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Muscles of the thigh to upper calf (MRI)

CHAPTER

10

The Muscular System

CHAPTER OUTLINE

INSIGHTS

Brushing Up

To understand this chapter, it is important that you understand or brush up on the following concepts:
- Gross anatomy of the skeleton (chapter 8)
- Movements of synovial joints (pp. 302–307)

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The **muscular system** consists of about 600 skeletal muscles—striated muscles that are usually attached to bone. (The term does not include smooth or cardiac muscle.) The form and function of the muscular system occupy a place of central importance in several fields of health care and fitness. Physical and occupational therapists must be well acquainted with the muscular system to design and carry out rehabilitation programs. Nurses and other health-care providers often move patients who are physically incapacitated, and to do this safely and effectively requires an understanding of joints and muscles. Even to give intramuscular injections safely requires a knowledge of the muscles and the nerves and blood vessels associated with them. Coaching, movement science, sports medicine, and dance benefit from a knowledge of skeletomuscular anatomy and mechanics.

Myology,[1] the study of muscles, is closely related to what we have covered in the preceding chapters. It relates muscle attachments to the bone structures described in chapter 8 and muscle function to the joint movements described in chapter 9. In this chapter, we consider the gross anatomy of the muscular system and how it relates to joint movements. In chapter 11, we examine the mechanisms of muscle contraction at the cellular and molecular levels.

The Structural and Functional Organization of Muscles

Objectives

When you have completed this section, you should be able to

- list several functions of muscles;
- describe the connective tissues associated with a skeletal muscle;
- explain what is meant by the origin, insertion, belly, action, and innervation of a muscle;
- describe the various shapes of skeletal muscles and relate this to their functions;
- describe the ways that muscles work in groups to aid, oppose, or moderate each other's actions;
- distinguish between intrinsic and extrinsic muscles; and
- translate several Latin words commonly used in the naming of muscles.

The Functions of Muscles

A muscle is an organ specialized to produce movement of a body part. Its cells convert the chemical energy of ATP into the mechanical energy of motion and exert a useful pull on another tissue. More specifically, muscle contraction serves the following overlapping functions:

- **Movement.** Most obviously, the muscles enable us to move from place to place and to move individual body parts. Muscular contractions also move body contents in the course of respiration, circulation, digestion, defecation, urination, and childbirth.
- **Stability.** Muscles maintain posture by resisting the pull of gravity and preventing unwanted movements. They hold some articulating bones in place by maintaining tension on the tendons.
- **Communication.** Muscles are used for facial expression, other body language, writing, and speech.
- **Control of body openings and passages.** Ringlike *sphincter muscles* around the eyelids, pupils, and mouth control the admission of light, food, and drink into the body; others that encircle the urethral and anal orifices control elimination of waste; and other sphincters control the movement of food, bile, and other materials through the body.
- **Heat production.** The skeletal muscles produce as much as 85% of our body heat, which is vital to the functioning of enzymes and therefore to all of our metabolism.

Some of these functions are shared by skeletal, cardiac, and smooth muscle. The remainder of this chapter, however, is concerned only with skeletal muscles.

Connective Tissues of a Muscle

A skeletal muscle is composed of both muscular tissue and connective tissue (fig. 10.1). A skeletal muscle cell (muscle fiber) is about 10 to 100 μm in diameter and up to 30 cm long. It is surrounded by a sparse layer of areolar connective tissue called the **endomysium**[2] (EN-doe-MIZ-ee-um), which allows room for blood capillaries and nerve fibers to reach each muscle fiber. Muscle fibers are grouped in bundles called **fascicles**[3] (FASS-ih-culs), which are visible to the naked eye as parallel strands. These are the "grain" in a cut of meat; tender meat is easily pulled apart along its fascicles. Each fascicle is separated from neighboring ones by a connective tissue sheath called the **perimysium,**[4] usually somewhat thicker than the endomysium. The muscle as a whole is surrounded by still another connective tissue layer, the **epimysium.**[5] The epimysium grades imperceptibly into connective tissue sheets called **fasciae** (FASH-ee-ee)—**deep fasciae** between adjacent muscles and a **superficial fascia** (hypodermis) between the muscles and skin. The superficial fascia is very adipose in areas such as the buttocks and abdomen, but the deep fasciae are devoid of fat.

There are two ways a muscle can attach to a bone. In a **direct (fleshy) attachment,** collagen fibers of the epimy-

[1] *myo* = muscle + *logy* = study of

[2] *endo* = within + *mys* = muscle
[3] *fasc* = bundle + *icle* = little
[4] *peri* = around
[5] *epi* = upon, above

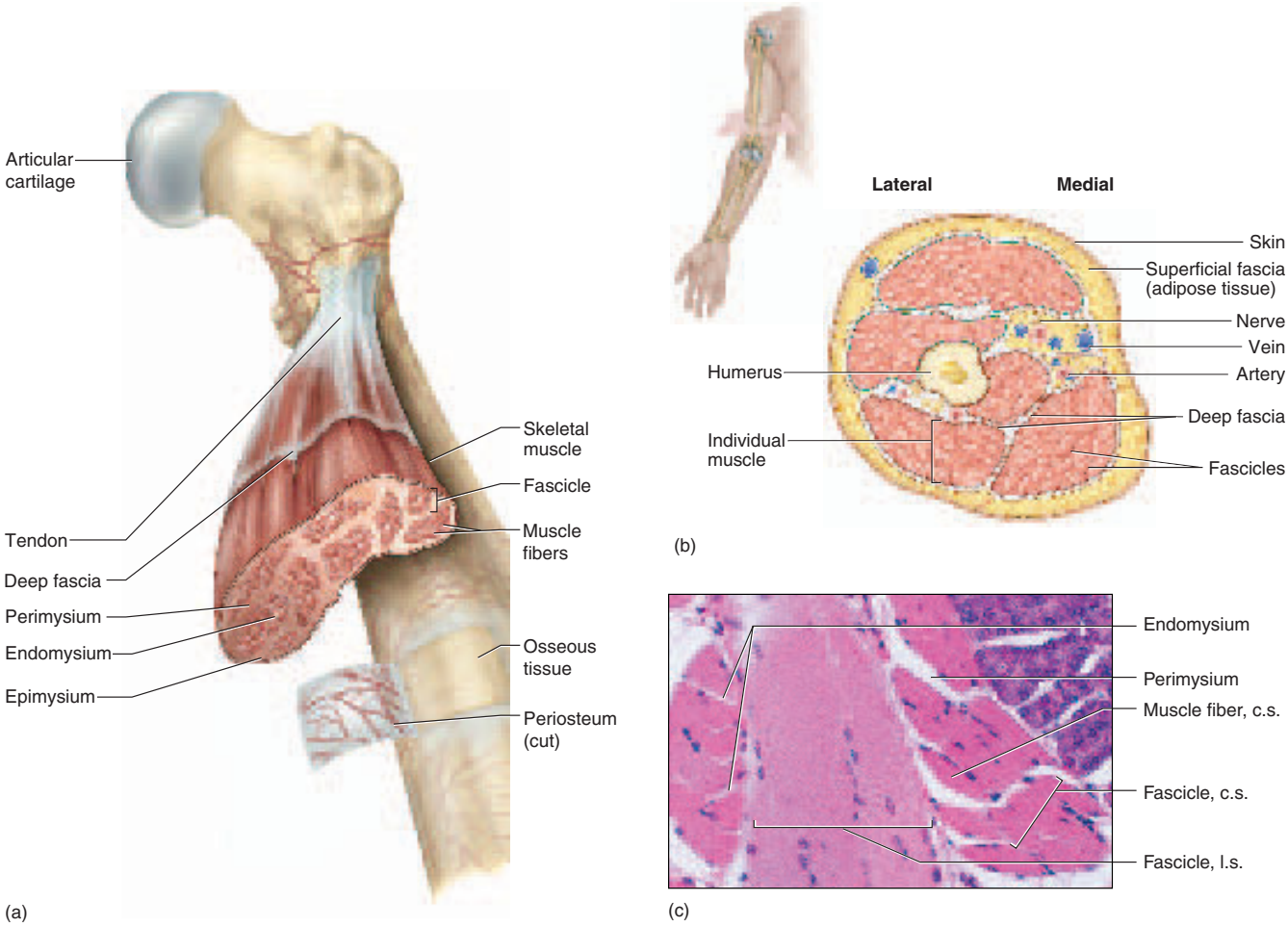

Figure 10.1 Connective Tissues of a Muscle. (*a*) The muscle-bone attachment. Here there is a continuity of connective tissues from the endomysium around the muscle fibers, to the perimysium, epimysium, deep fascia, and tendon, grading into the periosteum and finally the matrix of the bone. (*b*) A cross section of the arm showing the relationship of neighboring muscles to fascia and bone. (*c*) Muscle fascicles in the tongue. Vertical fascicles passing between the dorsal and ventral surfaces of the tongue are seen alternating with cross-sectioned horizontal fascicles that pass from the tip to the rear of the tongue. A fibrous perimysium can be seen between the fascicles, and endomysium between the muscle fibers within each fascicle.

sium are continuous with the periosteum, the fibrous sheath around a bone. The red muscle tissue appears to emerge directly from the bone. The *intercostal muscles* between the ribs show this type of attachment. In an **indirect attachment,** the collagen fibers of the epimysium continue as a strong fibrous **tendon** that merges into the periosteum of a nearby bone (fig. 10.1*a*). The attachment of the *biceps brachii muscle* to the scapula is one of many examples. Some collagen fibers of the periosteum continue into the bone matrix as *perforating fibers* (see chapter 7), so there is a strong structural continuity from endomysium to perimysium to epimysium to tendon to periosteum to bone matrix. Excessive stress is more likely to tear a tendon than to pull it loose from the muscle or bone.

In some cases, the epimysium of one muscle attaches to the fascia or tendon of another or to collagen fibers of the dermis. The ability of a muscle to produce facial expressions depends on the latter type of attachment. Some muscles are connected to a broad sheetlike tendon called an **aponeurosis**[6] (AP-oh-new-RO-sis). This term originally referred to the tendon located beneath the scalp, but now it also refers to similar tendons associated with certain abdominal, lumbar, hand, and foot muscles (see figs. 10.15*a* and 10.16).

In some places, groups of tendons from separate muscles pass under a band of connective tissue called a

[6] *apo* = upon, above + *neuro* = nerve

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retinaculum.[7] One of these covers each surface of the wrist like a bracelet, for example. The tendons of several forearm muscles pass under them on their way to the hand.

General Anatomy of Skeletal Muscles

Most skeletal muscles are attached to a different bone at each end, so either the muscle or its tendon spans at least one joint. When the muscle contracts, it moves one bone relative to the other. The muscle attachment at the relatively stationary end is called its **origin,** or **head.** Its attachment at the more mobile end is called its **insertion.** Many muscles are narrow at the origin and insertion and have a thicker middle region called the **belly** (fig. 10.2).

The strength of a muscle and the direction in which it pulls are determined partly by the orientation of its fascicles, illustrating the complementarity of form and function. Differences in fascicle orientation are the basis for classifying muscles into five types (fig. 10.3):

1. **Fusiform**[8] **muscles** are thick in the middle and tapered at each end. Their contractions are moderately strong. The *biceps brachii* of the arm and *gastrocnemius* of the calf are examples of this type.
2. **Parallel muscles** are long, straplike muscles of uniform width and parallel fascicles. They can span a great distance and shorten more than other muscle types, but they are weaker than fusiform muscles. Examples include the *rectus abdominis* of the abdomen, *sartorius* of the thigh, and *zygomaticus major* of the face.
3. **Convergent muscles** are fan-shaped—broad at the origin and converging toward a narrower insertion. These muscles are relatively strong because all of their fascicles exert their tension on a relatively small insertion. The *pectoralis major* in the chest is a muscle of this type.
4. **Pennate**[9] **muscles** are feather-shaped. Their fascicles insert obliquely on a tendon that runs the length of the muscle, like the shaft of a feather. There are three types of pennate muscles: *unipennate,* in which all fascicles approach the tendon from one side (for example, the *palmar interosseous muscles* of the hand and *semimembranosus* of the thigh); *bipennate,* in which fascicles approach the tendon from both sides (for example, the *rectus femoris* of the thigh); and *multipennate,* shaped like a bunch of feathers with their quills converging on a single point (for example, the *deltoid* of the shoulder).
5. **Circular muscles (sphincters)** form rings around body openings. These include the *orbicularis oris* of the lips and *orbicularis oculi* of the eyelids.

[7] *retinac* = retainer, bracelet + *cul* = little
[8] *fusi* = spindle + *form* = shape

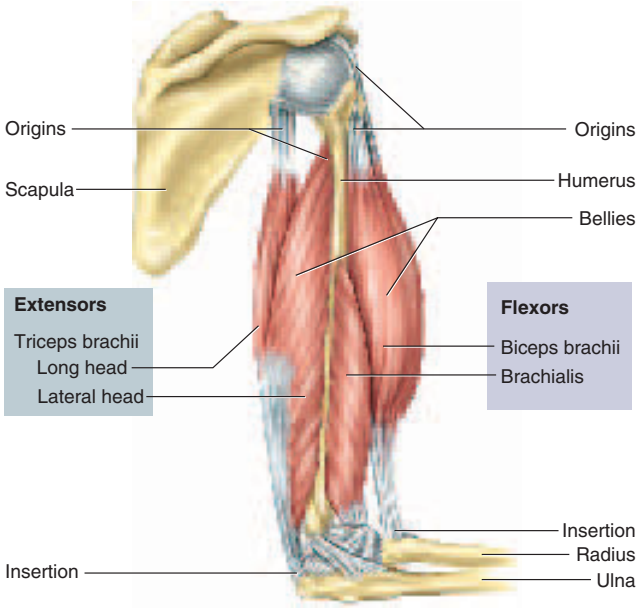

Figure 10.2 Synergistic and Antagonistic Muscle Pairs. The biceps brachii and brachialis muscles are synergists in elbow flexion. The triceps brachii is an antagonist of those two muscles and is the prime mover in elbow extension.

Coordinated Action of Muscle Groups

The movement produced by a muscle is called its **action.** Skeletal muscles seldom act independently; instead, they function in groups whose combined actions produce the coordinated motion of a joint. Muscles can be classified into at least four categories according to their actions, but it must be stressed that a particular muscle can act in a certain way during one joint action and in a different way during other actions of the same joint:

1. The **prime mover (agonist)** is the muscle that produces most of the force during a particular joint action. In flexing the elbow, for example, the prime mover is the biceps brachii.
2. A **synergist**[10] (SIN-ur-jist) is a muscle that aids the prime mover. Several synergists acting on a joint can produce more power than a single larger muscle. The *brachialis,* for example, lies deep to the biceps brachii and works with it as a synergist to flex the elbow. The actions of a prime mover and its

[9] *penna* = feather
[10] *syn* = together + *erg* = work

Chapter 10

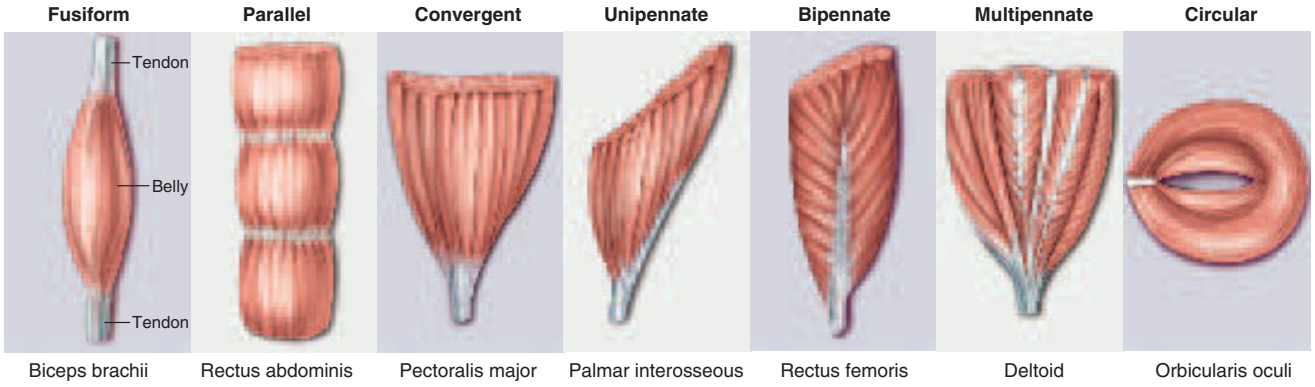

Figure 10.3 Classification of Muscles According to Fascicle Orientation. The fascicles are the "grain" visible in each illustration.

synergist are not necessarily identical and redundant. If the prime mover worked alone at a joint, it might cause rotation or other undesirable movements of a bone. A synergist may stabilize a joint and restrict these movements, or modify the direction of a movement, so that the action of the prime mover is more coordinated and specific.

3. An **antagonist**[11] is a muscle that opposes the prime mover. In some cases, it relaxes to give the prime mover almost complete control over an action. More often, however, the antagonist moderates the speed or range of the agonist, thus preventing excessive movement and joint injury. If you extend your arm to reach out and pick up a cup of tea, your *triceps brachii* is the prime mover of elbow extension and your biceps brachii acts as an antagonist to slow the extension and stop it at the appropriate point. If you extend your arm rapidly to throw a dart, the biceps must be quite relaxed. The biceps and triceps brachii represent an **antagonistic pair** of muscles that act on opposite sides of a joint (see fig. 10.2). We need antagonistic pairs at a joint because a muscle can only pull, not push—a single muscle cannot flex *and* extend the elbow, for example. Which member of the pair acts as the agonist depends on the motion under consideration. In flexion of the elbow, the biceps is the agonist and the triceps is the antagonist; when the elbow is extended, their roles are reversed.
4. A **fixator** is a muscle that prevents a bone from moving. To *fix* a bone means to hold it steady, allowing another muscle attached to it to pull on something else. For example, consider again the flexion of the elbow by the biceps brachii. The biceps originates on the scapula and inserts on the radius. The scapula is loosely attached to the axial skeleton, so when the biceps contracts, it seems that it would pull the scapula laterally. There are fixator muscles attached to the scapula, however, that contract at the same time. By holding the scapula firmly in place, they ensure that the force generated by the biceps moves the radius rather than the scapula.

[11] *ant* = against + *agonist* = competitor

Intrinsic and Extrinsic Muscles

In places such as the tongue, larynx, back, hand, and foot, anatomists distinguish between intrinsic and extrinsic muscles. An **intrinsic muscle** is entirely contained within a particular region, having both its origin and insertion there. An **extrinsic muscle** acts upon a designated region but has its origin elsewhere. For example, some movements of the fingers are produced by extrinsic muscles in the forearm, whose long tendons reach to the phalanges; other finger movements are produced by the intrinsic muscles located between the metacarpal bones of the hand.

Muscle Innervation

Innervation means the nerve supply to an organ. Knowing the innervation to each muscle enables clinicians to diagnose nerve and spinal cord injuries from their effects on muscle function and to set realistic goals for rehabilitation. The muscle tables of this chapter identify the innervation of each muscle. This information will be more meaningful after you have studied the peripheral nervous system (see chapters 13 and 14), but a brief orientation will be helpful here. Muscles of the head and neck are supplied by *cranial nerves* that arise from the base of the brain and emerge through the skull foramina. Cranial nerves are identified by numerals I to XII, although not all 12 of them innervate skeletal muscles. Muscles elsewhere are supplied by *spinal nerves,* which originate in the spinal cord, emerge

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through the intervertebral foramina, and branch into a *dorsal* and *ventral ramus*.[12] The spinal nerves are identified by letters and numbers that refer to the vertebrae—for example, T6 for the sixth thoracic nerve and S2 for the second sacral nerve. You will note references to nerve numbers and rami in many of the muscle tables. The term *plexus* in some of the tables refers to weblike networks of spinal nerves adjacent to the vertebral column. All of the nerves named here are illustrated, and most are also discussed, in chapters 13 and 14 (see tables 13.3–13.6 and 14.2).

How Muscles Are Named

Most of this chapter is a descriptive inventory of muscles, including their location, action, origin, insertion, and innervation. Learning the names of the muscles is much easier when you have some appreciation of the meanings behind the words. The Latin and English muscle names in this chapter are from the *Terminologia Anatomica* (T.A.) (see chapter 1). Although this book gives most terms in English rather than Latin, the customary English names for skeletal muscles are, at most, only slight modifications of the Latin names—for example, *anterior scalene muscle* is a derivative of the T.A. term, *musculus scalenus anterior.*

Some muscle names are several words long—for example, the *flexor digiti minimi brevis,* a "short muscle that flexes the little finger." Such names may seem intimidating at first, but they are really more of a help than an obstacle to understanding if you gain a little insight into the most commonly used Latin words. Several of these are interpreted in table 10.1, and others are explained in footnotes throughout the chapter. Familiarity with these terms will help you translate muscle names and remember the location, appearance, and action of the muscles.

A Learning Strategy

In the remainder of this chapter, we consider about 160 muscles. Many of the relatively superficial ones are shown in figure 10.4. The following suggestions may help you develop a rational strategy for learning the muscular system:

- Examine models, cadavers, dissected animals, or a photographic atlas as you read about these muscles. Visual images are often easier to remember than words, and direct observation of a muscle may stick in your memory better than descriptive text or two-dimensional drawings.
- When studying a particular muscle, palpate it on yourself if possible. Contract the muscle to feel it bulge and sense its action. This makes muscle locations and actions less abstract. Atlas B following this chapter shows where you can see and palpate several of these muscles on the living body.
- Locate the origins and insertions of muscles on an articulated skeleton. Some study skeletons are painted and labeled to show these. This helps you visualize the locations of muscles and understand how they produce particular joint actions.
- Study the derivation of each muscle name; the name usually describes the muscle's location, appearance, origin, insertion, or action.
- Say the names aloud to yourself or a study partner. It is harder to remember and spell terms you cannot pronounce, and silent pronunciation is not nearly as effective as speaking and hearing the names. Pronunciation guides are provided in the muscle tables for all but the most obvious cases.

[12] *ramus* = branch

Before You Go On

Answer the following questions to test your understanding of the preceding section:

1. List some functions of the muscular system other than movement of the body.
2. Describe the relationship of endomysium, perimysium, and epimysium to each other. Which of these separates one fascicle from another? Which separates one muscle from another?
3. Distinguish between direct and indirect muscle attachments to bones.
4. Define *origin, insertion, belly, action,* and *innervation.*
5. Describe the five basic muscle shapes (fascicle arrangements).
6. Distinguish among a synergist, antagonist, and fixator. Explain how each of these may affect the action of an agonist.
7. In muscle names, what do the words *brevis, teres, digitorum, pectoralis, triceps,* and *profundus* mean?

Muscles of the Head and Neck

Objectives

When you have completed this section, you should be able to

- name and locate the muscles that produce facial expressions;
- name and locate the muscles used for chewing and swallowing;
- name and locate the neck muscles that move the head; and
- identify the origin, insertion, action, and innervation of any of these muscles.

Muscles of Facial Expression

One of the most striking contrasts between a human face and that of a rat, horse, or dog, for example, is the variety and subtlety of human facial expression. This is made possible by a complex array of small muscles that insert in the

Table 10.1 Words Commonly Used to Name Muscles

Criterion	Term and Meaning	Examples of Usage
Size	*Major (large)*	*Pectoralis major*
	Maximus (largest)	*Gluteus maximus*
	Minor (small)	*Pectoralis minor*
	Minimus (smallest)	*Gluteus minimus*
	Longus (long)	*Abductor pollicis longus*
	Brevis (short)	*Extensor pollicis brevis*
Shape	*Rhomboideus (rhomboidal)*	*Rhomboideus major*
	Trapezius (trapezoidal)	*Trapezius*
	Teres (round, cylindrical)	*Pronator teres*
	Deltoid (triangular)	*Deltoid*
Location	*Capitis (of the head)*	*Splenius capitis*
	Cervicis (of the neck)	*Semispinalis cervicis*
	Pectoralis (of the chest)	*Pectoralis major*
	Thoracis (of the thorax)	*Spinalis thoracis*
	Intercostal (between the ribs)	*External intercostals*
	Abdominis (of the abdomen)	*Rectus abdominis*
	Lumborum (of the lower back)	*Quadratus lumborum*
	Femoris (of the femur, or thigh)	*Quadriceps femoris*
	Peroneus (of the fibula)	*Peroneus longus*
	Brachii (of the arm)	*Biceps brachii*
	Carpi (of the wrist)	*Flexor carpi ulnaris*
	Digiti (of a finger or toe, singular)	*Extensor digiti minimi*
	Digitorum (of the fingers or toes, plural)	*Flexor digitorum profundus*
	Pollicis (of the thumb)	*Opponens pollicis*
	Indicis (of the index finger)	*Extensor indicis*
	Hallucis (of the great toe)	*Abductor hallucis*
	Superficialis (superficial)	*Flexor digitorum superficialis*
	Profundus (deep)	*Flexor digitorum profundus*
Number of Heads	*Biceps (two heads)*	*Biceps femoris*
	Triceps (three heads)	*Triceps brachii*
	Quadriceps (four heads)	*Quadriceps femoris*
Orientation	*Rectus (straight)*	*Rectus abdominis*
	Transversus (transverse)	*Transversus abdominis*
	Oblique (slanted)	*External abdominal oblique*
Action	*Adductor (adducts a body part)*	*Adductor pollicis*
	Abductor (abducts a body part)	*Abductor digiti minimi*
	Flexor (flexes a joint)	*Flexor carpi radialis*
	Extensor (extends a joint)	*Extensor carpi radialis*
	Pronator (pronates forearm)	*Pronator teres*
	Supinator (supinates forearm)	*Supinator*
	Levator (elevates a body part)	*Levator scapulae*
	Depressor (depresses a body part)	*Depressor anguli oris*

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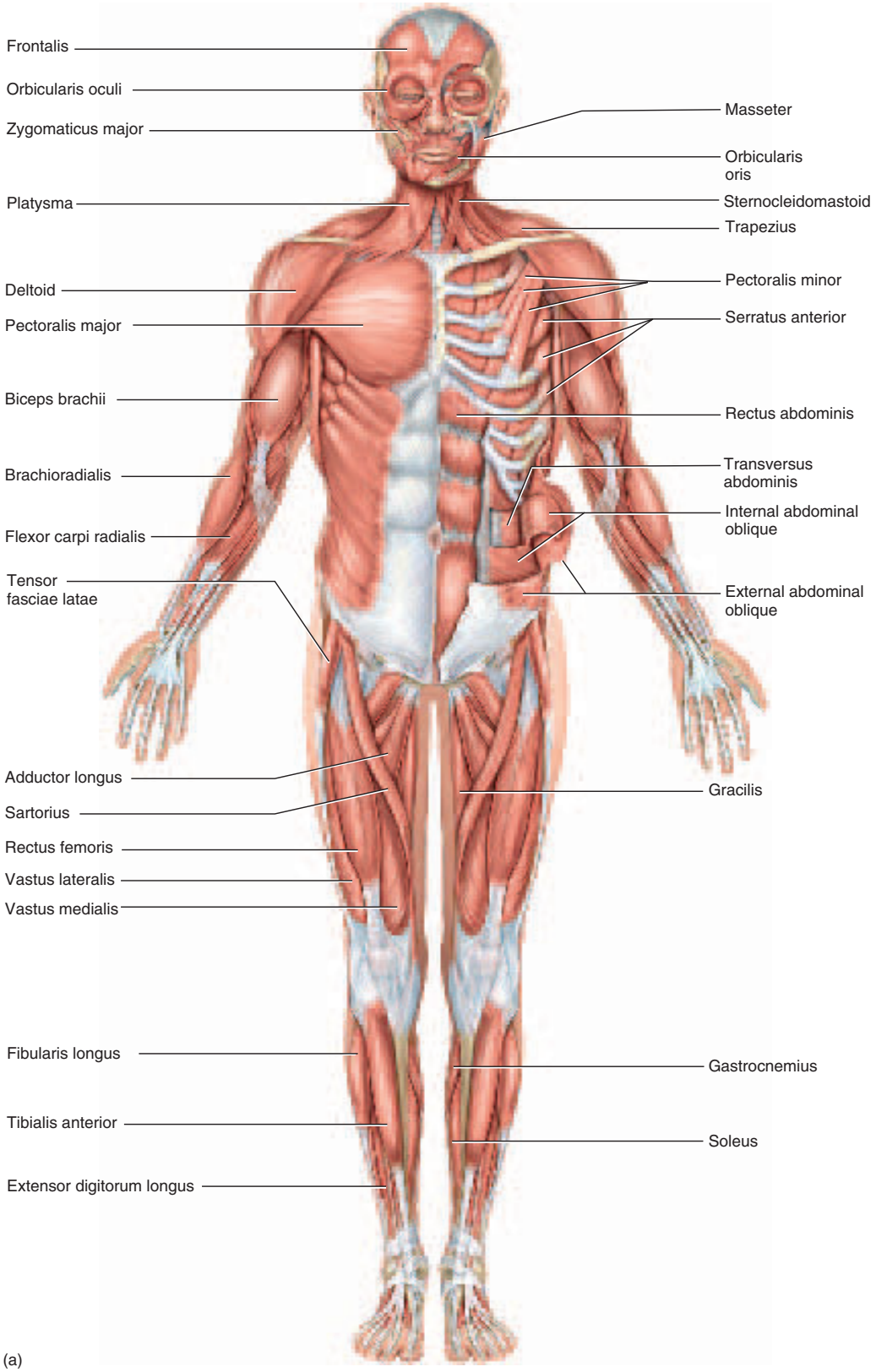

Figure 10.4 **The Muscular System.** (*a*) Anterior aspect. In each figure, major superficial muscles are shown on the anatomical *right*, and some of the deeper muscles of the trunk are shown on the *left*. Muscles not labeled here are shown in more detail in later figures.

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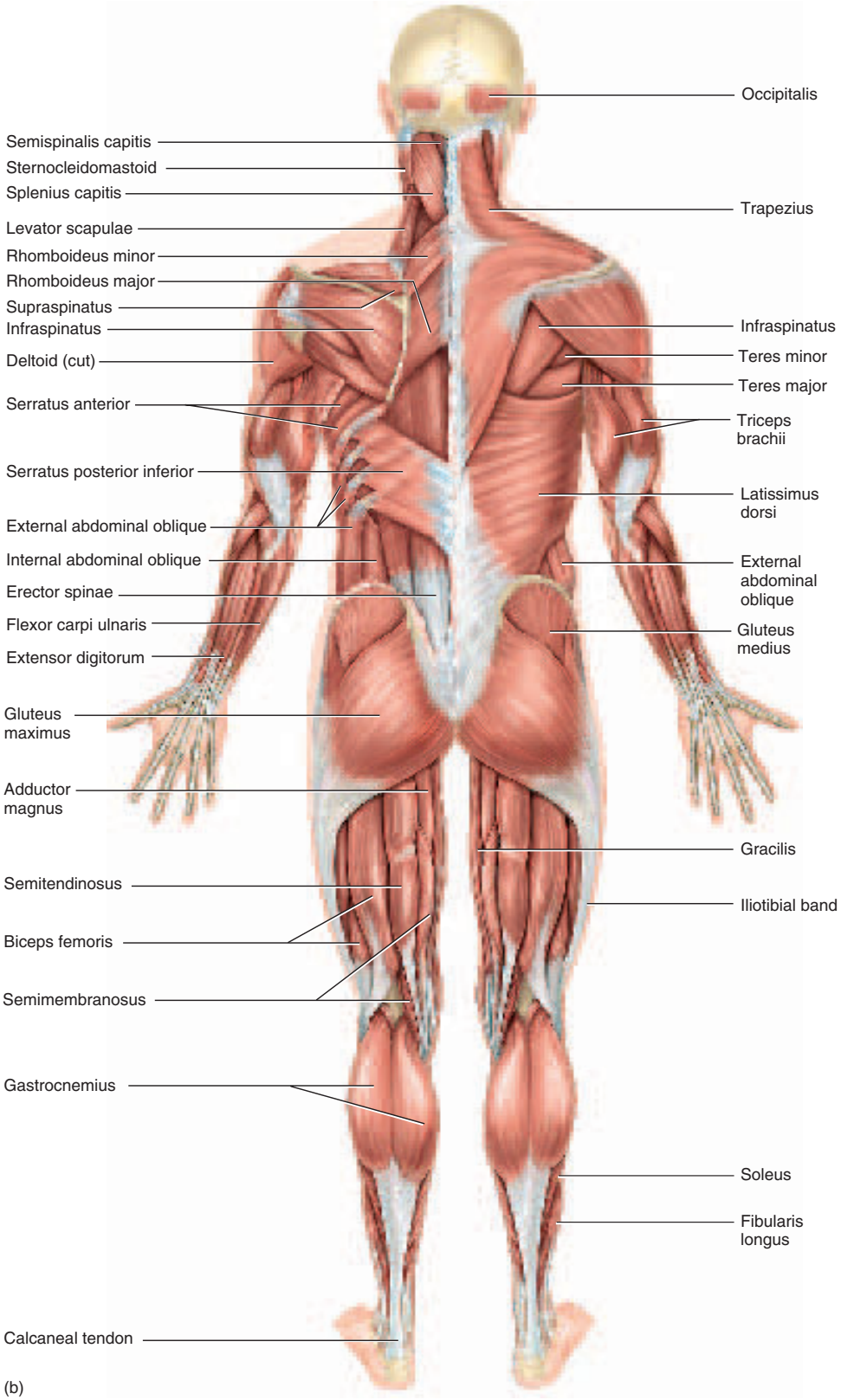

Figure 10.4 **The Muscular System *(continued).*** (*b*) Posterior aspect. In each figure, major superficial muscles are shown on the anatomical *right*, and some of the deeper muscles of the trunk are shown on the *left*. Muscles not labeled here are shown in more detail in later figures.

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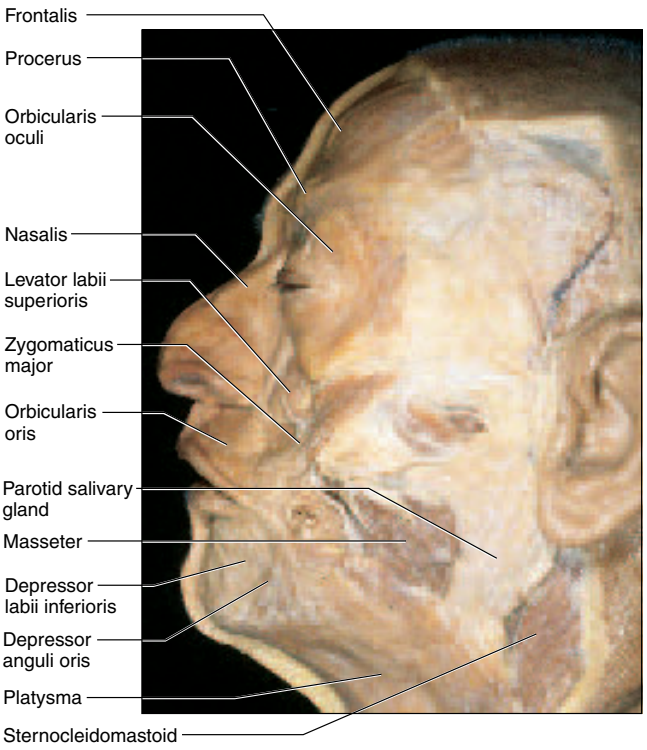

Figure 10.5 **Some Muscles of Facial Expression in the Cadaver.**

dermis and tense the skin when they contract (fig. 10.5). These muscles produce expressions as diverse as a pleasant smile, a threatening scowl, a puzzled frown, and a flirtatious wink (fig. 10.6). They add subtle shades of meaning to our spoken words and are enormously important in nonverbal communication.

We will briefly "tour" the scalp and face to get a general idea of the locations and actions of these muscles. Table 10.2 gives the details of their origins, insertions, and innervations. All of these muscles but one are innervated by branches of the facial nerve (cranial nerve VII). This nerve is especially vulnerable to damage from lacerations and skull fractures, which can paralyze the innervated muscles and cause parts of the face to sag.

The **occipitofrontalis** is the muscle of the scalp. It is divided into the **frontalis** of the forehead and **occipitalis** at the rear of the head, connected to each other by a broad aponeurosis, the **galea aponeurotica**[13] (GAY-lee-uh AP-oh-new-ROT-ih-cuh) (fig. 10.7). The occipitofrontalis moves the scalp, forehead skin, and eyebrows.

Each eye is encircled by the **orbicularis oculi,**[14] a sphincter that closes the eye. The **levator palpebrae superioris**[15] opens the eye; it lies deep to the orbicularis oculi in the eyelid and roof of the orbit. Other muscles of the orbital and nasal regions—the **corrugator supercilii,**[16] **procerus,**[17] and **nasalis**[18]—are described in table 10.2. Muscles within the orbit that produce movements of the eye itself are discussed in chapter 16.

The mouth is the most expressive part of the face, so it is not surprising that the muscles here are especially diverse. It is surrounded by the **orbicularis oris,**[19] a sphincter that closes the lips. Several other muscles approach the orbicularis oris from all directions. The first major muscle lateral to the nose is the **levator labii superioris,** a triangular muscle that originates at the middle of the orbicularis oculi. Next is the **zygomaticus**[20] **minor,** which originates near the lateral corner of the eye. Both of these converge on the orbicularis oris. The **zygomaticus major** originates in front of the ear and inserts on the superolateral corner of the mouth. The **levator anguli oris** originates on the maxilla and likewise inserts on the superolateral corner of the mouth. The **risorius**[21] approaches the mouth horizontally and inserts at the junction of the upper and lower lips. From their insertions, you can probably guess that the last five muscles draw the upper lip upward and laterally in such expressions as smiling and laughing.

Along the lower lip are muscles that draw it downward. The most lateral is the **depressor anguli oris,**[22] also known as the *triangularis* because of its shape. Lying deep to it and a little more medially is the **depressor labii inferioris.** Most medially, near the mental protuberance, is a pair of tiny **mentalis**[23] muscles. Unlike the other two, the mentalis muscles do not depress the lip. They originate on the mandible and insert in the dermis of the chin. When they contract, they pull the soft tissues of the chin upward, which wrinkles the chin, pushes the lower lip outward, and creates a pouting expression. People with especially thick mentalis muscles have a groove between them, the *mental cleft,* externally visible as a dimple of the chin.

The muscle of the cheek is the **buccinator,**[24] which has multiple functions in blowing, sucking, and chewing. The name literally means "trumpeter"—if the cheeks are inflated with air, compression of the buccinator muscles blows it out. Sucking is achieved by contracting the buccinators to draw the cheeks inward and then relaxing them. This action is especially important for nursing

[13] *galea* = helmet + *apo* = above + *neuro* = nerves, the brain
[14] *orb* = circle + *ocul* = eye
[15] *levator* = that which raises + *palpebr* = eyelid + *superior* = upper
[16] *corrug* = wrinkle + *supercilii* = of the eyebrow
[17] *procer* = long, slender
[18] *nasalis* = of the nose
[19] *oris* = of the mouth
[20] refers to the zygomatic arch
[21] *risor* = laughter
[22] *depressor* = that which lowers + *angul* = corner, angle
[23] *mentalis* = of the chin
[24] *bucc* = cheek

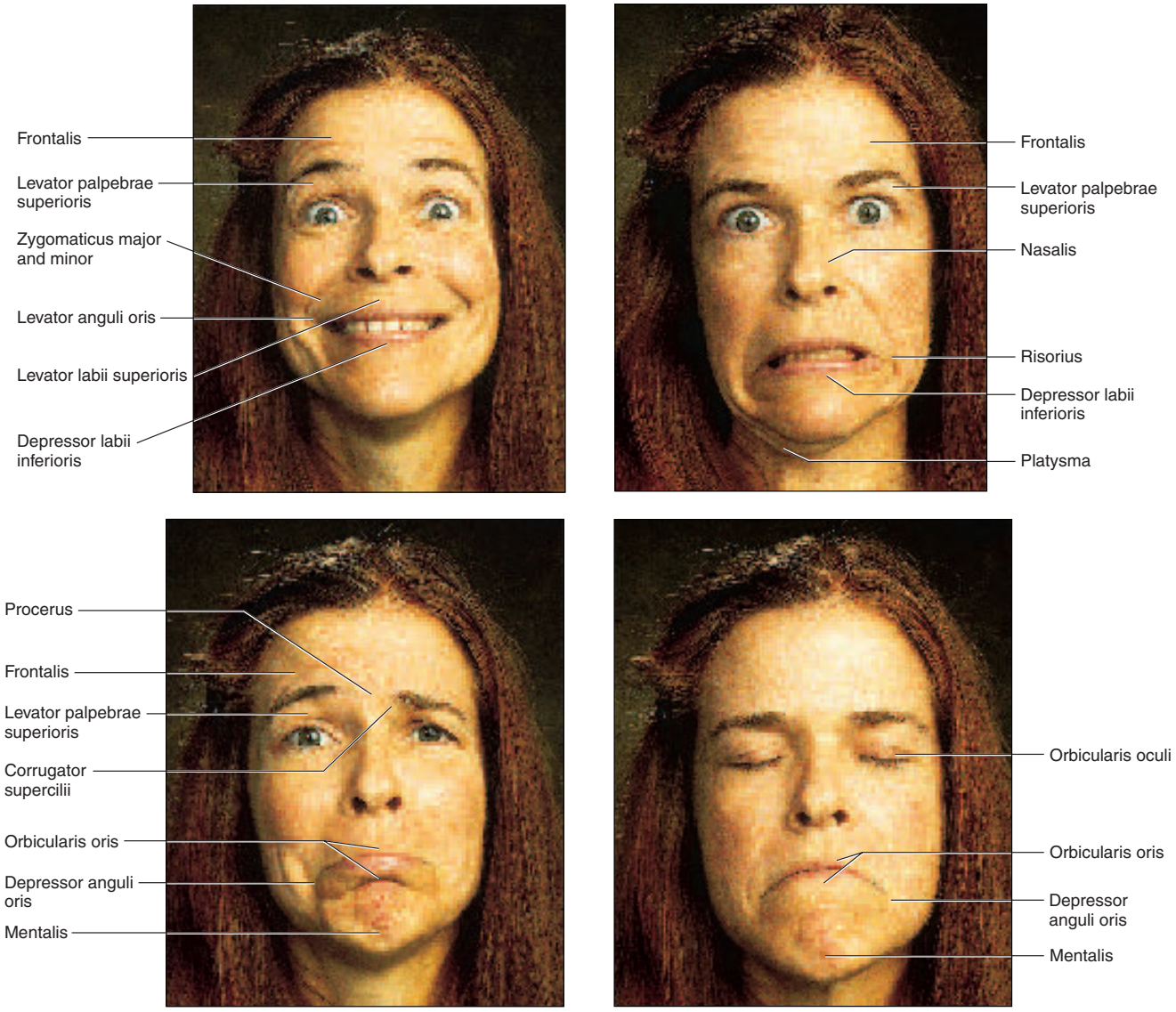

Figure 10.6 Expressions Produced by Several of the Facial Muscles. The ordinary actions of these muscles are usually more subtle than these demonstrations.

infants. To appreciate this action, hold your fingertips lightly on your cheeks as you make a kissing noise. You will feel the relaxation of the buccinators at the moment air is sharply drawn in through the pursed lips. The buccinators also aid chewing by pushing and retaining food between the teeth.

The **platysma**[25] is a thin superficial muscle that arises from the shoulder and upper chest and inserts broadly along the mandible and overlying skin. It depresses the mandible, helps to open and widen the mouth, and tenses the skin of the neck (during shaving, for example).

Muscles of Chewing and Swallowing

The following muscles contribute to facial expression and speech but are primarily concerned with manipulation of food, including tongue movements, chewing, and swallowing (table 10.3).

[25] *platy* = flat

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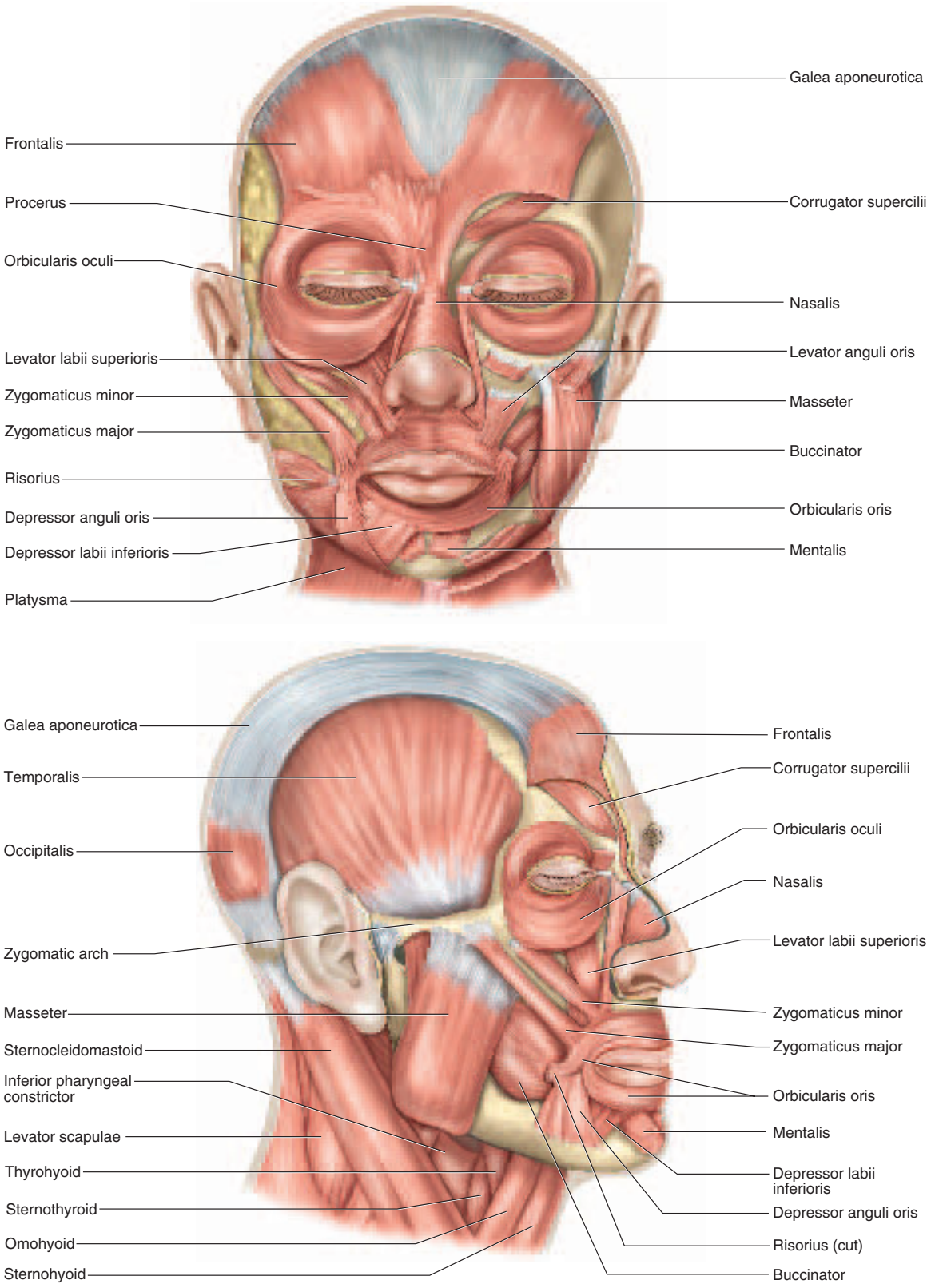

Figure 10.7 Muscles of Facial Expression.
What muscle occupies the glabella?

Table 10.2 Muscles of Facial Expression (see fig. 10.7)

O = origin, I = insertion, N = innervation (n. = nerve)

Occipitofrontalis (oc-SIP-ih-toe-frun-TAY-lis)		
Occipitalis		
Retracts scalp; fixes galea aponeurotica		
O: superior nuchal line	I: galea aponeurotica	N: facial n. (VII)
Frontalis		
Raises eyebrows and creates wrinkles in forehead when occipitalis is contracted; draws scalp forward when occipitalis is relaxed		
O: galea aponeurotica	I: skin of forehead	N: facial n. (VII)
Orbicularis Oculi (or-BIC-you-LERR-iss OC-you-lye)		
Closes eye; compresses lacrimal gland to promote flow of tears		
O: medial wall of orbit	I: eyelid	N: facial n. (VII)
Levator Palpebrae (leh-VAY-tur pal-PEE-bree) Superioris		
Opens eye; raises upper eyelid		
O: roof of orbit	I: upper eyelid	N: oculomotor n. (III)
Corrugator Supercilii (COR-oo-GAY-tur SOO-per-SIL-ee-eye)		
Medially depresses eyebrows and draws them closer together; wrinkles skin between eyebrows		
O: superciliary ridge	I: skin of eyebrow	N: facial n. (VII)
Procerus (pro-SER-us)		
Wrinkles skin between eyebrows; draws skin of forehead down		
O: skin on bridge of nose	I: skin of forehead	N: facial n. (VII)
Nasalis (nay-SAY-liss)		
One part widens nostrils; another part depresses nasal cartilages and compresses nostrils		
O: maxilla and nasal cartilages	I: bridge and alae of nose	N: facial n. (VII)
Orbicularis Oris (or-BIC-you-LERR-iss OR-iss)		
Closes lips; protrudes lips as in kissing; aids in speech		
O: muscle fibers around mouth	I: mucous membrane of lips	N: facial n. (VII)
Levator Labii Superioris		
Elevates upper lip		
O: zygomatic bone, maxilla	I: upper lip	N: facial n. (VII)
Levator Anguli (ANG-you-lye) Oris		
Elevates corners of mouth, as in smiling and laughing		
O: maxilla	I: superior corner of mouth	N: facial n. (VII)
Zygomaticus (ZY-go-MAT-ih-cus) Major and Zygomaticus Minor		
Draw corners of mouth laterally and upward, as in smiling and laughing		
O: zygomatic bone	I: superolateral corner of mouth	N: facial n. (VII)

(continued)

Table 10.2 Muscles of Facial Expression (see fig. 10.7) *(continued)*

Risorius (rih-SOR-ee-us)		
Draws corner of mouth laterally, as in grimacing		
O: fascia near ear	I: corner of mouth	N: facial n. (VII)
Depressor Anguli Oris, or Triangularis		
Depresses corner of mouth, as in frowning		
O: mandible	I: inferolateral corner of mouth	N: facial n. (VII)
Depressor Labii Inferioris		
Depresses lower lip		
O: near mental protuberance	I: lower lip	N: facial n. (VII)
Mentalis (men-TAY-lis)		
Pulls skin of chin upward; elevates and protrudes lower lip, as in pouting		
O: near mental protuberance	I: skin of chin	N: facial n. (VII)
Buccinator (BUCK-sin-AY-tur)		
Compresses cheek; pushes food between teeth; expels air or liquid from mouth; creates suction		
O: lateral aspects of maxilla and mandible	I: orbicularis oris	N: facial n. (VII)
Platysma (plah-TIZ-muh)		
Depresses mandible, opens and widens mouth, tenses skin of neck		
O: fasciae of deltoid and pectoralis major muscles	I: mandible, skin of lower face, muscles at corners of mouth	N: facial n. (VII)

The tongue is a very agile organ. Both intrinsic and extrinsic muscle groups are responsible for its complex movements. The intrinsic muscles consist of variable numbers of vertical muscles that extend from the superior to inferior side of the tongue, transverse muscles that extend from left to right, and longitudinal muscles that extend from root to tip. The extrinsic muscles connect the tongue to other structures in the head and neck. These include the **genioglossus,**[26] **hyoglossus,**[27] **styloglossus,**[28] and **palatoglossus**[29] (fig. 10.8). The tongue and buccinator muscle shift food into position between the molars for chewing (mastication), and the tongue later forces the chewed food into the pharynx for swallowing.

There are four paired muscles of mastication: the temporalis, masseter, and medial and lateral pterygoids. The **temporalis**[30] is a broad, fan-shaped muscle that arises from the temporal lines of the skull, passes behind the zygomatic arch, and inserts on the coronoid process of the mandible (fig. 10.9*a*). The **masseter**[31] is shorter and superficial to the temporalis, arising from the zygomatic arch and inserting on the lateral surface of the angle of the mandible (see fig. 10.7). It is a thick muscle easily palpated on the side of your jaw. The temporalis and masseter elevate the mandible to bite and chew food; they are two of the most powerful muscles in the body. Similar action is provided by the **medial** and **lateral pterygoids.** They arise from the pterygoid processes of the sphenoid bone and insert on the medial surface of the mandible (fig. 10.9*b*). The pterygoids elevate and protract the mandible and produce the lateral excursions used to grind food between the molars.

Several of the actions of chewing and swallowing are aided by eight pairs of *hyoid muscles* associated with the hyoid bone. Four of them, superior to the hyoid, form the **suprahyoid group**—the *digastric, geniohyoid, mylohyoid,* and *stylohyoid.* Those inferior to the hyoid form the **infrahyoid group**—the *thyrohyoid, omohyoid, sternohyoid,* and *sternothyroid.* (See fig. 10.8 for the geniohyoid and fig. 10.10 for the others.) Most of the hyoid muscles

[26] *genio* = chin + *gloss* = tongue
[27] refers to the hyoid bone
[28] refers to the styloid process of the skull
[29] *palato* = palate
[30] refers to the temporal bone
[31] *masset* = chew

Table 10.3 Muscles of Chewing and Swallowing (see figs. 10.8–10.10)

O = origin, I = insertion, N = innervation (n. = nerve)

Extrinsic Muscles of the Tongue		
Genioglossus (JEE-nee-oh-GLOSS-us)		
Depresses and protrudes tongue; creates dorsal groove in tongue that enables infants to grasp nipple and channel milk to pharynx		
O: mental spines of mandible	I: hyoid bone, lateral aspect of tongue	N: hypoglossal n. (XII)
Hyoglossus		
Depresses sides of tongue		
O: hyoid bone	I: lateral aspect of tongue	N: hypoglossal n. (XII)
Styloglossus		
Elevates and retracts tongue		
O: styloid process	I: lateral aspect of tongue	N: hypoglossal n. (XII)
Palatoglossus		
Elevates posterior part of tongue; constricts fauces (entry to pharynx)		
O: soft palate	I: lateral aspect of tongue	N: accessory n. (XI)
Muscles of Mastication		
Temporalis (TEM-po-RAY-liss)		
Elevates mandible for biting and chewing; retracts mandible		
O: temporal lines	I: coronoid process of mandible	N: trigeminal n. (V)
Masseter (ma-SEE-tur)		
Elevates mandible for biting and chewing; causes some lateral excursion of mandible		
O: zygomatic arch	I: lateral aspect of mandibular ramus and angle	N: trigeminal n. (V)
Medial Pterygoid (TERR-ih-goyd)		
Elevates mandible; produces lateral excursion		
O: pterygoid process of sphenoid bone	I: medial aspect of mandibular angle	N: trigeminal n. (V)
Lateral Pterygoid (TERR-ih-goyd)		
Protracts mandible; produces lateral excursion		
O: pterygoid process of sphenoid bone	I: slightly anterior to mandibular condyle	N: trigeminal n. (V)
Muscles of the Pharynx		
Pharyngeal Constrictors (three muscles)		
Constrict pharynx to force food into esophagus		
O: mandible, medial pterygoid plate, hyoid bone, larynx	I: posterior median raphe (fibrous seam) of pharynx	N: glossopharyngeal n. (IX), vagus n. (X)
Hyoid Muscles—Suprahyoid Group		
Digastric		
Retracts mandible; elevates and fixes hyoid; depresses mandible when hyoid is fixed		
O: mastoid notch and inner aspect of mandible near protuberance	I: hyoid, via fascial sling	N: trigeminal n. (V), facial n. (VII)

(continued)

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Table 10.3 Muscles of Chewing and Swallowing (see figs. 10.8–10.10) *(continued)*

Geniohyoid (JEE-nee-oh-HY-oyd)		
Elevates and protracts hyoid; dilates pharynx to receive food; opens mouth when hyoid is fixed		
O: inner aspect of mental protuberance	I: hyoid	N: hypoglossal n. (XII)
Mylohyoid		
Forms floor of mouth; elevates hyoid; opens mouth when hyoid is fixed		
O: inferior margin of mandible	I: hyoid	N: trigeminal n. (V)
Stylohyoid		
Elevates hyoid		
O: styloid process	I: hyoid	N: facial n. (VII)
Hyoid Muscles—Infrahyoid Group		
Omohyoid		
Depresses hyoid; fixes hyoid during opening of mouth		
O: superior border of scapula	I: hyoid	N: ansa cervicalis
Sternohyoid		
Depresses hyoid; fixes hyoid during opening of mouth		
O: manubrium, costal cartilage 1	I: hyoid	N: ansa cervicalis
Thyrohyoid		
Depresses hyoid; elevates larynx; fixes hyoid during opening of mouth		
O: thyroid cartilage of larynx	I: hyoid	N: hypoglossal n. (XII)
Sternothyroid		
Depresses larynx; fixes hyoid during opening of mouth		
O: manubrium, costal cartilage 1 or 2	I: thyroid cartilage of larynx	N: ansa cervicalis

receive their innervation from the *ansa cervicalis,* a loop of nerve at the side of the neck formed by certain fibers of the first through third cervical nerves.

The **digastric**[32] arises from the mastoid process and thickens into a *posterior belly* beneath the margin of the mandible. It then narrows, passes through a connective tissue loop *(fascial sling)* attached to the hyoid bone, widens into an *anterior belly,* and attaches to the mandible near the protuberance. When it contracts, it pulls on the sling and elevates the hyoid bone. When the hyoid is fixed by the infrahyoid muscles, however, the digastric muscle opens the mouth. The mouth normally drops open by itself when the temporalis and masseter muscles are relaxed, but the digastric, platysma, and mylohyoid can open it more widely. The **geniohyoid** protracts the hyoid to widen the pharynx when food is swallowed. The **mylohyoid**[33] muscles fuse at the midline, form the floor of the mouth, and work synergistically with the digastric to forcibly open the mouth. The **stylohyoid,** named for its origin and insertion, elevates the hyoid bone.

When food enters the pharynx, the superior, middle, and inferior **pharyngeal constrictors** contract in that order and force the food downward, into the esophagus. The **thyrohyoid,** named for the hyoid bone and large *thyroid cartilage* of the larynx, helps to prevent choking. It elevates the thyroid cartilage so that the larynx becomes sealed by a flap of tissue, the epiglottis. You can feel this

[32] *di* = two + *gastr* = belly

[33] *mylo* = mill, molar teeth

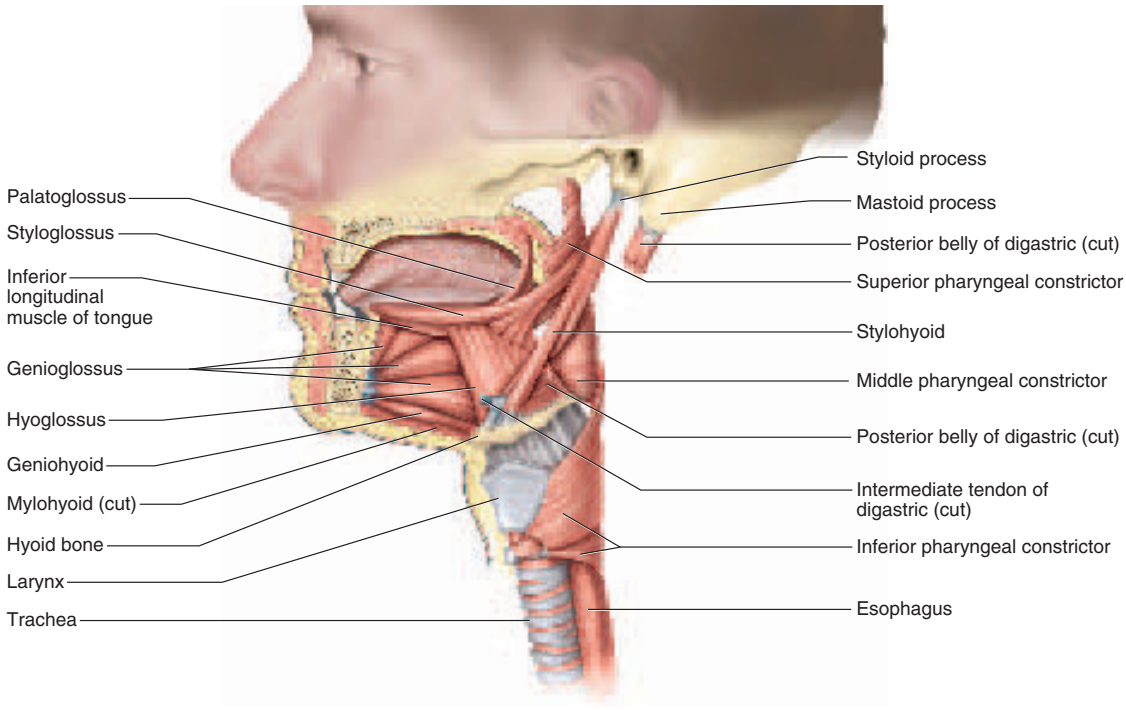


Figure 10.8 **Muscles of the Tongue and Pharynx.** Left lateral view.

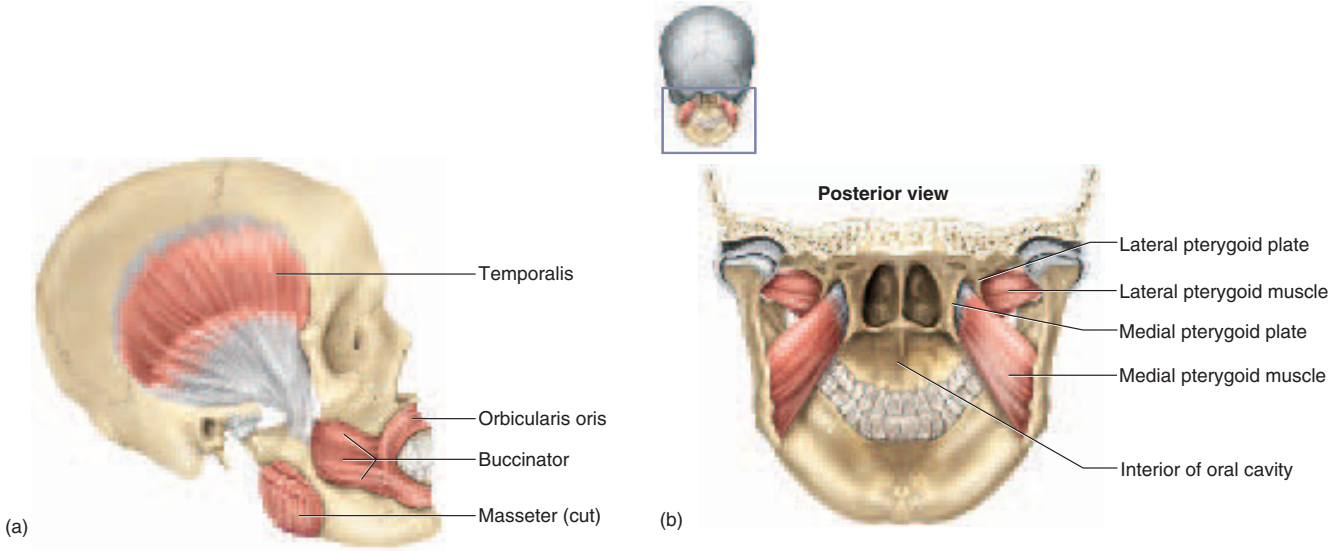


Figure 10.9 **Muscles of Chewing.** (*a*) Right lateral view. In order to expose the insertion of the temporalis muscle on the mandible, part of the zygomatic arch and masseter muscle are removed. (*b*) View of the pterygoid muscles looking into the oral cavity from behind the skull.

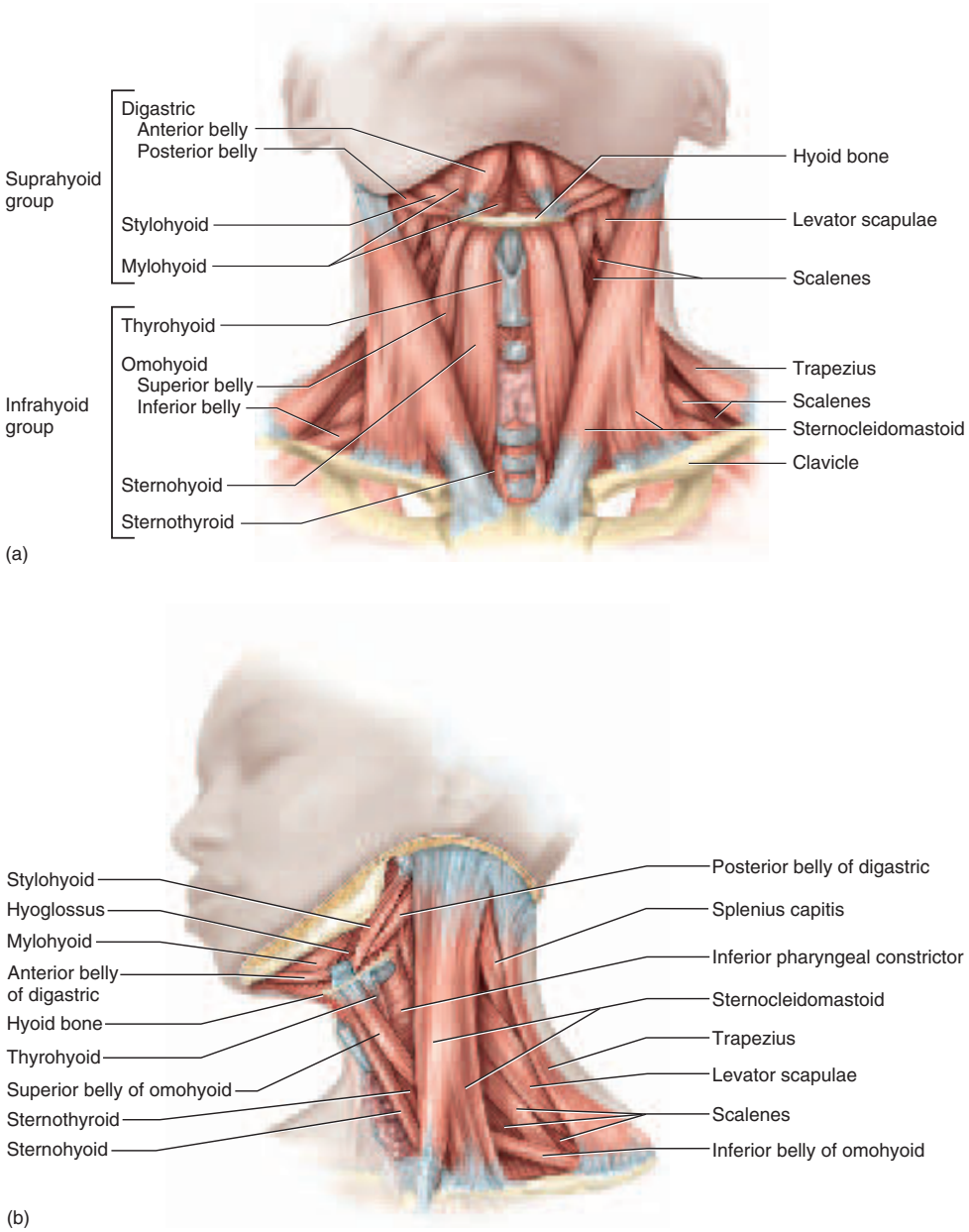


Figure 10.10 Muscles of the Neck. (*a*) The hyoid muscles, anterior view. The geniohyoid is deep to the mylohyoid and can be seen in figure 10.8. (*b*) Left lateral view.

effect by placing your fingers on your "Adam's apple" (a prominence of the thyroid cartilage) and feeling it bob up as you swallow. The **sternothyroid** then pulls the larynx down again. These infrahyoid muscles that act on the larynx are called the extrinsic muscles of the larynx. The larynx also has intrinsic muscles, which are concerned with control of the vocal cords and laryngeal opening (see chapter 22).

Insight 10.1 Medical History

Discovery of a New Muscle

New discoveries in physiology are an everyday occurrence, but one would think all the muscles of the human body had been discovered long ago. Some have even said that human gross anatomy is a completed science, a "dead discipline." Thus, anatomists were surprised by

the 1996 announcement of a new muscle of mastication discovered by U.S. dentists Gary Hack and Gwendolyn Dunn.

Hack and Dunn were studying the muscles of mastication using an unorthodox dissection method in which they entered the head from the front rather than from the side. "There it was," Hack said, "just staring at us"—a muscle, extending from the greater wing of the sphenoid to the medial side of the mandible, that everyone else had either overlooked or dismissed as part of the temporalis or medial pterygoid. Hack and Dunn named it the *sphenomandibularis*.

In chapter 1, we saw that some of history's greatest advances in scientific thinking came from people with the imagination to view things from a different angle than everyone else had done. In the discovery of the sphenomandibularis, we see that even little steps are made this way, and even the "finished" sciences hold surprises for people with imaginative approaches.

Muscles Acting on the Head

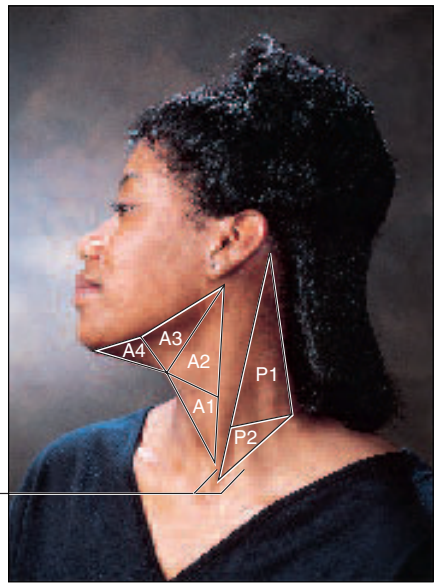
Muscles that move the head originate on the vertebral column, thoracic cage, and pectoral girdle and insert on the cranial bones (table 10.4). The principal flexors of the neck are the **sternocleidomastoid**[34] and three **scalenes** on each side (fig. 10.10). The prime mover is the sternocleidomastoid, a thick cordlike muscle that extends from the sternum and clavicle to the mastoid process behind the ear. It is most easily seen and palpated when the head is turned to one side and slightly extended. As it passes obliquely across the neck, the sternocleidomastoid divides it into **anterior** and **posterior triangles.** Other muscles and landmarks subdivide each of these into smaller triangles of surgical importance (fig. 10.11).

When both sternocleidomastoids contract, the neck flexes forward; for example, when you look down at something between your feet. When only the left one contracts, the head tilts down and to the right, and when the right one acts alone, it draws the head down and to the left. To visualize this action, hold the index finger of

[34] *sterno* = sternum + *cleido* = clavicle + *mastoid* = mastoid process of skull

Table 10.4 Muscles Acting on the Head (see figs. 10.10 and 10.17)

O = origin, I = insertion, N = innervation (n. = nerve, nn. = nerves)		
Flexors of the Neck		
Sternocleidomastoid (STIR-no-CLY-doe-MASS-toyd)		
Contraction of either one draws head down and toward the side opposite the contracting muscle; contraction of both draws head forward and down, as in looking between the feet		
O: clavicle, manubrium	I: mastoid process	N: accessory n. (XI)
Scalenes (SCAY-leens) (three muscles)		
Flex neck laterally; elevate ribs 1 and 2 in inspiration		
O: vertebrae C2–C6	I: ribs 1–2	N: C5–C8
Extensors of the Neck		
Trapezius (tra-PEE-zee-us)		
Abducts and extends neck (see other functions in table 10.9)		
O: external occipital protuberance, nuchal ligament, spinous processes of vertebrae C7–T12	I: clavicle, acromion, scapular spine	N: accessory n. (XI), C3–C4
Splenius Capitis (SPLEE-nee-us CAP-ih-tis) and Splenius Cervicis (SIR-vih-sis)		
Rotate head, extend neck		
O: *capitis*—spinous processes of vertebrae C7–T3 or T4; *cervicis*—spinous processes of T3–T6	I: *capitis*—mastoid process, superior nuchal line; *cervicis*—transverse processes of C1–C2 or C3	N: dorsal rami of middle and lower cervical nn.
Semispinalis (SEM-ee-spy-NAY-liss) Capitis		
Rotates and extends head (see other parts of semispinalis in table 10.7)		
O: transverse processes of vertebrae T1–T6, articular processes of C4–C7	I: occipital bone	N: dorsal rami of cervical nn.



Anterior triangles
A1. Muscular
A2. Carotid
A3. Submandibular
A4. Suprahyoid

Posterior triangles
P1. Occipital
P2. Omoclavicular

Sternocleidomastoid

Figure 10.11 **Triangles of the Neck.** The sternocleidomastoid muscle separates the anterior triangles from the posterior triangles.

your left hand on your left mastoid process and the index finger of your right hand on your sternal notch. Now contract the left sternocleidomastoid in a way that brings the two fingertips as close together as possible. You will note that this action causes you to look downward and to the right.

The extensors are located in the back of the neck. Their actions include extension (holding the head erect), hyperextension (as in looking upward toward the sky), abduction (tilting the head to one side), and rotation (as in looking to the left and right). Extension and hyperextension involve equal action of the right and left members of a pair; the other actions require the muscle on one side to contract more strongly than the opposite muscle. Many head movements result from a combination of these actions—for example, looking up over the shoulder involves a combination of rotation and extension.

We will consider only three primary extensors: the trapezius, splenius capitis, and semispinalis capitis (figs. 10.12 and 10.17). The **trapezius** is a vast triangular muscle of the upper back and neck; together, the right and left trapezius muscles form a trapezoid. The origin of the trapezius extends from the occipital protuberance of the skull to thoracic vertebra 12. The trapezius con-

Figure 10.12 **Muscles of the Shoulder and Nuchal Regions.**

verges to an insertion on the shoulder. The **splenius**[35] **capitis,** which lies just deep to the trapezius on the neck, has oblique fascicles that diverge from the vertebral column toward the ears. It is nicknamed the "bandage muscle" because of the way it tightly binds deeper neck muscles. The **semispinalis capitis** is slightly deeper, and its fascicles travel vertically up the back of the neck to insert on the occipital bone. A complex array of smaller, deeper extensors are synergists of these prime movers; they extend the head, rotate it, or both.

Think About It

Of the muscles you have studied so far, name three that you would consider intrinsic muscles of the head and three that you would classify as extrinsic. Explain your reason for each.

Before You Go On

Answer the following questions to test your understanding of the preceding section:

8. Name two muscles that elevate the upper lip and two that depress the lower lip.
9. Name the four paired muscles of mastication and state where they insert on the mandible.
10. Distinguish between the functions of the suprahyoid and infrahyoid muscles.
11. List the prime movers of neck extension and flexion.

[35] *spleni* = bandage

Muscles of the Trunk

Objectives

When you have completed this section, you should be able to

- name and locate the muscles of respiration and explain how they affect abdominal pressure;
- name and locate the muscles of the abdominal wall, back, and pelvic floor; and
- identify the origin, insertion, action, and innervation of any of these muscles.

Muscles of Respiration

We breathe primarily by means of muscles that enclose the thoracic cavity—the *diaphragm,* which forms its floor; 11 pairs of *external intercostal muscles,* which lie superficially between the ribs; and 11 pairs of *internal intercostal muscles* between the ribs deep to the external intercostals (fig. 10.13; table 10.5). The lungs themselves contain no skeletal muscle; they do not play an active part in their own ventilation.

The **diaphragm**[36] is a muscular dome between the abdominal and thoracic cavities. It has openings that allow passage of the esophagus and major blood vessels. Its fascicles converge from the margins toward a fibrous **central tendon.** When the diaphragm contracts, it flattens slightly, increasing the volume of the thoracic cage and

[36] *dia* = across + *phragm* = partition

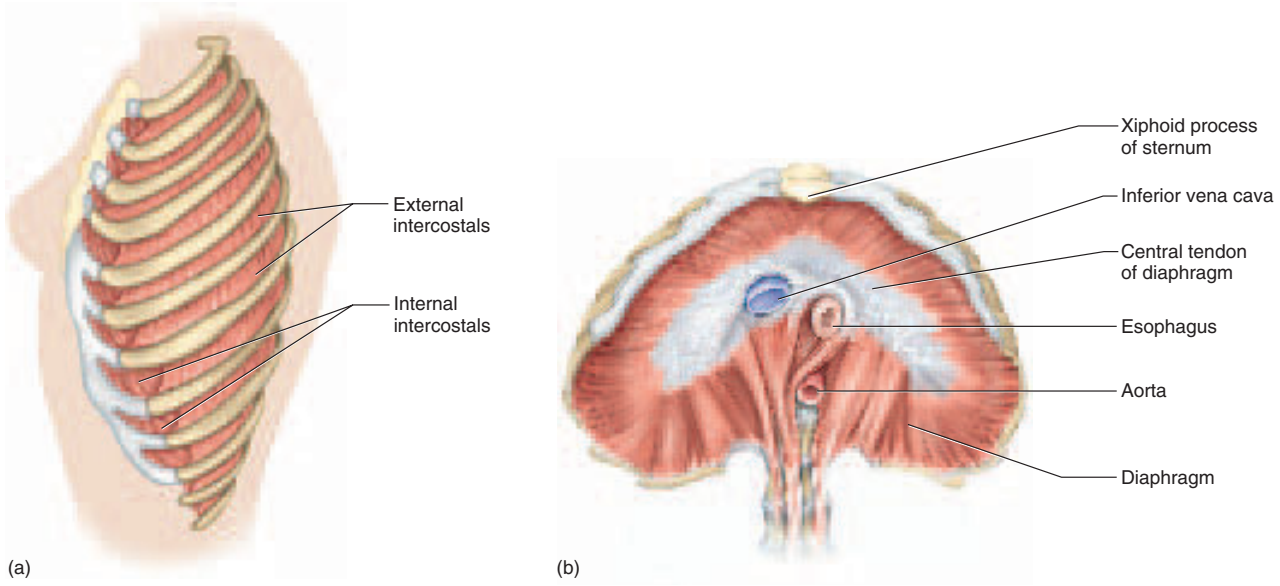


Figure 10.13 Muscles of Respiration. (*a*) The intercostal muscles, viewed from the left. (*b*) The diaphragm, viewed from below.

Table 10.5 Muscles of Respiration (see fig. 10.13)

O = origin, I = insertion, N = innervation (n. = nerve, nn. = nerves)

Diaphragm (DY-uh-fram)		
Prime mover of inspiration; compresses abdominal viscera to aid in such processes as defecation, urination, and childbirth		
O: xiphoid process, ribs 10–12, costal cartilages 5–9, lumbar vertebrae	I: central tendon	N: phrenic n.
External Intercostals (IN-tur-COSS-tulz)		
When scalenes fix rib 1, external intercostals draw ribs 2–12 upward and outward to expand thoracic cavity and inflate lungs		
O: inferior margins of ribs 1–11	I: superior margins of ribs 2–12	N: intercostal nn.
Internal Intercostals		
When quadratus lumborum and other muscles fix rib 12, internal intercostals draw ribs downward and inward to compress thoracic cavity and force air from lungs; not needed for relaxed expiration		
O: inferior margins of ribs 1–11	I: superior margins of ribs 2–12	N: intercostal nn.

Chapter 10

creating a partial vacuum that draws air into the lungs. Its contraction also raises pressure in the abdominal cavity below, thus helping to expel the contents of the bladder and rectum and facilitating childbirth—which is why people tend to take a deep breath and hold it during these functions.

The **external intercostals**[37] extend obliquely downward and anteriorly from each rib to the rib below it. When the scalenes fix the first rib, the external intercostals lift the others, pulling them up somewhat like bucket handles. This action pulls the ribs closer together and draws the entire rib cage upward and outward, expanding the thoracic cage and promoting inhalation.

When the diaphragm and external intercostals relax, the thoracic cage springs back to its prior size and expels the air. The only muscular effort normally expended in exhaling is for the inspiratory muscles to maintain partial tension (tonus) and exert a braking action, so exhalation is smooth and not explosive. However, forced expiration—exhaling more than the usual amount of air or exhaling quickly as in blowing out a candle—is achieved mainly by the **internal intercostals.** These also extend from one rib to the next, but they lie deep to the external intercostals and have fascicles at right angles to them. The abdominal muscles also aid in forced expiration by pushing the viscera up against the diaphragm.

Think About It

What muscles are eaten as "spare ribs"? What is the tough fibrous membrane between the meat and the bone?

[37] *inter* = between + *costa* = rib

Muscles of the Abdomen

The anterior and lateral walls of the abdomen are reinforced by four pairs of sheetlike muscles that support the viscera, stabilize the vertebral column during heavy lifting, and aid in respiration, urination, defecation, vomiting, and childbirth. They are the *rectus abdominis, external abdominal oblique, internal abdominal oblique,* and *transversus abdominis* (table 10.6; figs. 10.14–10.16).

The **rectus**[38] **abdominis** is a medial straplike muscle extending vertically from the pubis to the sternum. It is separated into four segments by fibrous **tendinous intersections** that give the abdomen a segmented appearance in well-muscled individuals. The rectus abdominis is enclosed in a fibrous sleeve called the **rectus sheath,** and the right and left muscles are separated by a vertical fibrous strip called the **linea alba.**[39]

The **external abdominal oblique** is the most superficial muscle of the lateral abdominal wall. Its fascicles run anteriorly and downward. Deep to it is the **internal abdominal oblique,** whose fascicles run anteriorly and upward. Deepest of all is the **transversus abdominis,** whose fascicles run horizontally across the abdomen. Unlike the thoracic cavity, the abdominal cavity lacks a protective bony enclosure. However, the wall formed by these three muscle layers is strengthened by the way their fascicles run in different directions like layers of plywood.

The tendons of the abdominal muscles are aponeuroses. They continue medially to form the rectus sheath and terminate at the linea alba. At its inferior margin, the

[38] *rect* = straight
[39] *linea* = line + *alb* = white

Table 10.6 Muscles of the Abdomen (see figs. 10.14 and 10.15)

O = origin, I = insertion, N = innervation (n. = nerve, nn. = nerves)

Rectus Abdominis (ab-DOM-ih-niss)		
Supports abdominal viscera; flexes waist as in sit-ups; depresses ribs; stabilizes pelvis during walking; increases intra-abdominal pressure to aid in urination, defecation, and childbirth		
O: pubis	I: xiphoid process, costal cartilages 5–7	N: intercostal nn. 7–12
External Abdominal Oblique		
Flexes waist as in sit-ups; flexes and rotates vertebral column		
O: ribs 5–12	I: xiphoid process, linea alba	N: intercostal nn. 8–12, iliohypogastric n., ilioinguinal n.
Internal Abdominal Oblique		
Similar to external oblique		
O: inguinal ligament, iliac crest, thoracolumbar fascia	I: xiphoid process, linea alba, pubis, ribs 10–12	N: same as external oblique
Transversus Abdominis		
Compresses abdomen, increases intra-abdominal pressure, flexes vertebral column		
O: inguinal ligament, iliac crest, thoracolumbar fascia, costal cartilages 7–12	I: xiphoid process, linea alba, pubis, inguinal ligament	N: intercostal nn. 8–12, iliohypogastric n., ilioinguinal n.

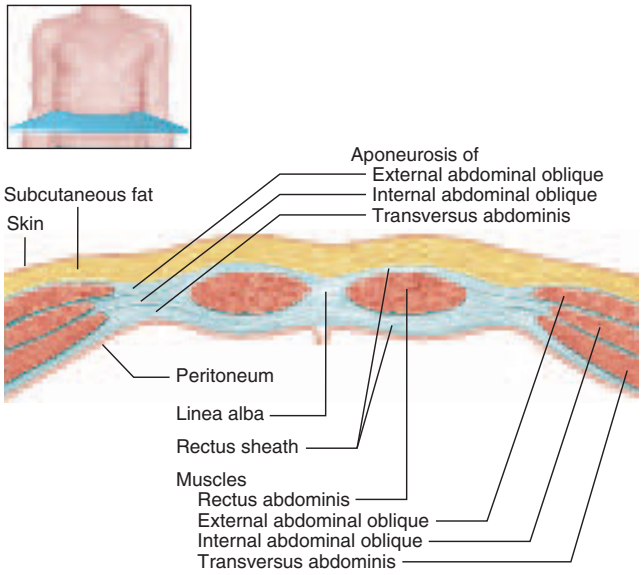


Figure 10.14 Cross Section of the Anterior Abdominal Wall.

aponeurosis of the external abdominal oblique forms a strong, cordlike **inguinal ligament** that extends from the pubis to the anterior superior spine of the ilium.

Muscles of the Back

We now consider muscles of the back that extend, rotate, and abduct the vertebral column (figs. 10.17–10.19). Back muscles that act on the pectoral girdle and arm are considered later. The muscles associated with the vertebral column moderate your motion when you bend forward and contract to return the trunk to the erect position. They are classified into two groups—a *superficial group,* which extends from the vertebrae to the ribs, and a *deep group,* which connects the vertebrae to each other.

In the superficial group, the prime mover of spinal extension is the **erector spinae.** You use this muscle to maintain your posture and to stand up straight after bending at the waist. It is divided into three "columns"—the **iliocostalis, longissimus,** and **spinalis.** These are complex, multipart muscles with cervical, thoracic, and lumbar portions. Some portions move the head and have already been discussed, while those that act on cervical and lower parts of the vertebral column are described in table 10.7. Most of the lower back (lumbar) muscles are in the longissimus group. Two **serratus posterior** muscles—one superior and one inferior—overlie the erector spinae and act to move the ribs.

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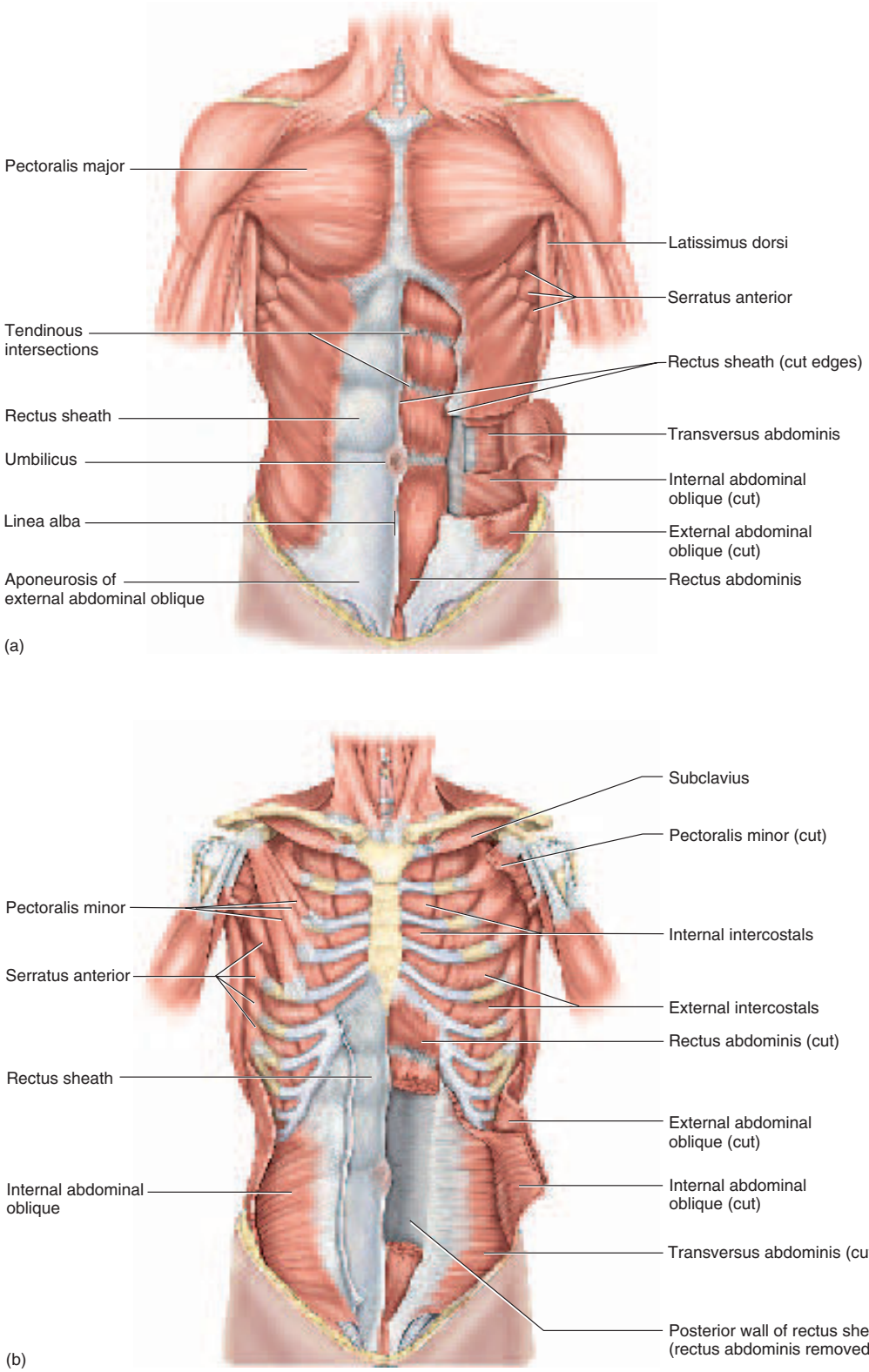

Figure 10.15 **Thoracic and Abdominal Muscles.** (*a*) Superficial muscles. The *left* rectus sheath is cut away to expose the rectus abdominis muscle. (*b*) Deep muscles. On the anatomical *right*, the external abdominal oblique has been removed to expose the internal abdominal oblique and the pectoralis major has been removed to expose the pectoralis minor. On the anatomical *left*, the internal abdominal oblique has been cut to expose the transversus abdominis, and the rectus abdominis has been cut to expose the posterior rectus sheath.

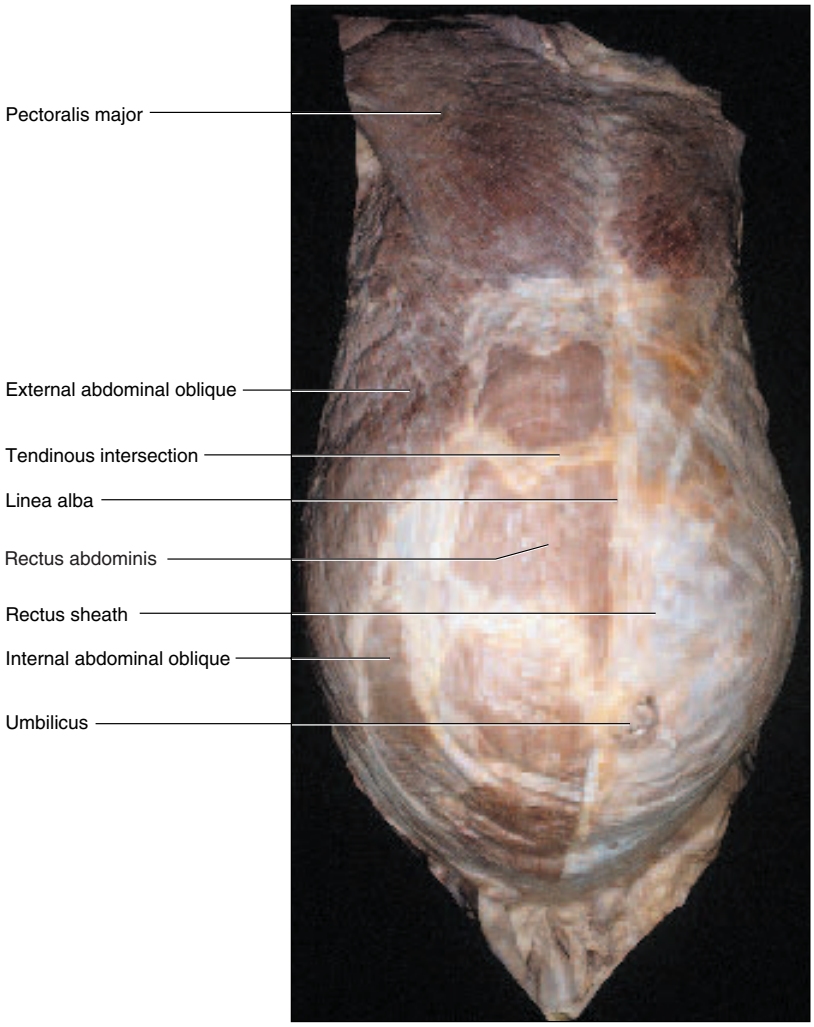

Figure 10.16 **Thoracic and Abdominal Muscles of the Cadaver.**

The major deep thoracic muscle is the **semispinalis.** This is divided into three parts, the **semispinalis capitis,** which we have already studied (see table 10.4), the **semispinalis cervicis,**[40] and **semispinalis thoracis,**[41] in that order from superior to inferior. In the lumbar region, the major deep muscle is the **quadratus**[42] **lumborum.** The erector spinae and quadratus lumborum are enclosed in a fibrous sheath called the **thoracolumbar fascia,** which is the origin of some of the abdominal and lumbar muscles. The **multifidus**[43] muscle deep to this connects the vertebrae to each other from the cervical to the lumbar region and acts to extend and rotate the vertebral column.

[40] *cervicis* = of the neck
[41] *thoracis* = of the thorax
[42] *quadrat* = four-sided
[43] *multi* = many + *fid* = split, sectioned

Insight 10.2 Clinical Application

Heavy Lifting and Back Injuries

When you are fully bent over forward, as in touching your toes, the erector spinae is fully stretched. Because of the *length-tension relationship* explained in chapter 11, muscles that are stretched to such extremes cannot contract very effectively. Standing up from such a position is therefore initiated by the hamstring muscles on the back of the thigh and the gluteus maximus of the buttocks. The erector spinae joins in the action when it is partially contracted.

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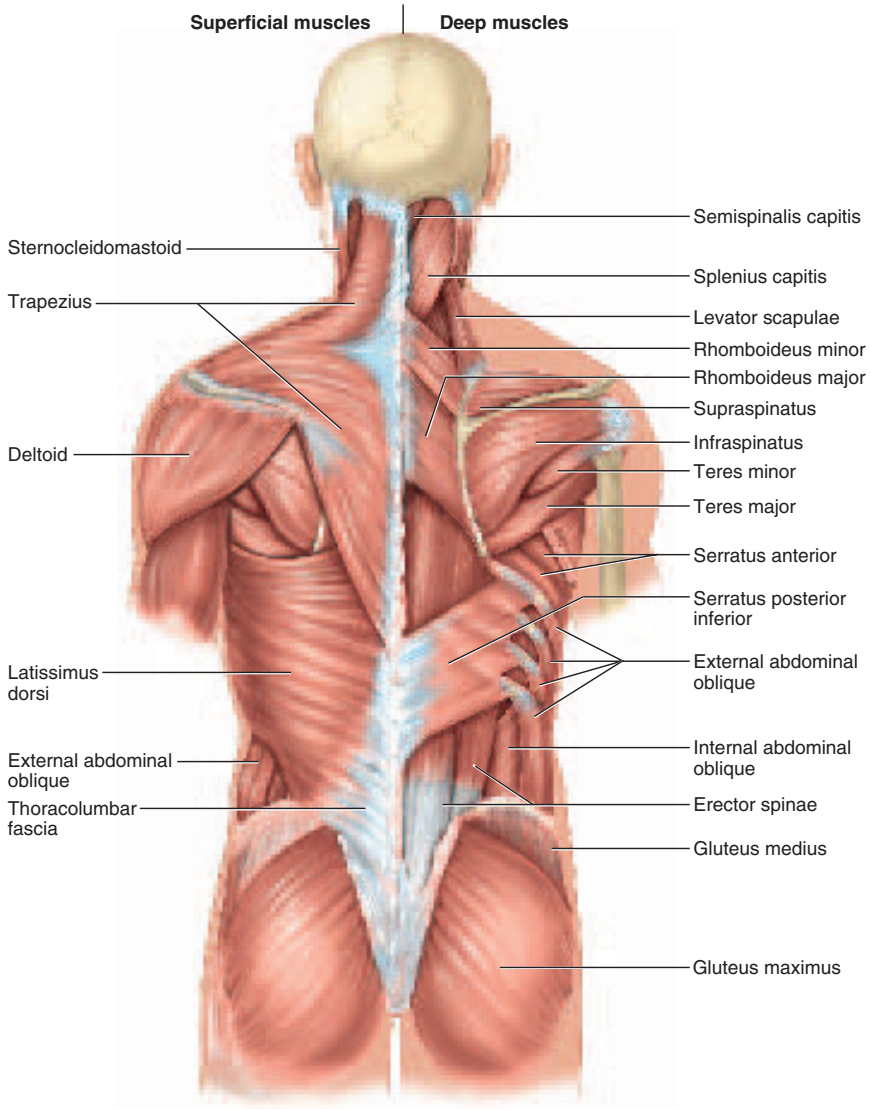


Figure 10.17 Neck, Back, and Gluteal Muscles. The most superficial muscles are shown on the *left,* and the next deeper layer on the *right.*

Standing too suddenly or improperly lifting a heavy weight, however, can strain the erector spinae, cause painful muscle spasms, tear tendons and ligaments of the lower back, and rupture intervertebral discs. The lumbar muscles are adapted for maintaining posture, not for lifting. This is why it is important, in heavy lifting, to kneel and use the powerful extensor muscles of the thighs and buttocks to lift the load.

Muscles of the Pelvic Floor

The floor of the pelvic cavity is formed by three layers of muscles and fasciae that span the pelvic outlet and support the viscera (table 10.8). It is penetrated by the anal canal, urethra, and vagina, which open into a diamond-shaped region between the thighs called the **perineum** (PERR-ih-NEE-um). The perineum is bordered by four bony landmarks—the pubic symphysis anteriorly, the coccyx posteriorly, and the ischial tuberosities laterally. The anterior half of the perineum is the **urogenital triangle** and the posterior half is the **anal triangle** (fig. 10.20*b*). These are especially important landmarks in obstetrics.

The pelvic floor is divided into three layers or "compartments." The one just deep to the skin, called the **superficial perineal space** (fig. 10.20*a, b*), contains three muscles. The **ischiocavernosus** muscles converge like a V from the ischial tuberosities toward the penis or clitoris and assist in

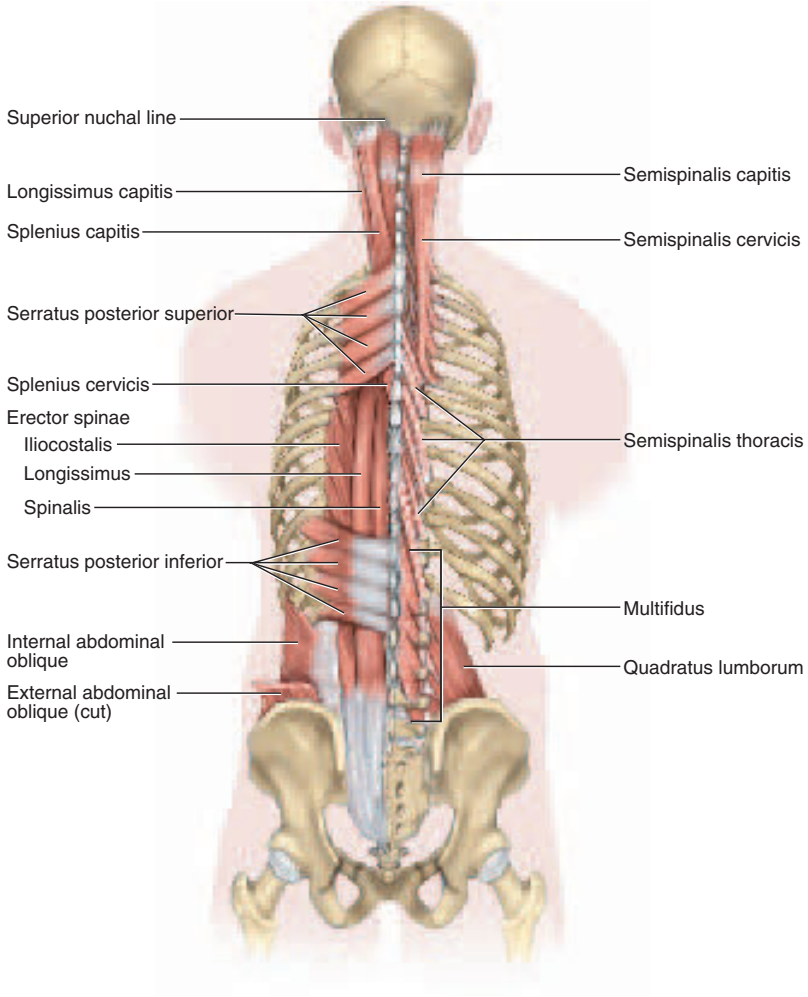


Figure 10.18 **Muscles Acting on the Vertebral Column.** Those on the *right* are deeper than those on the *left.*

erection. In males, the **bulbospongiosus (bulbocavernosus)** forms a sheath around the base (bulb) of the penis; it expels semen during ejaculation. In females, it encloses the vagina like a pair of parentheses and tightens on the penis during intercourse. Voluntary contractions of this muscle in both sexes also help void the last few milliliters of urine. The **superficial transverse perineus** extends from the ischial tuberosities to a strong **central tendon** of the perineum.

In the middle compartment, the urogenital triangle is spanned by a thin triangular sheet called the **urogenital diaphragm.** This is composed of a fibrous membrane and two muscles—the **deep transverse perineus** and the **external urethral sphincter** (fig. 10.20*c, d*). The anal triangle contains the **external anal sphincter.** The deepest compartment, called the **pelvic diaphragm,** is similar in both sexes. It consists of two muscle pairs shown in figure 10.20*e*—the **levator ani** and **coccygeus.**

Insight 10.3 Clinical Application

Hernias

A hernia is any condition in which the viscera protrude through a weak point in the muscular wall of the abdominopelvic cavity. The most common type to require treatment is an *inguinal hernia.* In the male fetus, each testis descends from the pelvic cavity into the scrotum by way of a passage called the *inguinal canal* through the muscles of the groin. This canal remains a weak point in the pelvic floor, especially in infants and children. When pressure rises in the abdominal cavity, it can force part of the intestine or bladder into this canal or even into the scrotum. This also sometimes occurs in men who hold their breath while lifting heavy weights. When the diaphragm and abdominal muscles contract, pressure in the abdominal cavity can soar to 1,500 pounds per square inch—more than 100 times the normal pressure and quite sufficient to produce an inguinal hernia, or "rupture." Inguinal hernias rarely occur in women.

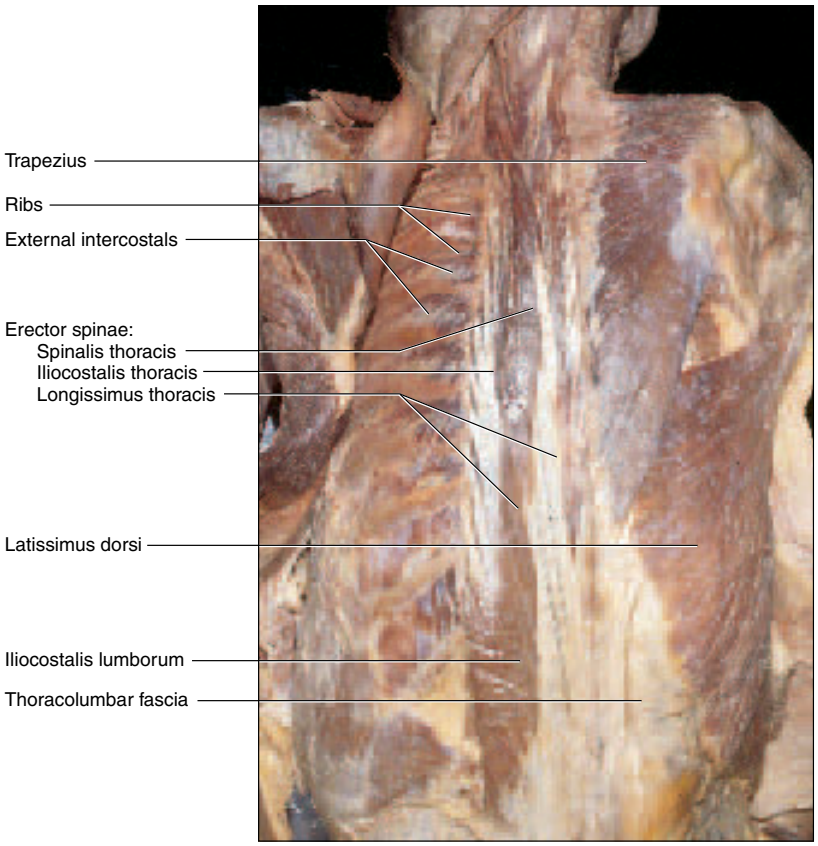


Figure 10.19 **Deep Back Muscles of the Cadaver.**

Two other sites of hernia are the diaphragm and navel. A *hiatal hernia* is a condition in which part of the stomach protrudes through the diaphragm into the thoracic cavity. This is most common in overweight people over 40. It may cause heartburn due to the regurgitation of stomach acid into the esophagus, but most cases go undetected. In an *umbilical hernia,* abdominal viscera protrude through the navel.

Before You Go On

Answer the following questions to test your understanding of the preceding section:

12. Which muscles are used more often, the external intercostals or internal intercostals? Explain.
13. Explain how pulmonary ventilation affects abdominal pressure and vice versa.
14. Name a major superficial muscle and two major deep muscles of the back.
15. Define *perineum, urogenital triangle,* and *anal triangle.*
16. Name one muscle in the superficial perineal space, one in the urogenital diaphragm, and one in the pelvic diaphragm. State the function of each.

Muscles Acting on the Shoulder and Upper Limb

Objectives

When you have completed this section, you should be able to

- name and locate the muscles that act on the pectoral girdle, shoulder, elbow, wrist, and hand;
- relate the actions of these muscles to the joint movements described in chapter 9; and
- describe the origin, insertion, and innervation of each muscle.

Muscles Acting on the Scapula

The scapula is loosely attached to the thoracic cage and is capable of considerable movement—rotation (as in raising and lowering the apex of the shoulder), elevation and depression (as in shrugging and lowering the shoulders), and protraction and retraction (pulling the shoulders forward or back) (fig. 10.21). The clavicle braces the shoulder and moderates these movements.

Table 10.7 Muscles of the Back (see figs. 10.17 and 10.18)

O = origin, I = insertion, N = innervation (n. = nerve, nn. = nerves)

Superficial Group—The Erector Spinae (ee-RECK-tur SPY-nee)		
Iliocostalis Cervicis (ILL-ee-oh-coss-TAH-liss SIR-vih-sis), Iliocostalis Thoracis (tho-RA-sis), and Iliocostalis Lumborum (lum-BORE-um)		
Extend and laterally flex vertebral column; thoracis and lumborum rotate ribs during forceful inspiration		
O: angles of ribs, sacrum, iliac crest	I: *cervicis*—vertebrae C4–C6; *thoracis*—vertebra C7, angles of ribs 1–6; *lumborum*—angles of ribs 7–12	N: dorsal rami of spinal nn.
Longissimus (lawn-JISS-ih-muss) Cervicis and Longissimus Thoracis		
Extend and laterally flex vertebral column		
O: *cervicis*—vertebrae T1 to T4 or T5; *thoracis*—sacrum, iliac crest, vertebrae T1–L5	I: *cervicis*—vertebrae C2–C6; *thoracis*— vertebrae T1–T12, ribs 3 or 4 to 12	N: dorsal rami of spinal nn.
Spinalis (spy-NAY-liss) Cervicis and Spinalis Thoracis		
Extend vertebral column		
O: *cervicis*—nuchal ligament, spinous process of vertebra C7; *thoracis*—spinous processes of T11–L2	I: *cervicis*—spinous process of axis; *thoracis*—spinous processes of upper thoracic vertebrae	N: dorsal rami of spinal nn.
Superficial Group—Serratus Posterior Muscles		
Serratus Posterior Superior (seh-RAY-tus)		
Elevates ribs 2–5 during inspiration		
O: spines of vertebrae C7–T3	I: ribs 2–5	N: intercostal nn. 2–5
Serratus Posterior Inferior		
Depresses ribs 9–12 during inspiration		
O: spines of vertebrae T10–L2	I: ribs 9–12	N: ventral rami of T9–T12
Deep Group		
Semispinalis Cervicis (SEM-ee-spy-NAY-liss SUR-vih-sis) and Semispinalis Thoracis (tho-RA-sis)		
Extend neck; extend and rotate vertebral column		
O: transverse processes of vertebrae T1–T10	I: spinous processes of vertebrae C2–T5	N: dorsal rami of spinal nn.
Quadratus Lumborum (quad-RAY-tus lum-BORE-um)		
Laterally flexes vertebral column, depresses rib 12		
O: iliac crest, lower lumbar vertebrae, thoracolumbar fascia	I: upper lumbar vertebrae, rib 12	N: ventral rami of L1–L3
Multifidus (mul-TIFF-ih-dus)		
Extends and rotates vertebral column		
O: sacrum, iliac crest, vertebrae C4–L5	I: laminae and spinous processes of vertebrae above origins	N: dorsal rami of spinal nn.

Table 10.8 Muscles of the Pelvic Floor (see fig. 10.20)

O = origin, I = insertion, N = innervation (n. = nerve)		
Superficial Muscles of the Perineum		
Ischiocavernosus (ISS-kee-oh-CAV-er-NO-sus)		
Aids in erection of penis and clitoris		
O: ischial and pubic rami, ischial tuberosity	I: penis, clitoris	N: pudendal n.
Bulbospongiosus (BUL-bo-SPUN-jee-OH-sus)		
Male: compresses urethra to expel semen or urine. Female: constricts vaginal orifice.		
O: central tendon of perineum, bulb of penis	I: fasciae of perineum, penis or clitoris	N: pudendal n.
Superficial Transverse Perineus (PERR-ih-NEE-us)		
Fixes central tendon of perineum, supports pelvic floor		
O: ischial ramus	I: central tendon of perineum	N: pudendal n.
Muscles of the Urogenital Diaphragm		
Deep Transverse Perineus		
Fixes central tendon of perineum; supports pelvic floor; expels last drops of urine in both sexes and semen in male		
O: ischial ramus	I: central tendon of perineum	N: pudendal n.
External Urethral Sphincter		
Compresses urethra to voluntarily inhibit urination		
O: ischial and pubic rami	I: medial raphe of male, vaginal wall of female	N: pudendal n.
Muscle of the Anal Triangle		
External Anal Sphincter		
Compresses anal canal to voluntarily inhibit defecation		
O: anococcygeal raphe	I: central tendon of perineum	N: pudendal n., S4
Muscles of the Pelvic Diaphragm		
Levator Ani (leh-VAY-tur AY-nye)		
Supports viscera; resists pressure surges in abdominal cavity; elevates anus during defecation; forms vaginal and anorectal sphincters		
O: os coxae from pubis to ischial spine	I: coccyx, anal canal, anococcygeal raphe	N: pudendal n., S3–S4
Coccygeus (coc-SIDJ-ee-us)		
Draws coccyx anteriorly after defecation or childbirth; supports and elevates pelvic floor; resists abdominal pressure surges		
O: ischial spine	I: lower sacrum to upper coccyx	N: S3 or S4

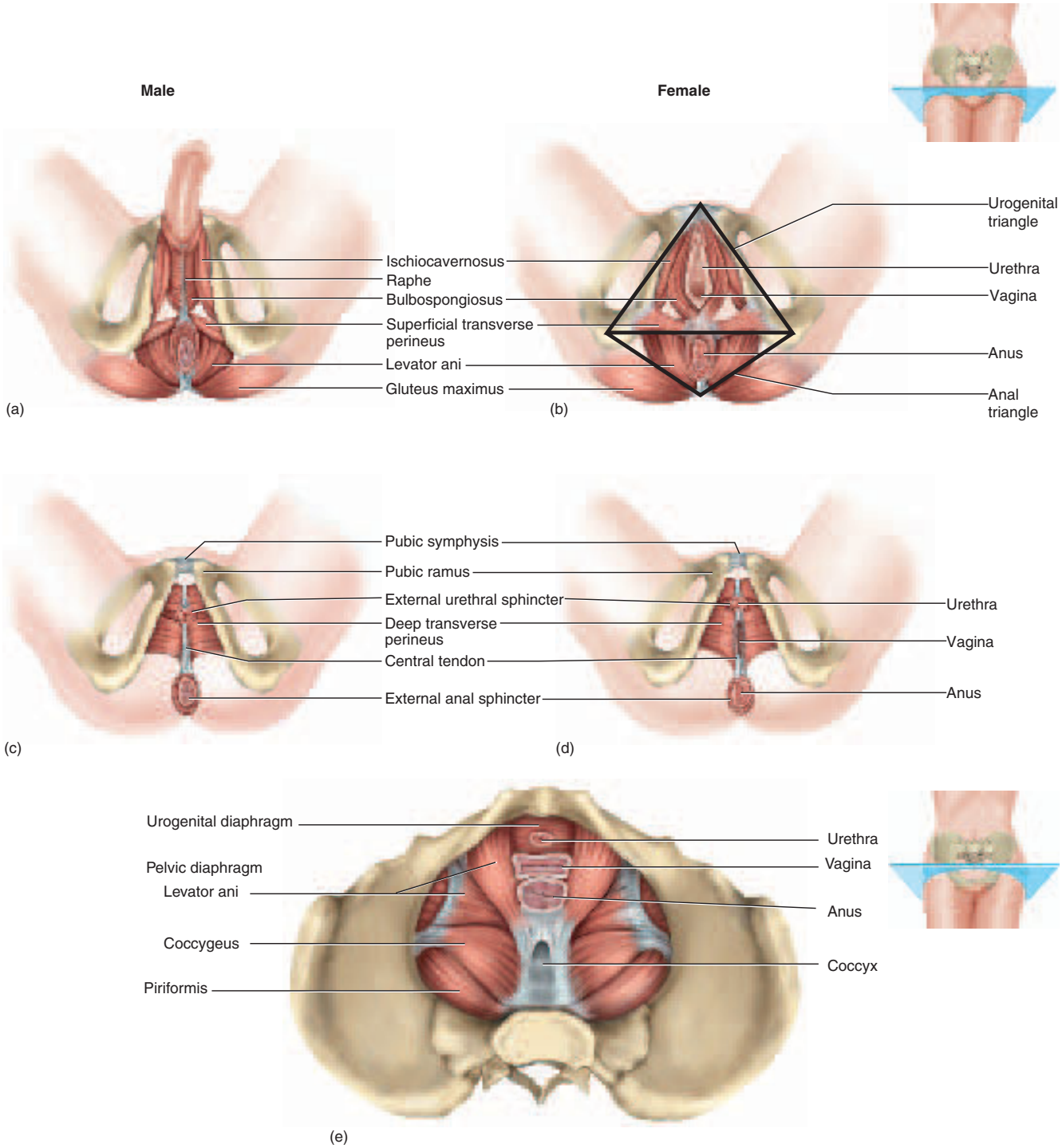


Figure 10.20 **Muscles of the Pelvic Floor.** (*a, b*) The superficial perineal space, inferior view. Triangles of the perineum are marked in *b*. (*c, d*) The urogenital diaphragm, inferior view; this is the next deeper layer after the muscles in *a* and *b*. (*e*) The pelvic diaphragm, the deepest layer, superior view (seen from within the pelvic cavity).

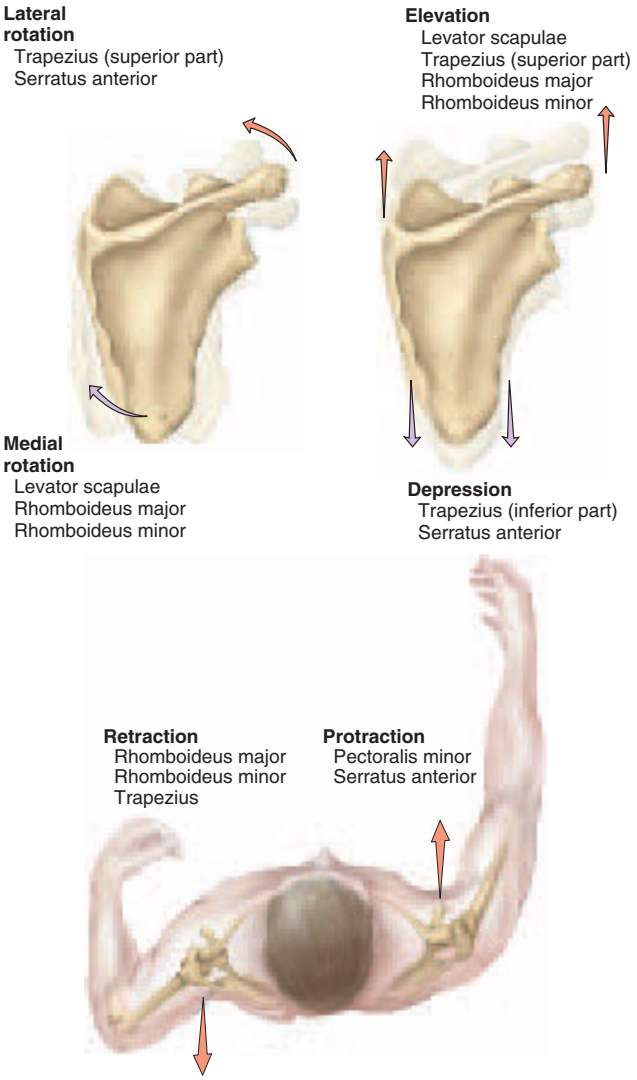


Figure 10.21 Actions of Some Thoracic Muscles on the Scapula. Note that an individual muscle can contribute to multiple actions, depending on which fibers contract and what synergists act with it. In the two upper figures, mark the insertion of each of the named muscles.

The muscles that act on the pectoral girdle originate on the axial skeleton and insert on the clavicle and scapula. They are divided into anterior and posterior groups (table 10.9). The important muscles of the anterior group are the **pectoralis minor** and **serratus anterior** (see fig. 10.15*b*). In the posterior group, we have the large, superficial trapezius, already studied, and three deep muscles, the **levator scapulae, rhomboideus major,** and **rhomboideus minor.** The action of the trapezius depends on whether its superior, middle, or inferior fibers contract and whether it acts alone or with other muscles. The levator scapulae and superior fibers of the trapezius rotate the scapula in opposite directions if either of them acts alone. If both act together, their opposite rotational effects balance each other and they elevate the scapula and shoulder, as when you carry a heavy weight on your shoulder. Depression of the scapula occurs mainly by gravitational pull, but the trapezius and serratus anterior can cause faster, more forcible depression, as in swimming, hammering, and rowing.

Muscles Acting on the Humerus

Nine muscles cross the humeroscapular (shoulder) joint and insert on the humerus (table 10.10). Two are called *axial muscles* because they originate primarily on the axial skeleton—the **pectoralis major** and **latissimus dorsi**[44] (see figs. 10.15, 10.22, and 10.23). The pectoralis major is the thick, fleshy muscle of the mammary region, and the latissimus dorsi is a broad muscle of the back that extends from the waist to the axilla. These muscles bear the primary responsibility for attachment of the arm to the trunk, and they are the prime movers of the shoulder joint. The pectoralis major flexes the shoulder as in pointing at something in front of you, and the latissimus dorsi extends it as in pointing at something behind you—thus, they are antagonists.

The other seven muscles of the shoulder are called *scapular muscles* because they originate on the scapula. Among these, the prime mover is the **deltoid**—the thick muscle that caps the shoulder. It acts like three different muscles. Its anterior fibers flex the shoulder, its posterior fibers extend it, and its lateral fibers abduct it. Abduction by the deltoid is antagonized by the combined action of the pectoralis major and latissimus dorsi. The **teres major** assists extension of the shoulder and the **coracobrachialis** assists flexion and adduction.

Tendons of the other four scapular muscles form the **rotator cuff**—the **supraspinatus, infraspinatus, teres minor,** and **subscapularis** (fig. 10.24), nicknamed the "SITS muscles" for their initial letters. The subscapularis fills most of the subscapular fossa on the anterior surface of the scapula. The other three originate on the posterior surface. The supraspinatus and infraspinatus occupy the corresponding fossae above and below the scapular spine, and the teres minor lies inferior to the infraspinatus. The tendons of these muscles merge with the joint capsule of the shoulder as they pass it en route to the humerus. They insert on the proximal end of the humerus, forming a partial sleeve around it. The rotator cuff reinforces the joint capsule and holds the head of the humerus in the glenoid cavity. These muscles act as synergists in shoulder movements. The rotator cuff, especially the tendon of the supraspinatus, is easily damaged by strenuous circumduction (see insight 10.6).

[44] *latissimus* = broadest + *dorsi* = of the back

Table 10.9 Muscles Acting on the Scapula (see figs. 10.15, 10.17, and 10.21)

O = origin, I = insertion, N = innervation (n. = nerve, nn. = nerves)

Anterior Group		
Pectoralis (PECK-toe-RAY-liss) Minor		
Protracts and depresses scapula when ribs are fixed; elevates ribs when scapula is fixed		
O: ribs 3–5	I: coracoid process	N: medial and lateral pectoral nn.
Serratus (serr-AY-tus) Anterior		
Holds scapula against rib cage; elevates ribs; abducts and rotates scapula to tilt glenoid cavity upward; forcefully depresses scapula; abducts and elevates arm; prime mover in forward thrusting, throwing, and pushing ("boxer's muscle")		
O: ribs 1–9	I: medial border of scapula	N: long thoracic n.
Posterior Group		
Trapezius (tra-PEE-zee-us)		
Superior fibers elevate scapula or rotate it to tilt glenoid cavity upward; middle fibers retract scapula; inferior fibers depress scapula. When scapula is fixed, one trapezius acting alone flexes neck laterally and both trapezius muscles working together extend neck		
O: external occipital protuberance, nuchal ligament, spinous processes of C7–T12	I: clavicle, acromion, scapular spine	N: accessory n. (XI), C3–C4
Levator Scapulae (leh-VAY-tur SCAP-you-lee)		
Rotates scapula to tilt glenoid cavity downward; flexes neck when scapula is fixed; elevates scapula when acting with superior fibers of trapezius		
O: transverse processes of vertebrae C1–C4	I: superior angle to medial border of scapula	N: C3–C4, dorsal scapular n.
Rhomboideus (rom-BOY-dee-us) Major and Rhomboideus Minor		
Retract and elevate scapula; rhomboideus major also fixes scapula and rotates it to tilt glenoid cavity downward		
O: spinous processes of vertebrae C7–T1 (r. minor) and T2–T5 (r. major)	I: medial border of scapula	N: dorsal scapular n.

Since the humeroscapular joint is capable of such a wide range of movements and is acted upon by so many muscles, its actions are summarized in table 10.11.

Think About It

Since a muscle can only pull, and not push, antagonistic muscles are needed to produce opposite actions at a joint. Reconcile this fact with the observation that the deltoid muscle both flexes and extends the shoulder.

Muscles Acting on the Forearm

The elbow and forearm are capable of four motions: flexion, extension, pronation, and supination (table 10.12). The principal flexors are on the anterior side of the humerus and include the superficial **biceps brachii**[45] and deeper **brachialis** (see fig. 10.22; table 10.13). In flexion of the elbow, the biceps elevates the radius while the brachialis elevates the ulna. The biceps is named for its two heads, which arise from separate tendons at the scapula. The tendon of the long head is important in holding the humerus in the glenoid cavity and stabilizing the shoulder joint. The two heads converge close to the elbow on a single distal tendon that inserts on the radial tuberosity.

The **brachioradialis** is a synergist in elbow flexion. Its belly lies in the antebrachium (forearm) beside the radius, rather than in the brachium with the other two flexors (see fig. 10.22*a*). It forms the thick, fleshy mass on the lateral side of the forearm just distal to the elbow. Its origin is on the distal end of the humerus, and its insertion is on the distal end of the radius. Since its insertion is so far from the fulcrum, the brachioradialis does not generate as much power as the prime movers; it is effective mainly when the prime movers have partially flexed the elbow.

The prime mover of extension is the **triceps brachii** on the posterior side of the humerus (see figs. 10.2 and 10.22).

[45] *bi* = two + *ceps* = head + *brachi* = arm. Note that *biceps* is singular, there is no such word as *bicep*. The plural form is *bicipites* (by-SIP-ih-teez).

Table 10.10 Muscles Acting on the Humerus (see figs. 10.22–10.24)

O = origin, I = insertion, N = innervation (n. = nerve, nn. = nerves)

Pectoralis (PECK-toe-RAY-liss) Major		
Prime mover of shoulder flexion; adducts and medially rotates humerus; depresses pectoral girdle; elevates ribs; aids in climbing, pushing, and throwing		
O: clavicle, sternum, costal cartilages 1–6	I: intertubercular groove of humerus	N: medial and lateral pectoral nn.
Latissimus Dorsi (la-TISS-ih-muss DOR-sye)		
Adducts and medially rotates humerus; extends shoulder joint; produces strong downward strokes of arm, as in hammering or swimming ("swimmer's muscle"); pulls body upward in climbing		
O: vertebrae T7–L5, lower three or four ribs, thoracolumbar fascia, iliac crest, inferior angle of scapula	I: intertubercular groove of humerus	N: thoracodorsal n.
Deltoid		
Lateral fibers abduct humerus; anterior fibers flex and medially rotate it; posterior fibers extend and laterally rotate it		
O: clavicle, scapular spine, acromion	I: deltoid tuberosity of humerus	N: axillary n.
Teres (TERR-eez) Major		
Adducts and medially rotates humerus; extends shoulder joint		
O: from inferior angle to lateral border of scapula	I: medial aspect of proximal shaft of humerus	N: subscapular n.
Coracobrachialis (COR-uh-co-BRAY-kee-AL-iss)		
Adducts arm; flexes shoulder joint		
O: coracoid process	I: medial aspect of shaft of humerus	N: musculocutaneous n.
Rotator Cuff		
All rotator cuff muscles hold head of humerus in glenoid cavity and stabilize shoulder joint in addition to performing the functions below.		
Infraspinatus (IN-fra-spy-NAY-tus)		
Extends and laterally rotates humerus		
O: infraspinous fossa of scapula	I: greater tubercle of humerus	N: suprascapular n.
Supraspinatus (SOO-pra-spy-NAY-tus)		
Abducts humerus; resists downward displacement when carrying heavy weight		
O: supraspinous fossa of scapula	I: lesser tubercle of humerus	N: suprascapular n.
Subscapularis (SUB-SCAP-you-LERR-iss)		
Medially rotates humerus		
O: subscapular fossa of scapula	I: lesser tubercle of humerus	N: subscapular n.
Teres Minor		
Adducts and laterally rotates humerus		
O: lateral border of scapula	I: greater tubercle of humerus	N: axillary n.

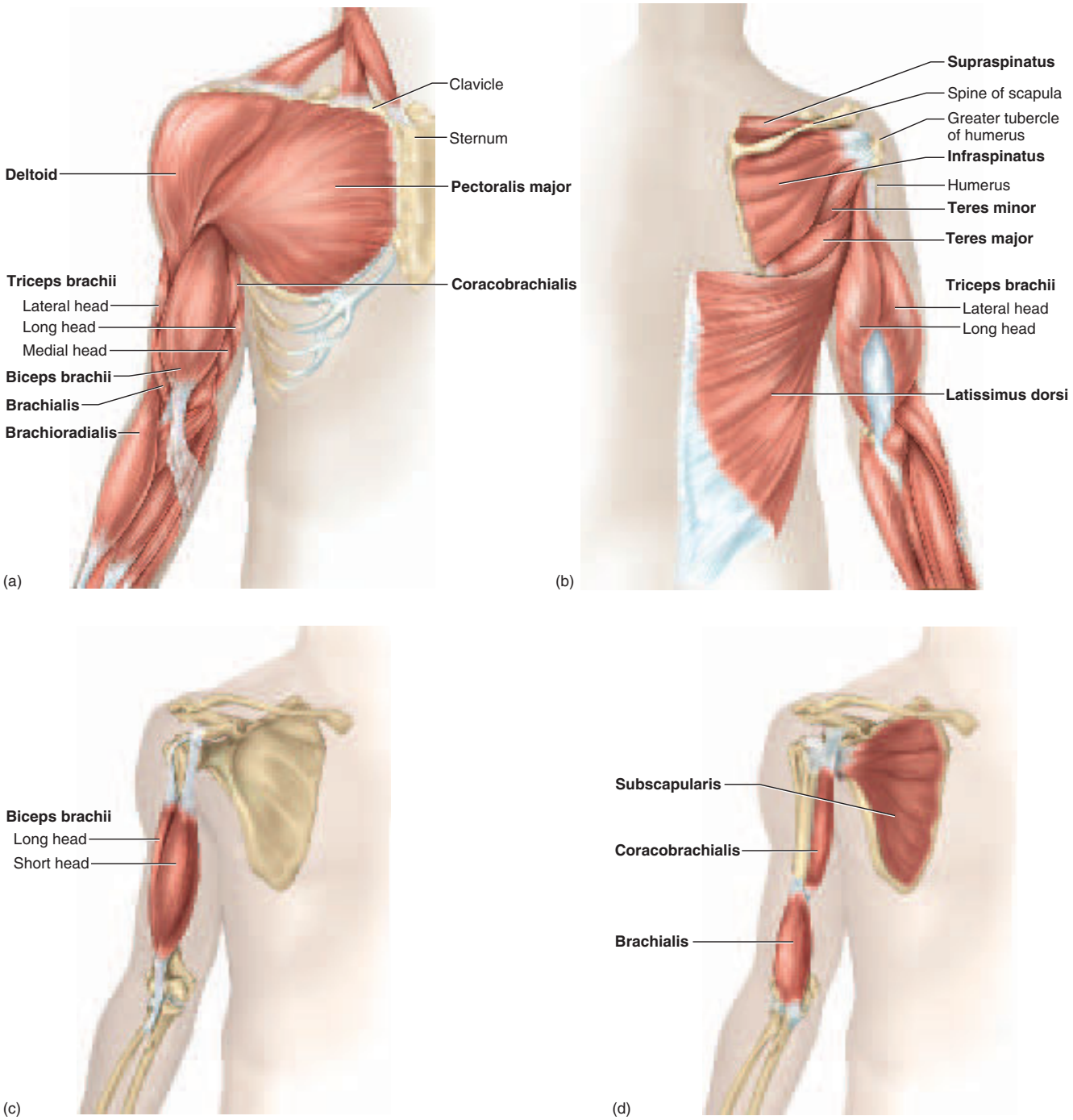
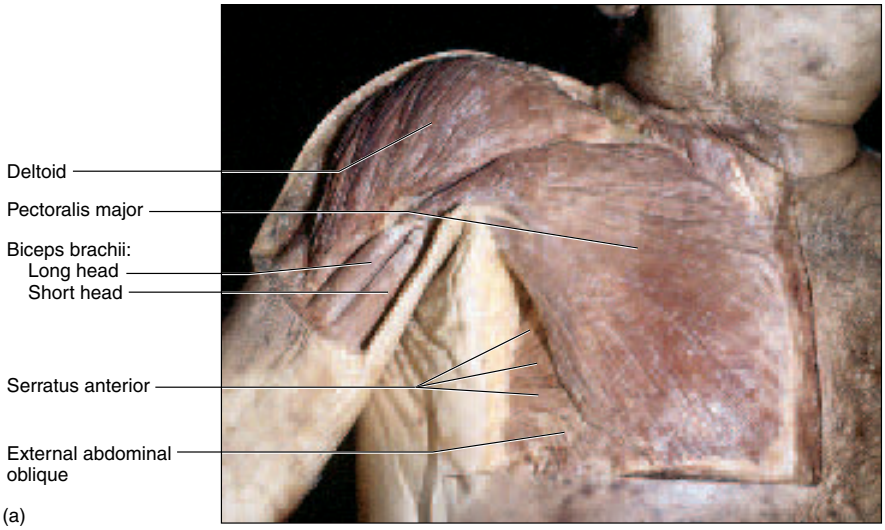


Figure 10.22 Pectoral and Brachial Muscles. (*a*) Anterior view. (*b*) Posterior view. (*c*) The biceps brachii, the superficial flexor of the elbow. (*d*) The brachialis, the deep flexor of the elbow, and the coracobrachialis and subscapularis, which act on the humerus.



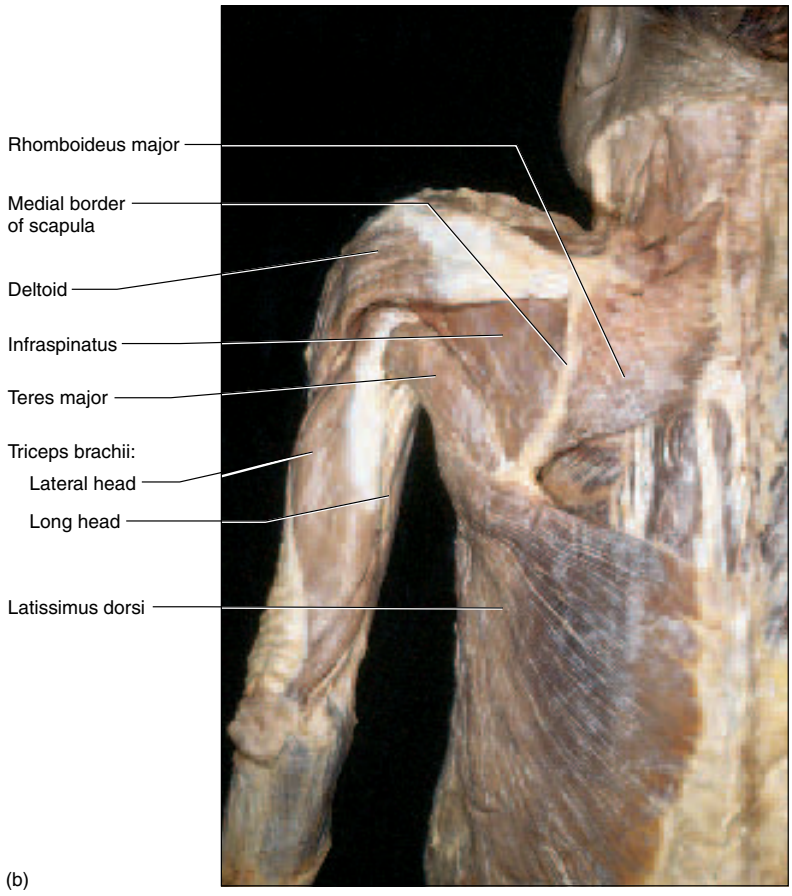


Figure 10.23 **Muscles of the Chest and Brachial Region of the Cadaver.** (*a*) Anterior view; (*b*) posterior view.
What muscles in these two figures would you remove to see more of the rotator cuff (SITS) muscles?

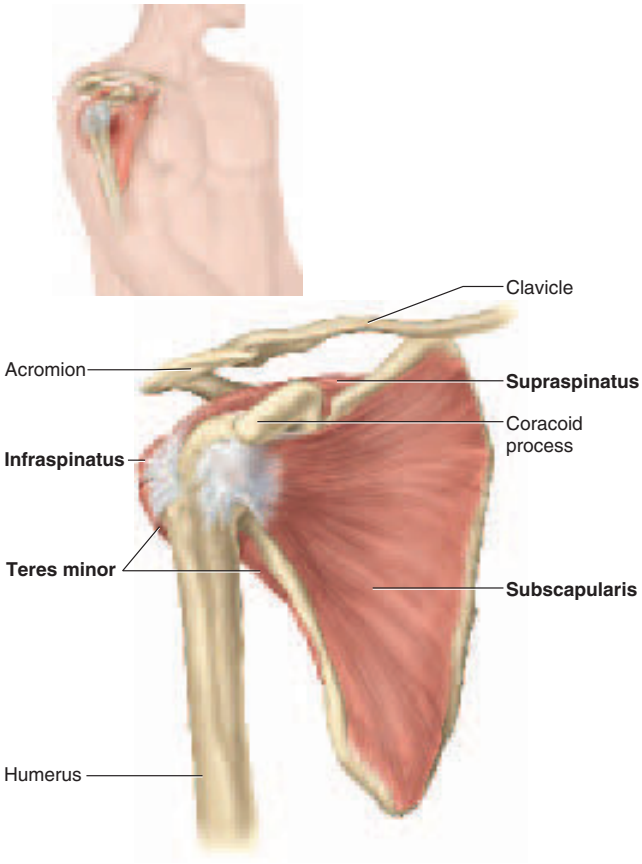


Figure 10.24 The Rotator Cuff. Anterolateral view of the right shoulder. The rotator cuff muscles are labeled in boldface.

The **anconeus**[46] is a weaker synergist of extension that crosses the posterior side of the elbow (see fig. 10.28*d, e*).

Pronation is achieved by two anterior muscles in the forearm—the **pronator teres** near the elbow and **pronator quadratus** near the wrist. Supination is achieved by the biceps brachii and the **supinator** of the posterior forearm (fig. 10.25).

Muscles Acting on the Wrist and Hand

The hand is acted upon by extrinsic muscles in the forearm and intrinsic muscles in the hand itself (table 10.14). The bellies of the extrinsic muscles form the fleshy roundness of the proximal forearm; their tendons extend into the wrist and hand. Their actions are mainly flexion and extension, but the wrist and fingers can be abducted and adducted, and the thumb and fingers can be opposed.

[46] *ancon* = elbow

Table 10.11 Actions of the Shoulder (Humeroscapular) Joint

Boldface indicates prime movers; others are synergists. Parentheses indicate only a slight effect.

Flexion	Extension
Anterior deltoid	**Posterior deltoid**
Pectoralis major	**Latissimus dorsi**
Coracobrachialis	Teres major
Biceps brachii	
Abduction	**Adduction**
Lateral deltoid	**Pectoralis major**
Supraspinatus	**Latissimus dorsi**
	Coracobrachialis
	Triceps brachii
	Teres major
	(Teres minor)
Medial Rotation	**Lateral Rotation**
Subscapularis	**Infraspinatus**
Teres major	**Teres minor**
Latissimus dorsi	Deltoid
Deltoid	
Pectoralis major	

Table 10.12 Actions of the Forearm

Boldface indicates prime movers; others are synergists. Parentheses indicate only a slight effect.

Flexion	Extension
Biceps brachii	**Triceps brachii**
Brachialis	Anconeus
Brachioradialis	
Flexor carpi radialis	
(Pronator teres)	
Pronation	**Supination**
Pronator teres	**Supinator**
Pronator quadratus	Biceps brachii

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Table 10.13 Muscles Acting on the Forearm (see figs. 10.22 and 10.25)

O = origin, I = insertion, N = innervation (n. = nerve, nn. = nerves)

Muscles with Bellies in the Arm (Brachium)		
Biceps Brachii (BY-seps BRAY-kee-eye)		
Flexes elbow; abducts arm; supinates forearm; holds head of humerus in glenoid cavity		
O: *long head*—supraglenoid tubercle of scapula; *short head*—coracoid process of scapula	I: radial tuberosity	N: musculocutaneous n.
Brachialis (BRAY-kee-AL-iss)		
Flexes elbow		
O: anterior distal shaft of humerus	I: coronoid process of ulna, capsule of elbow joint	N: musculocutaneous n., radial n.
Triceps Brachii (TRI-seps BRAY-kee-eye)		
Extends elbow; long head adducts humerus		
O: *long head*—infraglenoid tubercle of scapula; *lateral head*—proximal posterior shaft of humerus; *medial head*—posterior shaft of humerus	I: olecranon of ulna	N: radial n.
Muscles with Bellies in the Forearm (Antebrachium)		
Brachioradialis (BRAY-kee-oh-RAY-dee-AL-iss)		
Flexes elbow		
O: lateral supracondylar ridge of humerus	I: styloid process of radius	N: radial n.
Anconeus (an-CO-nee-us)		
Extends elbow		
O: lateral epicondyle of humerus	I: olecranon and posterior aspect of ulna	N: radial n.
Pronator Teres (PRO-nay-tur TERR-eez)		
Pronates forearm		
O: medial epicondyle of humerus, coronoid process of ulna	I: lateral midshaft of radius	N: median n.
Pronator Quadratus (PRO-nay-tur quad-RAY-tus)		
Pronates forearm		
O: anterior distal shaft of ulna	I: anterior distal shaft of radius	N: median n.
Supinator (SOO-pih-NAY-tur)		
Supinates forearm		
O: lateral epicondyle of humerus, proximal shaft of ulna	I: proximal shaft of radius	N: radial n.

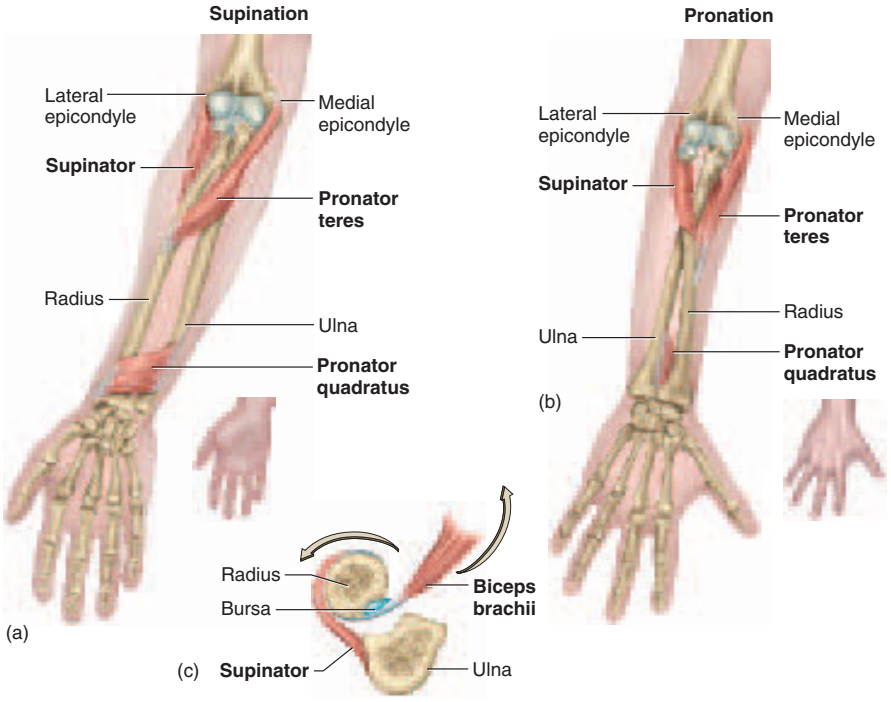


Figure 10.25 **Actions of the Rotator Muscles on the Forearm.** (*a*) Supination; (*b*) pronation; (*c*) cross section just distal to the elbow, showing how the biceps brachii aids in supination.
What do the names of the pronator teres and pronator quadratus muscles indicate about their shapes?

Table 10.14 Muscles Acting on the Wrist and Hand (see figs. 10.27 and 10.28)

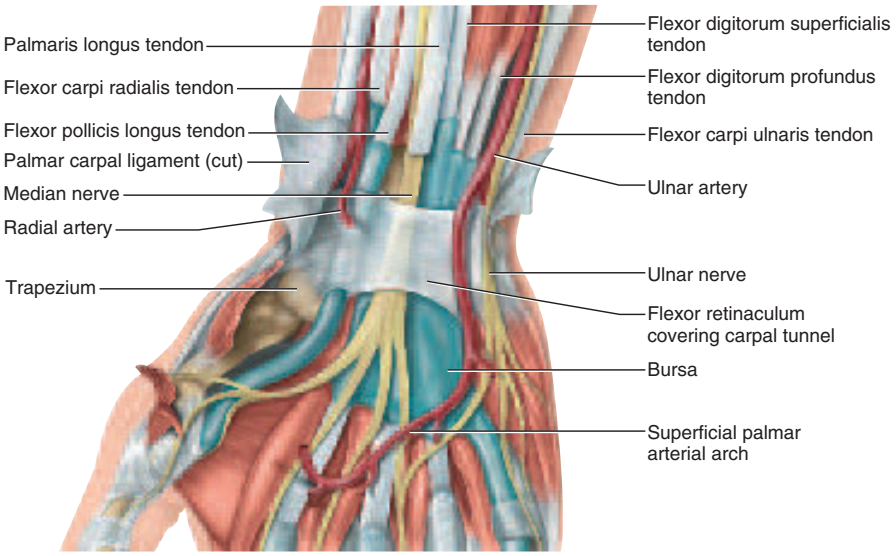
O = origin, I = insertion, N = innervation (n. = nerve, nn. = nerves)

Anterior Compartment—Superficial Layer		
Flexor Carpi Radialis (CAR-pie RAY-dee-AY-liss)		
Powerful wrist flexor; abducts hand; synergist in elbow flexion		
O: medial epicondyle of humerus	I: base of metacarpals II and III	N: median n.
Flexor Carpi Ulnaris (ul-NAY-riss)		
Flexes and adducts wrist; stabilizes wrist during extension of fingers		
O: medial epicondyle of humerus	I: pisiform, hamate, metacarpal V	N: ulnar n.
Flexor Digitorum Superficialis (DIDJ-ih-TOE-rum SOO-per-FISH-ee-AY-liss)		
Flexes fingers II–V at proximal interphalangeal joints; aids in flexion of wrist and metacarpophalangeal joints		
O: medial epicondyle of humerus, radius, coronoid process of ulna	I: four tendons leading to middle phalanges II–V	N: median n.
Palmaris (pall-MERR-iss) Longus		
Weakly flexes wrist; often absent		
O: medial epicondyle of humerus	I: palmar aponeurosis, flexor retinaculum	N: median n.

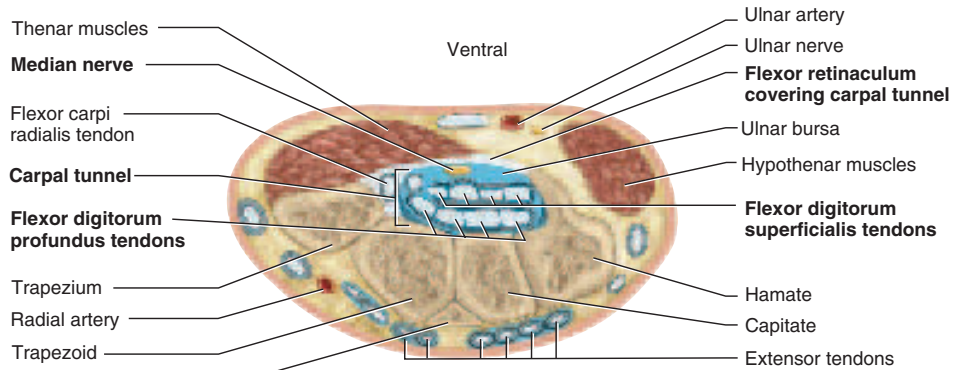
(continued)

Table 10.14 Muscles Acting on the Wrist and Hand (see figs. 10.27 and 10.28) *(continued)*

Anterior Compartment—Deep Layer		
Flexor Digitorum Profundus		
Flexes wrist and distal interphalangeal joints		
O: shaft of ulna, interosseous membrane	I: four tendons to distal phalanges II–V	N: median and ulnar nn.
Flexor Pollicis (PAHL-ih-sis) Longus		
Flexes interphalangeal joint of thumb; weakly flexes wrist		
O: radius, interosseous membrane	I: distal phalanx I	N: median n.
Posterior Compartment—Superficial Layer		
Extensor Carpi Radialis Longus		
Extends and abducts wrist		
O: lateral epicondyle of humerus	I: base of metacarpal II	N: radial n.
Extensor Carpi Radialis Brevis		
Extends and abducts wrist; fixes wrist during finger flexion		
O: lateral epicondyle of humerus	I: base of metacarpal III	N: radial n.
Extensor Carpi Ulnaris		
Extends and adducts wrist		
O: lateral epicondyle of humerus, posterior shaft of ulna	I: base of metacarpal V	N: radial n.
Extensor Digitorum (DIDJ-ih-TOE-rum)		
Extends fingers II–V at metacarpophalangeal joints		
O: lateral epicondyle of humerus	I: dorsal aspect of phalanges II–V	N: radial n.
Extensor Digiti Minimi (DIDJ-ih-ty MIN-in-my)		
Extends metacarpophalangeal joint of little finger; sometimes considered to be a detached portion of extensor digitorum		
O: lateral epicondyle of humerus	I: distal and middle phalanges V	N: radial n.
Posterior Compartment—Deep Layer		
Abductor Pollicis Longus		
Abducts and extends thumb; abducts wrist		
O: posterior aspect of radius and ulna, interosseous membrane	I: trapezium, base of metacarpal I	N: radial n.
Extensor Indicis (IN-dih-sis)		
Extends index finger at metacarpophalangeal joint		
O: shaft of ulna, interosseous membrane	I: middle and distal phalanges II	N: radial n.
Extensor Pollicis Longus		
Extends thumb at metacarpophalangeal joint		
O: shaft of ulna, interosseous membrane	I: distal phalanx I	N: radial n.
Extensor Pollicis Brevis		
Extends thumb at metacarpophalangeal joint		
O: shaft of radius, interosseous membrane	I: proximal phalanx I	N: radial n.



(a)



(b)

Figure 10.26 **The Carpal Tunnel.** (*a*) Dissection of the wrist (anterior aspect) showing the tendons, nerve, and bursae that pass under the flexor retinaculum. (*b*) Cross section of the wrist, ventral (anterior side) up. Note how the flexor tendons and median nerve are confined in the tight space between the carpal bones and flexor retinaculum.

It may seem as if the tendons would stand up like taut bowstrings when these muscles contracted, but this is prevented by the fact that most of them pass under a **flexor retinaculum (transverse carpal ligament)** on the anterior side of the wrist and an **extensor retinaculum (dorsal carpal ligament)** on the posterior side (see fig. 10.29). The **carpal tunnel** is a tight space between the carpal bones and flexor retinaculum (fig. 10.26). The flexor tendons passing through the tunnel are enclosed in tendon sheaths that enable them to slide back and forth quite easily, although this region is very subject to injury from repetitive motion (see insight 10.4).

Insight 10.4 Clinical Application

Carpal Tunnel Syndrome

Prolonged, repetitive motions of the wrist and fingers can cause tissues in the carpal tunnel to become inflamed, swollen, or fibrotic. Since the carpal tunnel cannot expand, swelling puts pressure on the median nerve of the wrist, which passes through the carpal tunnel with the flexor tendons. This pressure causes tingling and muscular weakness in the palm and medial side of the hand and pain that may radiate to the arm and shoulder. This condition, called *carpal tunnel syndrome,* is common among keyboard operators, pianists, meat cutters, and others

who spend long hours making repetitive wrist motions. Carpal tunnel syndrome is treated with aspirin and other anti-inflammatory drugs, immobilization of the wrist, and sometimes surgical removal of part or all of the flexor retinaculum to relieve pressure on the nerve.

Several of these muscles originate on the humerus; therefore, they cross the elbow joint and weakly contribute to flexion and extension of the elbow. This action is relatively negligible, however, and we focus on their action at the wrist and fingers. Although these muscles are numerous and complex, most of their names suggest their actions, and from their actions, their approximate locations in the forearm can generally be deduced.

The deep fasciae divide the muscles of the forearm into anterior and posterior compartments and each compartment into superficial and deep layers (fig. 10.27). The muscles are listed and classified this way in table 10.14. Most muscles of the anterior compartment are flexors of the wrist and fingers that arise from a common tendon on the humerus (fig. 10.28). At the distal end, the tendon of the **palmaris longus** passes over the flexor retinaculum while the other tendons pass beneath it. The two prominent tendons that you can palpate at the wrist belong to the palmaris longus on the medial side and the **flexor carpi radialis** on the lateral side. The latter is an important landmark for finding the radial artery, where the pulse is usually taken.

Muscles of the posterior compartment are mostly wrist and finger extensors that share a single proximal tendon arising from the humerus. One of the superficial muscles on this side, the **extensor digitorum,** has four distal tendons that can easily be seen and palpated on the back of the hand when the fingers are strongly hyperextended (fig. 10.28*d,* and see fig. B.8 in the atlas following this chapter). By strongly abducting and extending the thumb into a hitchhiker's position, you should also be able to see a deep dorsolateral pit at the base of the thumb, with a taut tendon on each side of it. This depression is called the *anatomical snuffbox* because it was once fashionable to place a pinch of snuff here and inhale it (see fig. B.8). It is bordered laterally by the tendons of the **abductor pollicis longus** and **extensor pollicis brevis** and medially by the tendon of the **extensor pollicis longus.**

Other muscles of the forearm were considered earlier because they act on the radius and ulna rather than on the hand. These are the pronator quadratus, pronator teres, supinator, anconeus, and brachioradialis.

Table 10.15 summarizes the muscles responsible for the major movements of the wrist and hand.

Think About It

Why are the prime movers of finger extension and flexion located in the forearm rather than in the hand, closer to the fingers?

The intrinsic muscles of the hand assist the flexors and extensors of the forearm and make finger movements more precise (fig. 10.29). You will note in table 10.16 that they are divided into three groups. The **thenar group** forms the thick fleshy mass *(thenar eminence)* at the base of the thumb, except for the *adductor pollicis,* which forms the web between the thumb and palm; the **hypothenar group** forms the fleshy mass *(hypothenar eminence)* at the base of the little finger; and the **midpalmar group** occupies the space between these. The midpalmar group consists of 11 muscles divided into three subgroups:

1. **Dorsal interosseous**[47] **muscles**—four bipennate muscles attached to both sides of the metacarpal bones, serving to abduct (spread) the fingers.
2. **Palmar interosseous muscles**—three unipennate muscles that arise from metacarpals II, IV, and V and adduct the fingers (draw them together).
3. **Lumbrical**[48] **muscles**—four wormlike muscles that flex the metacarpophalangeal joints (proximal knuckles) but extend the interphalangeal joints (distal knuckles).

Before You Go On

Answer the following questions to test your understanding of the preceding section:

17. Name a muscle that inserts on the scapula and plays a significant role in each of the following actions: (a) pushing a stalled car, (b) paddling a canoe, (c) squaring the shoulders in military attention, (d) lifting the shoulder to carry a heavy box on it, and (e) lowering the shoulder to lift a suitcase.
18. Describe three contrasting actions of the deltoid muscle.
19. Name the four rotator cuff muscles and identify the scapular surfaces against which they lie.
20. Name the prime movers of elbow flexion and extension.
21. Identify three functions of the biceps brachii.
22. Name three extrinsic muscles and two intrinsic muscles that flex the phalanges.

[47] *inter* = between + *osse* = bone
[48] *lumbric* = earthworm

Insight 10.5 Clinical Application

Intramuscular Injections

Muscles with thick bellies are commonly used for intramuscular (I.M.) drug injections. Since drugs injected into these muscles are absorbed into the bloodstream gradually, it is safe to administer relatively large doses (up to 5 mL) that could be dangerous or even fatal if injected directly into the bloodstream. I.M. injections also cause less tissue irritation than subcutaneous injections.

Knowledge of subsurface anatomy is necessary to avoid damaging nerves or accidentally injecting a drug into a blood vessel. Anatomical

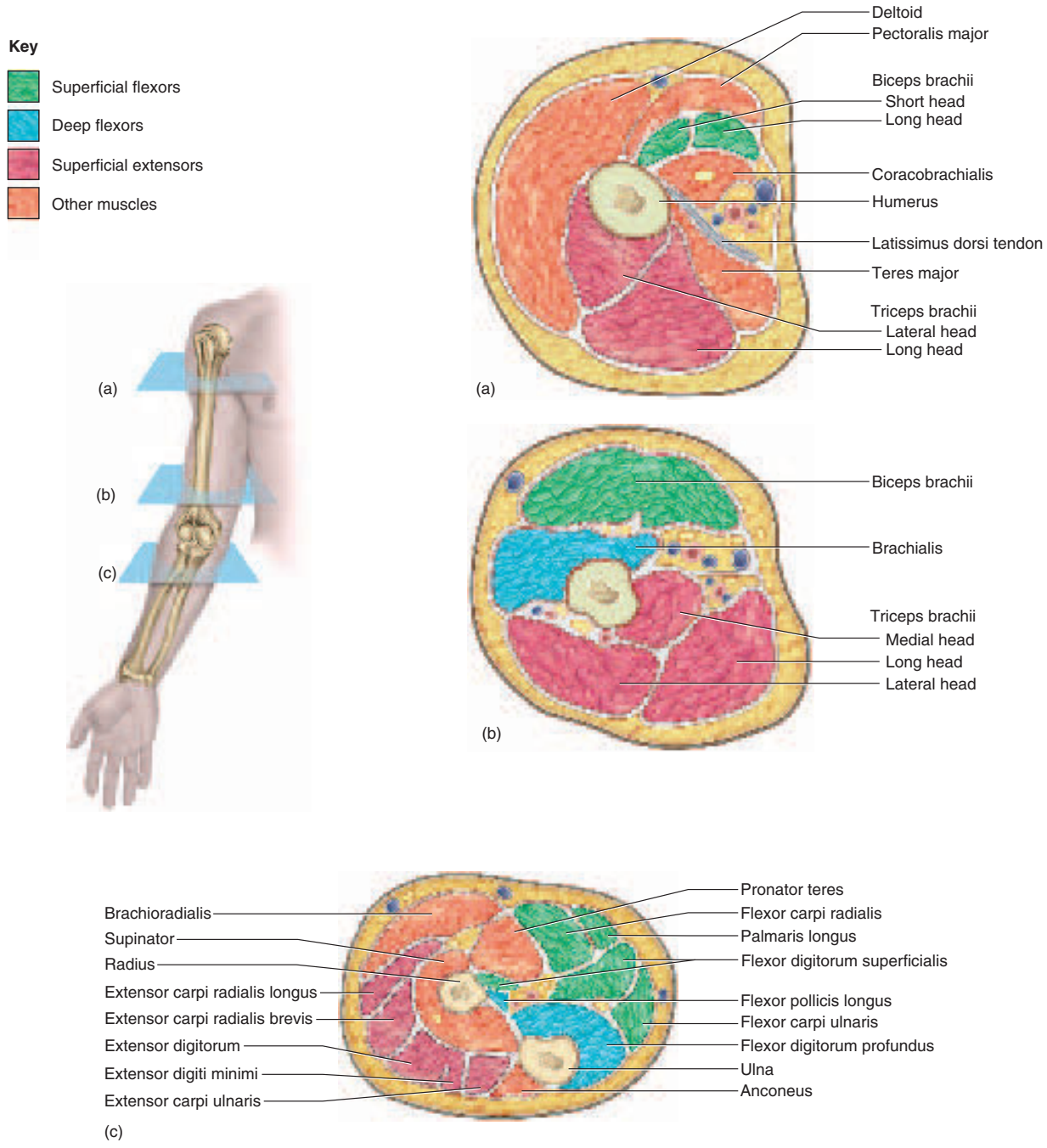


Figure 10.27 Serial Cross Sections Through the Upper Limb. Each section is taken at the correspondingly lettered level in the figure at the *left* and is pictured with the posterior muscle compartment facing the bottom of the page, as if you were viewing the right arm of a person facing you with the arm extended and the palm up.

Why are the extensor pollicis longus and extensor indicis not seen in figure *c*?

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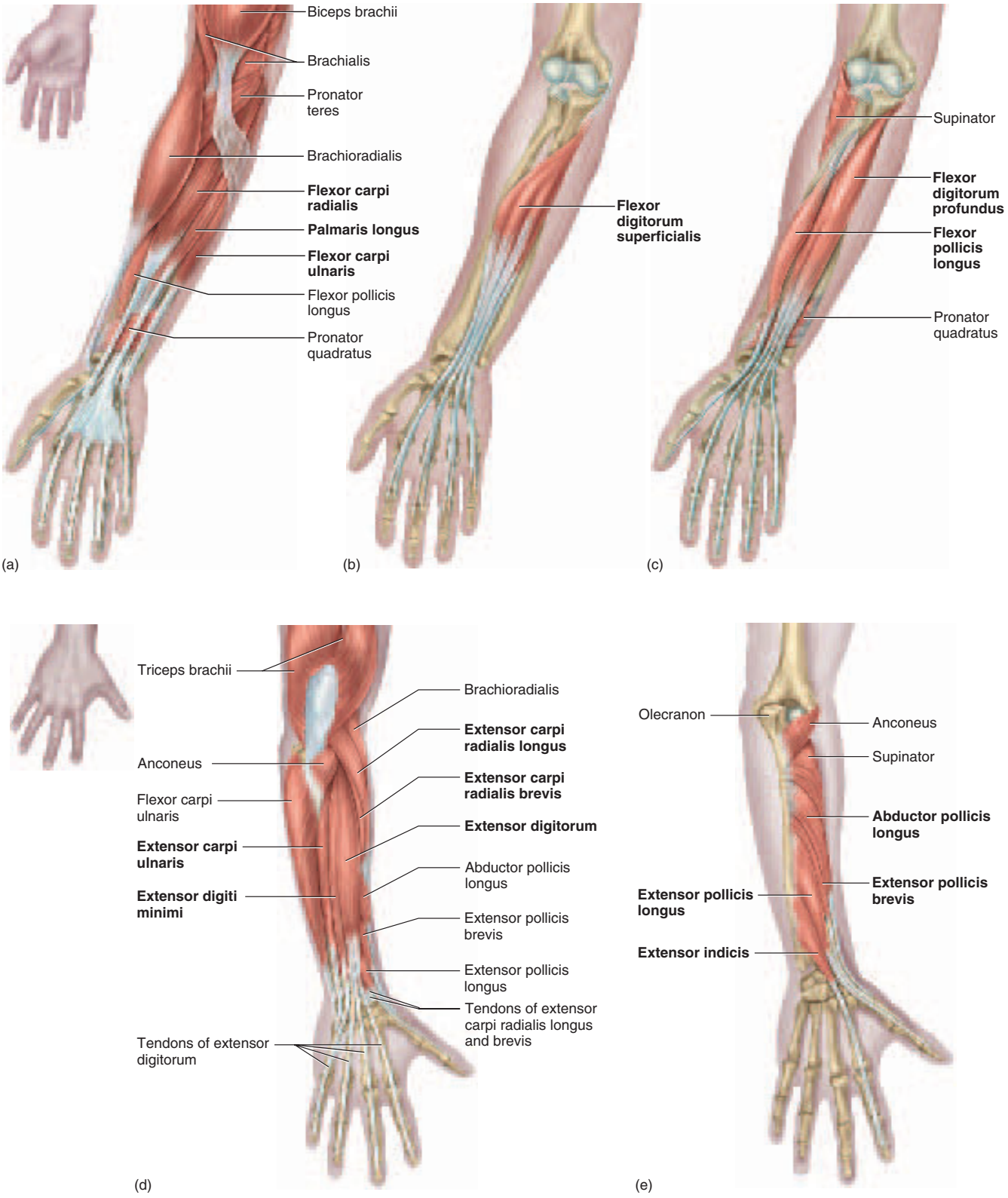

Figure 10.28 **Muscles of the Forearm.** Figures *a*–*c* are anterior views and figures *d*–*e* are posterior. Boldface labels indicate: (*a*) superficial flexors; (*b*) the flexor digitorum superficialis, deep to the muscles in *a* but also classified as a superficial flexor; (*c*) deep flexors; (*d*) superficial extensors; and (*e*) deep extensors.

Table 10.15 Actions of the Wrist and Hand

Boldface indicates prime movers; others are synergists. Parentheses indicate only a slight effect.

Wrist Flexion	Wrist Extension
Flexor carpi radialis	**Extensor digitorum**
Flexor carpi ulnaris	Extensor carpi radialis longus
Flexor digitorum superficialis	Extensor carpi radialis brevis
(Palmaris longus)	Extensor carpi ulnaris
(Flexor pollicis longus)	

Wrist Abduction	Wrist Adduction
Flexor carpi radialis	Flexor carpi ulnaris
Extensor carpi radialis longus	Extensor carpi ulnaris
Extensor carpi radialis brevis	
Abductor pollicis longus	

Finger Flexion	Finger Extension	Thumb Opposition
Flexor digitorum superficialis	Extensor pollicis longus	Opponens pollicis
Flexor digitorum profundus	Extensor pollicis brevis	Opponens digiti minimi
Flexor pollicis longus	Extensor digitorum	
	Extensor indicis	

knowledge also enables a clinician to position a patient so that the muscle is relaxed, making the injection less painful.

Amounts up to 2 mL are commonly injected into the deltoid muscle about two finger widths below the acromion. Amounts over 2 mL are commonly injected into the gluteus medius, in the superolateral quadrant of the gluteal area, at a safe distance from the sciatic nerve and major gluteal blood vessels. Injections are often given to infants and young children in the vastus lateralis of the thigh, because their deltoid and gluteal muscles are not well developed.

Muscles Acting on the Hip and Lower Limb

Objectives

When you have completed this section, you should be able to

- name and locate the muscles that act on the hip, knee, ankle, and toe joints;
- relate the actions of these muscles to the joint movements described in chapter 9; and
- describe the origin, insertion, and innervation of each muscle.

The largest and strongest muscles in the body are found in the lower limb. Unlike those of the upper limb, they are adapted less for precision than for the strength needed to stand, maintain balance, walk, and run. Several of them cross and act upon two or more joints, such as the hip and knee.

To avoid confusion in this discussion, remember that in the anatomical sense the word *leg* refers only to that part of the limb between the knee and ankle. The term *foot* includes the tarsal region (ankle), metatarsal region, and toes.

Muscles Acting on the Hip and Femur

Most muscles that act on the femur (table 10.17) originate on the os coxae. The two principal anterior muscles are the **iliacus,** which fills most of the broad iliac fossa of the pelvis, and the **psoas major,** a thick, rounded muscle that originates mainly on the lumbar vertebrae. Collectively, they are called the **iliopsoas** (ILL-ee-oh-SO-us) (fig. 10.30). They converge on a single tendon that inserts on the femur and flexes the hip joint—for example, when you bend forward at the waist, swing the leg forward in walking, or raise the thigh in a marching stance.

On the lateral and posterior sides of the hip are the **tensor fasciae latae** and three gluteal muscles—the **gluteus maximus, gluteus medius,** and **gluteus minimus** (figs. 10.31 and 10.34). The gluteus maximus is the largest muscle of this group and forms most of the mass of the buttocks. It is an extensor of the hip joint that produces the backswing of the leg in walking and provides most of the lift when you climb stairs. It generates the most force when the thigh is flexed at a 45° angle to the trunk. This is the advantage in starting a foot race from a crouched position.

Think About It

What muscles produce the downstroke in pedaling a bicycle? In view of this, what is one reason that racing bicycles are designed to make the rider lean forward?

The deep **lateral rotators** of the pelvic region (table 10.17; fig. 10.31) rotate the femur laterally, as when you cross your legs to rest an ankle on your knee. Thus, they oppose medial rotation by the gluteus medius and minimus. Most of them also abduct or adduct the femur. The abductors are important in walking because, when we lift one foot from the ground, they shift the body weight to the other leg and prevent us from falling over.

The **fascia lata**[49] is a fibrous sheath that encircles the thigh and tightly binds its muscles. On the lateral surface,

[49] *fasc* = band + *lata* = broad

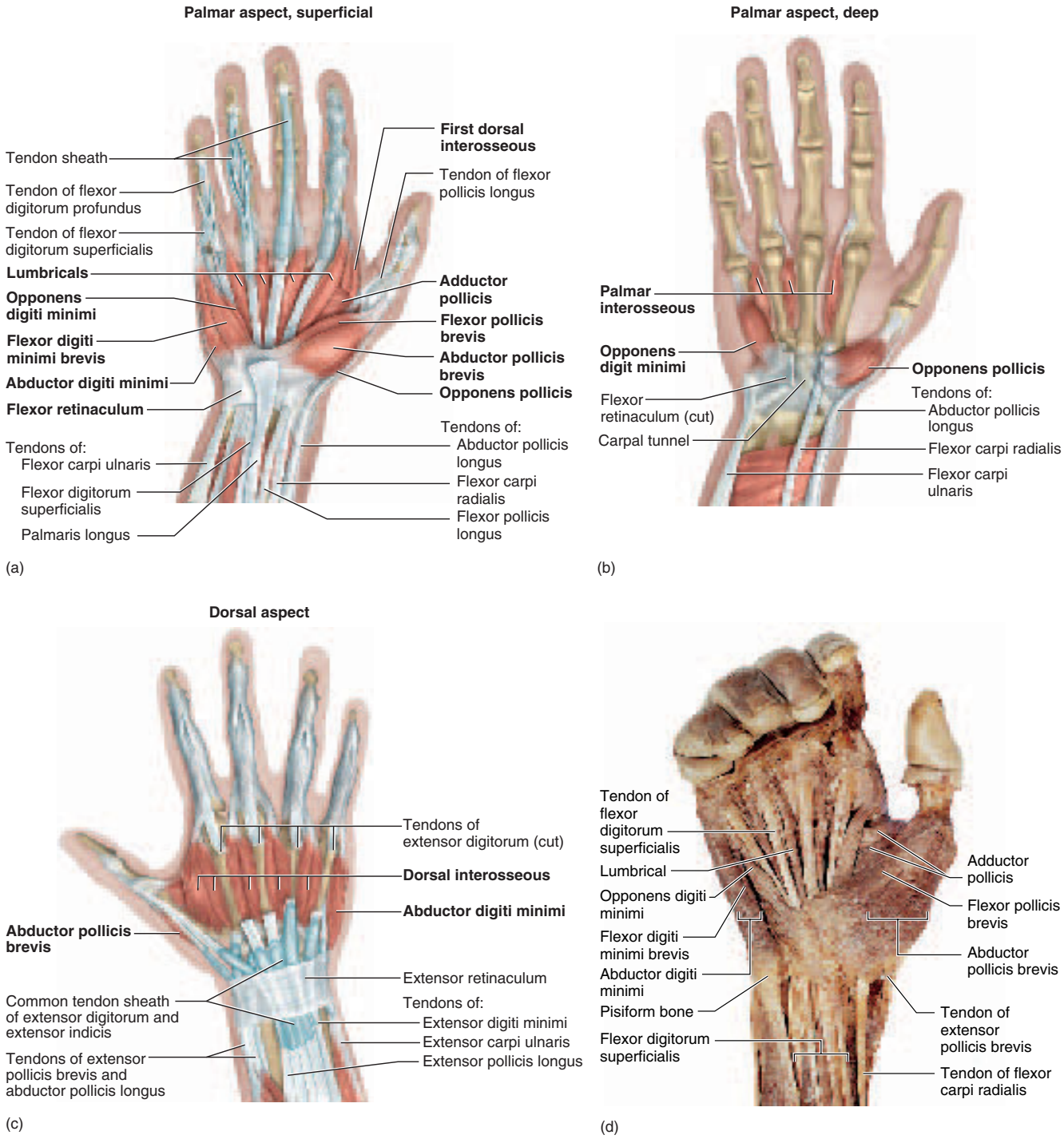

Figure 10.29 **Intrinsic Muscles of the Hand.** Boldface labels indicate: (*a*) superficial muscles, anterior (palmar) view; (*b*) deep muscles, anterior view; (*c*) superficial muscles, posterior (dorsal) view; (*d*) anterior (palmar) view of cadaver hand.

Table 10.16 Intrinsic Muscles of the Hand (see fig. 10.29)

O = origin, I = insertion, N = innervation (n. = nerve, nn. = nerves)

Thenar Group		
Abductor Pollicis (PAHL-ih-sis) Brevis		
Abducts thumb O: scaphoid, trapezium, flexor retinaculum	I: lateral aspect of proximal phalanx I	N: median n.
Adductor Pollicis		
Adducts thumb and opposes it to the fingers O: trapezium, trapezoid, capitate, metacarpals II–IV	I: medial aspect of proximal phalanx I	N: ulnar n.
Flexor Pollicis Brevis		
Flexes thumb at metacarpophalangeal joint O: trapezium, flexor retinaculum	I: proximal phalanx I	N: median and ulnar nn.
Opponens (op-OH-nens) Pollicis		
Opposes thumb to fingers O: trapezium, flexor retinaculum	I: metacarpal I	N: median n.
Hypothenar Group		
Abductor Digiti Minimi		
Abducts little finger O: pisiform, tendon of flexor carpi ulnaris	I: medial aspect of proximal phalanx V	N: ulnar n.
Flexor Digiti Minimi Brevis		
Flexes little finger at metacarpophalangeal joint O: hamulus of hamate, flexor retinaculum	I: medial aspect of proximal phalanx V	N: ulnar n.
Opponens Digiti Minimi		
Opposes little finger to thumb; deepens pit of palm O: hamulus of hamate, flexor retinaculum	I: medial aspect of metacarpal V	N: ulnar n.
Midpalmar Group		
Dorsal Interosseous (IN-tur-OSS-ee-us) Muscles (four muscles)		
Abduct digits II–IV O: two heads on facing sides of adjacent metacarpals	I: proximal phalanges II–IV	N: ulnar n.
Palmar Interosseous Muscles (three muscles)		
Adduct digits II, IV, and V O: metacarpals II, IV, and V	I: proximal phalanges II, IV, and V	N: ulnar n.
Lumbricals (four muscles)		
Flex metacarpophalangeal joints; extend interphalangeal joints O: tendons of flexor digitorum profundus	I: proximal phalanges II–V	N: median and ulnar nn.

Table 10.17 Muscles Acting on the Hip and Femur (see figs. 10.30–10.34)

O = origin, I = insertion, N = innervation (n. = nerve, nn. = nerves)

Anterior Muscles of the Hip (Iliopsoas)		
Iliacus (ih-LY-uh-cus)		
Flexes hip joint; medially rotates femur		
O: iliac fossa	I: lesser trochanter of femur, capsule of coxal joint	N: femoral n.
Psoas (SO-ass) Major		
Flexes hip joint; medially rotates femur		
O: vertebral bodies T12–L5	I: lesser trochanter of femur	N: lumbar plexus
Lateral and Posterior Muscles of the Hip		
Tensor Fasciae Latae (TEN-sor FASH-ee-ee LAY-tee)		
Flexes hip joint; abducts and medially rotates femur, tenses fascia lata and braces knee when opposite foot is lifted from ground		
O: iliac crest near anterior superior spine	I: lateral condyle of tibia	N: superior gluteal n.
Gluteus Maximus		
Extends hip joint; abducts and laterally rotates femur; important in the backswing of the stride		
O: ilium and sacrum	I: gluteal tuberosity of femur, fascia lata	N: inferior gluteal n.
Gluteus Medius and Gluteus Minimus		
Abduct and medially rotate femur; maintain balance by shifting body weight during walking		
O: ilium	I: greater trochanter of femur	N: superior gluteal n.
Lateral Rotators		
Gemellus (jeh-MEL-us) Superior and Gemellus Inferior		
Laterally rotate femur		
O: body of ischium	I: obturator internus tendon	N: sacral plexus
Obturator (OB-too-RAY-tur) Externus		
Laterally rotates femur		
O: anterior margin of obturator foramen	I: greater trochanter of femur	N: obturator n.
Obturator Internus		
Abducts and laterally rotates femur		
O: posterior margin of obturator foramen	I: greater trochanter of femur	N: sacral plexus
Piriformis (PIR-ih-FOR-miss)		
Abducts and laterally rotates femur		
O: anterolateral aspect of sacroiliac region	I: greater trochanter of femur	N: ventral rami of S1–S2
Quadratus Femoris (quad-RAY-tus FEM-oh-riss)		
Adducts and laterally rotates femur		
O: ischial tuberosity	I: intertrochanteric ridge of femur	N: sacral plexus
Medial (Adductor) Compartment of the Thigh		
Adductor Longus and Adductor Brevis		
Adduct and laterally rotate femur; flex hip joint		
O: pubis	I: posterior shaft of femur	N: obturator n.

(continued)

Table 10.17 Muscles Acting on the Hip and Femur (see figs. 10.30–10.34) *(continued)*

Adductor Magnus		
Anterior part adducts and laterally rotates femur and flexes hip joint; posterior part extends hip joint		
O: ischium	I: posterior shaft of femur	N: obturator and tibial nn.
Gracilis (GRASS-ih-lis)		
Adducts femur; flexes knee; medially rotates tibia		
O: pubis	I: medial aspect of proximal tibia	N: obturator n.
Pectineus (pec-TIN-ee-us)		
Adducts and laterally rotates femur; flexes hip		
O: pubis	I: posterior aspect of proximal femur	N: femoral n.

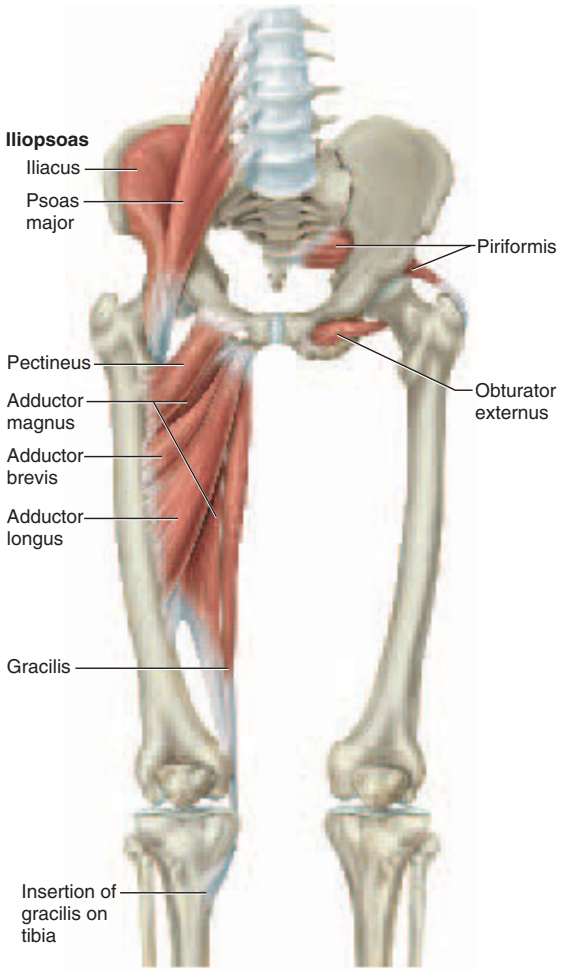

Figure 10.30 **Muscles Acting on the Hip and Femur.** Anterior view.

it combines with the tendons of the gluteus maximus and tensor fasciae latae to form the **iliotibial band,** which extends from the iliac crest to the lateral condyle of the tibia (fig. 10.32). The tensor fasciae latae tautens the iliotibial band and braces the knee, especially when we raise the opposite foot.

The fascia lata divides the thigh muscles into three compartments, each with its own nerve and blood supply: the *anterior (extensor) compartment, medial (adductor) compartment,* and *posterior (flexor) compartment.* Muscles of the anterior compartment function mainly as extensors of the knee, those of the medial compartment as adductors of the femur, and those of the posterior compartment as extensors of the hip and flexors of the knee.

In the medial compartment are five muscles that act on the hip joint—the **adductor longus, adductor brevis, adductor magnus, gracilis,**[50] and **pectineus**[51] (see fig. 10.30). All of them adduct the thigh, but some cross both the hip and knee joints and have additional actions noted in table 10.17.

Muscles Acting on the Knee

The following muscles form most of the mass of the thigh and produce their most obvious actions on the knee joint. Some of them, however, cross both the hip and knee joints and produce actions at both, moving the femur, tibia, and fibula (table 10.18).

The anterior compartment of the thigh contains the large **quadriceps femoris** muscle, the prime mover of knee extension and the most powerful muscle of the body (figs. 10.32 and 10.33). As the name implies, it has four heads—the **rectus femoris, vastus lateralis, vastus medialis,** and **vastus intermedius.** All four converge on a

[50] *gracil* = slender
[51] *pectin* = comb

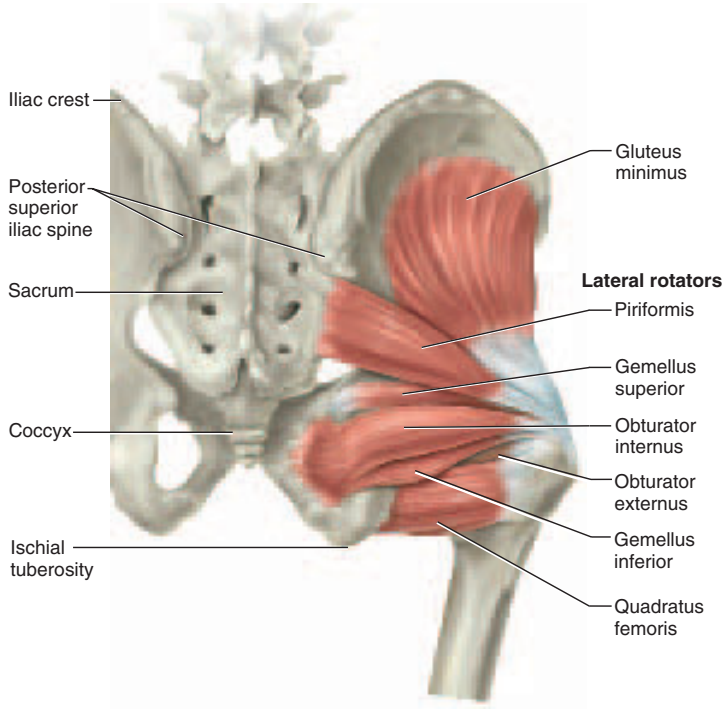

Figure 10.31 **Deep Gluteal Muscles.** For the superficial gluteal muscles, see figure 10.34.

single **quadriceps (patellar) tendon,** which extends to the patella, then continues as the **patellar ligament** and inserts on the tibial tuberosity. (Remember that a tendon usually extends from muscle to bone and a ligament from bone to bone.) The patellar ligament is struck with a rubber mallet to test the knee-jerk reflex. The quadriceps extends the knee when you stand up, take a step, or kick a ball. It is very important in running because, together with the iliopsoas, it flexes the hip in each airborne phase of the leg's cycle of motion. The rectus femoris also flexes the hip in such actions as high kicks or simply in drawing the leg forward during a stride.

Crossing the quadriceps from the lateral side of the hip to the medial side of the knee is the narrow, straplike **sartorius,**[52] the longest muscle of the body. It flexes the hip and knee joints and laterally rotates the thigh, as in crossing the legs. It is colloquially called the "tailor's muscle" after the cross-legged stance of a tailor supporting his work on the raised knee.

The posterior compartment contains the **biceps femoris, semimembranosus,** and **semitendinosus** (fig. 10.34). These muscles are colloquially known as the "hamstrings" because their tendons at the knee of a hog are commonly used to hang a ham for curing. They flex the knee and, aided by the gluteus maximus, they extend the hip during walking and running. The pit at the rear of the knee, called the *popliteal fossa,* is bordered by the biceps tendon on the lateral side and the tendons of the semimembranosus and semitendinosus on the medial side. When wolves attack large prey, they often attempt to sever the hamstring tendons, because this renders the prey helpless. Hamstring injuries are common among sprinters, soccer players, and other athletes who rely on quick acceleration.

Muscles Acting on the Foot

The fleshy mass of the leg proper (below the knee) is formed by a group of **crural muscles,** which act on the foot (fig. 10.35; table 10.19). These muscles are tightly bound together by deep fasciae, which compress them and aid in the return of blood from the legs. The fasciae separate the crural muscles into anterior, lateral, and posterior compartments, each with its own nerve and blood supply.

Muscles of the anterior compartment dorsiflex the ankle and prevent the toes from scuffing the ground during walking. These are the **extensor digitorum longus** (extensor of toes II–V), **extensor hallucis**[53] **longus** (exten-

[52] *sartor* = tailor

[53] *halluc* = great toe

Table 10.18 Muscles Acting on the Knee (see figs. 10.32 and 10.34)

O = origin, I = insertion, N = innervation (n. = nerve)		
Anterior (Extensor) Compartment of Thigh		
Quadriceps Femoris (QUAD-rih-seps FEM-oh-riss)		
Extends knee; rectus femoris also flexes hip		
O: *rectus femoris*—anterior inferior spine of ilium; *vastus lateralis*—posterolateral shaft of femur; *vastus medialis*—linea aspera of femur; *vastus intermedius*—anterior shaft of femur	I: tibial tuberosity	N: femoral n.
Sartorius		
Flexes hip and knee; rotates femur medially; rotates tibia laterally; used in crossing legs		
O: anterior superior spine of ilium	I: medial aspect of tibial tuberosity	N: femoral n.
Posterior (Flexor) Compartment of Thigh (Hamstring Group)		
Biceps Femoris		
Flexes knee; extends hip; laterally rotates leg		
O: *long head*—ischial tuberosity; *short head*—posterior midshaft of femur	I: head of fibula	N: *long head*—tibial n.; *short head*—common peroneal n.
Semimembranosus (SEM-ee-MEM-bran-OH-sis)		
Flexes knee; extends hip; medially rotates tibia; tenses joint capsule of knee		
O: ischial tuberosity	I: medial condyle of tibia, collateral ligament of knee	N: tibial n.
Semitendinosus		
Flexes knee; extends hip; medially rotates tibia		
O: ischial tuberosity	I: near tibial tuberosity	N: tibial n.
Posterior Compartment of Leg		
Popliteus (pop-LIT-ee-us)		
Unlocks knee to allow flexion; flexes knee; medially rotates tibia		
O: lateral condyle of femur	I: posterior proximal tibia	N: tibial n.

sor of the great toe), **fibularis (peroneus[54]) tertius,** and **tibialis anterior.** Their tendons are held tightly against the ankle and kept from bowing by two **extensor retinacula** similar to the one at the wrist (fig. 10.36).

The posterior compartment has superficial and deep muscle groups. The three muscles of the superficial group are plantar flexors—the **gastrocnemius,**[55] **soleus,**[56] and **plantaris**[57] (fig. 10.37). The first two of these, collectively known as the **triceps surae,**[58] insert on the calcaneus by way of the **calcaneal (Achilles) tendon.** This is the strongest tendon of the body but is nevertheless a common site of sports injuries resulting from sudden stress. The plantaris inserts medially on the calcaneus by a tendon of its own.

There are four muscles in the deep group (fig. 10.38). The **flexor digitorum longus, flexor hallucis longus,** and **tibialis posterior** are plantar flexors. The **popliteus** unlocks the knee joint so that it can be flexed and functions in flexion and medial rotation at the knee.

The lateral (peroneal) compartment includes the **fibularis (peroneus) brevis** and **fibularis (peroneus) longus** (figs. 10.37*b,* 10.38*a,* and 10.39*b*). They plantar flex and evert the foot. Plantar flexion is important not only in standing on tiptoes but in providing lift and forward thrust each time you take a step.

[54] *peroneo* = fibula
[55] *gastro* = belly + *cnem* = leg
[56] named for its resemblance to a flatfish, the sole
[57] *planta* = sole of foot
[58] *sura* = calf of leg

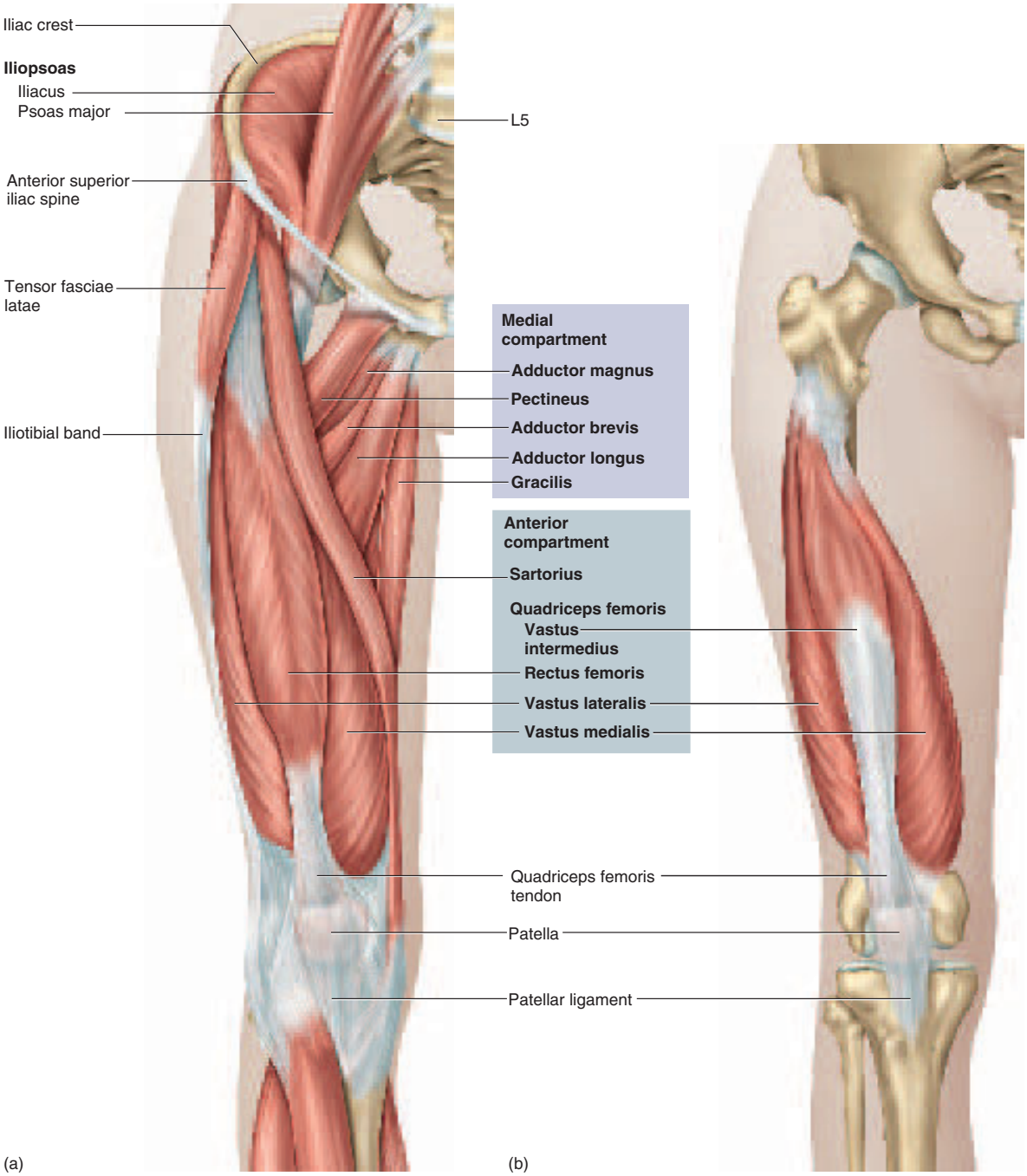

Figure 10.32 Muscles of the Thigh. Anterior view. (*a*) Superficial muscles; (*b*) rectus femoris and other muscles removed to expose the other three heads of the quadriceps femoris.

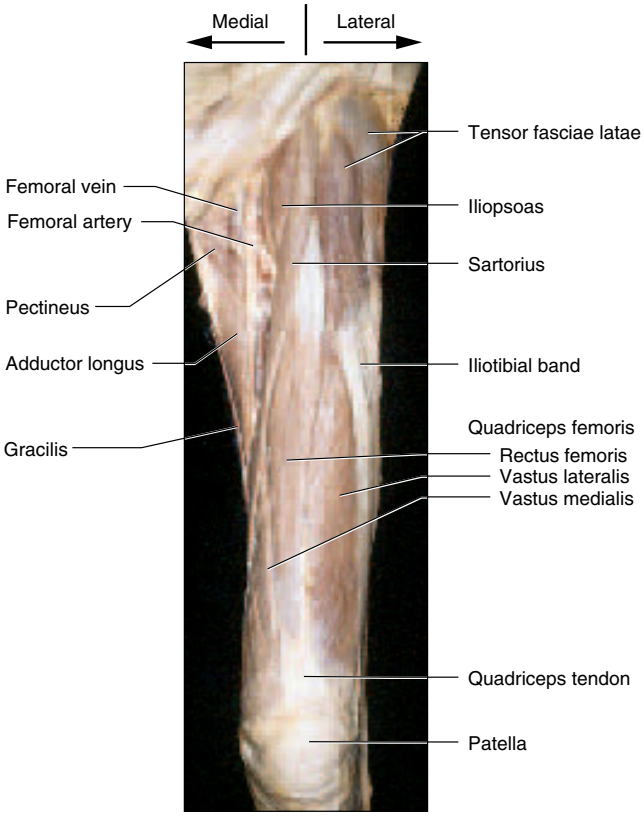

Figure 10.33 **Superficial Anterior Muscles of the Thigh of the Cadaver.**

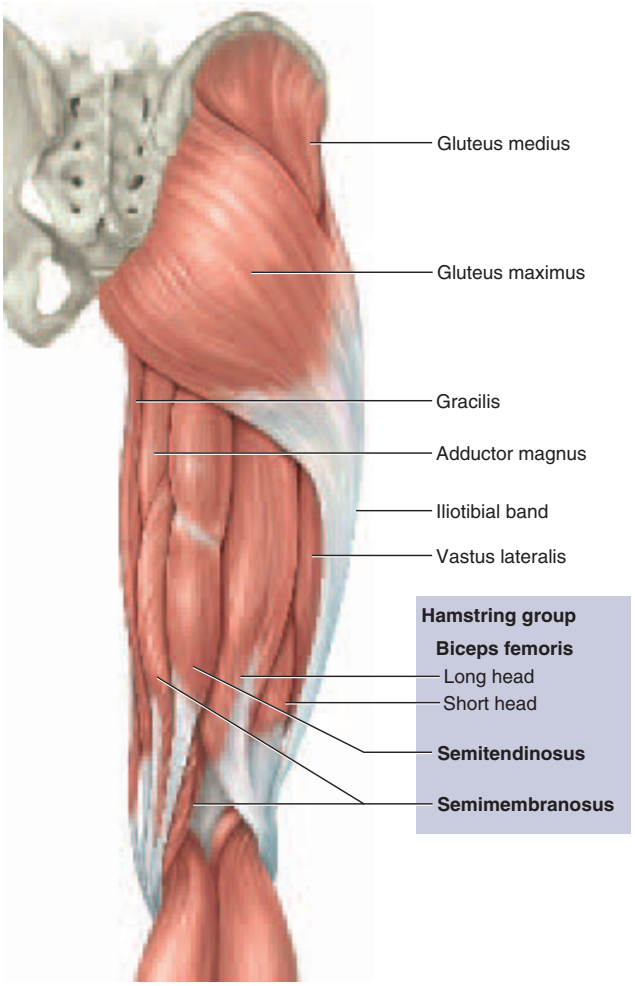

Figure 10.34 **Gluteal and Thigh Muscles.** Posterior view.

The intrinsic muscles of the foot support the arches and act on the toes in ways that aid locomotion (table 10.20). Several of them are similar in name and location to the intrinsic muscles of the hand. One of these muscles, the **extensor digitorum brevis,**[59] is on the dorsal side of the foot. The others are ventral or lie between the metatarsals. They are grouped in four layers:

1. The most superficial layer includes the stout **flexor digitorum brevis** medially, with four tendons that supply all the digits except the hallux. It is flanked by the **abductor digiti minimi**[60] laterally and **abductor hallucis**[61] medially; the tendons of these two muscles serve the little toe and great toe, respectively (fig. 10.40*a*).
2. The second layer, deep to the first, consists of the thick medial **quadratus plantae,** which joins the tendons of the flexor digitorum longus, and the four **lumbrical muscles** located between the metatarsals (fig. 10.40*b*).
3. The third layer includes the **adductor hallucis, flexor digiti minimi brevis,** and **flexor hallucis brevis** (fig. 10.40*c*). The adductor hallucis has an oblique head that crosses the foot and inserts at the base of the great toe, and a transverse head that passes across the bases of digits II–V and meets the long head at the base of the hallux.
4. The deepest layer consists of four **dorsal interosseous muscles** and three **plantar interosseous muscles** located between the metatarsals. Each dorsal interosseous muscle is bipennate and originates on two adjacent metatarsals. The plantar interosseous muscles are unipennate and originate on only one metatarsal each (fig. 10.40*d, e*).

[59] "short extensor of the digits"
[60] "abductor of the little toe"
[61] "abductor of the hallux (great toe)"

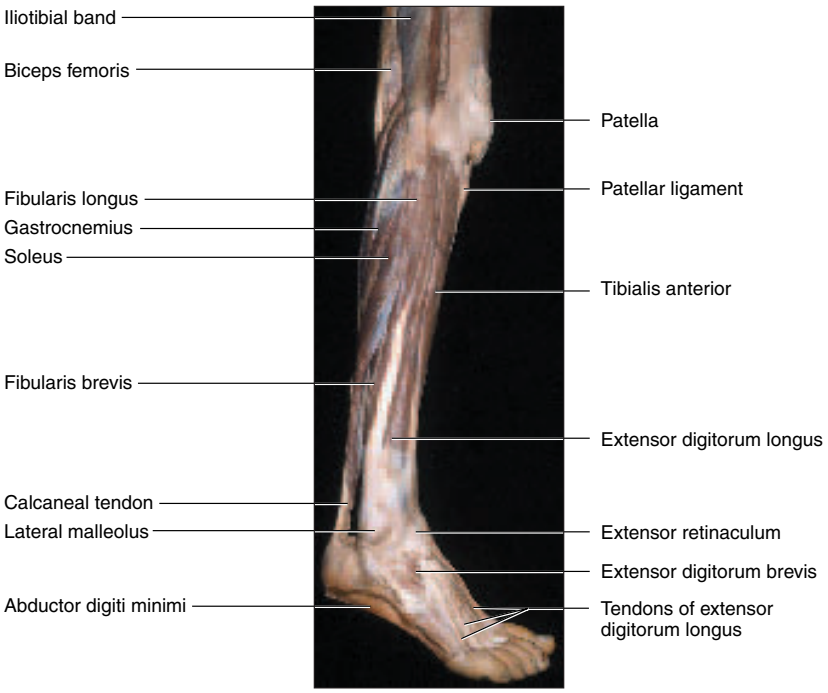

Figure 10.35 **Superficial Muscles of the Leg of the Cadaver.** Right lateral view.

Table 10.19 Muscles Acting on the Foot (see figs. 10.36 and 10.37)

O = origin, I = insertion, N = innervation (n. = nerve)

Anterior Compartment of Leg		
Extensor Digitorum (DIDJ-ih-TOE-um) Longus		
Extends toes II–V; dorsiflexes and everts foot O: lateral condyle of tibia, shaft of fibula, interosseous membrane	I: middle and distal phalanges II–V	N: deep peroneal n.
Extensor Hallucis (hal-OO-sis) Longus		
Extends hallux (great toe); dorsiflexes and inverts foot O: medial aspect of fibula, interosseous membrane	I: distal phalanx I	N: deep peroneal n.
Fibularis Tertius (FIB-you-LAIR-iss TUR-she-us)		
Dorsiflexes and everts foot O: distal shaft of fibula	I: metatarsal V	N: deep peroneal n.
Tibialis (TIB-ee-AY-lis) Anterior		
Dorsiflexes and inverts foot O: lateral tibia, interosseous membrane	I: medial cuneiform, metatarsal I	N: deep peroneal n.

(continued)

Table 10.19 Muscles Acting on the Foot (see figs. 10.36 and 10.37) *(continued)*

Posterior Compartment of Leg—Superficial Group		
Gastrocnemius (GAS-trock-NEE-me-us)		
Flexes knee; plantar flexes foot O: medial and lateral epicondyles of femur	I: calcaneus	N: tibial n.
Soleus (SO-lee-us)		
Plantar flexes foot O: proximal one-third of tibia and fibula	I: calcaneus	N: tibial n.
Plantaris (plan-TERR-is)		
Flexes knee; plantar flexes foot. Sometimes absent. O: distal femur	I: calcaneus	N: tibial n.
Posterior Compartment of Leg—Deep Group		
Flexor Digitorum Longus		
Flexes toes II–V; plantar flexes and inverts foot O: midshaft of tibia	I: distal phalanges II–V	N: tibial n.
Flexor Hallucis Longus		
Flexes hallux (great toe); plantar flexes and inverts foot O: shaft of fibula	I: distal phalanx I	N: tibial n.
Tibialis Posterior		
Plantar flexes and inverts foot O: proximal half of tibia, fibula, interosseous membrane	I: navicular, cuneiforms, metatarsals II–IV	N: tibial n.
Lateral (fibular) Compartment of Leg		
Fibularis (peroneus) Brevis		
Plantar flexes and everts foot O: shaft of fibula	I: base of metatarsal V	N: superficial peroneal n.
Fibularis (peroneus) Longus		
Plantar flexes and everts foot O: proximal half of fibula, lateral condyle of tibia	I: medial cuneiform, metatarsal I	N: superficial peroneal n.

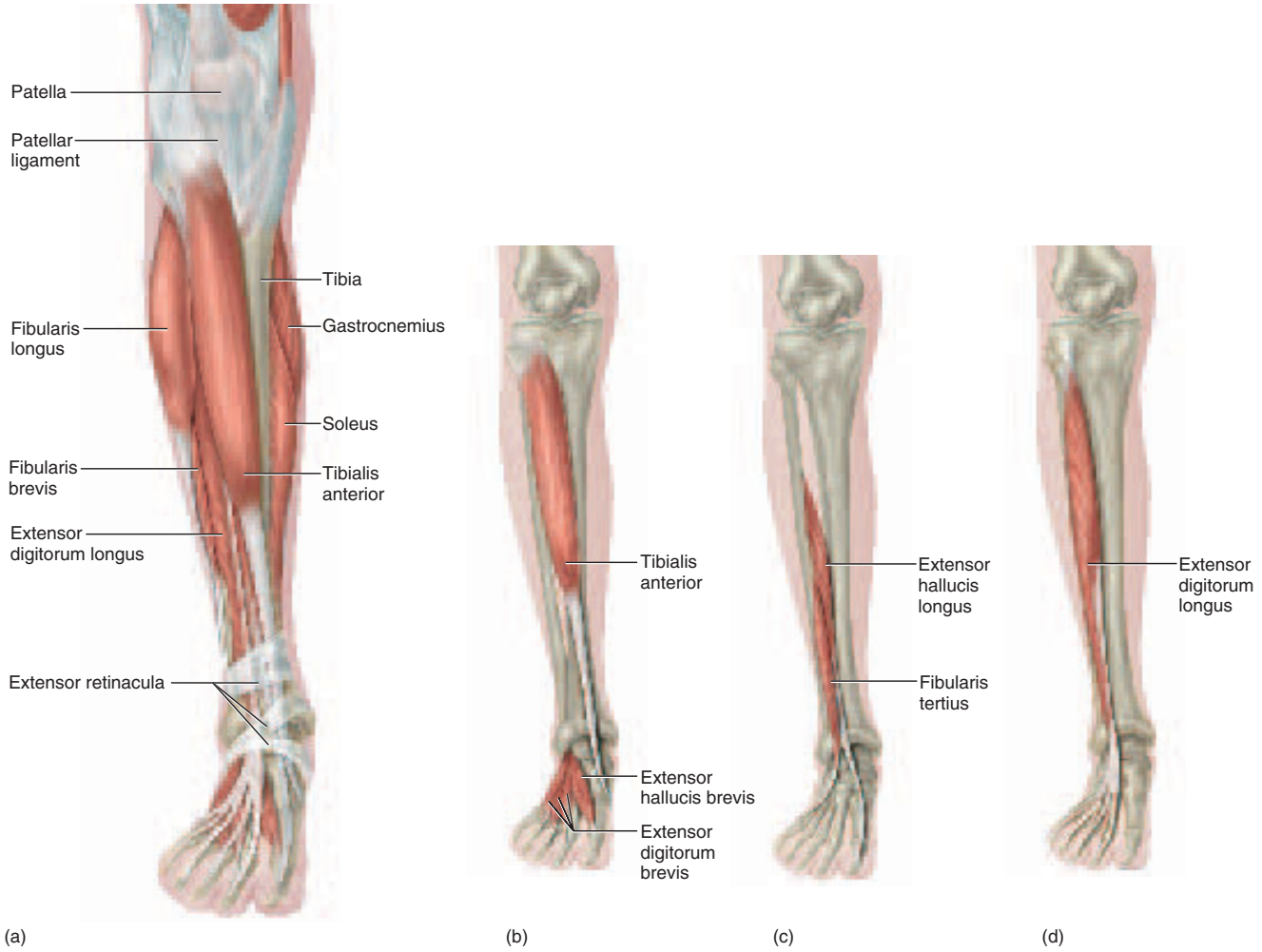

Figure 10.36 Muscles of the Leg. Anterior view. (*a*) A view showing some muscles of the anterior, lateral, and posterior compartments. (*b–d*) Individual muscles of the anterior compartment of the leg and dorsal aspect of the foot.

Several of the muscles in the first three layers originate on a broad **plantar aponeurosis,** which lies between the plantar skin and muscles. It diverges like a fan from the calcaneus to the bases of all five toes.

Think About It

Not everyone has the same muscles. From the information provided in this chapter, identify two muscles that are lacking in some people.

Before You Go On

Answer the following questions to test your understanding of the preceding section:

23. In the middle of a stride, you have one foot on the ground and you are about to swing the other leg forward. What muscles produce the movements of that leg?
24. Name the muscles that cross both the hip and knee joints and produce actions at both.
25. List the major actions of the muscles of the anterior, medial, and posterior compartments of the thigh.
26. Describe the role of plantar flexion and dorsiflexion in walking. What muscles produce these actions?

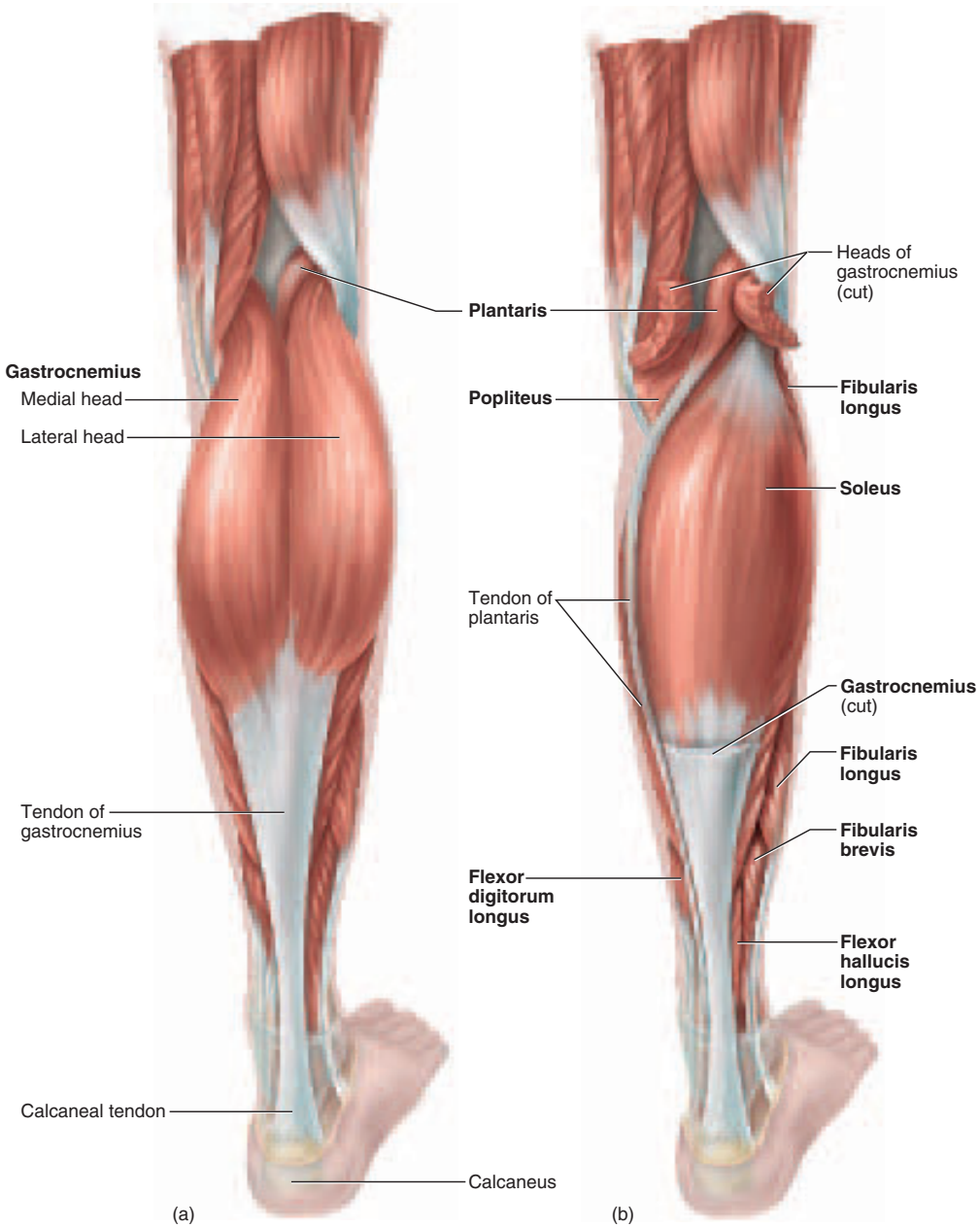

Figure 10.37 Superficial Muscles of the Leg, Posterior Compartment. (*a*) The gastrocnemius. (*b*) The soleus, deep to the gastrocnemius and sharing the calcaneal tendon with it.

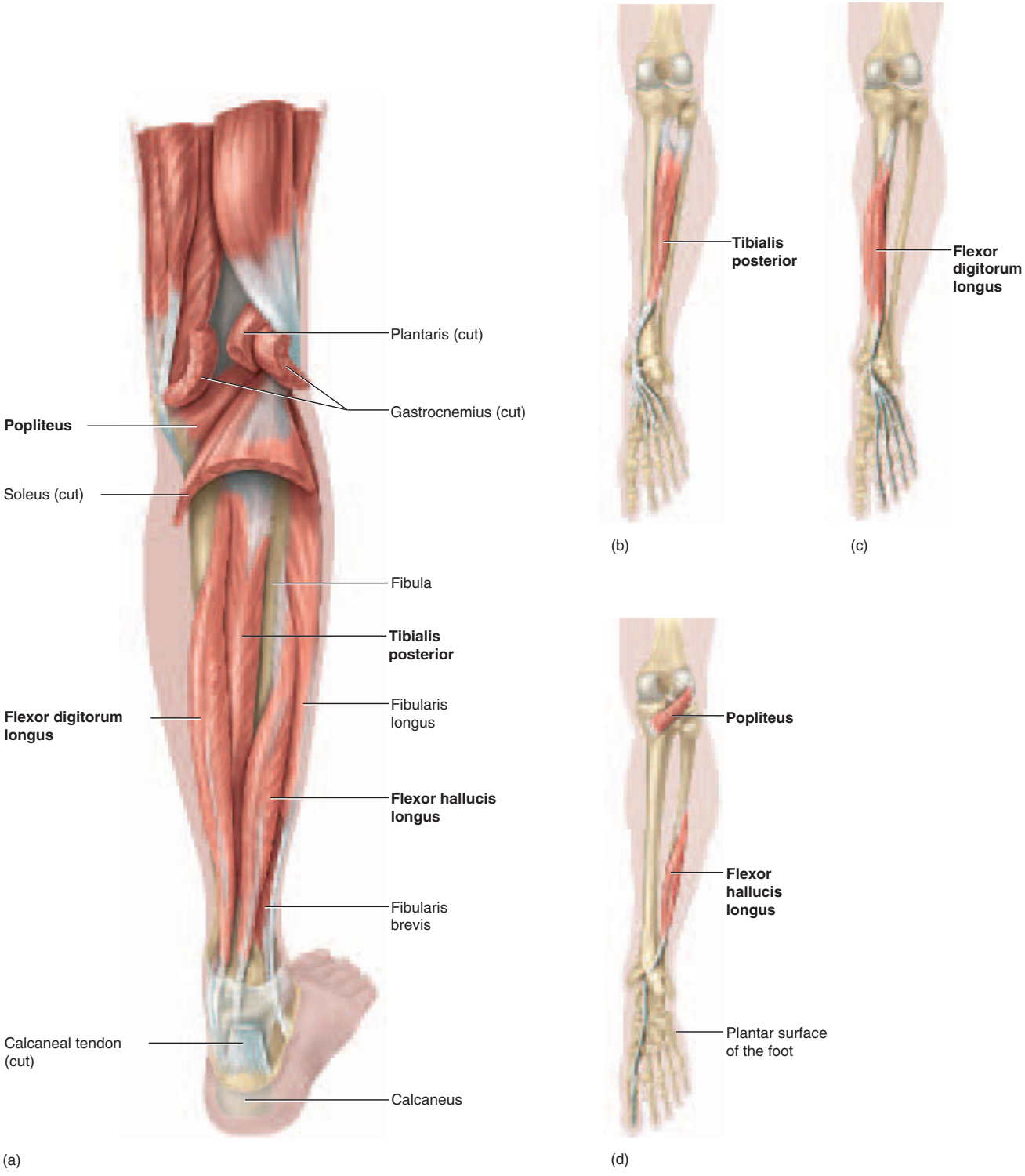

Figure 10.38 Deep Muscles of the Leg, Posterior and Lateral Compartments. (*a*) Muscles deep to the soleus. (*b–d*) Exposure of some individual deep muscles with foot plantar flexed.

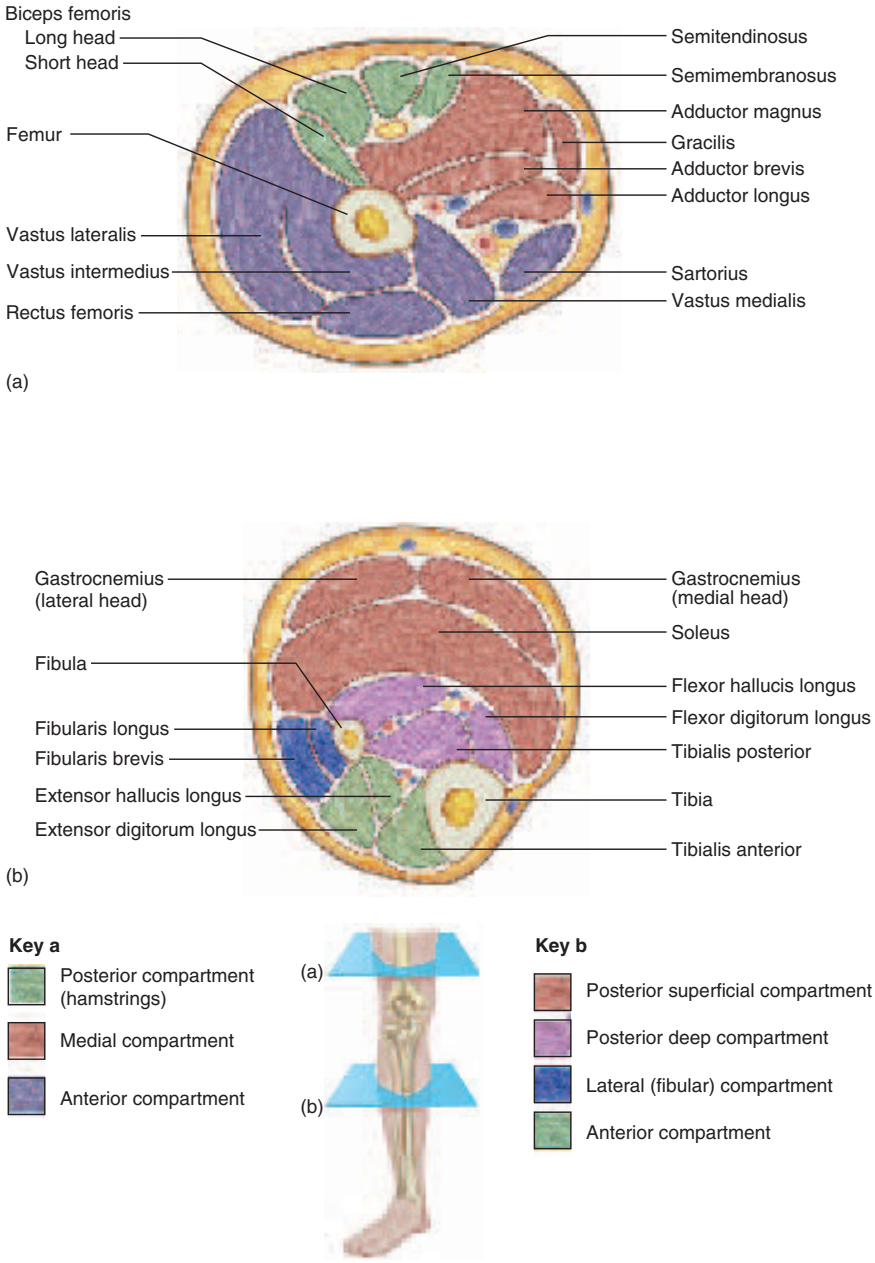

Figure 10.39 Serial Cross Sections Through the Lower Limb. Each section is taken at the correspondingly lettered level at the bottom of the figure and is pictured with the posterior muscle compartment facing the top of the page.
Which of these muscles are named for the adjacent bones?

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Table 10.20 Intrinsic Muscles of the Foot (see fig. 10.40)

O = origin, I = insertion, N = innervation (n. = nerve, nn. = nerves)

Dorsal Aspect of Foot		
Extensor Digitorum (DIDJ-ih-TOE-rum) Brevis		
Extends toes		
O: dorsal aspect of calcaneus	I: tendons of extensor digitorum longus	N: deep peroneal n.
Ventral Layer 1 (Most Superficial)		
Flexor Digitorum Brevis		
Flexes toes II–V		
O: calcaneus, plantar aponeurosis	I: middle phalanges II–V	N: medial plantar n.
Abductor Digiti Minimi		
Abducts and flexes little toe; supports lateral longitudinal arch		
O: calcaneus, plantar aponeurosis	I: proximal phalanx V	N: lateral plantar n.
Abductor Hallucis (hal-OO-sis)		
Flexes hallux (great toe); supports medial longitudinal arch		
O: calcaneus, plantar aponeurosis	I: proximal phalanx I	N: medial plantar n.
Ventral Layer 2		
Quadratus Plantae (quad-RAY-tus PLAN-tee)		
Flexes toes		
O: calcaneus, plantar aponeurosis	I: tendons of flexor digitorum	N: lateral plantar n.
Lumbricals (four muscles)		
Flex metatarsophalangeal joints; extend interphalangeal joints		
O: tendon of flexor digitorum longus	I: extensor tendons to digits II–V	N: lateral and medial plantar nn.
Ventral Layer 3		
Adductor Hallucis		
Adducts hallux		
O: metatarsals II–IV	I: proximal phalanx I	N: medial plantar n.
Flexor Digiti Minimi Brevis		
Flexes little toe		
O: metatarsal V, plantar aponeurosis	I: proximal phalanx V	N: lateral plantar n.
Flexor Hallucis Brevis		
Flexes hallux		
O: cuboid, plantar aponeurosis	I: proximal phalanx I	N: medial plantar n.
Ventral Layer 4 (Deepest)		
Dorsal Interosseous Muscles (four muscles)		
Abduct toes II–V		
O: each with two heads arising from adjacent metatarsals	I: proximal phalanges II–IV	N: lateral plantar n.
Plantar Interosseous Muscles (three muscles)		
Adduct toes III–V		
O: medial aspect of metatarsals III–V	I: proximal phalanges III–V	N: lateral plantar n.

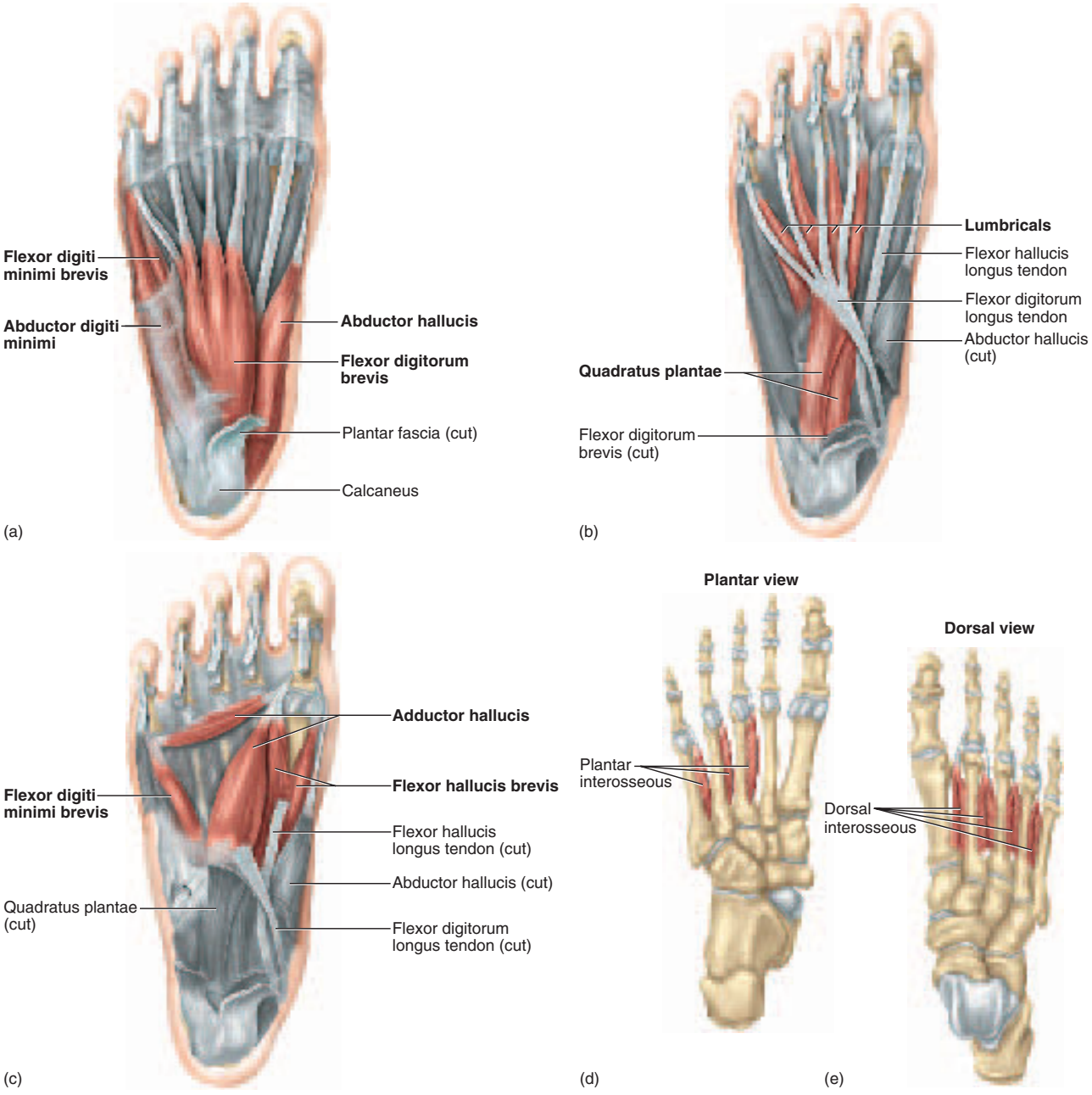

Figure 10.40 **Intrinsic Muscles of the Foot.** (*a–d*) First through fourth layers, respectively, in ventral (plantar) views; (e) fourth layer, dorsal view.

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Insight 10.6 Clinical Application

Athletic Injuries

Although the muscular system is subject to fewer diseases than most organ systems, it is particularly vulnerable to injuries resulting from sudden and intense stress placed on muscles and tendons. Each year, thousands of athletes from the high school to professional level sustain some type of injury to their muscles, as do the increasing numbers of people who have taken up running and other forms of physical conditioning. Overzealous exertion without proper conditioning and warm-up is frequently the cause. Some of the more common athletic injuries are:

Baseball finger—tears in the extensor tendons of the fingers resulting from the impact of a baseball with the extended fingertip.

Blocker's arm—ectopic ossification in the lateral margin of the forearm as a result of repeated impact with opposing players.

Charley horse—any painful tear, stiffness, and blood clotting in a muscle. A charley horse of the quadriceps femoris is often caused by football tackles.

Compartment syndrome—a condition in which overuse, contusion, or muscle strain damages blood vessels in a compartment of the arm or leg. Since the fasciae enclosing a compartment are tight and cannot stretch, blood or tissue fluid accumulating in the compartment can put pressure on the muscles, nerves, and blood vessels. The lack of blood flow in the compartment can cause destruction of nerves if untreated within 2 to 4 hours and death of muscle tissue if it goes untreated for 6 hours or more. Nerves can regenerate if blood flow is restored, but muscle damage is irreversible. Depending on its severity, compartment syndrome may be treated with immobilization and rest or an incision to drain fluid from the compartment or otherwise relieve the pressure.

Pitcher's arm—inflammation at the origin of the flexor carpi resulting from hard wrist flexion in releasing a baseball.

Pulled groin—strain in the adductor muscles of the thigh. It is common in gymnasts and dancers who perform splits and high kicks.

Pulled hamstrings—strained hamstring muscles or a partial tear in the tendinous origin, often with a hematoma (blood clot) in the fascia lata. This condition is frequently caused by repetitive kicking (as in football and soccer) or long, hard running.

Rider's bones—abnormal ossification in the tendons of the adductor muscles of the medial thigh. It results from prolonged abduction of the thighs when riding horses.

Rotator cuff injury—a tear in the tendon of any of the SITS (rotator cuff) muscles, most often the tendon of the supraspinatus. Such injuries are caused by strenuous circumduction of the arm, shoulder dislocation, or repetitive use of the arm in a position above horizontal. They are common among baseball pitchers and third basemen, bowlers, swimmers, weight lifters, and in racquet sports. Recurrent inflammation of a SITS tendon can cause a tendon to degenerate and then to rupture in response to moderate stress. Injury causes pain and makes the shoulder joint unstable and subject to dislocation.

Shinsplints—a general term embracing several kinds of injury with pain in the crural region: tendinitis of the tibialis posterior muscle, inflammation of the tibial periosteum, and anterior compartment syndrome. Shinsplints may result from unaccustomed jogging, walking on snowshoes, or any vigorous activity of the legs after a period of relative inactivity.

Tennis elbow—inflammation at the origin of the extensor carpi muscles on the lateral epicondyle of the humerus. It occurs when these muscles are repeatedly tensed during backhand strokes and then strained by sudden impact with the tennis ball. Any activity that requires rotary movements of the forearm and a firm grip of the hand (for example, using a screwdriver) can cause the symptoms of tennis elbow.

Tennis leg—a partial tear in the lateral origin of the gastrocnemius muscle. It results from repeated strains put on the muscle while supporting the body weight on the toes.

Most athletic injuries can be prevented by proper conditioning. A person who suddenly takes up vigorous exercise may not have sufficient muscle and bone mass to withstand the stresses such exercise entails. These must be developed gradually. Stretching exercises keep ligaments and joint capsules supple and therefore reduce injuries. Warm-up exercises promote more efficient and less injurious musculoskeletal function in several ways, discussed in chapter 11. Most of all, moderation is important, as most injuries simply result from overuse of the muscles. "No pain, no gain" is a dangerous misconception.

Muscular injuries can be treated initially with "RICE": rest, ice, compression, and elevation. Rest prevents further injury and allows repair processes to occur; ice reduces swelling; compression with an elastic bandage helps to prevent fluid accumulation and swelling; and elevation of an injured limb promotes drainage of blood from the affected area and limits further swelling. If these measures are not enough, anti-inflammatory drugs may be employed, including corticosteroids as well as aspirin and other nonsteroidal agents.

Connective Issues

Interactions Between the MUSCULAR SYSTEM and Other Organ Systems

← Indicates ways in which this system affects other systems
→ Indicates ways in which other systems affect this one

Integumentary System

← Facial muscles pull on skin to provide facial expressions

→ Covers and protects superficial muscles; initiates synthesis of calcitriol, which promotes absorption of calcium needed for muscle contraction; dissipates heat generated by muscles

Skeletal System

← Muscles move and stabilize joints and produce stress that affects ossification, bone remodeling, and shapes of mature bones

→ Provides levers that enable muscles to act; stores calcium needed for muscle contraction

Nervous System

← Muscles give expression to thoughts, emotions, and motor commands that arise in the central nervous system

→ Stimulates muscle contraction; monitors and adjusts muscle tension; adjusts cardiopulmonary functions to meet needs of muscles during exercise

Endocrine System

← Exercise stimulates secretion of stress hormones; skeletal muscles protect some endocrine organs

→ Hormones stimulate growth and development of muscles and regulate levels of glucose and electrolytes important for muscle contraction

Circulatory System

← Muscle contractions help to move blood through veins; exercise stimulates growth of new blood vessels

→ Delivers O_2 and nutrients; carries away wastes and heat generated by muscles; cardiovascular efficiency, RBC count, hemoglobin level, and density of blood capillaries in muscle greatly affect muscular endurance

Lymphatic and Immune Systems

← Muscle contractions promote lymph flow; exercise elevates level of immune cells and antibodies; excess exercise inhibits immune responses

→ Lymphatic system drains fluid from muscles; immune system protects muscles from pathogens and promotes tissue repair

Respiratory System

← Muscle contractions ventilate lungs; muscles of larynx and pharynx regulate air flow; CO_2 generated by exercise stimulates respiratory rate and depth

→ Provides O_2 and removes CO_2; respiratory efficiency greatly affects muscular endurance

Urinary System

← Muscles control voluntary urination; muscles of pelvic floor support bladder

→ Eliminates wastes generated by muscles; regulates levels of electrolytes important for muscle contraction

Digestive System

← Muscles enable chewing and swallowing; control voluntary defecation; abdominal and lumbar muscles protect lower digestive organs

→ Absorbs nutrients needed by muscles; liver regulates blood glucose levels and metabolizes lactic acid generated by anaerobic muscle metabolism

Reproductive System

← Muscles contribute to erection and ejaculation; abdominal and pelvic muscles aid childbirth

→ Gonadal steroids affect muscular growth and development

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Chapter Review

Review of Key Concepts

The Structural and Functional Organization of Muscles (p. 326)

1. The muscular system consists of the skeletal muscles. The study of this system is *myology.*
2. The muscular system serves for body movements, stability, communication, control of body openings and passages, and heat production.
3. Each skeletal muscle fiber (cell) is enclosed in a fibrous *endomysium.* A *fascicle* is a bundle of muscle fibers enclosed in a fibrous *perimysium.* The muscle as a whole is enclosed in a fibrous *epimysium.* Connective tissue *deep fasciae* separate neighboring muscles from each other, and the *superficial fascia* separates the muscles from the skin.
4. A muscle may have a *direct attachment* to a bone in which the muscle fibers reach all the way to the bone, or an *indirect attachment* in which a tendon intervenes between the muscle and bone.
5. A muscle typically has a stationary *origin (head)* on one bone, a mobile *insertion* on another bone, and a thicker *belly* between the origin and insertion.
6. Muscles are classified according to the orientation of their fascicles as *fusiform, parallel, convergent, pennate,* and *circular* (fig. 10.3). Circular muscles are also called *sphincters.*
7. The motion produced by a muscle is called its *action.* Muscles work in groups across a joint. In a given joint action, the *prime mover* produces most of the force, a *synergist* aids the prime mover or modifies its action, an *antagonist* opposes that action, and a *fixator* prevents a bone from moving. These muscles may change roles in a different action at the same joint.
8. *Intrinsic muscles* are entirely contained in a region of study such as the head or hand; *extrinsic muscles* have their origin in a region other than the site of their action, such as forearm muscles that move the fingers.
9. Muscles are *innervated* by cranial nerves and spinal nerves.
10. Muscle names, often in Latin, frequently refer to their size, shape, location, number of heads, orientation, or action (table 10.1).

Muscles of the Head and Neck (p. 330)

1. Table 10.2 describes numerous muscles of the face that move the eyelids, nose, lips, jaw, and other regions, producing varied facial actions and expressions.
2. Table 10.3 describes several muscles that move the tongue and aid in chewing and swallowing.
3. Table 10.4 describes muscles of the neck that move the head.

Muscles of the Trunk (p. 345)

1. Table 10.5 describes the intercostal muscles and diaphragm, which are the principal muscles of respiration.
2. Table 10.6 describes the principal anterior and lateral muscles of the abdomen.
3. Table 10.7 describes numerous muscles of the back that act principally on the vertebral column.
4. Table 10.8 describes the three layers of muscles of the pelvic floor, or perineum. This region is divided by bony landmarks into two triangular areas, the urogenital and anal triangles, which help to define the locations of these muscles.

Muscles Acting on the Shoulder and Upper Limb (p. 352)

1. Table 10.9 describes several muscles of the upper back and chest that act on the scapula.
2. Table 10.10 describes nine muscles that cross the shoulder joint and act on the humerus, including the four *rotator cuff* muscles, whose tendons are often injured in strenuous and repetitive athletic and work activities.
3. Table 10.13 describes muscles of the brachium and antebrachium that move the antebrachium (forearm).
4. Table 10.14 describes muscles of the antebrachium that act on the wrist and hand. These numerous and complex muscles are divided into flexors in the *anterior compartment* and extensors in the *posterior compartment.* Each compartment is divided by connective tissue fasciae into superficial and deep layers.
5. Table 10.16 describes the intrinsic muscles of the hand, which move the fingers. These are arranged in *thenar, midpalmar,* and *hypothenar* groups.

Muscles Acting on the Hip and Lower Limb (p. 369)

1. Table 10.17 describes muscles that act on the hip and femur; most of these originate on the os coxae.
2. Table 10.18 describes muscles that act on the knee; these muscles form much of the bulk of the thigh, especially the quadriceps femoris anteriorly and hamstring muscles posteriorly.
3. Table 10.19 describes extrinsic muscles acting on the foot; these muscles form much of the bulk of the leg proper, especially the gastrocnemius muscle of the calf. Most muscles of the anterior compartment dorsiflex the foot, and most in the posterior compartment plantar flex the foot and flex the toes.
4. Table 10.20 describes intrinsic muscles of the foot that support the foot arches and act on the toes.

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Selected Vocabulary

fascicle 326
fascia 326
tendon 327
aponeurosis 327
retinaculum 328
origin 328
insertion 328
belly 328
sphincter 328
action 328
prime mover 328
synergist 328
antagonist 329
fixator 329
intrinsic muscle 329
extrinsic muscle 329
innervation 329
perineum 350
rotator cuff 356
carpal tunnel 365

Testing Your Recall

1. Which of the following muscles is the prime mover in spitting out a mouthful of liquid?
   a. platysma
   b. buccinator
   c. risorius
   d. masseter
   e. palatoglossus
2. Each muscle fiber has a sleeve of areolar connective tissue around it called
   a. the deep fascia.
   b. the superficial fascia.
   c. the perimysium.
   d. the epimysium.
   e. the endomysium.
3. Which of these is *not* a suprahyoid muscle?
   a. genioglossus
   b. geniohyoid
   c. stylohyoid
   d. mylohyoid
   e. digastric
4. Which of these muscles is an extensor of the neck?
   a. external oblique
   b. sternocleidomastoid
   c. splenius capitis
   d. iliocostalis
   e. latissimus dorsi
5. Which of these muscles of the pelvic floor is the deepest?
   a. superficial transverse perineus
   b. bulbospongiosus
   c. ischiocavernosus
   d. deep transverse perineus
   e. levator ani
6. Which of these actions is *not* performed by the trapezius?
   a. extension of the neck
   b. depression of the scapula
   c. elevation of the scapula
   d. rotation of the scapula
   e. adduction of the humerus
7. Both the hands and feet are acted upon by a muscle or muscles called
   a. the extensor digitorum.
   b. the abductor digiti minimi.
   c. the flexor digitorum profundus.
   d. the abductor hallucis.
   e. the flexor digitorum longus.
8. Which of the following muscles does *not* extend the hip joint?
   a. quadriceps femoris
   b. gluteus maximus
   c. biceps femoris
   d. semitendinosus
   e. semimembranosus
9. Both the gastrocnemius and _____ muscles insert on the heel by way of the calcaneal tendon.
   a. semimembranosus
   b. tibialis posterior
   c. tibialis anterior
   d. soleus
   e. plantaris
10. Which of the following muscles raises the upper lip?
    a. levator palpebrae superioris
    b. orbicularis oris
    c. zygomaticus minor
    d. masseter
    e. mentalis
11. The _____ of a muscle is the point where it attaches to a relatively stationary bone.
12. A bundle of muscle fibers surrounded by perimysium is called a/an _____.
13. The _____ is the muscle primarily responsible for a given movement at a joint.
14. The three large muscles on the posterior side of the thigh are commonly known as the _____ muscles.
15. Connective tissue bands called _____ prevent flexor tendons from rising like bowstrings.
16. The anterior half of the perineum is a region called the _____.
17. The abdominal aponeuroses converge on a median fibrous band on the abdomen called the _____.
18. A muscle that works with another to produce the same or similar movement is called a/an _____.
19. A muscle somewhat like a feather, with fibers obliquely approaching its tendon from both sides, is called a/an _____ muscle.
20. A circular muscle that closes a body opening is called a/an _____.

Chapter 10

Answers in Appendix B

True or False

Determine which five of the following statements are false, and briefly explain why.

1. Cutting the phrenic nerves would paralyze the prime mover of respiration.
2. The orbicularis oculi and orbicularis oris are sphincters.
3. The origin of the sternocleidomastoid muscle is the mastoid process of the skull.
4. To push someone away from you, you would use the serratus anterior more than the trapezius.
5. Both the extensor digitorum and the extensor digiti minimi extend the little finger.
6. Curling the toes employs the quadratus plantae.
7. The scalenes are superficial to the trapezius.
8. Exhaling requires contraction of the internal intercostal muscles.
9. Hamstring injuries often result from rapid flexion of the knee.
10. The tibialis anterior and tibialis posterior are synergists.

Answers in Appendix B

Testing Your Comprehension

1. Radical mastectomy, once a common treatment for breast cancer, involved removal of the pectoralis major along with the breast. What functional impairments would result from this? What synergists could a physical therapist train a patient to use to recover some lost function?
2. Removal of cancerous lymph nodes from the neck sometimes requires removal of the sternocleidomastoid on that side. How would this affect a patient's range of head movement?
3. In a disease called tick paralysis, the saliva from a tick bite paralyzes skeletal muscles beginning with the lower limbs and progressing superiorly. What would be the most urgent threat to the life of a tick paralysis patient?
4. Women who habitually wear high heels may suffer painful "high heel syndrome" when they go barefoot or wear flat shoes. What muscle(s) and tendon(s) are involved? Explain.
5. A student moving out of a dormitory kneels down, in correct fashion, to lift a heavy box of books. What prime movers are involved as he straightens his legs to lift the box?

Answers at the Online Learning Center

Answers to Figure Legend Questions

10.7 The procerus
10.21 (To be answered by marking the illustration.)
10.25 Pronator teres refers to the round or cordlike shape of this muscle, and pronator quadratus refers to the four-sided shape of this muscle.
10.27 Figure *c* represents a cross section cut too high on the forearm to include these muscles.
10.39 The biceps femoris, rectus femoris, fibularis longus and brevis, and tibialis posterior and anterior

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