figure 10.12** (continued)

(b) Lateral view of the palate, pharynx, and larynx. Part of the mandible is removed to reveal the deeper structures.

## Movements of the Eyeball

The eyeball rotates within the orbit to allow vision in a wide range of directions. The movements of each eye are accomplished by six muscles named for the orientation of their fasciculi relative to the spherical eye (table 10.7; figure 10.13).

Each rectus muscle (so named because the fibers are nearly straight with the axis of the eye) attaches to the eyeball anterior to the center of the sphere. The superior rectus rotates the anterior portion of the eyeball superiorly so that the pupil, and thus the gaze, are directed superiorly (looking up). The inferior rectus depresses the gaze, the lateral rectus laterally deviates the gaze (looking to the side), and the medial rectus medially deviates the gaze (looking toward the nose). The superior rectus and inferior rectus are not completely straight in their orientation to the eye; thus they also medially deviate the gaze as they contract.

The oblique muscles (so named because their fibers are oriented obliquely to the axis of the eye) insert onto the posterolateral margin of the eyeball so that both muscles laterally deviate the gaze as they contract. The superior oblique elevates the posterior part of the eye, thus directing the pupil inferiorly and depressing the gaze. The inferior oblique elevates the gaze.

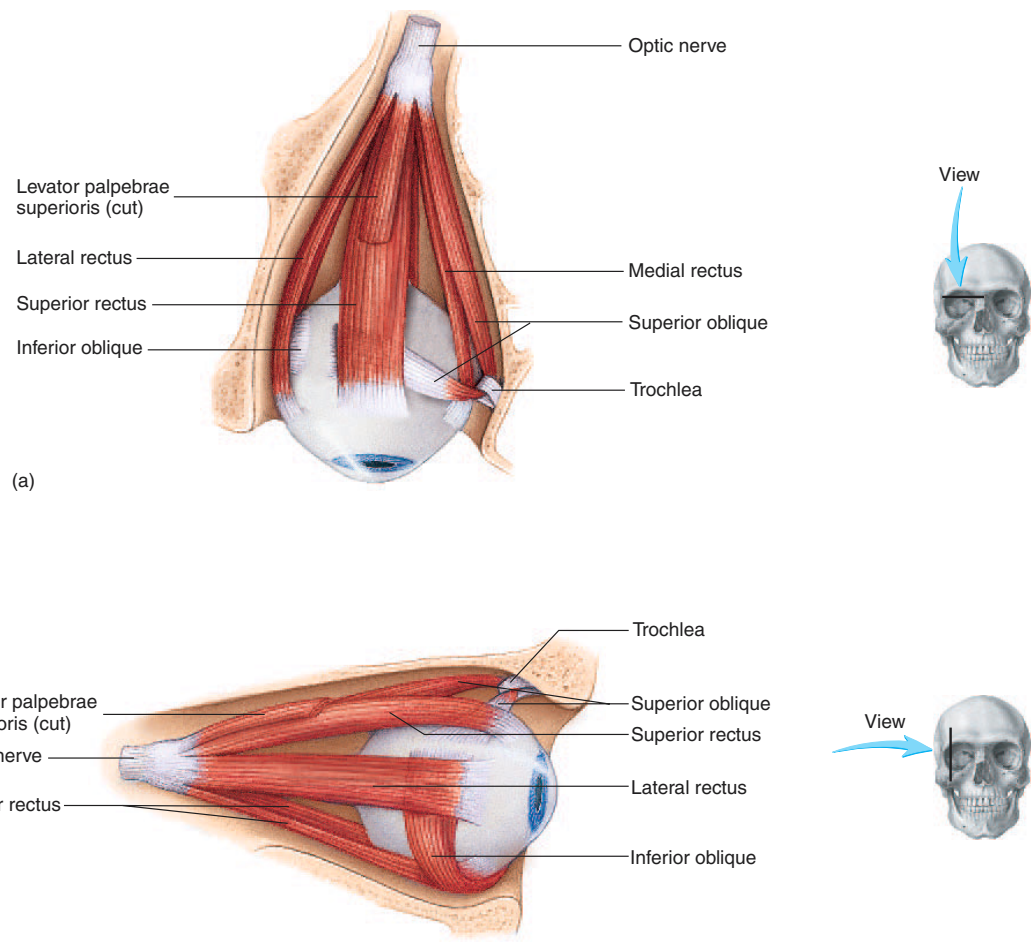
9. Name the muscles responsible for opening and closing the jaw and for lateral and medial excursion of the jaw.
10. Contrast the movements produced by the extrinsic and intrinsic tongue muscles.
11. Explain the interaction of the suprahyoid and infrahyoid muscles to depress the mandible and to elevate the larynx.
12. Which muscles open and close the openings to the auditory tube and larynx?
13. Describe the muscles of the eye and the movements that they cause.

### P R E D I C T 3

Strabismus (stra-biz'mūs) is a condition in which one or both eyes deviate in a medial or lateral direction. In some cases the condition may be caused by a weakness in either the medial or lateral rectus muscle. If the lateral rectus of the right eye is weak, in which direction would the eye deviate?

**Table 10.7** Muscles Moving the Eye (see figure 10.13)

| Muscle         | Origin                   | Insertion     | Nerve      | Action                                |
|----------------|--------------------------|---------------|------------|---------------------------------------|
| <b>Oblique</b> |                          |               |            |                                       |
| Inferior       | Orbital plate of maxilla | Sclera of eye | Oculomotor | Elevates and laterally deviates gaze  |
| Superior       | Fibrous ring             | Sclera of eye | Trochlear  | Depresses and laterally deviates gaze |
| <b>Rectus</b>  |                          |               |            |                                       |
| Inferior       | Fibrous ring             | Sclera of eye | Oculomotor | Depresses and medially deviates gaze  |
| Lateral        | Fibrous ring             | Sclera of eye | Abducens   | Laterally deviates gaze               |
| Medial         | Fibrous ring             | Sclera of eye | Oculomotor | Medially deviates gaze                |
| Superior       | Fibrous ring             | Sclera of eye | Oculomotor | Elevates and medially deviates gaze   |



**Figure 10.13** Muscles Moving the Eyeball

(a) Superior view of the right eyeball. (b) Lateral view of the right eyeball.



## Trunk Muscles

### Objectives

- List and give the actions for the muscles that move the vertebral column.
- Describe and give the actions of the muscles of the thorax and abdominal wall.
- Describe the pelvic floor and perineum.

## Muscles Moving the Vertebral Column

The muscles that extend, abduct, and rotate the vertebral column are divided into deep and superficial groups (table 10.8). In general, the muscles of the deep group extend from vertebra to vertebra, whereas the muscles of the superficial group extend from the vertebrae to the ribs. In humans, these back muscles are very strong to maintain erect posture. Comparable muscles in cattle are relatively delicate, although quite large. They constitute the

**Table 10.8** Muscles Acting on the Vertebral Column (see figures 10.5 and 10.14)

| Muscle                                                                          | Origin                                      | Insertion                           | Nerve                                     | Action                                                  |
|---------------------------------------------------------------------------------|---------------------------------------------|-------------------------------------|-------------------------------------------|---------------------------------------------------------|
| <b>Superficial</b>                                                              |                                             |                                     |                                           |                                                         |
| Erector spinae<br>(ē-rek'tōr, ē-rek'tōr spī'nē)<br>(divides into three columns) |                                             |                                     |                                           |                                                         |
| Iliocostalis<br>(il'ē-ō-kos-tā'lis)                                             | Sacrum, ilium, and lumbar spines            | Ribs and vertebrae                  | Dorsal rami of spinal nerves              | Extends vertebral column                                |
| Cervicis (ser-vī'sis)                                                           | Superior six ribs                           | Middle cervical vertebrae           | Dorsal rami of thoracic nerves            | Extends, laterally flexes, and rotates vertebral column |
| Thoracis (thō-ra'sis)                                                           | Inferior six ribs                           | Superior six ribs                   | Dorsal rami of thoracic nerves            | Extends, laterally flexes, and rotates vertebral column |
| Lumborum<br>(lum-bōr'ūm)                                                        | Sacrum, ilium, and lumbar vertebrae         | Inferior six ribs                   | Dorsal rami of thoracic and lumbar nerves | Extends, laterally flexes, and rotates vertebral column |
| Longissimus<br>(lon-gis'i-mūs)                                                  |                                             |                                     |                                           |                                                         |
| Capitis<br>(ka'pī-tis)                                                          | Upper thoracic and lower cervical vertebrae | Mastoid process                     | Dorsal rami of cervical nerves            | Extends head                                            |
| Cervicis<br>(ser-vī'sis)                                                        | Upper thoracic vertebrae                    | Upper cervical vertebrae            | Dorsal rami of cervical nerves            | Extends neck                                            |
| Thoracis<br>(thō-ra'sis)                                                        | Ribs and lower thoracic vertebrae           | Upper lumbar vertebrae and ribs     | Dorsal rami of thoracic and lumbar nerves | Extends vertebral column                                |
| Spinalis<br>(spī-nā'lis)                                                        |                                             |                                     |                                           |                                                         |
| Cervicis<br>(ser-vī'sis)<br>(not illustrated)                                   | C6–C7                                       | C2–C3                               | Dorsal rami of cervical nerves            | Extends neck                                            |
| Thoracis<br>(thō-ra'sis)                                                        | T11–L2                                      | Middle and upper thoracic vertebrae | Dorsal rami of thoracic nerves            | Extends vertebral column                                |
| Semispinalis<br>(sem'ē-spī-nā'lis)                                              |                                             |                                     |                                           |                                                         |
| Cervicis<br>(ser-vī'sis)                                                        | Transverse processes of T2–T5               | Spinous processes of C2–C5          | Dorsal rami of cervical nerves            | Extends neck                                            |
| Thoracis<br>(thō-ra'sis)                                                        | Transverse processes of T5–T11              | Spinous processes of C5–T4          | Dorsal rami of thoracic nerves            | Extends vertebral column                                |
| Splenius cervicis<br>(splē'nē-ūs ser-vī'sis)                                    | C3–C5                                       | C1–C3                               | Dorsal rami of cervical nerves            | Rotates and extends neck                                |
| Longus colli<br>(lon'gūs kō'lī)<br>(not illustrated)                            | C3–T3                                       | C1–C6                               | Ventral rami of cervical nerves           | Rotates and flexes neck                                 |

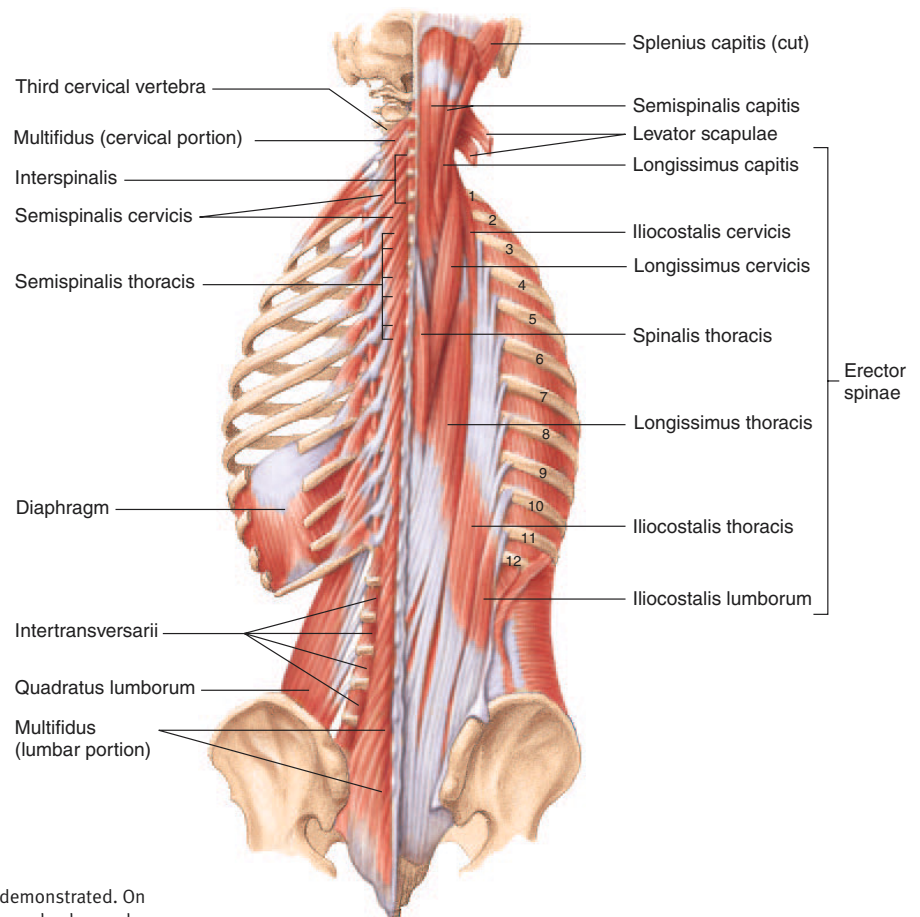
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**Table 10.8** *continued*

| Muscle                                           | Origin                                                                   | Insertion                                     | Nerve                        | Action                               |
|--------------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------|------------------------------|--------------------------------------|
| <b>Deep</b>                                      |                                                                          |                                               |                              |                                      |
| Interspinales<br>(in-ter-spī-nā'lēz)             | Spinous processes of all vertebrae                                       | Next superior spinous process                 | Dorsal rami of spinal nerves | Extends back and neck                |
| Intertransversarii<br>(in-ter-trans'ver-sār'ē-ī) | Transverse processes of all vertebrae                                    | Next superior transverse process              | Dorsal rami of spinal nerves | Laterally flexes vertebral column    |
| Multifidus<br>(mūl-tif'i-dūs)                    | Transverse processes of vertebrae, posterior surface of sacrum and ilium | Spinous processes of next superior vertebrae  | Dorsal rami of spinal nerves | Extends and rotates vertebral column |
| Psoas minor<br>(sō'as mī'ner)                    | T12–L1                                                                   | Near pubic crest                              | L1                           | Flexes vertebral column              |
| Rotatores<br>(rō-tā'tōrz)<br>(not illustrated)   | Transverse processes of all vertebrae                                    | Base of spinous process of superior vertebrae | Dorsal rami of spinal nerves | Extends and rotates vertebral column |

area from which tenderloin steaks are cut. The **erector spinae** (spī'nē) group of muscles on each side of the back consists of three subgroups: the **iliocostalis** (il'ē-ō-kos-tā'lis), the **longis-**

**simus** (lon-gis'i-mūs), and the **spinalis** (sp-ī-nā'lis). The longissimus group accounts for most of the muscle mass in the lower back (figure 10.14).



**Figure 10.14** Deep Back Muscles

On the right, the erector spinae group of muscles is demonstrated. On the left, these muscles are removed to reveal the deeper back muscles.

### Back Pain

**Low back pain** can result from poor posture, from being overweight, or from having a poor fitness level. A few changes may help: sitting and standing up straight; using a low-back support when sitting; losing weight; exercising, especially the back and abdominal muscles; and sleeping on your side on a firm mattress. Sleeping on your side all night, however, may be difficult because most people change position over 40 times during the night.

### Thoracic Muscles

The muscles of the thorax are involved mainly in the process of breathing (see chapter 23). Four major groups of muscles are associated with the rib cage (table 10.9 and figure 10.15). The **scalene** (skā'lēn) muscles elevate the first two ribs during inspiration. The **external intercostals** (in-ter-kos'tälz) also elevate the ribs during inspiration. The **internal intercostals** and **transversus thoracis** (thō-ra'sis) muscles depress the ribs during forced expiration.

The **diaphragm** (dī'ä-fram; see figure 10.15a) causes the major movement produced during quiet breathing. It is a dome-shaped structure and when it contracts, the dome flattens slightly, causing the volume of the thoracic cavity to increase, resulting in inspiration. If this dome of skeletal muscle or the phrenic nerve supplying it is severely damaged, the amount of air moving into and out of the lungs may be so small that the individual is likely to die unless connected to an artificial respirator.

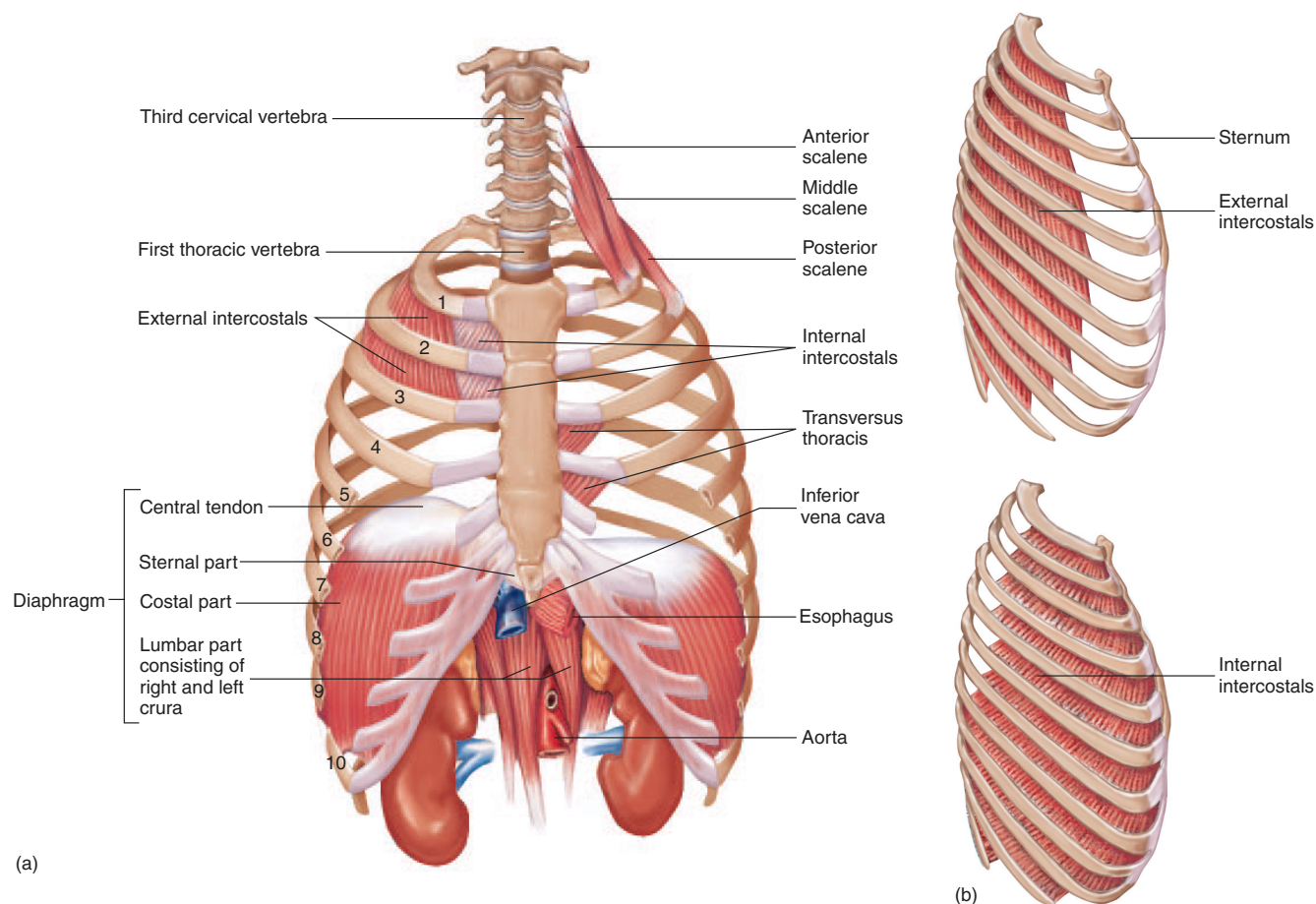
### Abdominal Wall

The muscles of the anterior abdominal wall (table 10.10 and figures 10.16–10.18) flex and rotate the vertebral column. Contraction of the abdominal muscles when the vertebral column is fixed decreases the volume of the abdominal cavity and the thoracic cavity and can aid in such functions as forced expiration, vomiting, defecation, urination, and childbirth. The crossing pattern of the abdominal muscles creates a strong anterior wall that holds in and protects the abdominal viscera.

In a relatively muscular person with little fat, a vertical line is visible, extending from the area of the xiphoid process of the sternum through the navel to the pubis. This tendinous area of the abdominal wall is devoid of muscle; the **linea alba** (lin'ē-ä al'bä), or white line, is so named because it consists of white connective tissue rather than muscle (see figure 10.16). On each side of the linea alba is the **rectus abdominis** (see figures 10.16–10.18). **Tendinous intersections** (tendinous inscriptions) transect the rectus abdominis at three, or sometimes more, locations, causing the abdominal wall of a well-muscled person to appear segmented. Lateral to the rectus abdominis is the **linea semilunaris** (sem-ē-loo-nar'is, meaning a crescent- or half-moon-shaped line); lateral to it are three layers of muscle (see figures 10.16 through 10.18). From superficial to deep, these muscles are the **external abdominal oblique**, **internal abdominal oblique**, and **transversus abdominis**.

**Table 10.9** Muscles of the Thorax (see figure 10.15)

| Muscle                                                            | Origin                                          | Insertion                         | Nerve                          | Action                                   |
|-------------------------------------------------------------------|-------------------------------------------------|-----------------------------------|--------------------------------|------------------------------------------|
| Diaphragm                                                         | Interior of ribs, sternum, and lumbar vertebrae | Central tendon of diaphragm       | Phrenic                        | Inspiration; depresses floor of thorax   |
| Intercostalis (in'ter-kos-ta'lis)                                 |                                                 |                                   |                                |                                          |
| External                                                          | Inferior margin of each rib                     | Superior border of next rib below | Intercostal                    | Inspiration; elevates ribs               |
| Internal                                                          | Superior margin of each rib                     | Inferior border of next rib above | Intercostal                    | Expiration; depresses ribs               |
| Scalenus (skā-lē'nūs)                                             |                                                 |                                   |                                |                                          |
| Anterior                                                          | C3–C6                                           | First rib                         | Cervical plexus                | Elevates first rib                       |
| Medial                                                            | C2–C6                                           | First rib                         | Cervical plexus                | Elevates first rib                       |
| Posterior                                                         | C4–C6                                           | Second rib                        | Cervical and brachial plexuses | Elevates second rib                      |
| Serratus posterior (sēr-ä'tūs)                                    |                                                 |                                   |                                |                                          |
| Inferior (not illustrated)                                        | T11–L2                                          | Inferior four ribs                | Ninth to twelfth intercostals  | Depresses inferior ribs and extends back |
| Superior (not illustrated)                                        | C6–T2                                           | Second to fifth ribs              | First to fourth intercostals   | Elevates superior ribs                   |
| Transversus thoracis (trans-ver'sus thō-ra'sis) (not illustrated) | Sternum and xiphoid process                     | Second to sixth costal cartilages | Intercostal                    | Decreases diameter of thorax             |



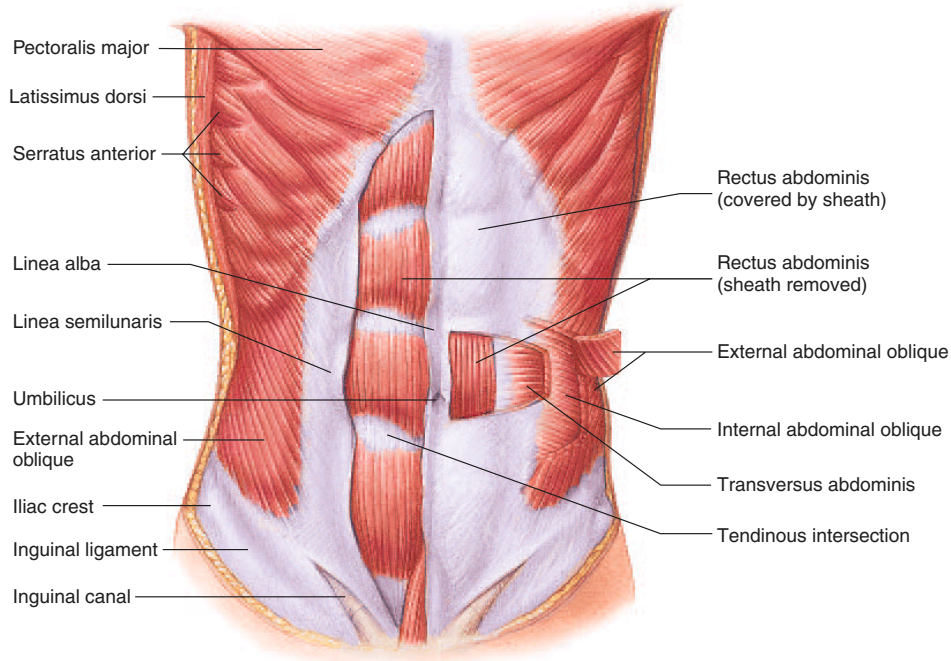
**Figure 10.15** Muscles of Respiration

(a) Anterior view. A few selected intercostal muscles and the diaphragm are demonstrated. (b) Lateral view.

**Table 10.10** Muscles of the Abdominal Wall (see figures 10.4, 10.17, and 10.18)

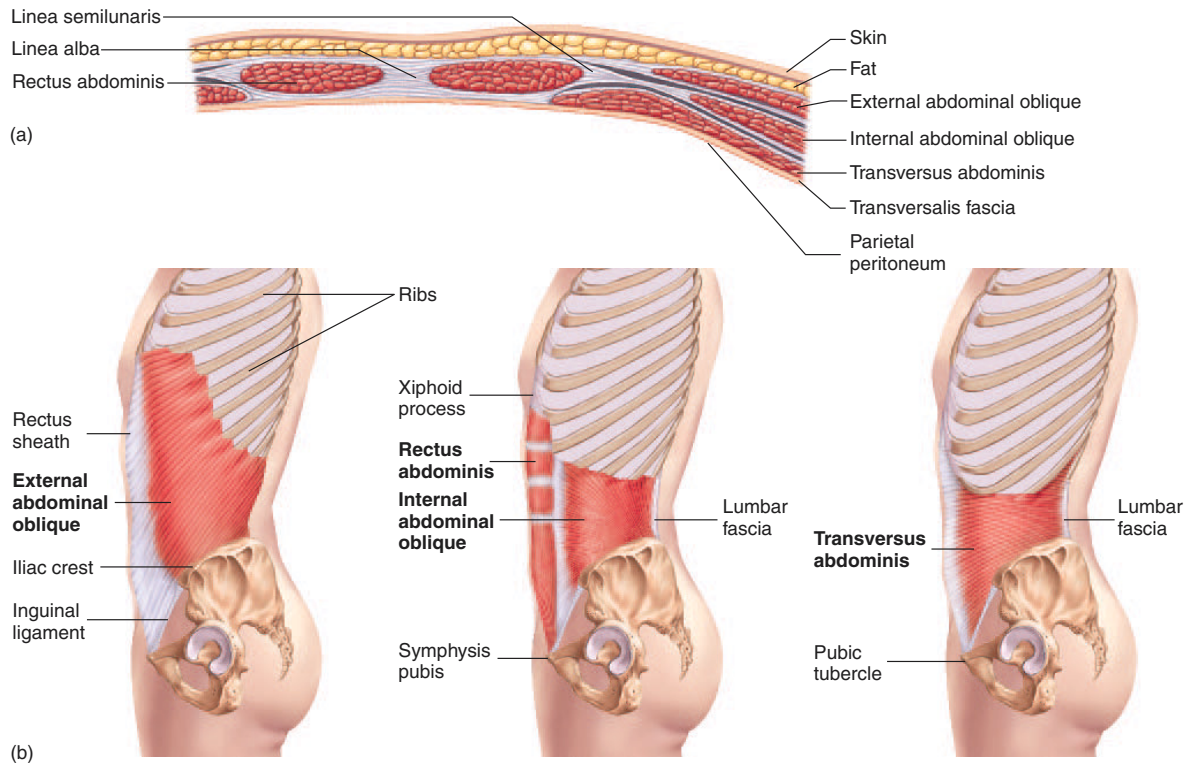
| Muscle                                                | Origin                                                                                  | Insertion                                         | Nerve                      | Action                                                                    |
|-------------------------------------------------------|-----------------------------------------------------------------------------------------|---------------------------------------------------|----------------------------|---------------------------------------------------------------------------|
| <b>Anterior</b>                                       |                                                                                         |                                                   |                            |                                                                           |
| Rectus abdominis<br>(rek'tūs ab-dom'i-nis)            | Pubic crest and symphysis pubis                                                         | Xiphoid process and inferior ribs                 | Branches of lower thoracic | Flexes vertebral column; compresses abdomen                               |
| External abdominal oblique                            | Fifth to twelfth ribs                                                                   | Iliac crest, inguinal ligament, and rectus sheath | Branches of lower thoracic | Flexes and rotates vertebral column; compresses abdomen; depresses thorax |
| Internal abdominal oblique                            | Iliac crest, inguinal ligament, and lumbar fascia                                       | Tenth to twelfth ribs and rectus sheath           | Lower thoracic             | Flexes and rotates vertebral column; compresses abdomen; depresses thorax |
| Transversus abdominis<br>(trans-ver'sūs ab-dom'i-nis) | Seventh to twelfth costal cartilages, lumbar fascia, iliac crest, and inguinal ligament | Xiphoid process, linea alba, and pubic tubercle   | Lower thoracic             | Compresses abdomen                                                        |
| <b>Posterior</b>                                      |                                                                                         |                                                   |                            |                                                                           |
| Quadratus lumborum<br>(kwah-drā'tūs lūm-bōr'ūm)       | Iliac crest and lower lumbar vertebrae                                                  | Twelfth rib and upper lumbar vertebrae            | Upper lumbar               | Laterally flexes vertebral column and depresses twelfth rib               |





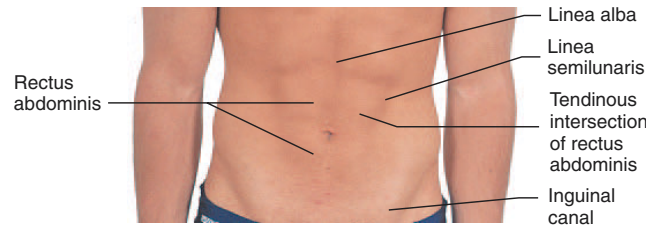
**Figure 10.16** Muscles of the Anterior Abdominal Wall

Windows in the side reveal the various muscle layers.



**Figure 10.17** Muscles of the Anterior Abdominal Wall

(a) Cross section superior to the umbilicus. (b) Abdominal muscles shown individually (lateral view).



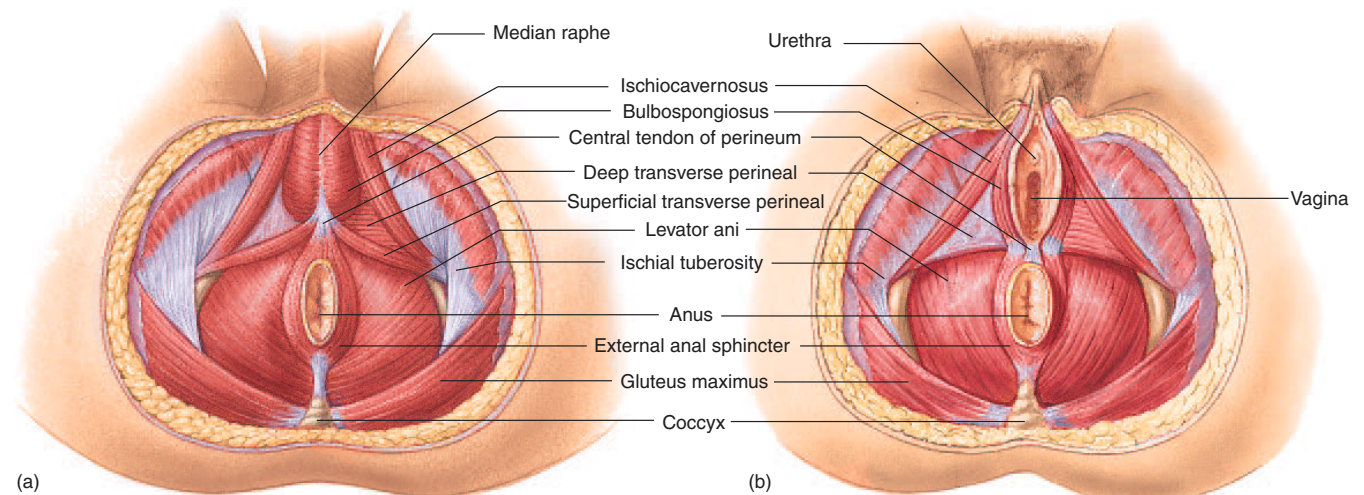
**Figure 10.18** Surface Anatomy, Muscles of the Anterior Abdominal Wall

## Pelvic Floor and Perineum

The pelvis is a ring of bone (see chapter 7) with an inferior opening that is closed by a muscular wall through which the anus and the urogenital openings penetrate (table 10.11). Most of the pelvic floor is formed by the **coccygeus** (kok-si'jē-ūs) muscle and the **levator ani** (a'nī) muscle, referred to jointly as the **pelvic diaphragm**. The area inferior to the pelvic floor is the **perineum** (per'i-nē'ūm), which is somewhat diamond-shaped (figure 10.19). The anterior

**Table 10.11** Muscles of the Pelvic Floor and Perineum (see figure 10.19)

| Muscle                                                                      | Origin                                                    | Insertion                                 | Nerve                     | Action                                 |
|-----------------------------------------------------------------------------|-----------------------------------------------------------|-------------------------------------------|---------------------------|----------------------------------------|
| Bulbospongiosus<br>(bul'bō-spūn'jē-ō'sūs)                                   | Male—central tendon of perineum and median raphe of penis | Dorsal surface of penis and bulb of penis | Pudendal                  | Constricts urethra; erects penis       |
|                                                                             | Female—central tendon of perineum                         | Base of clitoris                          | Pudendal                  | Erects clitoris                        |
| Coccygeus (kok-si'jē-ūs)<br>(not illustrated)                               | Ischial spine                                             | Coccyx                                    | S3 and S4                 | Elevates and supports pelvic floor     |
| Ischiocavernosus<br>(ish'ē-ō-kav'er-nō'sūs)                                 | Ischial ramus                                             | Corpus cavernosum                         | Perineal                  | Compresses base of penis or clitoris   |
| Levator ani<br>(lē-vā'tor, le-vā'ter ā'nī)                                  | Posterior pubis and ischial spine                         | Sacrum and coccyx                         | Fourth sacral             | Elevates anus; supports pelvic viscera |
| External anal sphincter<br>(ā'nā l sfīngk'ter)                              | Coccyx                                                    | Central tendon of perineum                | Fourth sacral and pudenda | Keeps orifice of anal canal closed     |
| External urethral sphincter<br>(ū-rē'thrāl sfīngk'ter)<br>(not illustrated) | Pubic ramus                                               | Median raphe                              | Pudendal                  | Constricts urethra                     |
| Transverse perinei<br>(pēr'i-nē'ī)                                          |                                                           |                                           |                           |                                        |
| Deep                                                                        | Ischial ramus                                             | Median raphe                              | Pudendal                  | Supports pelvic floor                  |
| Superficial                                                                 | Ischial ramus                                             | Central perineal                          | Pudendal                  | Fixes central tendon                   |



**Figure 10.19** Muscles of the Pelvic Floor and Perineum

Inferior view. (a) Male. (b) Female.

half of the diamond is the urogenital triangle, and the posterior half is the anal triangle (see chapter 28). The urogenital triangle contains the **urogenital diaphragm**, which forms a “subfloor” to the pelvis in that area and consists of the **deep transverse perineal** (pě’i-ně’äl) muscle and the **external urethral sphincter** muscle. During pregnancy, the muscles of the pelvic diaphragm and urogenital diaphragm may be stretched by the extra weight of the fetus, and specific exercises are designed to strengthen them.

- 14. List the actions of the group of back muscles that attaches to the vertebrae or ribs (or both). What is the name of the superficial group?
- 15. Name the muscle that is mainly responsible for respiratory movements. How do other muscles aid this movement?
- 16. Explain the anatomic basis for the segments (“cuts”) seen on a well-muscled individual’s abdomen. What are the functions of the abdominal muscles? List the muscles of the anterior abdominal wall.
- 17. What openings penetrate the pelvic floor muscles? Name the area inferior to the pelvic floor.

## Upper Limb Muscles

### Objectives

- List the muscles forming the rotator cuff, and describe their function.

- Describe the movements of the arm and the muscles involved.
- Name the muscles that extend and flex the forearm.
- Describe the two functional groups of forearm muscles and the movements they produce.
- Describe and give the functions of the extrinsic and intrinsic hand muscles.

The muscles of the upper limb include those that move the scapula, and those that move the arm, the forearm, and the hand.

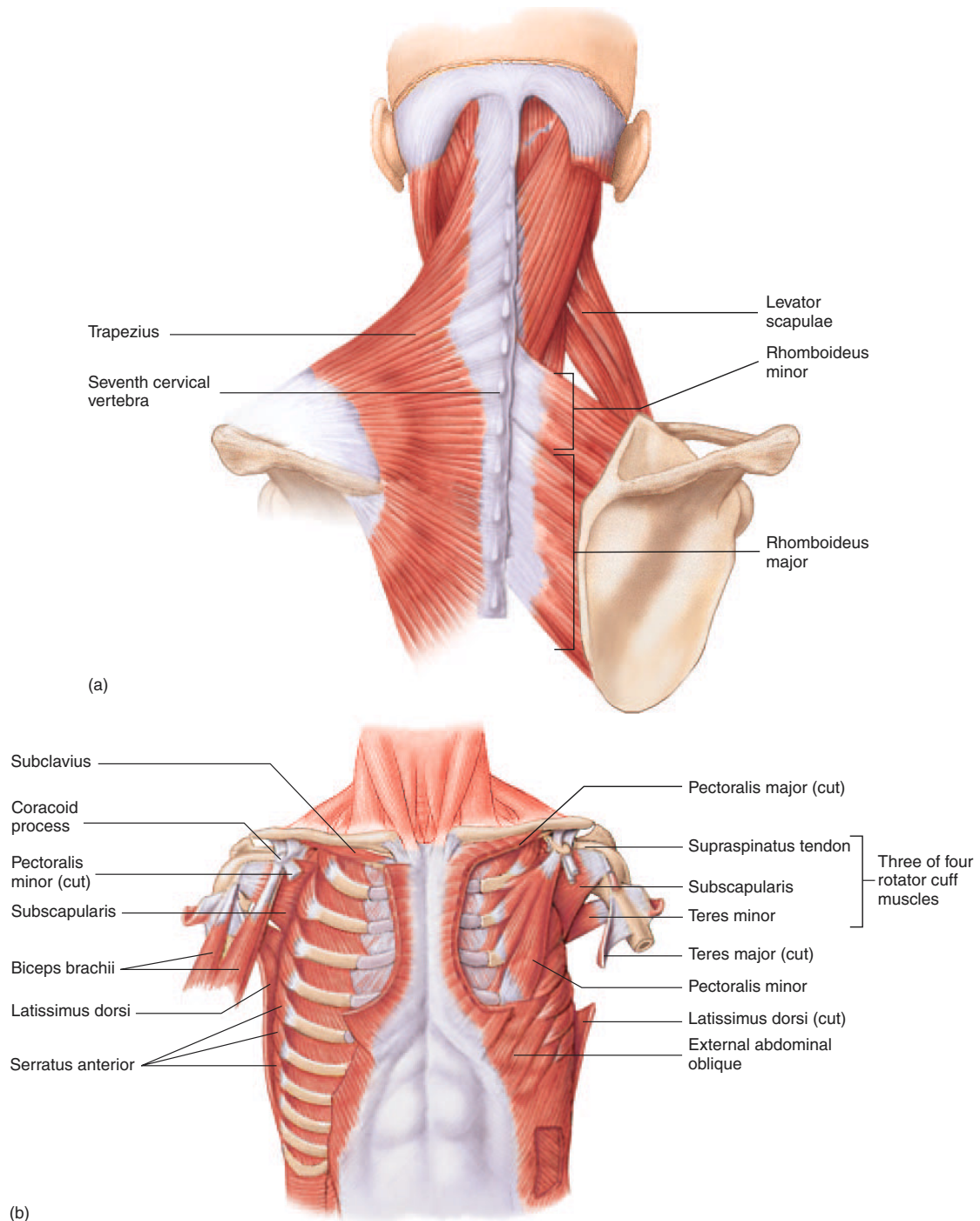
## Scapular Movements

The major connection of the upper limb to the body is accomplished by muscles (table 10.12 and figure 10.20). The muscles attaching the scapula to the thorax include the **trapezius**, **levator scapulae** (skap’ū-lē), **rhomboideus** (rom-bō-id’ē-ūs) **major** and **minor**, **serratus** (sě-rā’tūs) **anterior**, and **pectoralis** (pek’tō-ra’lis) **minor**. These muscles move the scapula, permitting a wide range of movements of the upper limb, or act as fixators to hold the scapula firmly in position when the muscles of the arm contract. The superficial muscles that act on the scapula can be easily seen on a living person (see figure 10.22a and c): the trapezius forms the upper line from each shoulder to the neck, and the origin of the serratus anterior from the first eight or nine ribs can be seen along the lateral thorax.

**Table 10.12** Muscles Acting on the Scapula (see figure 10.20)

| Muscle                                                  | Origin                                                                  | Insertion                                            | Nerve                            | Action                                                                        |
|---------------------------------------------------------|-------------------------------------------------------------------------|------------------------------------------------------|----------------------------------|-------------------------------------------------------------------------------|
| Levator scapulae<br>(lē-vā’tor, le-vā’ter<br>skap’ū-lē) | C1–C4                                                                   | Superior angle of<br>scapula                         | Dorsal scapular                  | Elevates, retracts, and<br>rotates scapula; laterally<br>flexes neck          |
| Pectoralis minor<br>(pek’tō-ra’lis)                     | Third to fifth ribs                                                     | Coracoid process<br>of scapula                       | Anterior thoracic                | Depresses scapula or<br>elevates ribs                                         |
| Rhomboideus<br>(rom-bō-id’ē-ūs)                         |                                                                         |                                                      |                                  |                                                                               |
| Major                                                   | T1–T4                                                                   | Medial border<br>of scapula                          | Dorsal scapular                  | Retracts, rotates, and<br>fixes scapula                                       |
| Minor                                                   | C6–C7                                                                   | Medial border<br>of scapula                          | Dorsal scapular                  | Retracts, slightly elevates,<br>rotates, and fixes scapula                    |
| Serratus anterior<br>(ser-ā’tūs)                        | First to ninth ribs                                                     | Medial border<br>of scapula                          | Long thoracic                    | Rotates and protracts scapula;<br>elevates ribs                               |
| Subclavius<br>(sūb-klā’vē-ūs)                           | First rib                                                               | Clavicle                                             | Subclavian                       | Fixes clavicle or elevates<br>first rib                                       |
| Trapezius<br>(tra-pē’zē-ūs)                             | External occipital<br>protuberance,<br>ligamentum nuchae,<br>and C7–T12 | Clavicle, acromion<br>process, and<br>scapular spine | Accessory and<br>cervical plexus | Elevates, depresses, retracts,<br>rotates, and fixes scapula;<br>extends neck |





**Figure 10.20** Muscles Acting on the Scapula

(a) Posterior view. Trapezius is removed on the right to reveal the deeper muscles. (b) Anterior view. Pectoralis major is removed on both sides. The pectoralis minor is also removed on the right side.



## Arm Movements

The arm is attached to the thorax by the **pectoralis major** and the **latissimus dorsi** (lă-tis'i-mūs dōr'sī) muscles (table 10.13 and figure 10.21; see figure 10.20*b*). Notice that the pectoralis major muscle is listed in table 10.13 as both a flexor and extensor. The muscle flexes the extended shoulder and extends the flexed shoulder. Try these movements yourself and notice the position and action of the muscle. The **deltoid** (deltoideus) muscle also is listed in table 10.13 as a flexor and extensor. The deltoid muscle is like three muscles in one: the anterior fibers flex the shoulder; the lateral fibers abduct

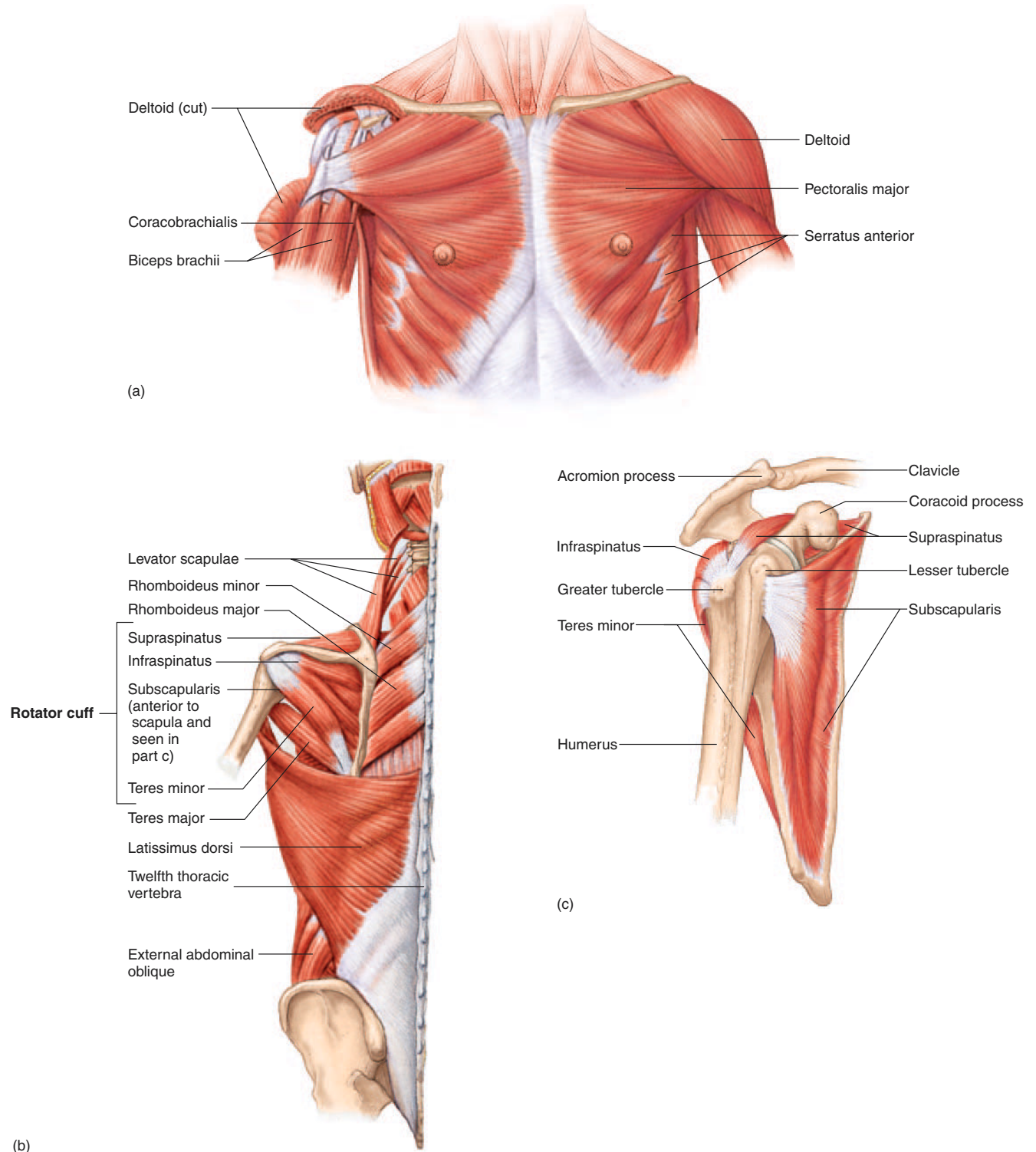
the arm; and the posterior fibers extend the shoulder. The deltoid muscle is part of the group of muscles that binds the humerus to the scapula. The primary muscles holding the head of the humerus in the glenoid fossa, however, are called the **rotator cuff muscles** (listed separately in table 10.13) because they form a cuff or cap over the proximal humerus (figure 10.21*c*). A rotator cuff injury involves damage to one or more of these muscles or their tendons, usually the supraspinatus muscle. The muscles moving the arm are involved in flexion, extension, abduction, adduction, rotation, and circumduction (table 10.14).

**Table 10.13** Muscles Acting on the Arm (see figures 10.20, 10.21, 10.22, and 10.23)

| Muscle                                      | Origin                                         | Insertion                               | Nerve                   | Action                                                                                   |
|---------------------------------------------|------------------------------------------------|-----------------------------------------|-------------------------|------------------------------------------------------------------------------------------|
| Coracobrachialis<br>(kōr'ă-kō-bră-kē-ă'lis) | Coracoid process of scapula                    | Midshaft of humerus                     | Musculocutaneous        | Adducts arm and flexes shoulder                                                          |
| Deltoid (del'toyd)                          | Clavicle, acromion process, and scapular spine | Deltoid tuberosity                      | Axillary                | Flexes and extends shoulder; abducts and medially and laterally rotates arm              |
| Latissimus dorsi<br>(lă-tis'i-mūs dōr'sī)   | T7–L5, sacrum and iliac crest                  | Medial crest of intertubercular groove  | Thoracodorsal           | Adducts and medially rotates arm; extends shoulder                                       |
| Pectoralis major<br>(pek'tō-ră'lis)         | Clavicle, sternum, and abdominal aponeurosis   | Lateral crest of intertubercular groove | Anterior thoracic       | Flexes shoulder; adducts and medially rotates arm; extends shoulder from flexed position |
| Teres major (ter'ēz, tēr-ēz)                | Lateral border of scapula                      | Medial crest of intertubercular groove  | Subscapular C5 and C6   | Extends shoulder; adducts and medially rotates arm                                       |
| <b>Rotator Cuff</b>                         |                                                |                                         |                         |                                                                                          |
| Infraspinatus<br>(in-fră-spī-nă'tūs)        | Infraspinous fossa of scapula                  | Greater tubercle of humerus             | Suprascapular C5 and C6 | Extends shoulder and laterally rotates arm                                               |
| Subscapularis<br>(sūb-skap-ū-lă'ris)        | Subscapular fossa                              | Lesser tubercle of humerus              | Subscapular C5 and C6   | Extends shoulder and medially rotates arm                                                |
| Supraspinatus<br>(soo-pră-spī-nă'tūs)       | Supraspinous fossa                             | Greater tubercle of humerus             | Suprascapular C5 and C6 | Abducts arm                                                                              |
| Teres minor (ter'ēz, tēr-ēz)                | Lateral border of scapula                      | Greater tubercle of humerus             | Axillary C5 and C6      | Extends shoulder; adducts and laterally rotates arm                                      |

**Table 10.14** Summary of Muscle Actions on the Shoulder and Arm

| Flexion          | Extension                           | Abduction     | Adduction                                          | Medial Rotation          | Lateral Rotation |
|------------------|-------------------------------------|---------------|----------------------------------------------------|--------------------------|------------------|
| Deltoid          | Deltoid                             | Deltoid       | Pectoralis major                                   | Pectoralis major         | Deltoid          |
| Pectoralis major | Teres major                         | Supraspinatus | Latissimus dorsi                                   | Teres major              | Infraspinatus    |
| Coracobrachialis | Latissimus dorsi                    |               | Teres major                                        | Latissimus dorsi         | Teres minor      |
| Biceps brachii   | Pectoralis major<br>Triceps brachii |               | Teres minor<br>Triceps brachii<br>Coracobrachialis | Deltoid<br>Subscapularis |                  |



**Figure 10.21 Muscles Attaching the Upper Limb to the Body**

(a) Anterior view. (b) Posterior view. (c) Anterior view of the rotator cuff, showing the teres minor, infraspinatus, supraspinatus, and subscapularis muscles.

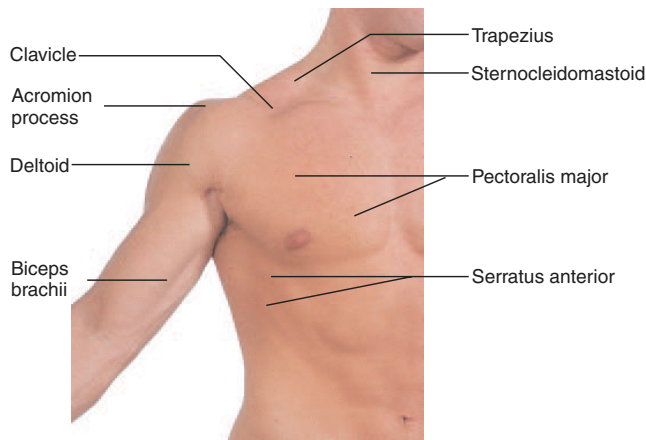
Abduction of the arm involves the deltoid, rotator cuff muscles, and the trapezius. Abduction from the anatomic position through the first 90 degrees (to the point at which the hand is level to the shoulder) is accomplished almost entirely by the deltoid muscle. Place your hand on your deltoid and feel it contract as you abduct 90 degrees. Abduction from 90 degrees to 180 degrees, so that the hand is held high above the head, primarily involves rotation of the scapula, which is accomplished by the trapezius. Feel the inferior angle of your scapula as you abduct to 90 degrees and then to 180 degrees. Do you notice a big difference? Abduction from 90 degrees to 180 degrees, however, cannot occur unless the head of the humerus is held tightly in the glenoid cavity by the

rotator cuff muscles. Damage to the supraspinatus muscle can prevent abduction past 90 degrees.

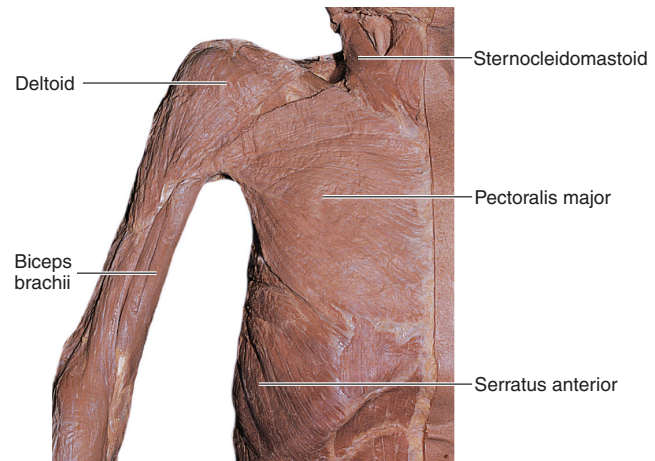
#### P R E D I C T 4

A tennis player complains of pain in the shoulder when attempting to serve or when attempting an overhead volley (extreme abduction). What rotator cuff muscle is probably damaged? What is the cause of the pain?

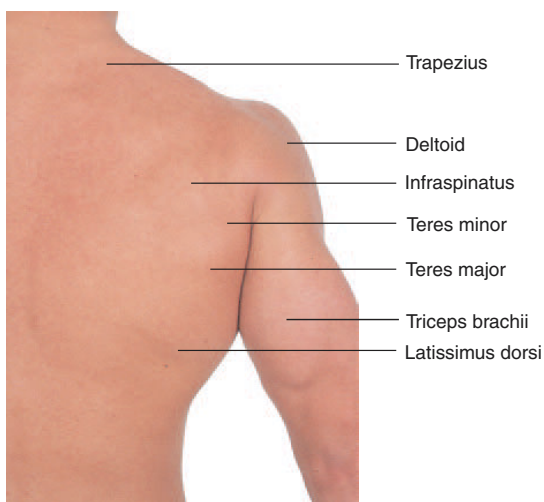
Several muscles acting on the arm can be seen very clearly in the living individual (figure 10.22). The pectoralis major forms the upper chest, and the deltoids are prominent over the shoulders. The deltoid is a common site for administering injections.



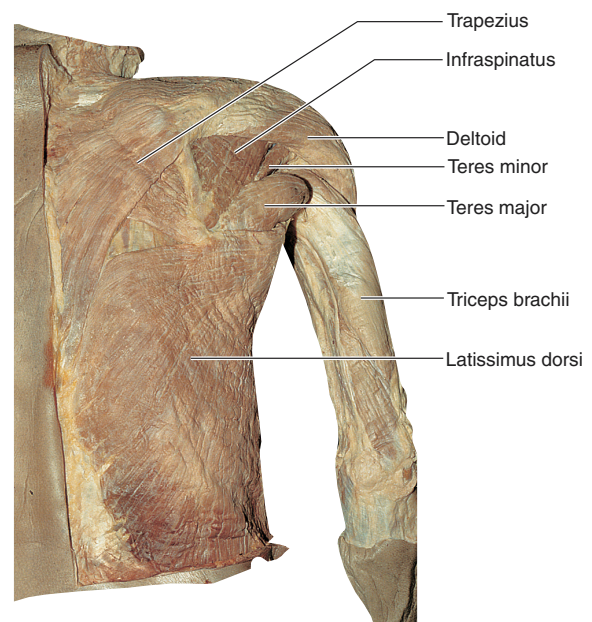
(a)



(b)



(c)



(d)

**Figure 10.22 Shoulder**

(a) Surface anatomy of the anterior shoulder. (b) Photograph showing a dissection of the anterior shoulder. (c) Surface anatomy of the posterior shoulder. (d) Photograph showing a dissection of the posterior shoulder.

## Forearm Movements

The surface anatomy of the arm muscles is illustrated in figure 10.22. The triceps constitute the main mass visible on the posterior aspect of the arm (see figure 10.26). The biceps brachii is readily visible on the anterior aspect of the arm. The brachialis lies deep to the biceps and can be seen only as a mass on the medial and lateral sides of the arm. The brachioradialis forms a bulge on the anterolateral side of the forearm just distal to the elbow. If the elbow is forcefully flexed in the midprone position (midway between pronation and supination), the brachioradialis stands out clearly on the forearm.

### Flexion and Extension of the Elbow

Extension of the elbow is accomplished by the **triceps brachii** (brā'kē-ī) and **anconeus** (ang-kō'nē-ūs); flexion of the elbow is accomplished by the **brachialis** (brā'kē-al'is), **biceps brachii**, and **brachioradialis** (brā'kē-ō-rā'dē-al'is; table 10.15; see figure 10.23).

### Supination and Pronation

Supination of the forearm is accomplished by the **supinator** and the **biceps brachii** (see figures 10.23*b* and 10.24*c* and *d*). Pronation is a function of the **pronator quadratus** (kwah-drā'tūs) and the **pronator teres** (ter'ēz, tēr-ēz) (figure 10.24*a* and *c*).

- 18. Name seven muscles that attach the humerus to the scapula. What two muscles attach the humerus directly to the trunk?
- 19. List the muscles forming the rotator cuff, and describe their function.
- 20. What muscles cause flexion and extension of the shoulder? Abduction and adduction of the arm? What muscle is involved in abduction of the arm to 90 degrees? Above 90 degrees? What muscles cause rotation of the arm?
- 21. List the muscles that cause flexion and extension of the elbow. Where are these muscles located?
- 22. Supination and pronation of the forearm are produced by what muscles? Where are these muscles located?

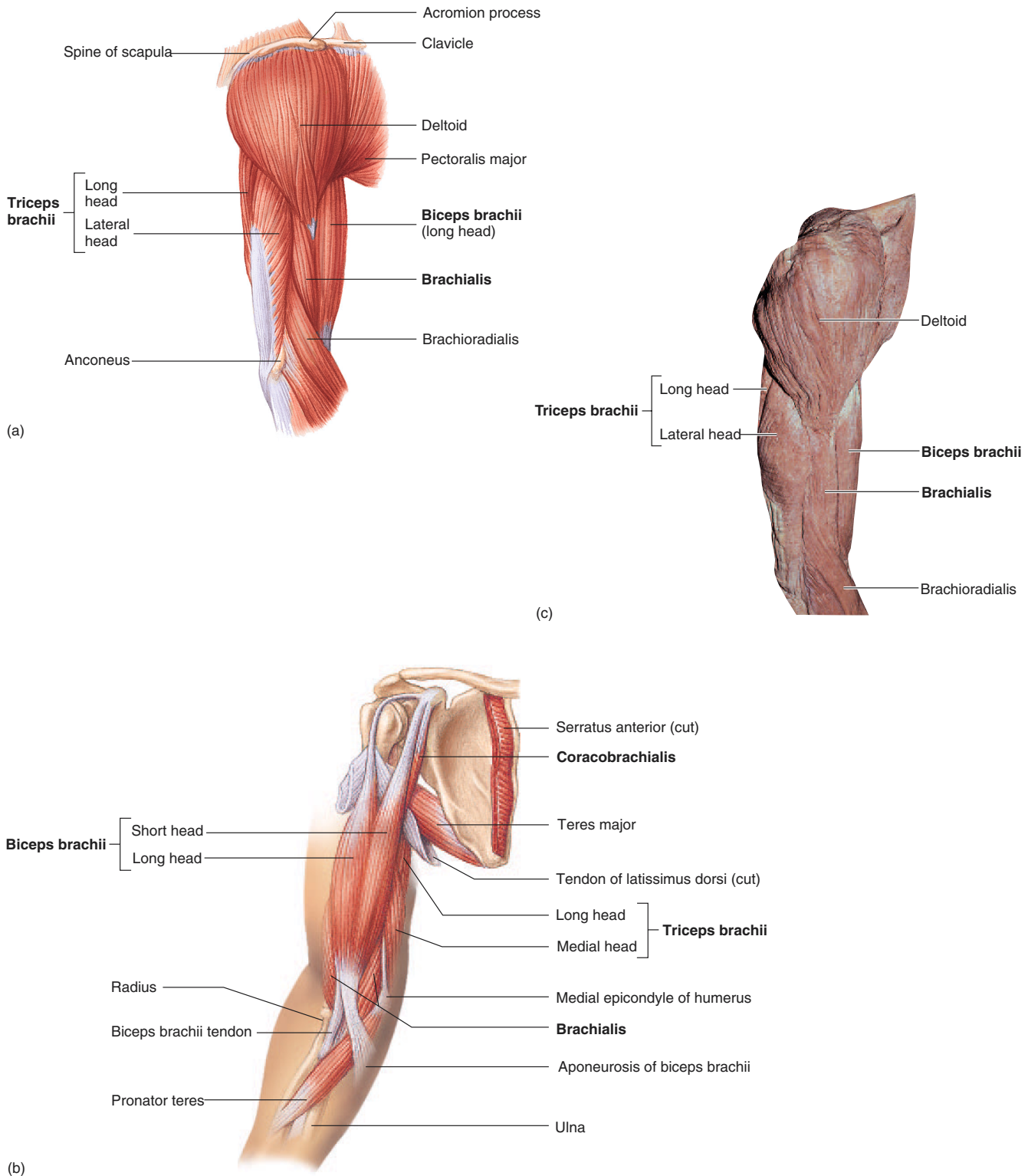
#### P R E D I C T 5

Explain the difference between doing chin-ups with the forearm supinated versus pronated. Which muscle or muscles are used in each type of chin-up? Which type is easier? Why?

**Table 10.15** Muscles Acting on the Forearm (see figures 10.23 and 10.24)

| Muscle                                                      | Origin                                                                                                                                | Insertion                            | Nerve                       | Action                                          |
|-------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-----------------------------|-------------------------------------------------|
| <b>Arm</b>                                                  |                                                                                                                                       |                                      |                             |                                                 |
| Biceps brachii<br>(bī'seps brā'kē-ī)                        | Long head—supraglenoid tubercle<br><br>Short head—coracoid process                                                                    | Radial tuberosity                    | Musculocutaneous            | Flexes shoulder and elbow; supinates hand       |
| Brachialis<br>(brā'kē-al'is)                                | Humerus                                                                                                                               | Coronoid process of ulna             | Musculocutaneous and radial | Flexes elbow                                    |
| Triceps brachii<br>(trī'seps brā'kē-ī)                      | Long head—lateral border of scapula<br><br>Lateral head—lateral and posterior surface of humerus<br><br>Medial head—posterior humerus | Olecranon process of ulna            | Radial                      | Extends elbow; extends shoulder and adducts arm |
| <b>Forearm</b>                                              |                                                                                                                                       |                                      |                             |                                                 |
| Anconeus<br>(ang-kō'nē-ūs)                                  | Lateral epicondyle of humerus                                                                                                         | Olecranon process and posterior ulna | Radial                      | Extends elbow                                   |
| Brachioradialis<br>(brā'kē-ō-rā'dē-al'is)                   | Lateral supracondylar ridge of humerus                                                                                                | Styloid process of radius            | Radial                      | Flexes elbow                                    |
| Pronator quadratus<br>(prō-nā-ter, prō-nā-tōr kwah-drā'tūs) | Distal ulna                                                                                                                           | Distal radius                        | Anterior interosseous       | Pronates forearm                                |
| Pronator teres<br>(prō-nā-tōr ter'ēz, tēr-ēz)               | Medial epicondyle of humerus and coronoid process of ulna                                                                             | Radius                               | Median                      | Pronates forearm                                |
| Supinator<br>(soo'pi-nā-ter, soo'pi-nā-tōr)                 | Lateral epicondyle of humerus and ulna                                                                                                | Radius                               | Radial                      | Supinates forearm                               |



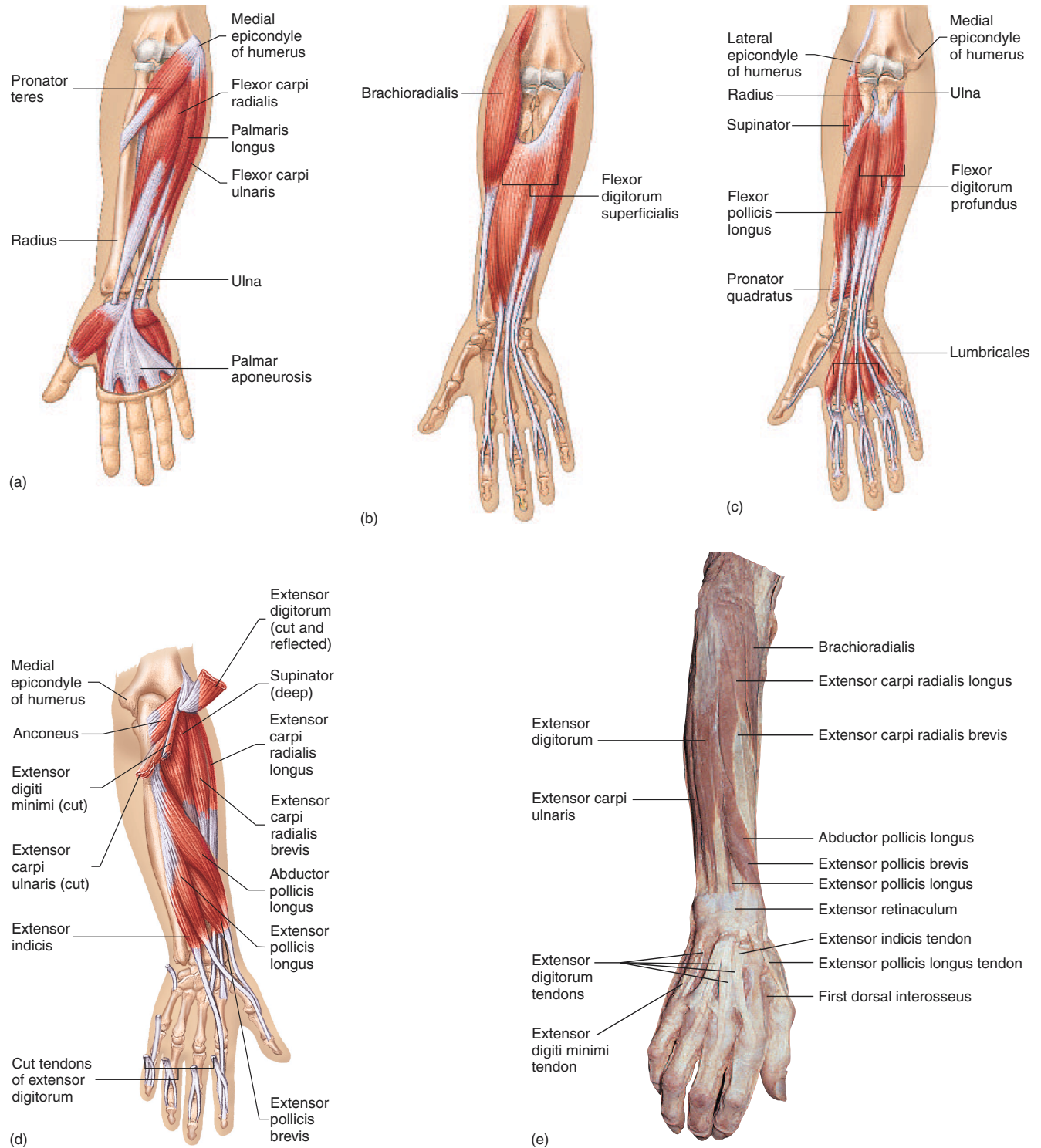


**Figure 10.23 Muscles of the Arm**

(a) Lateral view of the right shoulder and arm. (b) Anterior view of the right shoulder and arm (deep). Deltoid, pectoralis major, and pectoralis minor muscles are removed to reveal deeper structures. (c) Photograph of arm muscles.

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**Figure 10.24** Muscles of the Forearm

(a) Anterior view of the right forearm (superficial). Brachioradialis muscle is removed. (b) Anterior view of the right forearm (deeper than a). Pronator teres, flexor carpi radialis and ulnaris, and palmaris longus muscles are removed. (c) Anterior view of the right forearm (deeper than a or b). Brachioradialis, pronator teres, flexor carpi radialis and ulnaris, palmaris longus, and flexor digitorum superficialis muscles are removed. (d) Deep muscles of the right posterior forearm. Extensor digitorum, extensor digiti minimi, and extensor carpi ulnaris muscles are cut to reveal deeper muscles. (e) Photograph showing dissection of the posterior right forearm and hand.

## Wrist, Hand, and Finger Movements

The forearm muscles are divided into anterior and posterior groups (table 10.16; see figure 10.24). Most of the anterior forearm muscles are responsible for flexion of the wrist and fingers. Most of the posterior forearm muscles cause extension of the wrist and fingers.

### Extrinsic Hand Muscles

The **extrinsic hand muscles** are in the forearm but have tendons that extend into the hand. A strong band of fibrous connective tissue, the **retinaculum** (ret-i-nak'ū-lŭm; bracelet), covers the flexor

and extensor tendons and holds them in place around the wrist so that they do not “bowstring” during muscle contraction (see figure 10.24e).

Two major anterior muscles, the **flexor carpi radialis** (kar'pī rā-dē-ā'lis) and the **flexor carpi ulnaris** (ŭl-nā'ris), flex the wrist; and three posterior muscles, the **extensor carpi radialis longus**, the **extensor carpi radialis brevis**, and the **extensor carpi ulnaris**, extend the wrist. The wrist flexors and extensors are visible on the anterior and posterior surfaces of the forearm. The tendon of the flexor carpi radialis is an important landmark because the radial pulse can be felt just lateral to the tendon (see figure 10.24a).

**Table 10.16** Muscles of the Forearm Acting on the Wrist, Hand, and Fingers (see figure 10.24)

| Muscle                                                                | Origin                                                     | Insertion                        | Nerve            | Action                                   |
|-----------------------------------------------------------------------|------------------------------------------------------------|----------------------------------|------------------|------------------------------------------|
| <b>Anterior Forearm</b>                                               |                                                            |                                  |                  |                                          |
| Flexor carpi radialis<br>(kar'pī rā-dē-ā'lis)                         | Medial epicondyle of humerus                               | Second and third metacarpals     | Median           | Flexes and abducts wrist                 |
| Flexor carpi ulnaris<br>(kar'pī ŭl-nā'ris)                            | Medial epicondyle of humerus and ulna                      | Pisiform                         | Ulnar            | Flexes and adducts wrist                 |
| Flexor digitorum profundus<br>(dij'i-tōr'ŭm prō-fŭn'dŭs)              | Ulna                                                       | Distal phalanges of digits 2–5   | Ulnar and median | Flexes fingers and wrist                 |
| Flexor digitorum superficialis<br>(dij'i-tōr'ŭm soo'per-fish-ē-ā'lis) | Medial epicondyle of humerus, coronoid process, and radius | Middle phalanges of digits 2–5   | Median           | Flexes fingers and wrist                 |
| Flexor pollicis longus<br>(pol'i-sis lon'gŭs)                         | Radius                                                     | Distal phalanx of thumb          | Median           | Flexes thumb and wrist                   |
| Palmaris longus<br>(pawl-mār'is lon'gŭs)                              | Medial epicondyle of humerus                               | Palmar fascia                    | Median           | Tenses palmar fascia; flexes wrist       |
| <b>Posterior Forearm</b>                                              |                                                            |                                  |                  |                                          |
| Abductor pollicis longus<br>(pol'i-sis lon'gŭs)                       | Posterior ulna and radius and interosseous membrane        | Base of first metacarpal         | Radial           | Abducts and extends thumb; abducts wrist |
| Extensor carpi radialis brevis<br>(kar'pī rā-dē-ā'lis brev'is)        | Lateral epicondyle of humerus                              | Base of third metacarpal         | Radial           | Extends and abducts wrist                |
| Extensor carpi radialis longus<br>(kar'pī rā-dē-ā'lis lon'gŭs)        | Lateral supracondylar ridge of humerus                     | Base of second metacarpal        | Radial           | Extends and abducts wrist                |
| Extensor carpi ulnaris<br>(kar'pī ŭl-nā'ris)                          | Lateral epicondyle of humerus and ulna                     | Base of fifth metacarpal         | Radial           | Extends and adducts wrist                |
| Extensor digiti minimi<br>(dij'i-tī mī'nī-mī)                         | Lateral epicondyle of humerus                              | Phalanges of fifth digit         | Radial           | Extends little finger and wrist          |
| Extensor digitorum<br>(dij'i-tōr'ŭm)                                  | Lateral epicondyle of humerus                              | Bases of phalanges of digits 2–5 | Radial           | Extends fingers and wrist                |
| Extensor indicis<br>(in'di-sis)                                       | Ulna                                                       | Second digit                     | Radial           | Extends forefinger and wrist             |
| Extensor pollicis brevis<br>(pol'i-sis brev'is)                       | Radius                                                     | Proximal phalanx of thumb        | Radial           | Extends and abducts thumb; abducts wrist |
| Extensor pollicis longus<br>(pol'i-sis lon'gŭs)                       | Ulna                                                       | Distal phalanx of thumb          | Radial           | Extends thumb                            |

## Tennis Elbow

Forceful, repetitive use of the forearm extensor muscles can damage them where they attach to the lateral epicondyle. This condition is often called **tennis elbow** because it can result from playing tennis. It is also called **lateral epicondylitis** because it can result from other sports and activities such as shoveling snow.



Flexion of the four medial digits is a function of the **flexor digitorum** (dij'i-tor'üm) **superficialis** and **flexor digitorum profundus** (prō-fūn'dūs; deep). Extension is accomplished by the **extensor digitorum**. The tendons of this muscle are very visible on the dorsum of the hand (see figure 10.26b). The little finger has an additional extensor, the **extensor digiti minimi** (dij'i-tī min'i-mī). The index finger also has an additional extensor, the **extensor indicis** (in'di-sis).

Movement of the thumb is caused in part by the **abductor pollicis** (pol'i-sis) **longus**, the **extensor pollicis longus**, and the **extensor pollicis brevis**. These tendons form the sides of a depression on the posterolateral side of the wrist called the “anatomical snuffbox” (see figure 10.26b). When snuff was in use, a small pinch could be placed into the anatomical snuffbox and inhaled through the nose.

## Intrinsic Hand Muscles

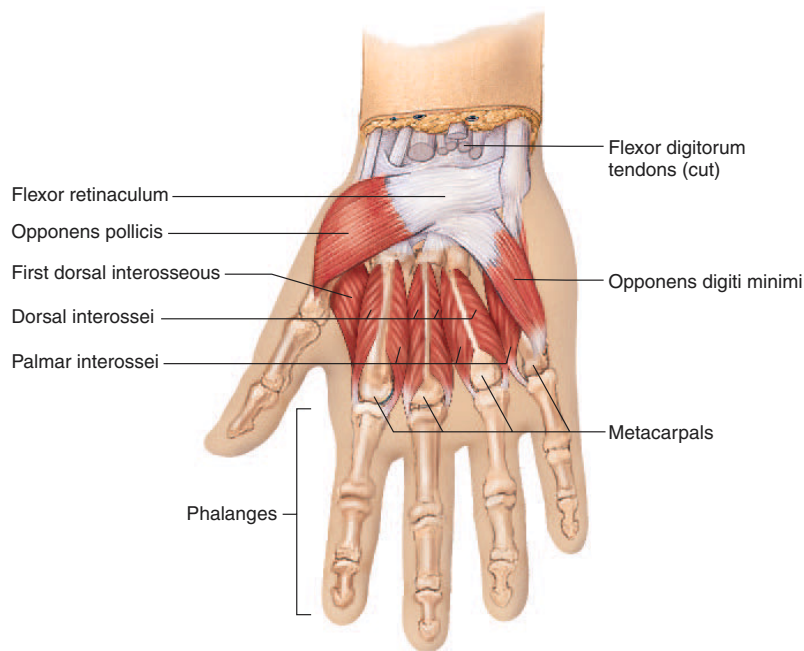
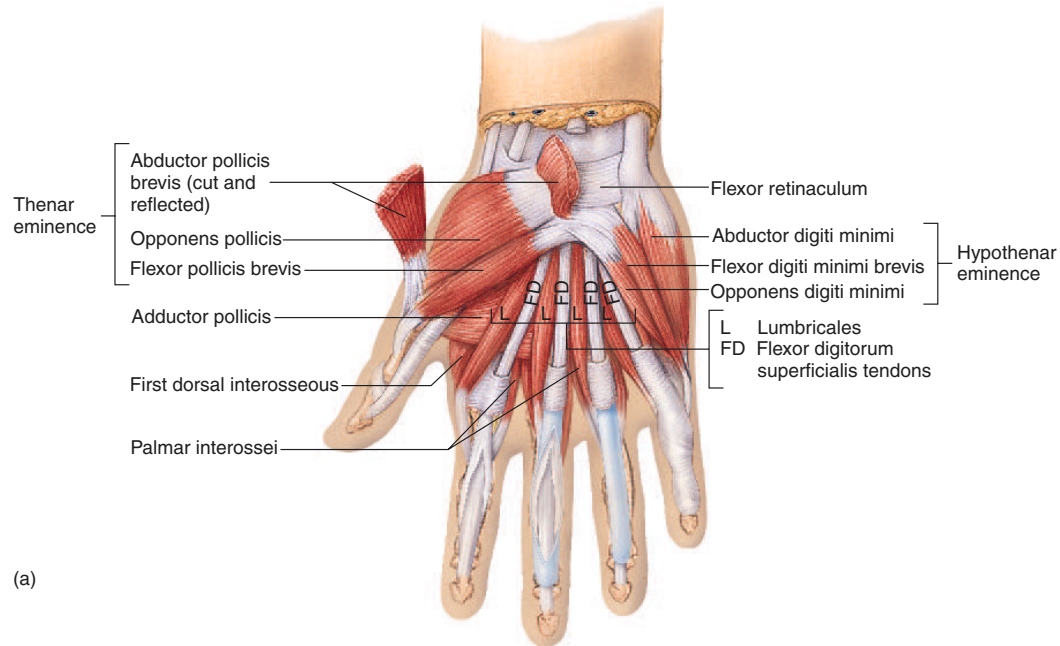
The **intrinsic hand muscles** are entirely within the hand (table 10.17 and figure 10.25). Abduction of the fingers is accomplished by the **interossei dorsales** (in'ter-os'e-i dōr-sa'lēz) and the **abductor digiti minimi**, whereas adduction is a function of the **interossei palmares** (pawl-mär'ēz).

The **flexor pollicis brevis**, the **abductor pollicis brevis**, and the **opponens pollicis** form a fleshy prominence at the base of the thumb called the **thenar** (thē'nar) **eminence** (see figures 10.25 and

**Table 10.17** Intrinsic Hand Muscles (see figure 10.25)

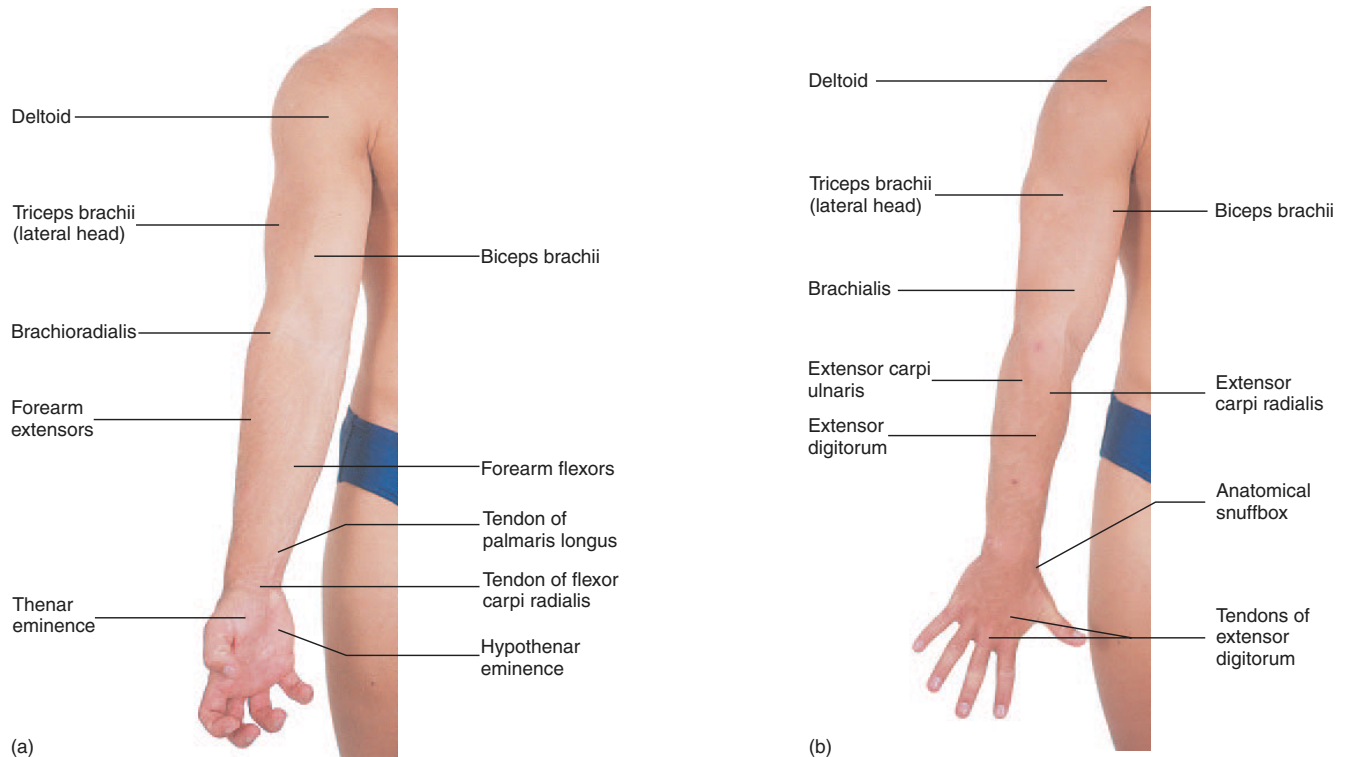
| Muscle                                                                 | Origin                                                      | Insertion                                              | Nerve                                              | Action                                                  |
|------------------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------|---------------------------------------------------------|
| <b>Midpalmar Muscles</b>                                               |                                                             |                                                        |                                                    |                                                         |
| Interossei<br>(in'ter-os'e-i)                                          |                                                             |                                                        |                                                    |                                                         |
| Dorsales<br>(dōr-sā'lēz)                                               | Sides of metacarpal bones                                   | Proximal phalanges of second, third, and fourth digits | Ulnar                                              | Abducts second, third, and fourth digits                |
| Palmares<br>(pawl-mär'ēz)                                              | Second, fourth, and fifth metacarpals                       | Second, fourth, and fifth digits                       | Ulnar                                              | Adducts second, fourth, and fifth digits                |
| Lumbricales<br>(lum-brā-ka'lēz)                                        | Tendons of flexor digitorum profundus                       | Second through fifth digits                            | Two on radial side—median; two on ulnar side—ulnar | Flexes proximal and extends middle and distal phalanges |
| <b>Thenar Muscles</b>                                                  |                                                             |                                                        |                                                    |                                                         |
| Abductor pollicis brevis<br>(ab-dūk-ter, ab-dūk-tōr pol'i-sis brev'is) | Flexor retinaculum, trapezium, and scaphoid                 | Proximal phalanx of thumb                              | Median                                             | Abducts thumb                                           |
| Adductor pollicis<br>(ab-dūk-ter, ab-dūk-tōr pol'i-sis)                | Third metacarpal, second metacarpal, trapezoid, and capitae | Proximal phalanx of thumb                              | Ulnar                                              | Adducts thumb                                           |
| Flexor pollicis brevis<br>(pol'i-sis brev'is)                          | Flexor retinaculum and first metacarpal                     | Proximal phalanx of thumb                              | Median and ulnar                                   | Flexes thumb                                            |
| Opponens pollicis<br>(ō-pō'nens pol'i-sis)                             | Trapezium and flexor retinaculum                            | First metacarpal                                       | Median                                             | Opposes thumb                                           |
| <b>Hypothenar Muscles</b>                                              |                                                             |                                                        |                                                    |                                                         |
| Abductor digiti minimi<br>(ab-dūk-ter, ab-dūk-tōr dij'i-tī min'imī)    | Pisiform                                                    | Base of fifth digit                                    | Ulnar                                              | Abducts and flexes little finger                        |
| Flexor digiti minimi brevis<br>(dij'i-tī min'imī brev'is)              | Hamate                                                      | Middle and proximal phalanx of fifth digit             | Ulnar                                              | Flexes little finger                                    |
| Opponens digiti minimi<br>(ō-pō'nens dij'i-tī min'imī)                 | Hamate and flexor retinaculum                               | Fifth metacarpal                                       | Ulnar                                              | Opposes little finger                                   |





**Figure 10.25 Hand**

Palmar surface of the right hand. Abductor pollicis brevis is cut.



**Figure 10.26** Surface Anatomy, Muscles of the Upper Limb

(a) Anterior view. (b) Lateral and posterior view.

10.26a). The **abductor digiti minimi**, **flexor digiti minimi brevis**, and **opponens digiti minimi** constitute the **hypothenar eminence** on the ulnar side of the hand. The thenar and hypothenar muscles are involved in the control of the thumb and little finger.

- 23. Describe the muscle groups that cause flexion and extension of the wrist.
- 24. Contrast the location and actions of the extrinsic and intrinsic hand muscles. What is the retinaculum? What is the location and action of the thenar and hypothenar muscles?
- 25. Describe the muscles that move the thumb. The tendons of what muscles form the anatomical snuffbox?

## Lower Limb Muscles

### Objectives

- Describe the movements of the thigh, and list the muscles involved in each movement.
- Describe the movements of the leg and list the muscles involved in each movement.
- List the muscles in each compartment of the leg, and give their action.
- Describe and give the functions of the extrinsic and intrinsic foot muscles.

## Thigh Movements

Several hip muscles originate on the coxa and insert onto the femur (table 10.18 and figures 10.27 through 10.29). These muscles are divided into three groups: anterior, posterolateral, and deep.

The anterior muscles, the **iliacus** (il-ī'ă-kŭs) and the **psoas** (sō'as) **major**, flex the hip. Because these muscles share a common insertion and produce the same movement, they often are referred to as the **iliopsoas** (il'ē-ō-sō'as). When the thigh is fixed, the iliopsoas flexes the trunk on the thigh. For example, the iliopsoas actually does most of the work when a person does sit-ups.

The posterolateral hip muscles consist of the gluteal muscles and the **tensor fasciae latae** (fash'ē-ē lă'tē). The **gluteus** (gloo-tē'ŭs) **maximus** contributes most of the mass that can be seen as the buttocks, and the **gluteus medius**, a common site for injections, creates a smaller mass just superior and lateral to the maximus. The gluteus maximus functions at its maximum force in extension of the thigh when the hip is flexed at a 45-degree angle so that the muscle is optimally stretched, which accounts for both the sprinter's stance and the bicycle racing posture.

The deep hip muscles function as lateral thigh rotators (see table 10.18). The gluteus medius and minimus muscles help tilt the pelvis during walking.

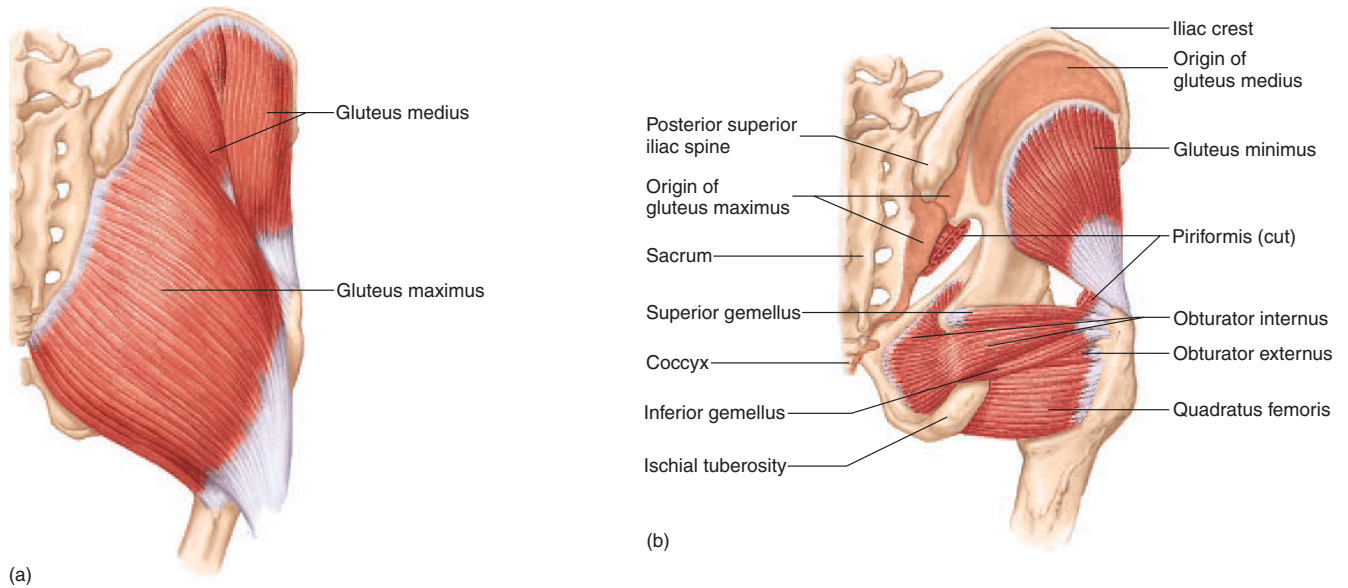
**Table 10.18** Muscles Acting on the Thigh (see figure 10.27)

| Muscle                                           | Origin                               | Insertion                                            | Nerve             | Action                                                                                          |
|--------------------------------------------------|--------------------------------------|------------------------------------------------------|-------------------|-------------------------------------------------------------------------------------------------|
| <b>Anterior</b>                                  |                                      |                                                      |                   |                                                                                                 |
| Iliopsoas<br>(il'ē-ō-sō'as)                      |                                      |                                                      |                   |                                                                                                 |
| Iliacus<br>(il-ī'ă-kus)                          | Iliac fossa                          | Lesser trochanter of femur and capsule of hip joint  | Lumbar plexus     | Flexes hip and laterally rotates thigh                                                          |
| Psoas major<br>(sō'as)                           | T12–L5                               | Lesser trochanter of femur                           | Lumbar plexus     | Flexes hip                                                                                      |
| <b>Posterior and Lateral</b>                     |                                      |                                                      |                   |                                                                                                 |
| Gluteus maximus<br>(gloo-tē'ūs mak'si-mūs)       | Ilium, sacrum, and coccyx            | Gluteal tuberosity of femur and the fascia lata      | Inferior gluteal  | Extends hip; abducts and laterally rotates thigh                                                |
| Gluteus medius<br>(gloo-tē'ūs mē'dē-ūs)          | Ilium                                | Greater trochanter of femur                          | Superior gluteal  | Abducts and medially rotates thigh; depresses side of pelvis                                    |
| Gluteus minimus<br>(gloo-tē'ūs min-i-mūs)        | Ilium                                | Greater trochanter of femur                          | Superior gluteal  | Abducts and medially rotates thigh; depresses side of pelvis                                    |
| Tensor fasciae latae<br>(ten'sôr fash'ē-ē lâ'tē) | Anterior superior iliac spine        | Through iliotibial tract to lateral condyle of tibia | Superior gluteal  | Tenses lateral fascia; flexes hip; abducts and medially rotates thigh; depresses side of pelvis |
| <b>Deep Thigh Rotators</b>                       |                                      |                                                      |                   |                                                                                                 |
| Gemellus<br>(jē-mel'ūs)                          |                                      |                                                      |                   |                                                                                                 |
| Inferior                                         | Ischial tuberosity                   | Obturator internus tendon                            | L5 and S1         | Laterally rotates and abducts thigh                                                             |
| Superior                                         | Ischial spine                        | Obturator internus tendon                            | L5 and S1         | Laterally rotates and abducts thigh                                                             |
| Obturator (ob'too-rā-tōr)                        |                                      |                                                      |                   |                                                                                                 |
| Externus<br>(eks-ter'nūs)                        | Inferior margin of obturator foramen | Greater trochanter of femur                          | Obturator         | Laterally rotates thigh                                                                         |
| Internus<br>(in-ter'nūs)                         | Margin of obturator foramen          | Greater trochanter of femur                          | Ischiadic plexus* | Laterally rotates and abducts thigh                                                             |
| Piriformis<br>(pir'i-fôr'mis)                    | Sacrum and ilium                     | Greater trochanter of femur                          | Ischiadic plexus* | Laterally rotates and abducts thigh                                                             |
| Quadratus femoris<br>(kwah'-drā'tūs fem'ō-ris)   | Ischial tuberosity                   | Intertrochanteric ridge of femur                     | Ischiadic plexus* | Laterally rotates thigh                                                                         |

\*Formerly referred to as the sciatic nerve.

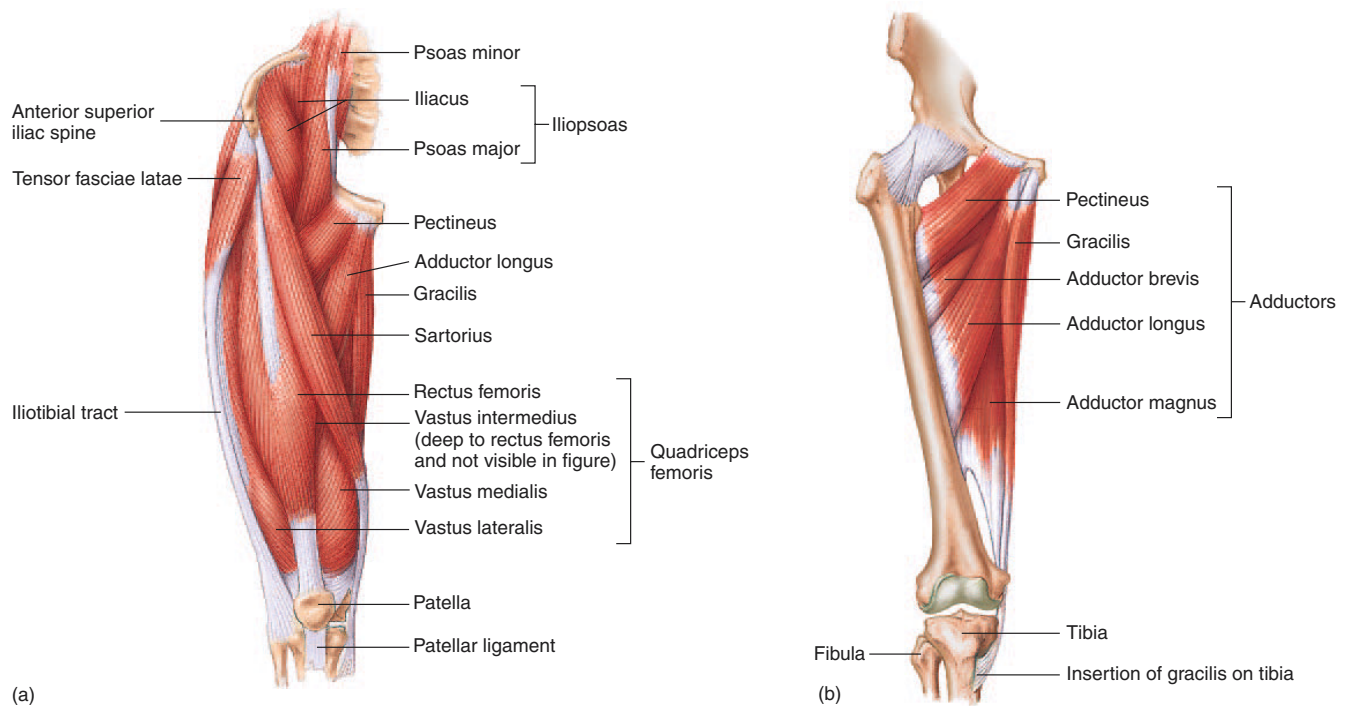
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**Figure 10.27** Muscles of the Posterior Hip

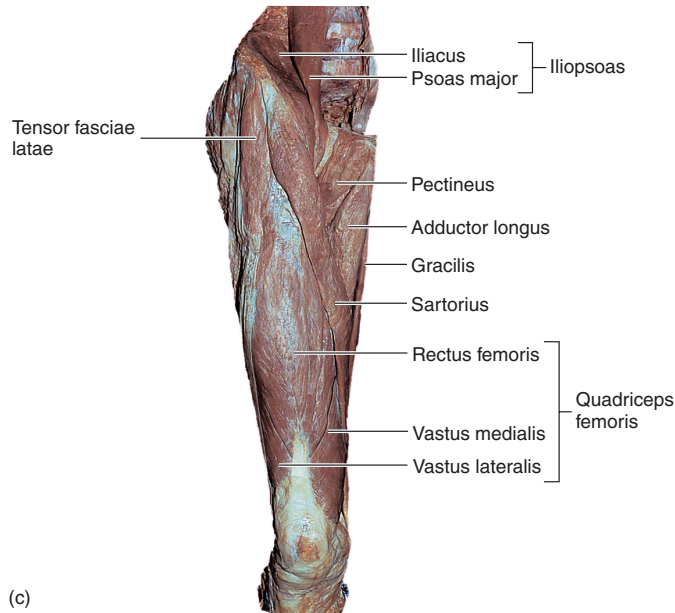
(a) Posterior view of the right hip, superficial. (b) Posterior view of the right hip, deep. Gluteus maximus and medius are removed to reveal deeper muscles. The piriformis is cut.



**Figure 10.28** Muscles of the Anterior Thigh

(a) Anterior view of the right thigh. (b) Adductor region of the right thigh. Tensor fasciae latae, sartorius, and quadriceps femoris muscles are removed.



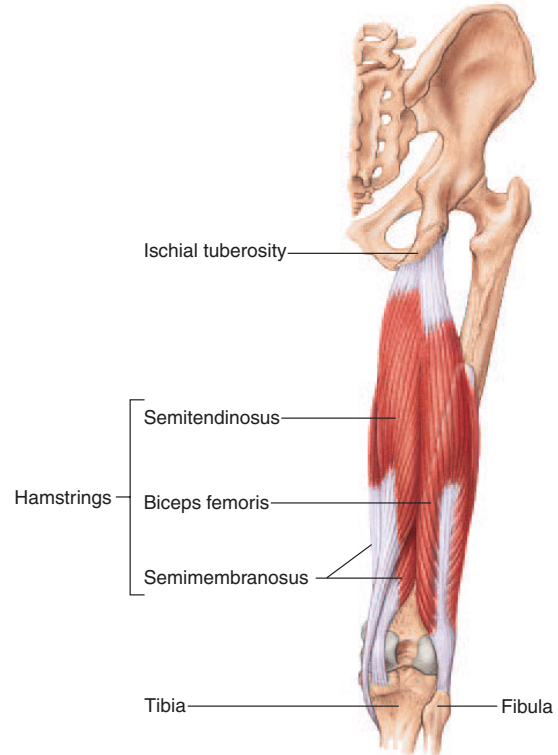


(c)

**Figure 10.28** (continued)

(c) Photograph of the thigh muscles.

In addition to the hip muscles, some of the muscles located in the thigh originate on the coxa and can cause movement of the thigh (tables 10.19 and 10.20). Three groups of thigh muscles have been identified based on their location in the thigh: the anterior, which flex the hip; the posterior, which extend the hip; and the medial, which adduct the thigh.



**Figure 10.29** Posterior Muscles of the Right Thigh

Hip muscles are removed.

**Table 10.19** Summary of Muscle Actions on the Hip and Thigh

| Flexion              | Extension       | Abduction                      | Adduction       | Medial Rotation      | Lateral Rotation   |
|----------------------|-----------------|--------------------------------|-----------------|----------------------|--------------------|
| Iliopsoas            | Gluteus maximus | Gluteus maximus                | Adductor magnus | Tensor fasciae latae | Gluteus maximus    |
| Tensor fasciae latae | Semitendinosus  | Gluteus medius                 | Adductor longus | Gluteus medius       | Obturator internus |
| Rectus femoris       | Semimembranosus | Gluteus minimus                | Adductor brevis | Gluteus minimus      | Obturator externus |
| Sartorius            | Biceps femoris  | Tensor fasciae latae           | Pectineus       |                      | Superior gemellus  |
| Adductor longus      | Adductor magnus | Obturator internus             | Gracilis        |                      | Inferior gemellus  |
| Adductor brevis      |                 | Gemellus superior and inferior |                 |                      | Quadratus femoris  |
| Pectineus            |                 | Piriformis                     |                 |                      | Piriformis         |
|                      |                 |                                |                 |                      | Adductor magnus    |
|                      |                 |                                |                 |                      | Adductor longus    |
|                      |                 |                                |                 |                      | Adductor brevis    |

**Table 10.20** Muscles of the Thigh (see figures 10.28 and 10.29)

| Muscle                                            | Origin                                                                                                                                           | Insertion                                                          | Nerve                                                | Action                                                                                |
|---------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Anterior Compartment</b>                       |                                                                                                                                                  |                                                                    |                                                      |                                                                                       |
| Quadriceps femoris<br>(kwah'dri-seps fem'ō-ris)   | Rectus femoris—<br>anterior inferior<br>iliac spine<br>Vastus lateralis—femur<br>Vastus intermedius—<br>femur<br>Vastus medialis—linea<br>aspera | Patella and onto tibial<br>tuberosity through<br>patellar ligament | Femoral                                              | Extends knee: rectus femoris<br>also flexes hip                                       |
| Sartorius<br>(sar-tōr'ē-ūs)                       | Anterior superior<br>iliac spine                                                                                                                 | Medial side of tibial<br>tuberosity                                | Femoral                                              | Flexes hip and knee: rotates<br>thigh laterally and leg medially                      |
| <b>Medial Compartment</b>                         |                                                                                                                                                  |                                                                    |                                                      |                                                                                       |
| Adductor brevis<br>(a-dūk'ter, a-dūk'tōr brev'is) | Pubis                                                                                                                                            | Femur                                                              | Obturator                                            | Adducts, laterally rotates thigh,<br>and flexes hip                                   |
| Adductor longus<br>(a-dūk'ter, a-dūk'tōr lon'gūs) | Pubis                                                                                                                                            | Femur                                                              | Obturator                                            | Adducts, laterally rotates thigh,<br>and flexes hip                                   |
| Adductor magnus<br>(a-dūk'ter, a-dūk'tōr mag'nūs) | Pubis and ischium                                                                                                                                | Femur                                                              | Obturator and<br>tibial                              | Adducts, laterally rotates thigh,<br>and extends hip                                  |
| Gracilis<br>(gras'i-lis)                          | Pubis near<br>symphysis                                                                                                                          | Tibia                                                              | Obturator                                            | Adducts thigh; flexes knee                                                            |
| Pectineus<br>(pek'ti-nē'ūs)                       | Pubic crest                                                                                                                                      | Pectineal line of femur                                            | Femoral and obturator                                | Adducts thigh and flexes hip                                                          |
| <b>Posterior Compartment</b>                      |                                                                                                                                                  |                                                                    |                                                      |                                                                                       |
| Biceps femoris<br>(bī'seps fem'ō-ris)             | Long head—ischial<br>tuberosity<br>Short head—femur                                                                                              | Head of fibula                                                     | Long head—tibial<br><br>Short head—common<br>fibular | Flexes knee and laterally rotates<br>leg; extends hip                                 |
| Semimembranosus<br>(sem'ē-mem-brā-nō'sūs)         | Ischial tuberosity                                                                                                                               | Medial condyle of tibia<br>and collateral ligament                 | Tibial                                               | Flexes knee and medially rotates<br>leg; tenses capsule<br>of knee joint; extends hip |
| Semitendinosus<br>(sem'ē-ten-di-nō'sūs)           | Ischial tuberosity                                                                                                                               | Tibia                                                              | Tibial                                               | Flexes knee and medially rotates<br>leg; extends hip                                  |

## Leg Movements

The anterior thigh muscles are the **quadriceps femoris** (fem'ō-ris) and the **sartorius** (sar-tōr'ē-ūs) (see table 10.20 and figure 10.28a). The quadriceps femoris is actually four muscles: the **rectus femoris**, the **vastus lateralis**, the **vastus medialis**, and the **vastus intermedius**. The quadriceps group extends the knee. The rectus femoris also flexes the hip because it crosses both the hip and knee joints. The vastus lateralis sometimes is used as an injection site, especially in infants who may not have well-developed deltoid or gluteal muscles. The muscles of the quadriceps femoris have a common insertion, the patellar tendon, on and around the patella. The patellar ligament is an extension of the patellar tendon onto the tibial tuberosity. The patellar ligament is the point that is tapped with a rubber hammer when testing the knee-jerk reflex in a physical examination.

The sartorius is the longest muscle of the body, crossing from the lateral side of the hip to the medial side of the knee. As the muscle contracts, it flexes the hip and knee and laterally rotates the thigh. This movement is the action required for crossing the legs.

## Sartorius—the Tailor's Muscle



The term *sartorius* means tailor. The sartorius muscle is so named because its action is to cross the legs, a common position traditionally preferred by tailors because they can hold their sewing in their lap as they sit and sew by hand.

The medial thigh muscles are involved primarily in adduction of the thigh (figure 10.28b and c). Some of these muscles also laterally rotate the thigh and/or flex or extend the hip. The gracilis also flexes the knee.

The posterior thigh muscles are collectively called the hamstring muscles and consist of the **biceps femoris**, **semimembranosus** (sem'ē-mem-brā-nō'sūs), and **semitendinosus** (sem'ē-ten-di-nō'sūs) (see table 10.20 and figure 10.29). Their tendons are easily felt and seen on the medial and lateral posterior aspect of a slightly bent knee (see figure 10.31).

## Hamstrings

The **hamstrings** are so named because in pigs these tendons can be used to suspend hams during curing. Some animals such as wolves often bring down their prey by biting through the hamstrings; therefore, “to hamstring” someone is to render the person helpless. A “pulled hamstring” results from tearing one or more of these muscles or their tendons, usually near the origin of the muscle.



## Ankle, Foot, and Toe Movements

Muscles of the leg that move the ankle and the foot are listed in table 10.21 and are illustrated in figures 10.30 and 10.31. These **extrinsic foot muscles** are divided into three groups, each located within a separate compartment of the leg (figure 10.32): anterior, posterior, and lateral. The anterior leg muscles are extensor muscles involved in dorsiflexion and eversion or inversion of the foot and extension of the toes.

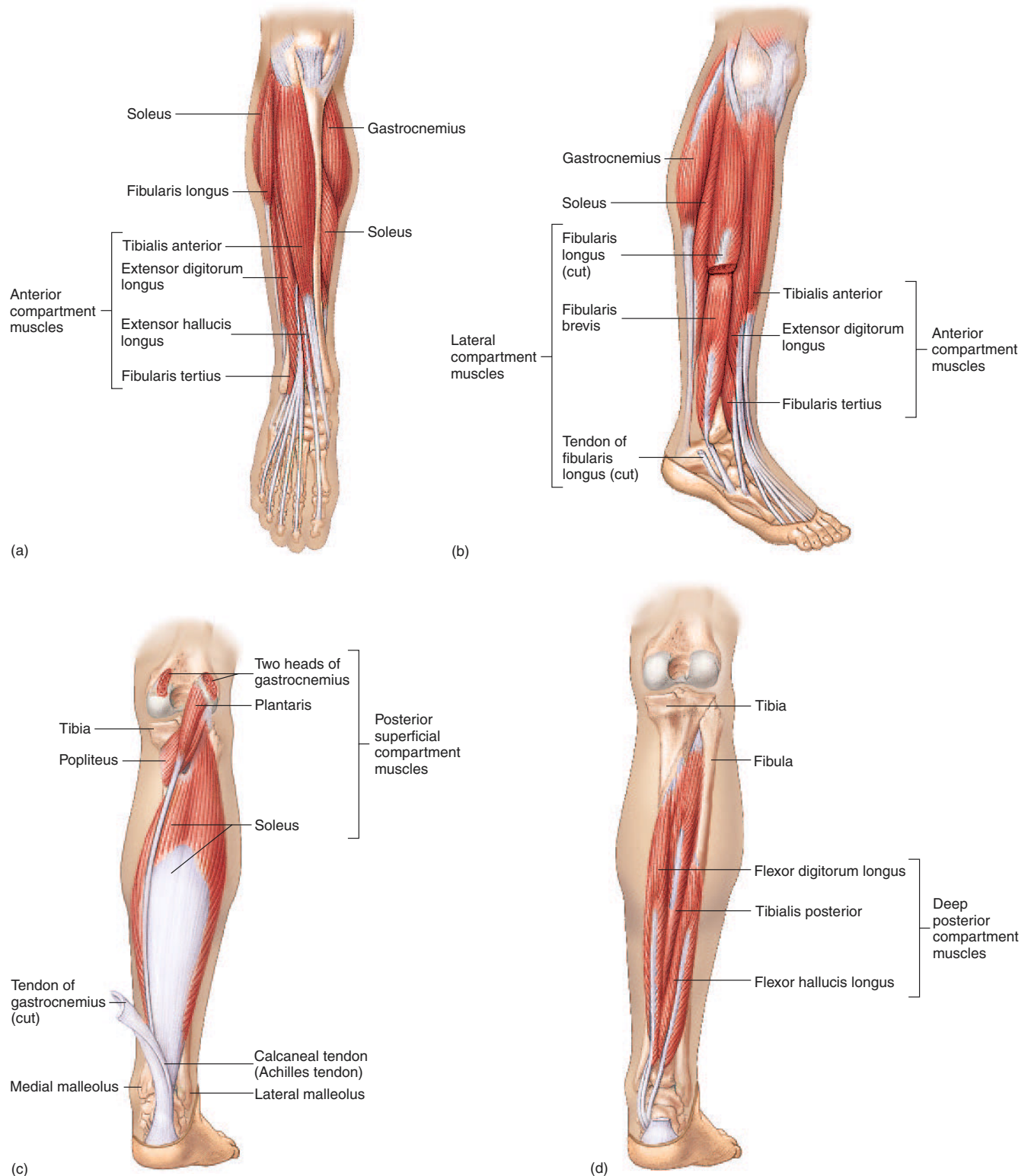
**Table 10.21** Muscles of the Leg Acting on the Leg, Ankle, and Foot (see figures 10.30 and 10.32)

| Muscle                                                              | Origin                                   | Insertion                                                            | Nerve                | Action                                                    |
|---------------------------------------------------------------------|------------------------------------------|----------------------------------------------------------------------|----------------------|-----------------------------------------------------------|
| <b>Anterior Compartment</b>                                         |                                          |                                                                      |                      |                                                           |
| Extensor digitorum longus<br>(dij'i-tōr'ŭm lon'gŭs)                 | Lateral condyle of tibia and fibula      | Four tendons to phalanges of four lateral toes                       | Deep fibular*        | Extends four lateral toes; dorsiflexes and everts foot    |
| Extensor hallucis longus<br>(hal'i-sis lon'gŭs)                     | Middle fibula and interosseous membrane  | Distal phalanx of great toe                                          | Deep fibular*        | Extends great toe; dorsiflexes and inverts foot           |
| Tibialis anterior<br>(tib-ē-a'lis)                                  | Tibia and interosseous membrane          | Medial cuneiform and first metatarsal                                | Deep fibular*        | Dorsiflexes and inverts foot                              |
| Fibularis tertius<br>(peroneus tertius)<br>(per'ō-nē'ŭs ter'shē-ŭs) | Fibula and interosseous membrane         | Fifth metatarsal                                                     | Deep fibular*        | Dorsiflexes and everts foot                               |
| <b>Posterior Compartment</b>                                        |                                          |                                                                      |                      |                                                           |
| <b>Superficial</b>                                                  |                                          |                                                                      |                      |                                                           |
| Gastrocnemius<br>(gas-trok-nē'mē-ŭs)                                | Medial and lateral condyles of femur     | Through calcaneal (Achilles) tendon to calcaneus                     | Tibial               | Plantar flexes foot; flexes knee                          |
| Plantaris<br>(plan-tār'is)                                          | Femur                                    | Through calcaneal tendon to calcaneus                                | Tibial               | Plantar flexes foot; flexes knee                          |
| Soleus<br>(sō-lē'ŭs)                                                | Fibula and tibia                         | Through calcaneal tendon to calcaneus                                | Tibial               | Plantar flexes foot                                       |
| <b>Deep</b>                                                         |                                          |                                                                      |                      |                                                           |
| Flexor digitorum longus<br>(dij'i-tōr'ŭm lon'gŭs)                   | Tibia                                    | Four tendons to distal phalanges of four lateral toes                | Tibial               | Flexes four lateral toes; plantar flexes and inverts foot |
| Flexor hallucis longus<br>(hal'i-sis lon'gŭs)                       | Fibula                                   | Distal phalanx of great toe                                          | Tibial               | Flexes great toe; plantar flexes and inverts foot         |
| Popliteus<br>(pop-li-tē'ŭs)                                         | Lateral femoral condyle                  | Posterior tibia                                                      | Tibial               | Flexes knee and medially rotates leg                      |
| Tibialis posterior<br>(tib-ē-a'lis)                                 | Tibia, interosseous membrane, and fibula | Navicular, cuneiforms, cuboid, and second through fourth metatarsals | Tibial               | Plantar flexes and inverts foot                           |
| <b>Lateral Compartment</b>                                          |                                          |                                                                      |                      |                                                           |
| Fibularis brevis<br>(peroneus brevis)<br>(fib-ŭ-lā'ris brev'is)     | Fibula                                   | Fifth metatarsal                                                     | Superficial fibular* | Everts and plantar flexes foot                            |
| Fibularis longus<br>(peroneus longus)<br>(fib-ŭ-lā'ris lon'gŭs)     | Fibula                                   | Medial cuneiform and first metatarsal                                | Superficial fibular* | Everts and plantar flexes foot                            |

\*Formerly referred to as the peroneal nerve.

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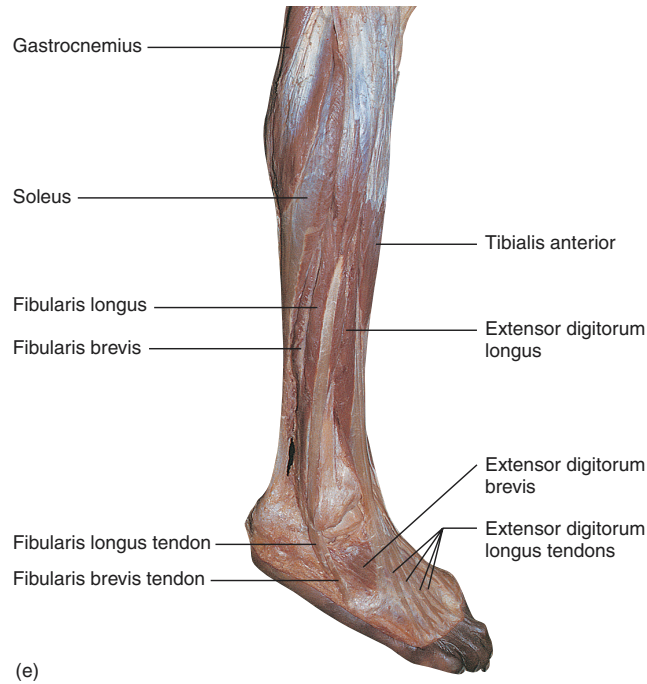
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**Figure 10.30 Muscles of the Leg**

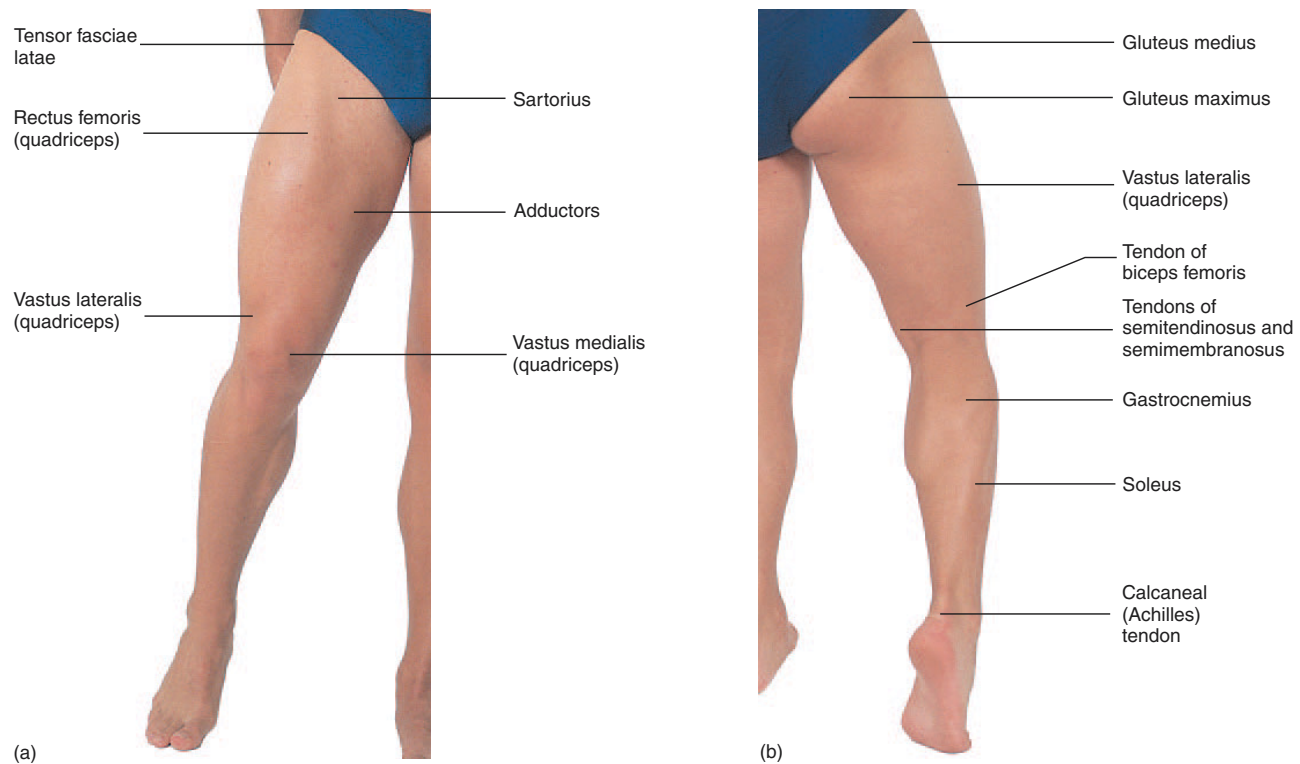
(a) Anterior view of the right leg. (b) Lateral view of the right leg. (c) Posterior view of the right calf, superficial. Gastrocnemius is removed. (d) Posterior view of the right calf, deep. Gastrocnemius, plantaris, and soleus muscles are removed.





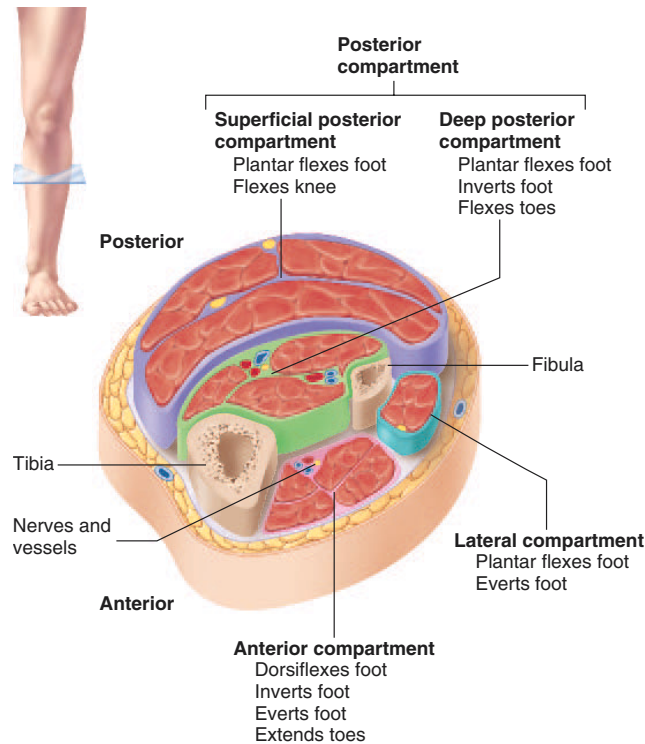
**Figure 10.30** (continued)

(e) Photograph of leg muscles.



**Figure 10.31** Surface Anatomy, Muscles of the Lower Limb

(a) Anterior view. (b) Posterior view.



**Figure 10.32** Cross Section Through the Right Leg

Drawing of the muscular compartments.

### Shinsplints

**Shinsplints** is a catchall term involving any one of the following four conditions associated with pain in the anterior portion of the leg:

1. Excessive stress on the tibialis posterior, resulting in pain along the origin of the muscle.
2. Tibial periostitis, an inflammation of the tibial periosteum.
3. Anterior compartment syndrome. During hard exercise, the anterior compartment muscles may swell with blood. The overlying fascia is very tough and does not expand; thus the nerves and vessels are compressed, causing pain.
4. Stress fracture of the tibia 2–5 cm distal to the knee.

The best treatment for any of these types of shinsplints is to rest the leg for 1–4 weeks, depending on the type of shinsplint.

The superficial muscles of the posterior compartment, the **gastrocnemius** (gas-trok-nē'mē-ūs) and **soleus**, form the bulge of the calf (posterior leg) (see figures 10.30 and 10.31). They join with the small **plantaris** muscle to form the common **calcaneal** (kal-kā'nē-al), or **Achilles, tendon** (see figure 10.30c). These muscles are involved in plantar flexion of the foot. The deep muscles of the posterior compartment plantar flex and invert the foot and flex the toes.

### Achilles Tendon

The **Achilles tendon** derives its name from a hero of Greek mythology. When Achilles was a baby, his mother dipped him into magic water, which made him invulnerable to harm everywhere the water touched his skin. His mother, however, held him by the heel and failed to submerge this part of his body under the water. Consequently, his heel was vulnerable and proved to be his undoing; he was shot in the heel with an arrow at the battle of Troy and died. Thus, saying that someone has an “Achilles’ heel” means that the person has a weak spot that can be attacked.

The lateral muscles are primarily everters of the foot, but they also aid plantar flexion.

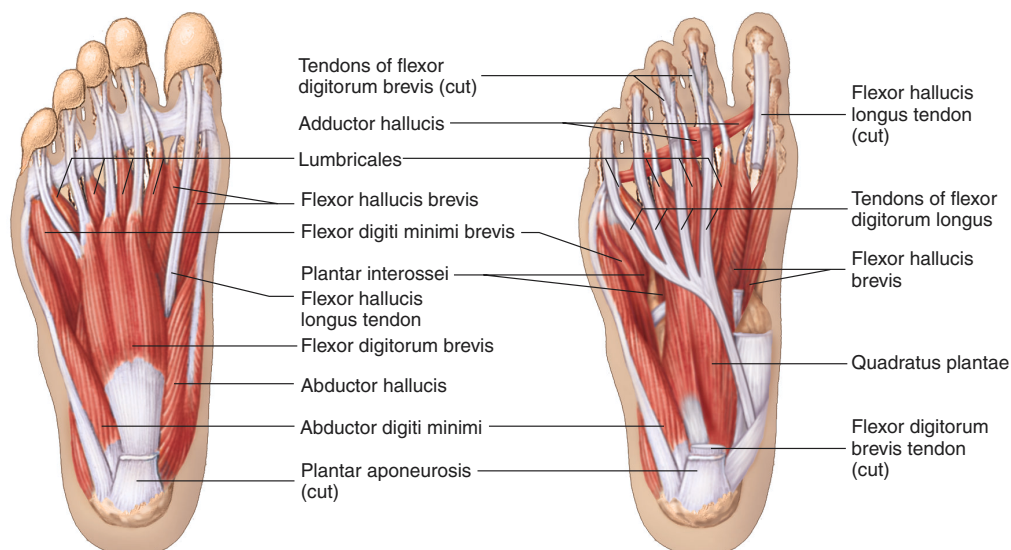
**Intrinsic foot muscles**, located within the foot itself (table 10.22 and figure 10.33), flex, extend, abduct, and adduct the toes. They are arranged in a manner similar to that of the intrinsic muscles of the hand.

26. Name the anterior hip muscle that flexes the hip. What muscles act as synergists to this muscle?
27. Describe the movements produced by the gluteus muscles.
28. Name the muscle compartments of the thigh and the movements produced by the muscles of each compartment. List the muscles of each compartment and the individual action of each muscle.
29. How is it possible for thigh muscles to move both the thigh and the leg? Name at least four muscles that can do this.
30. What movements are produced by the three muscle compartments of the leg? Name the muscles of each compartment, and describe the movements for which each muscle is responsible.
31. What movement do the fibularis (peroneus) muscles have in common? The tibialis muscles?
32. Name the leg muscles that flex the knee. Which of them can also plantar flex the foot?
33. List the general actions performed by the intrinsic foot muscles.

**Table 10.22** Intrinsic Muscles of the Foot (see figure 10.33)

| Muscle                                                                     | Origin                                   | Insertion                                                          | Nerve                         | Action                                                         |
|----------------------------------------------------------------------------|------------------------------------------|--------------------------------------------------------------------|-------------------------------|----------------------------------------------------------------|
| Abductor digiti minimi<br>(ab-dŭk'ter, ab-dŭk'tŏr<br>dij'i-tī min'i-mī)    | Calcaneus                                | Proximal phalanx of<br>fifth toe                                   | Lateral plantar               | Abducts and flexes little toe                                  |
| Abductor hallucis<br>(ab-dŭk'ter, ab-dŭk'tŏr<br>hal'i-sis)                 | Calcaneus                                | Great toe                                                          | Medial plantar                | Abducts great toe                                              |
| Adductor hallucis<br>(a-dŭk'ter, a-dŭk'tŏr<br>hal'i-sis) (not illustrated) | Lateral four<br>metatarsals              | Proximal phalanx of<br>great toe                                   | Lateral plantar               | Adducts great toe                                              |
| Extensor digitorum brevis<br>(dij'i-tŏr'ŭm brev'is)<br>(not illustrated)   | Calcaneus                                | Four tendons fused<br>with tendons of extensor<br>digitorum longus | Deep fibular*                 | Extends toes                                                   |
| Flexor digiti minimi brevis<br>(dij'i-tī min'i-mī<br>brev'is)              | Fifth metatarsal                         | Proximal phalanx of<br>fifth digit                                 | Lateral plantar               | Flexes little toe (proximal<br>phalanx)                        |
| Flexor digitorum brevis<br>(dij'i-tŏr'ŭm brev'is)                          | Calcaneus and<br>plantar fascia          | Four tendons to middle<br>phalanges of four<br>lateral toes        | Medial plantar                | Flexes lateral four toes                                       |
| Flexor hallucis brevis<br>(hal'i-sis brev'is)                              | Cuboid; medial<br>and lateral cuneiforms | Two tendons to proximal<br>phalanx of great toe                    | Medial and lateral<br>plantar | Flexes great toe                                               |
| Dorsal interossei<br>(in'ter-os'e-ī)<br>(not illustrated)                  | Metatarsal bones                         | Proximal phalanges of<br>second, third, and<br>fourth digits       | Lateral plantar               | Abduct second, third, and<br>fourth toes; adduct second<br>toe |
| Plantar interossei<br>(plan'tār in'ter-os'e-ī)                             | Third, fourth, and<br>fifth metatarsals  | Proximal phalanges<br>of third, fourth, and<br>fifth digits        | Lateral plantar               | Adduct third, fourth, and<br>fifth toes                        |
| Lumbricales<br>(lum'bri-kā-lēz)                                            | Tendons of flexor<br>digitorum longus    | Second through fifth<br>digits                                     | Lateral and medial<br>plantar | Flex proximal and extend<br>middle and distal phalanges        |
| Quadratus plantae<br>(kwah'drā'tŭs plan'tē)                                | Calcaneus                                | Tendons of flexor<br>digitorum longus                              | Lateral plantar               | Flexes toes                                                    |

\*Formerly referred to as the peroneal nerve.



**Figure 10.33** Muscles of the Foot

Plantar view of the right foot.

## Clinical Focus Bodybuilding

Bodybuilding is a popular sport worldwide. Participants in this sport combine diet and specific weight training to develop maximum muscle mass and minimum body fat, with their major goal being a well-balanced, complete physique. An uninformed, untrained muscle builder can build some muscles and ignore others; the result is a disproportioned body. Skill, training, and concentration are required to build a well-proportioned, muscular body and to know which exercises build a large number of muscles and which are specialized to build certain parts of the body. Is the old adage “no pain, no gain” correct? Not really. Overexercising can cause small tears in muscles and soreness. Torn muscles are weaker, and it may take up to 3 weeks to repair the damage, even though the soreness may only last 5–10 days.

Bodybuilders concentrate on increasing skeletal muscle mass. Endurance tests conducted years ago demonstrated that the cardiovascular and respiratory abilities of bodybuilders were similar to those abilities in normal, healthy persons untrained in a sport. More recent studies, however, indicate that the cardiorespiratory fitness of bodybuilders is similar to that of other well-trained athletes. The difference between



Figure A Bodybuilders

the results of the new studies and the older ones is attributed to modern bodybuilding techniques that include aerobic exercise and running, as well as “pumping iron.”

Bodybuilding has its own language. Bodybuilders refer to the “lats,” “traps,” and “deltoids” rather than the latissimus dorsi, trapezius, and deltoids. The exer-

cises also have special names such as “lat pulldowns,” “preacher curls,” and “triceps extensions.”

Photographs of bodybuilders are very useful in the study of anatomy because they enable easy identification of the surface anatomy of muscles that cannot usually be seen in untrained people (figure A).

## S U M M A R Y

Body movements result from the contraction of skeletal muscles.

### General Principles (p. 314)

1. The less movable end of a muscle attachment is the origin; the more movable end is the insertion.
2. Synergists are muscles that function together to produce movement. Antagonists oppose or reverse the movement of another muscle.
3. Prime movers are mainly responsible for a movement. Fixators stabilize the action of prime movers.

### Muscle Shapes

Muscle shape is determined primarily by the arrangement of muscle fasciculi.

### Nomenclature

Muscles are named according to their location, size, shape, orientation of fasciculi, origin and insertion, number of heads, or function.

### Movements Accomplished by Muscles

Contracting muscles generate a force that acts on bones (levers) across joints (fulcrums) to create movement. Three classes of levers have been identified.

### Head Muscles (p. 319)

#### Head and Neck Muscles

Origins of these muscles are mainly on the cervical vertebrae (except for the sternocleidomastoid); insertions are on the occipital bone or mastoid process. They cause flexion, extension, rotation, abduction, and adduction of the head.

#### Facial Expression

Origins of facial muscles are on skull bones or fascia; insertions are into the skin, causing movement of the facial skin, lips, and eyelids.

#### Mastication

Three pairs of muscles close the jaw; gravity opens the jaw. Forced opening is caused by the lateral pterygoids and the hyoid muscles.

#### Tongue Movements

Intrinsic tongue muscles change the shape of the tongue; extrinsic tongue muscles move the tongue.



## Swallowing and the Larynx

1. Hyoid muscles can depress the jaw and assist in swallowing.
2. Muscles open and close the openings to the nasal cavity, auditory tubes, and larynx.

## Movements of the Eyeball

Six muscles with their origins on the orbital bones insert on the eyeball and cause it to move within the orbit.

## Trunk Muscles (p. 332)

### Muscles Moving the Vertebral Column

1. These muscles extend, abduct, rotate, or flex the vertebral column.
2. A deep group of muscles connects adjacent vertebrae.
3. A more superficial group of muscles runs from the pelvis to the skull, extending from the vertebrae to the ribs.

## Thoracic Muscles

1. Most respiratory movement is caused by the diaphragm.
2. Muscles attached to the ribs aid in respiration.

## Abdominal Wall

Abdominal wall muscles hold and protect abdominal organs and cause flexion, rotation, and lateral flexion of the vertebral column.

## Pelvic Floor and Perineum

These muscles support the abdominal organs inferiorly.

## Upper Limb Muscles (p. 338)

### Scapular Movements

Six muscles attach the scapula to the trunk and enable the scapula to function as an anchor point for the muscles and bones of the arm.

## Arm Movements

Seven muscles attach the humerus to the scapula. Two additional muscles attach the humerus to the trunk. These muscles cause flexion and extension of the shoulder and abduction, adduction, rotation, and circumduction of the arm.

## Forearm Movements

1. Flexion and extension of the elbow are accomplished by three muscles located in the arm and two in the forearm.
2. Supination and pronation are accomplished primarily by forearm muscles.

## Wrist, Hand, and Finger Movements

1. Forearm muscles that originate on the medial epicondyle are responsible for flexion of the wrist and fingers. Muscles extending the wrist and fingers originate on the lateral epicondyle.
2. Extrinsic hand muscles are in the forearm. Intrinsic hand muscles are in the hand.

## Lower Limb Muscles (p. 349)

### Thigh Movements

1. Anterior pelvic muscles cause flexion of the hip.
2. Muscles of the buttocks are responsible for extension of the hip and abduction and rotation of the thigh.
3. The thigh can be divided into three compartments.
  - The medial compartment muscles adduct the thigh.
  - The anterior compartment muscles flex the hip.
  - The posterior compartment muscles extend the hip.

## Leg Movements

Some muscles of the thigh also act on the leg. The anterior thigh muscles extend the leg, and the posterior thigh muscles flex the leg.

## Ankle, Foot, and Toe Movements

1. The leg is divided into three compartments.
  - Muscles in the anterior compartment cause dorsiflexion, inversion, or eversion of the foot and extension of the toes.
  - Muscles of the lateral compartment plantar flex and evert the foot.
  - Muscles of the posterior compartment flex the leg, plantar flex and invert the foot, and flex the toes.
2. Intrinsic foot muscles flex or extend and abduct or adduct the toes.

## R E V I E W A N D C O M P R E H E N S I O N

1. Muscles that oppose one another are
  - a. synergists.
  - b. levers.
  - c. hateful.
  - d. antagonists.
  - e. fixators.
2. The most movable attachment of a muscle is its
  - a. origin.
  - b. insertion.
  - c. fascia.
  - d. fulcrum.
  - e. belly.
3. Which of these muscles is correctly matched with its type of fascicle orientation?
  - a. pectoralis major—pennate
  - b. transversus abdominis—circular
  - c. temporalis—convergent
  - d. biceps femoris—parallel
  - e. orbicularis oris—parallel
4. The muscle whose name means it is larger and round is the
  - a. gluteus maximus.
  - b. vastus lateralis.
  - c. teres major.
  - d. latissimus dorsi.
  - e. adductor magnus.
5. In a class III lever system the
  - a. fulcrum is located between the pull and the weight.
  - b. weight is located between the fulcrum and the pull.
  - c. pull is located between the fulcrum and the weight.
6. A prominent lateral muscle of the neck that can cause flexion of the neck or rotate the head is the
  - a. digastric.
  - b. mylohyoid.
  - c. sternocleidomastoid.
  - d. buccinator.
  - e. platysma.

Chapter 10 Muscular System: Gross Anatomy

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7. Harry Wolf has just picked up his date for the evening. She's wearing a stunning new outfit. Harry shows his appreciation by moving his eyebrows up and down, winking, smiling, and finally kissing her. Given the muscles listed:
  1. zygomaticus
  2. levator labii superioris
  3. occipitofrontalis
  4. orbicularis oris
  5. orbicularis oculi
 In which order did Harry use these muscles?
  - a. 2,3,4,1
  - b. 2,5,3,1
  - c. 2,5,4,3
  - d. 3,5,1,4
  - e. 3,5,2,4
8. An aerial circus performer who supports herself only by her teeth while spinning around should have strong
  - a. temporalis muscles.
  - b. masseter muscles.
  - c. buccinator muscles.
  - d. both a and b.
  - e. all of the above.
9. The tongue curls and folds *primarily* because of the action of the
  - a. extrinsic tongue muscles.
  - b. intrinsic tongue muscles.
10. The infrahyoid muscles
  - a. elevate the mandible.
  - b. move the mandible from side to side.
  - c. fix (prevent movement of) the hyoid.
  - d. both a and b.
  - e. all of the above.
11. The soft palate muscles
  - a. prevent food from entering the nasal cavity.
  - b. close the auditory tube.
  - c. force food into the esophagus.
  - d. prevent food from entering the larynx.
  - e. elevate the larynx.
12. Which of these movements is *not* caused by contraction of the erector spinae muscles?
  - a. flexion of the vertebral column
  - b. lateral flexion of the vertebral column
  - c. extension of the vertebral column
  - d. rotation of the vertebral column
13. Which of these muscles is (are) responsible for flexion of the vertebral column (below the neck)?
  - a. deep back muscles
  - b. superficial back muscles (erector spinae)
  - c. rectus abdominis
  - d. both a and b
  - e. all of the above
14. Which of these muscles is *not* involved with the inspiration of air?
  - a. diaphragm
  - b. external intercostals
  - c. scalene
  - d. transversus thoracis
15. Given these muscles:
  1. external abdominal oblique
  2. internal abdominal oblique
  3. transversus abdominis
 Choose the arrangement that lists the muscles from most superficial to deepest.
  - a. 1,2,3
  - b. 1,3,2
  - c. 2,1,3
  - d. 2,3,1
  - e. 3,1,2
16. Tendinous intersections
  - a. attach the rectus abdominis muscles to the xiphoid process.
  - b. divide the rectus abdominis muscles into segments.
  - c. separate the abdominal wall from the thigh.
  - d. are the site of exit of blood vessels from the abdomen into the thigh.
  - e. are the central point of attachment for all the abdominal muscles.
17. Which of these muscles can both elevate and depress the scapula?
  - a. rhomboideus major and minor
  - b. levator scapulae
  - c. serratus anterior
  - d. trapezius
  - e. pectoralis minor
18. Which of these muscles does *not* adduct the arm (humerus)?
  - a. latissimus dorsi
  - b. deltoid
  - c. teres major
  - d. pectoralis major
  - e. coracobrachialis
19. Which of these muscles abducts the arm (humerus)?
  - a. supraspinatus
  - b. infraspinatus
  - c. teres minor
  - d. teres major
  - e. subscapularis
20. Which of these muscles would you expect to be especially well developed in a boxer known for his powerful jab (punching straight ahead)?
  - a. biceps brachii
  - b. brachialis
  - c. trapezius
  - d. triceps brachii
  - e. supinator
21. Which of these muscles is an antagonist of the triceps brachii?
  - a. biceps brachii
  - b. anconeus
  - c. latissimus dorsi
  - d. brachioradialis
  - e. supinator
22. The posterior group of forearm muscles is responsible for
  - a. flexion of the wrist.
  - b. flexion of the fingers.
  - c. extension of the fingers.
  - d. both a and b.
  - e. all of the above.
23. Which of these muscle(s) is an intrinsic hand muscle that moves the thumb?
  - a. thenar muscles
  - b. hypothenar muscles
  - c. flexor pollicis longus
  - d. extensor pollicis longus
  - e. all of the above
24. Which of these muscles can extend the hip?
  - a. gluteus maximus
  - b. gluteus medius
  - c. gluteus minimus
  - d. tensor fasciae latae
  - e. sartorius

25. Given these muscles:
  1. iliopsoas
  2. rectus femoris
  3. sartoriusWhich of the muscles act to flex the hip?
  - a. 1
  - b. 1,2
  - c. 1,3
  - d. 2,3
  - e. 1,2,3
26. Which of these muscles is found in the medial compartment of the thigh?
  - a. rectus femoris
  - b. sartorius
  - c. gracilis
  - d. vastus medialis
  - e. semitendinosus
27. Which of these is *not* a muscle that can flex the knee?
  - a. biceps femoris
  - b. vastus medialis
  - c. gastrocnemius
  - d. gracilis
  - e. sartorius
28. The \_\_\_\_\_ muscles evert the foot, whereas the \_\_\_\_\_ muscles invert the foot.
  - a. fibularis (peroneus), gastrocnemius
  - b. fibularis (peroneus), tibialis
  - c. tibialis, fibularis (peroneus)
  - d. tibialis, flexor
  - e. flexor, extensor
29. Which of these muscles causes plantar flexion of the foot?
  - a. tibialis anterior
  - b. extensor digitorum longus
  - c. fibularis (peroneus) tertius
  - d. soleus
  - e. sartorius

Answers in Appendix F

## C R I T I C A L T H I N K I N G

1. For each of the following muscles, (1) describe the movement that the muscle produces, and (2) name the muscles that act as synergists and antagonists for them: longus capitis, erector spinae, coracobrachialis.
2. Propose an exercise that would benefit each of the following muscles specifically: biceps brachii, triceps brachii, deltoid, rectus abdominis, quadriceps femoris, and gastrocnemius.
3. Consider only the effect of the brachioradialis muscle for this question. If a weight is held in the hand and the forearm is flexed, what type of lever system is in action? If the weight is placed on the forearm? Which system can lift more weight, and how far?
4. A patient was involved in an automobile accident in which the car was “rear-ended,” resulting in whiplash injury of the head (hyperextension). What neck muscles might be injured in this type of accident? What is the easiest way to prevent such injury in an automobile accident?
5. During surgery, a branch of the patient’s facial nerve was accidentally cut on one side of the face. As a result, after the operation, the lower eyelid and the corner of the patient’s mouth drooped on that side of the face. What muscles were apparently affected?
6. When a person becomes unconscious, the tongue muscles relax, and the tongue tends to retract or fall back and obstruct the airway. Which tongue muscle is responsible? How can this be prevented or reversed?
7. The mechanical support of the head of the humerus in the glenoid fossa is weakest in the inferior direction. What muscles help prevent dislocation of the shoulder when a heavy weight such as a suitcase is carried?
8. How would paralysis of the quadriceps femoris of the left leg affect a person’s ability to walk?
9. Speedy Sprinter started a 200 m dash and fell to the ground in pain. Examination of her right leg revealed the following symptoms: inability to plantar flex the foot against resistance, normal ability to evert the foot, dorsiflexion of the foot more than normal, and abnormal bulging of the calf muscles. Explain the nature of her injury.
10. What muscles are required to turn this page?

Answers in Appendix G

## A N S W E R S T O P R E D I C T Q U E S T I O N S

1. Shortening the right sternocleidomastoid muscle rotates the head to the left. It also slightly elevates the chin.
2. Raising eyebrows—occipitofrontalis; winking—orbicularis oculi and then levator palpebrae superioris; whistling—orbicularis oris and buccinator; smiling—levator anguli oris, risorius, zygomaticus major, and zygomaticus minor; frowning—corrugator supercilii and procerus; flaring nostrils—levator labii superioris alaeque nasi and nasalis.
3. Weakness of the lateral rectus allows the eye to deviate medially.
4. Pain in one of the four rotator cuff muscles, which are associated with abduction, involves the supraspinatus. The pain occurs because as the arm is abducted the supraspinatus tendon rubs against the acromion process.
5. Two arm muscles are involved in flexion of the elbow: the brachialis and the biceps brachii. The brachialis only flexes, whereas the biceps brachii both flexes the elbow and supinates the forearm. With the forearm supinated, both muscles can flex the elbow optimally; when pronated, the biceps brachii does less to flex the elbow. Chin-ups with the elbow supinated are therefore easier because both muscles flex the forearm optimally in this position. Bodybuilders who wish to build up the brachialis muscle perform chin-ups with the forearms pronated.

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